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State-of-practice and State-of-Art for the Project Cycle Time Reduction

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Abstract

There are no formal decision tools or guidelines to assist owners and contractors in choosing delivery systems and project strategies that would allow for a radical reduction in project cycle time – from the preplanning phase through project start up. Therefore, it is important to identify the state-of-practice and the state-of-art on methods of achieving radical reduction defined as a reduction of 25% or more in overall project cycle time. A comprehensive literature review, three questionnaire surveys, and the seven case studies were conducted and the data obtained from them were analyzed to establish the state-of-practice and state-of-art for project cycle time reduction techniques.

Keywords: Project Management, Radical Reduction, Construction Scheduling, Project Cycle Time, Questionnaire Surveys

1. INTRODUCTION

With increasing frequency, owners are demanding that the construction industry deliver projects within shorter and shorter time frames (Songer et al. 2000). Reducing the time required for project delivery has been identified by the CII member companies as a significant means for the U.S. competitiveness in the domestic and international markets. Reducing the delivery time of projects in the engineering and construction (E&C) industry has been one of the goals set by the Construction Industry Institute (CII) for this decade (Eldin 1996).

The project delivery system defines the relationships, roles and responsibilities of project team members and the sequence of activities required to provide a facility. Several systems have evolved over the years. 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 helping undertake assessment of project delivery systems with an aim to reducing capital facility planning and construction time.

Therefore, this paper introduces the state-of-practice and the state-of-art on methods of achieving radical reduction in project cycle time. In this research, radical reduction is defined by CII as a reduction of 25% or more in overall project cycle time (i.e., Pre-project planning (PPP), Design (D), Material Management (MM), Construction (C), and Start-up (SU)) when compared to current industry standard for projects of similar size and scope. A project cycle is defined to begin at the pre-planning stage when owner's engineering gets involved in the project and concludes at the start-up of the projects.

The scope of this research includes investigation of case studies and best practices of recently completed projects with unusual success in reducing cycle time. It is expected that a study of high performing projects would lead to the discovery of delivery practices, which, if applied broadly and routinely, would improve delivery time across the general construction industry. Additionally, the research assesses the barriers to radical reduction in cycle time and investigates methods used by other industries to shorten cycle time. Sample projects that have been successful in achieving radical reduction have been analyzed to determine practices that lead to radical reduction in project cycle time. Data were collected through questionnaire surveys, personnel interviews, site visits, and literature review. The literature review, which included academic research, technical reports, CII reference, new articles, and online resources, assisted the research team in identifying criteria that were important to establish the state-of-practice and evaluation of project cycle time reduction techniques.

2. LITERATURE REVIEW

The brief literature reviews are summarized in the following subsection. Due to editorial constraints, please refer to Hastak et al. (2004) for detail information regarding the literature review.

2.1 Need for radical reduction

For the risks associated with a fast track approach to be justified, there have to be significant benefits from reduction in project cycle time. These benefits will naturally vary with the industry and circumstances of the company. These are usually financial benefits of exceptional increased profit or reduced loss from early use of the assets as a result of one or more of the following (Back et al. 1998):

- Earlier income generation from the new facility or manufactured goods.
- Ability to deliver against commitments/contractual obligations.
- Earlier completion of urgent works of restoration following accident or incident, i.e., flood damage, bridge collapse, train crash.
- Reduced cost of providing alternative facilities.
- Earlier closure of old and less efficient plants.
- Earlier investment payback.
- New product to market ahead of completion

- Increased market share
- Compliance with inviolable regulatory requirements which would otherwise result in closure of the facility.
- Benefiting from changes in the tax structure.
- Earlier start to other projects following release of resources.

The client may have other reasons for the achievement of reduced project duration, such as:

- To improve the financial standing of the company.
- Minimized disruption to customers.
- Reduced period of adverse publicity where new or modified equipment is needed to solve a problem.
- Completion in time for a special occasion or inauguration.

In practice there may be cost increases and at the same time opportunities for cost reduction. The balance at the end of the project will depend on the astuteness with which the project manager and his team have dealt with both threats and opportunities.

Cost saving opportunities can arise from strategies that are embedded in a fast track approach, such as:

- “Lean” design, optimizing the process and minimizing number/size of equipment.
- Standard or reusable design.
- Reduced development costs through focused evaluation of options.
- Purchase of standard or off-the shelf equipment.
- Economy of optimum construction period.
- Reduced establishment costs resulting from shorter time.

2.2. Contractor Benefits

From the contractor’ point of view, there are fewer reasons to embrace a fast track strategy unless the relationship is such that they are able to share in the benefits that caused the client to commit to such a strategy in the first place. It is customary for the client to propose the use of a fast track strategy or to set such as a tight completion data that the only way to achieve it is to adopt a fast track strategy (Mathews and Ashley 1986). It is still the case that many contractors only become involved following receipt of bid documents, and then they are unable to influence earlier stages of the project during which decisions may have been made that determine the success or failure of the strategy. Potential benefits to the contractor 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.
- Enhanced reputation leading to opportunities with other clients

2.3 Current status and new trends in construction industry

Project delivery systems in the construction industry have gone through an evolutionary process to reduce project delivery time while maintaining quality and containing costs (Eldin 1996). The most commonly utilized project delivery systems prevalent today are

- Traditional design-bid-build
- Construction managed by a professional construction manager
- Bridging
- Design-Build (Lump-sum & Guaranteed Maximum Price)

Bridging is a hybrid of design-build and the traditional process. The contract documents are prepared by the client's Architect and Engineer. They specify the project's functional and esthetic requirements, but the details of construction technology are described with performance specifications. The construction contracts are awarded halfway through design. Fast-track is jargon for overlapping design and construction to accelerate completion. It may be done with the traditional process, bridging, design-build or any other process. There is no technical reason not to overlap design and construction. The problem is cost control: construction begins before the design is complete, so the final scope and therefore the final price may be disputed. The most recent and the one currently favored by owners is the "Design-Build" system of project delivery. Engineering News Record (ENR 1995) pointed out "A variety of market forces have conspired to reintroduced owners to Design-Build and they are now asking for it on a wider range of projects than ever before. What owners apparently want is certainty (in price and schedule) and they want it sooner in the construction. The most powerful forces in U.S. industry today invariably seem to favor Design-Build."

CII Research Report, RR 131-11 done by Sanvido and Konchar. (1998), used data from 351 building projects that showed Design-Build to be superior to traditional design-bid-build due to (i) reduction in unit cost (avg. of 6.1%), (ii) increase in construction speed (12%), (iii) reduction in overall project delivery (as much as 33.5%), and (iv) equal or better quality.

Owners are showing an increased willingness to fund more detailed scope definition commonly known as front-end loading for capital facility projects. While Design-Build and Front-end Loading are improvements to the traditional project delivery systems, neither is capable of achieving dramatic improvements in project delivery cycle.

Construction Integration and Automation Technology (CONSIAT) program, funded through a consortium including NIST and CII, is hoping to achieve significant cycle time and life-cycle cost reductions through integration and automation of project information from the site into project information management system (NIST 2001). However, the construction industry faces special challenges in reaping the full benefits of the information technology revolution that has brought and continues to bring rich rewards to many other industries. These challenges include low R&D investment, the fragmentation of the industry, and the strong project-oriented nature of its processes.

Table 1. Questionnaire I: Summary of responses

Project Name	Comments/Techniques	Offered By	Cost ($)	Std. Duration (months)	Actual Duration (months)	% Reduction	Benchmarking
Data Withheld		Data Withheld	$900 M	60	59	2%	IPA
	Modular Construction/ Factory assembly & testing		$35 M	29	26	10%	CII/IPA
	Able to utilize same key personnel Owner/Engineer/Contractor		$50.5 M	16.5	14.3	13%	NA
			$53.3 M	16.5	14.3	13%	NA
	Extraordinary Team Integration/ Extra pre-task planning/Aggressive CP monitoring/ Multi-shifting of construction		$50 M	29	25	14%	IPA
			$55.3 M	16.5	14	15%	NA
			$4.5 M	14.5	12	17%	NA
			$930 M	41	32	22%	IPA
			$300 M	50	38	24%	IPA
			$6.0 M	14.5	11	24%	NA
			$130 M	36	27	25%	NA
			Unknown	16	12	25%	NA
	Techniques for Schedule Reduction applied		$9.0 M	12	9	25%	IPA
			$58 M	15	11	27%	Internal
			$2.0 M	12.5	9	28%	NA
			$18 M	10	7	30%	Internal
			Unknown	12	8	33%	NA
			$31 M	24	16	33%	NA
	Craft overtime/ Coordinated design, permitting, fabrication effort. 2 week startup		$100 M	6	3.7	38%	Internal
			$1.7 T	60	36	40%	NA

3. DATA COLLECTION AND ANALYSIS

3.1 Questionnaire Surveys

Questionnaires assisted the research team in identify a set of criteria that were important to establish the state-of-practice and the state-of-art for cycle time reduction. This section analyzes the data collected through three set of questionnaires.

3.2 Questionnaire I

This questionnaire survey was mailed to all CII member organizations. Its main purpose was to identify projects that have achieved radical reduction (defined to be a reduction of 25% or greater over normal project cycle time). 22 responses were received with several companies providing multiple projects that had achieved cycle time reduction. All the responses were tabulated and analyzed. Table 1 shows a summary of the responses provided by the companies.

3.3 Questionnaire II

Questionnaire II was designed as a follow-up to Questionnaire I and was sent to two sets of respondents. The first set included the CII membership and the second set included case study participants identified through Questionnaire I. A total of 22 responses were received from the 104 questionnaires mailed to the CII member companies and 15 more from members participating in the seven case studies which is explained in the following section.

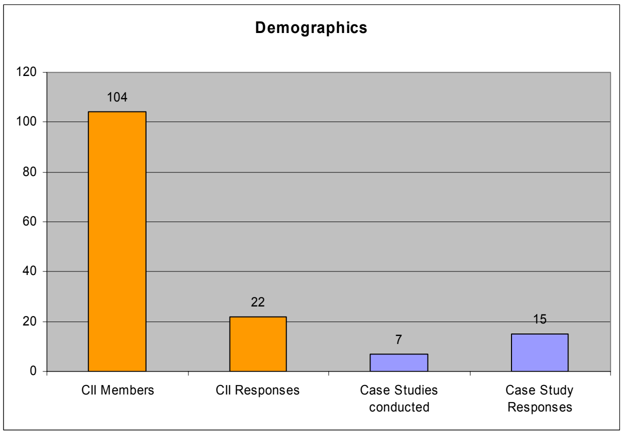

Figure 1. Breakdown of Responses

All the responses received were tabulated and analyzed together (refer to Figure 1).

3.3.1 Section I: General Information

Respondents to the questionnaire had different responsibilities in their respective companies including executive, construction management (CM), executive management (EM), and others. The majority of the respondents were at the executive management level and construction managerial level. The responses are shown in Figure 2.

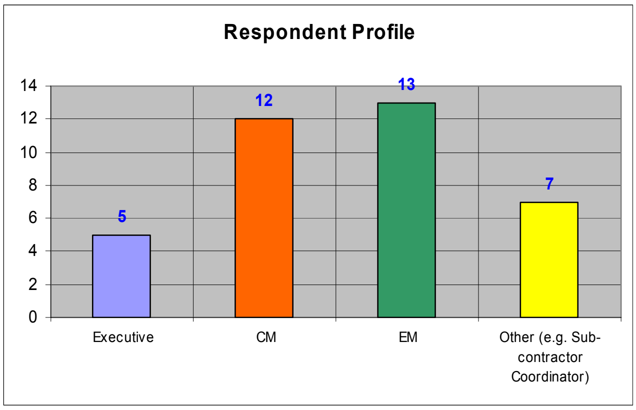

Figure 2. Respondent profile

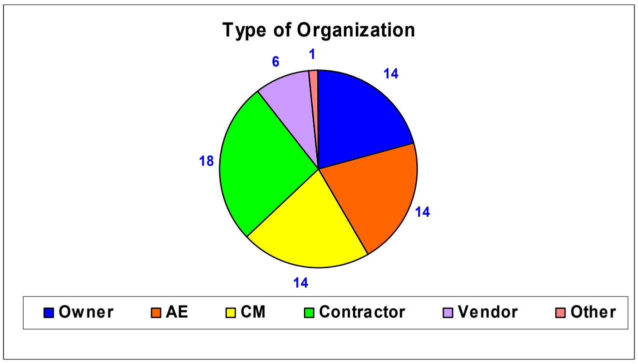

Figure 3. Types of Organizations Responding

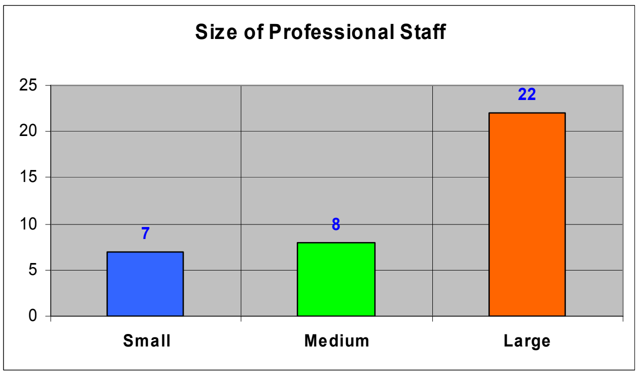

Figure 4. Size of the firm

Respondents were from different types of organizations like owners, architects/engineers, construction management, contractor, vendors, and other. As shown in Figure 3, the maximum respondents were contractors. The size of the companies responding varied from small (under 200 people) to large (over 500 people). As seen from in Figure 4, the majority responses were from the larger companies

The primary project types undertaken by the responding companies included general building construction, transportation, manufacturing, industrial process, petroleum, power, environmental, telecom and others (such as paper and pulp etc.). 15 respondents mentioned industrial processes as their major business, while 14 of them indicated power plants (refer to Figure 5).

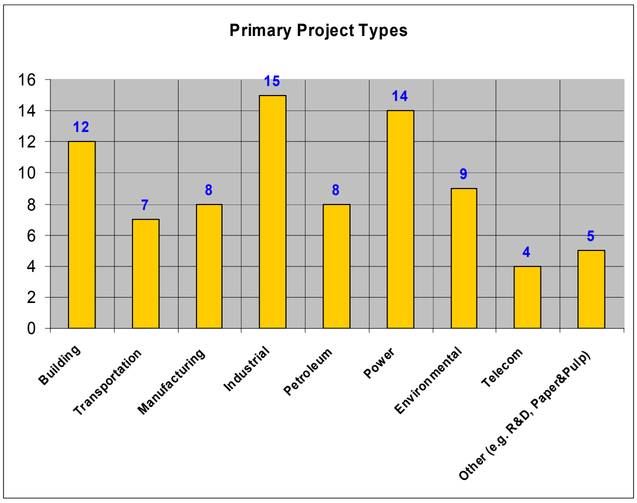

Figure 5. Types of projects undertaken by the respondents

3.3.2 Section II: Project Cycle Reduction - Part I

This section collected data from respondents for whom radical reduction was an important factor. If the respondent answered 'No' to this question, they were asked to proceed to section III, without answering any questions from this section. For the questions discussed in this section, respondents answered based on a scale of 1 to 4, where 1 implies that they "strongly agree" and 4 implies that they "strongly disagree." Hence, the lower the score, the more important that particular reduction technique.

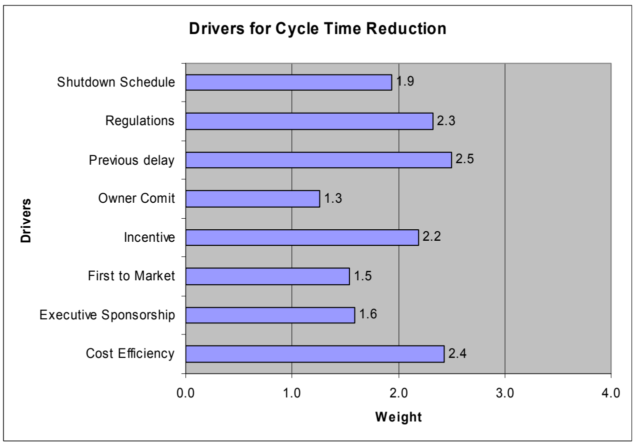

Figure 6. Drivers for Cycle Time Reduction

As shown in Figure 6, "Owner Commitment" in projects was considered the most important driver for cycle time reduction. "First to market" and "Executive sponsorship" were also considered as other important drivers.

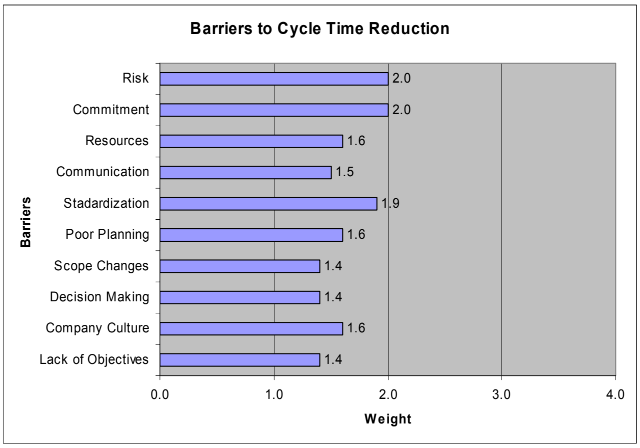

Figure 7. Barrier to Cycle Time Reduction

Respondents were also asked to rank possible barriers to cycle time reduction. As shown in Figure 7, "Scope changes," "Decision making," and "Lack of objectives" were ranked as the most important barriers followed by "Communication."

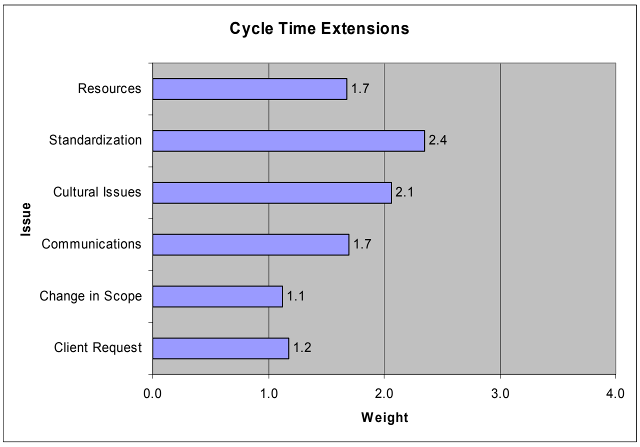

Figure 8. Cycle Time Extensions

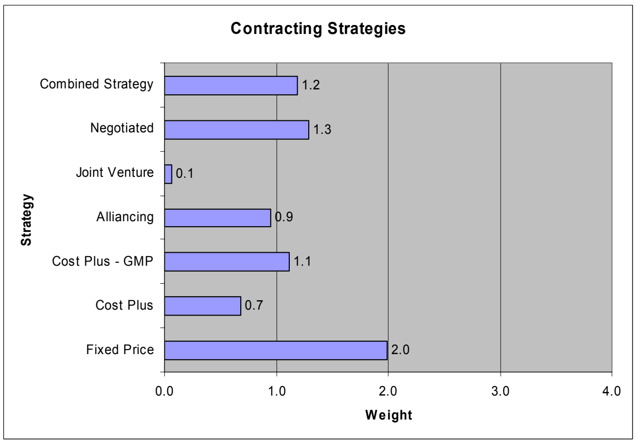

Figure 9. Preferred Contracting Strategy

On being asked what were the problem/issues that cause cycle time extensions, majority of respondents answered that "Change in scope" and "Client requests" were the main causes for extending cycle time (refer to Figure 8). Among various contracting strategies (refer to Figure 9) forming "Joint Ventures" has been the preferred contracting strategy from the viewpoint of reducing cycle time. "Cost plus" and "Alliancing" are the other preferred contracting strategies. A "Fixed price" type of contract was the least preferred by the respondents.

Respondents were asked to indicate the CII Best Practices[1)] that were implemented in their organization and how they were modified to achieve radical reduction. The following indicates the comments were received with respect to each of the CII best practices:

(i) Front End Loading
- Integrate teams with approval meetings.
- Bi-weekly execution planning meeting with targeted subjective area.
- Early alignment.
- Get team focused early.
- Standardize across organization.
- Perform aggressive estimate in-house.
- Address tactical issues early.

(ii) Culture
- Recognize difference between true 'High Performing' teams and well performing teams.
- Dedicate more/senior experienced personnel.
- Enforce drop dead dates in decision making.
- Maximize delegation of authority.
- Empower project teams - remove constraints.
- Develop efforts based on each team member's strengths.
- More authority to Project Manager especially for Product Based Specialty projects.
- Task force concept.

(iii) Design
- Dedicated project team with access to decision makers or authority.
- Phased construction and early work orders.
- Design adopts industry standards.
- Construction input into design critical.
- Sequence construction.
- Provide flexibility for construction means and methods.
- Front End Loading to maximize input.
- Data driven CAD.

(iv) Procurement
- Value creating alliances.
- Get key suppliers on board early.

[1)] A Construction Institute Industry (CII) Best Practice is defined as a process or method that, when executed effectively, leads to enhance project performance.

- Assign individual(s) specific procurement items.
- Reduce number of suppliers.
- Long lead items - early decision.
- Preferred suppliers.

(v) Start-up

- Rigorous utilization of system turnover concept.
- Incorporate PM criterion into the data base for instrumentation items.
- Early Front End Loading.
- Get systems and procedures and resources aligned early.
- Phased Turnover/Commissioning.

(vi) Organization

- Increase use of Best Practices
- Ensure follow-up sessions are done in an effective manner.
- Technology exists for "Virtual Teams" - No owner "buy in."
- Focus on value creation.
- Incentive balanced between cost and schedule drivers.
- Define risks with owner/subs and allocate properly.
- Do not allow disputes to impact construction for over five days.
- Improve Risk Management tool set - poor at best.
- Must align contract with project goals on a common set of deliverables.
- Create template for high level risks allocation. Pull out specific risks following standard expected value format.

(ix) Safety/Risk/Technology

- Safety should always come first
- Standardization of IT will shorten several aspects of the project.
- No radical changes needed in safety area.
- Educate engineering on project hazards.
- Too many problems to overcome with automated identification.
- Integrate CAD/data/documents/cost/schedule
- Work with owner/designer to develop system with shared information.
- Eliminate slow communication

In addition, 28 respondents said that lessons learned from crisis situations could be transferred to every day projects in a sustainable, systemic manner, while three of them believe they could be. Four respondents chose not to comment. The following is a summary of comments obtained to this question:

- Crisis is a result of poor planning or an unexpected event. Decisions made in crisis situations carry greater risk (that desired outcomes will not be achieved).
- Crisis situation may result in poor work quality. Crisis situations may result from under resourcing of earlier phases.
- The time it takes to review, document, and archive crisis situation analysis often means that the specific information can not be transferred to other projects.
- In crisis modes, teams tend to work as 'high performance' teams with a sense of urgency.
- Crisis rescue should reinforce the need to make changes in order to avoid crises.
- Often organizations tend to reward 'fire fighting' rather than those who make 'systemic' changes.
- Project overruns can be eliminated by managing projects based on tight control on 'earned man-hours' in lieu of 'financial information'.
- Crisis occurs when basic practices and procedures are not followed.
- Structured project delivery can prevent most crises.
- In crisis situations, cost becomes a secondary element with respect to schedule. Decisions made during this time take the form of 'time & material' change orders or 'construction directive' that is agreed by all parties.
- Although the Senior Management agrees in principle to 50% probability of meeting a specified estimate, they often seem to forget this.
- Project control systems utilized do not give sufficient advanced warning of potential cost over-runs resulting in a crisis situation.

3.3.3 Section II: Project Cycle Reduction - Part II

This concluding section of the questionnaire asked the respondents what type of projects could benefit from implementing radical reduction and the types of projects that would benefit the least. The questionnaire concluded by asking the respondent, if they were willing to participate in a case study.

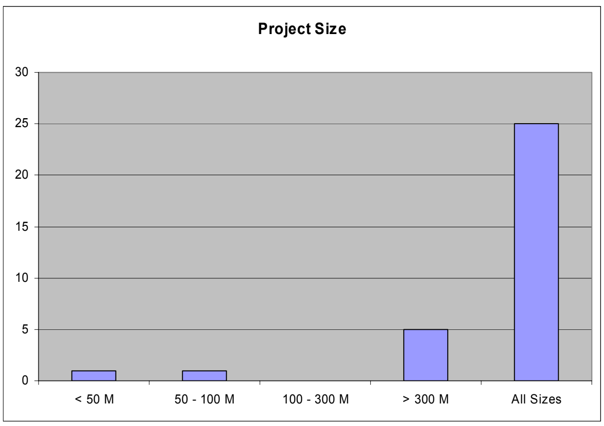

Figure 10. Projects that would benefit most from cycle time reduction Techniques

As shown in Figure 10, respondents seemed to agree that almost all types of projects would benefit from cycle time reduction techniques. In a horizontal axis of Figure 10, “M” represents the Million dollars.

The following is a summary of what the respondents felt were the types of projects that would benefit least from cycle time reduction techniques:

- Low complexity, i.e., renovation office space.
- Small, streamlined projects.
- Non-profit making projects that are not schedule driven.
- Projects done for upgrading capability.
- New product entries projects.
- Cost plus and cost plus with guaranteed fee.
- Better defined projects.
- Environmental/regulatory projects (owner usually want to delay these projects until the last possible start).
- Infrastructure projects.

3.4 Questionnaire III

This questionnaire was to the seven case study teams. All seven responses have been received and analyzed in this section. This questionnaire was aimed at helping research teams in identifying best practices that if applied broadly and routinely, would improve delivery time across the general construction industry.

3.4.1 Part A

Except for general information regarding the participant, the three important project parameters viz., safety, cost, and quality were questioned. The main objective of this section was to determine if reducing cycle time had any adverse impact on the above mentioned three project parameters.

The respondents were asked to rate if the "Overall Safety" on the case study project was Better, Equal, or Reduced as compared to other similar projects. Four respondents indicated that the overall safety was Better as compared to other projects, while two indicated that it was the same and one respondent felt that the overall safety was reduced due to the accelerated nature of the project.

Respondents were also asked to categorize "Lost Workday Injury and Illness" cases on a scale of None, Below, Average, and Above Average. One respondent indicated that lost workday due to injury and illness cases were below average on their projects while the six others said that they had no lost workdays due to injury and illness on their projects.

As shown in Figure 11, three respondents indicated that there were no recordable incidences, while other three indicated that they had between one-five recordable incidences on the case study project. Only one respondent indicated more than five, but less than ten recordable incidences.

Respondents were also asked to indicate the "Overall Quality" achieved on the case study project as Better, Same, or Reduced as compared to projects of a similar kind. Four respondents indicated that they achieved better quality on the case study project than other comparable projects while three indicated the overall project quality remained unchanged. None of the participants reports reduced overall quality.

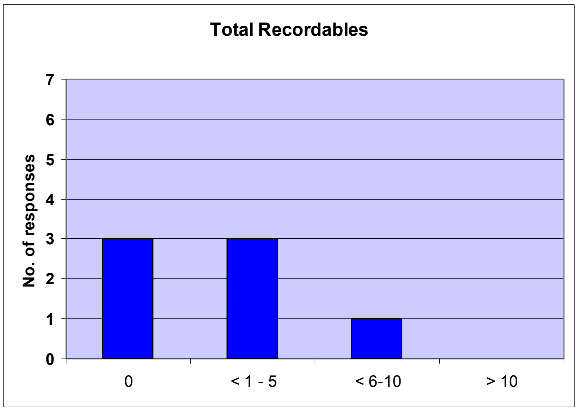

Figure 11. Total Recordable Incidences

Respondents were asked to indicate the amount of rework required on the case study project on a scale of "Lot More, Slightly More, Same, Slight Less, and Lot Less." Three respondents indicated that the same amount of rework was required as compared to other similar projects, while two indicated slightly less and the other two indicated that a lot less rework was required.

Regarding the overall cost of project, five respondents indicated that compared to other projects where reduction was not a driver, the case project showed a 5 - 20 % decrease in cost, one respondent indicated that they achieved greater than 20% reduction in cost, while one respondent indicated that their project had a 5 -20 % cost increase because of the reduction.

3.4.2 Part B

This section of the questionnaire contains a collection of “Insights” obtained (refer to Hastak et al. 2004) from the case study responses. The respondents were asked to indicate whether they “Agreed” or “Disagreed” that the mentioned “Insight” could be a valuable cycle time reduction technique. Figure 12 summarizes the responses.

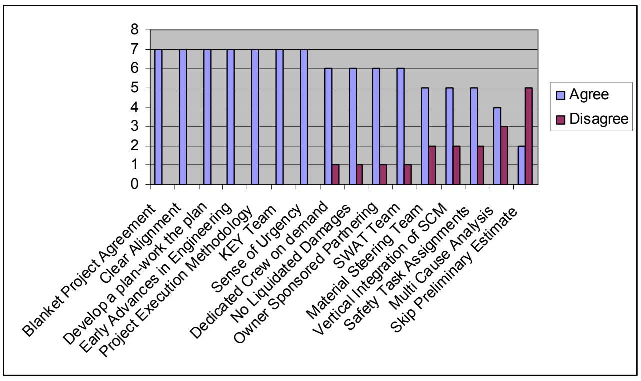

Figure 12. Insights

All the respondents agreed that Blanket Project Agreement, Clear Alignment, Developing a Plan and Working as per it, Early Advances in Engineering, Project Execution Methodology (PEP), Swat Team and Key Team were important techniques for achieving radical reduction in project cycle time. A majority of the respondents disagreed that Skipping Preliminary Estimate was an important radical reduction techniques. Also, less than 50% respondents though that Multi Cause Analysis, Safety Task Assignments, and Vertical Integration of Supply Chain Management were not appropriate radical reduction techniques.

As a continuation of this of the questionnaire, respondents were asked to indicate whether the mentioned radical reduction techniques (Insights) could be applicable to any type of projects within their organization. Figure 13 shows the analysis. Blanket Project Agreement, Early Advances in Engineering, KEY Team, Sense of Urgency, No Liquidated Damages, Owner Sponsored Partnering and Material Steering Team are Insights which could be applied to a typical project.

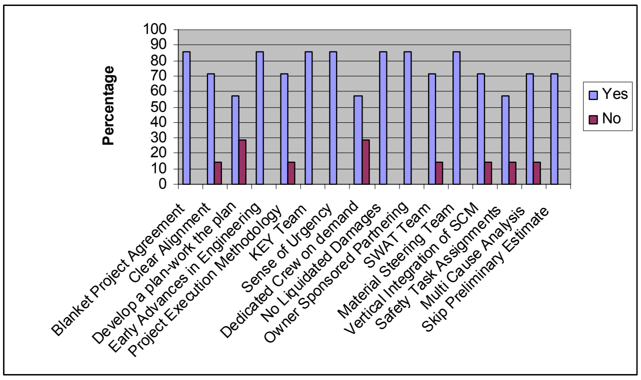

Figure 13. Applicability of Radical Reduction Techniques

4. CASE STUDY BACKGROUND AND ANALYSIS

The purpose of the case studies was to establish best practices and radical reduction techniques used by the construction industry and to compare them with results obtained through the questionnaire survey and literature review done by the research team. Case studies clarified certain issues i.e., barriers raised through the questionnaire survey and also helped identify radical reduction techniques called ‘Insights’. The seven case studies were identified, which were conducted over period of four months (refer to Table 2). Each case study was conducted for approximately 4 hours. The essential criterion for selecting a project case study was that the project should have achieved a minimum of 25% cycle time reduction. The percentage reduction varied from 25% to as high as 60%. The results of the case studies have been summarized in this section.

Table 2. Case Study Summaries

Project Name	Offered By	Cost($)	Std. Duration (Months)	Actual Duration (Months)	% Reduction	Benchmarking
Project A	R Chemicals	$ 9.0M	12	9	25%	IPA
Project B	R Chemicals	$ 45 M	21	10	52%	Internal
Project C	S Engineering	$ 335 M	28	20	30%	Internal
Project D	T & M	$ 16 M	12	6	50%	Internal
Project E	AZ Petroleum	$ 13 M	18	9	50%	IPA
F Purification Plant	SUV Incorporated	$ 94 M	60	36	40%	Internal
M Biotech	LS Construction	$ 25 M	4	2	50%	Internal

4.1 Case Study I: R Chemicals

At R Chemicals a typical project team consists of the project manager, manufacturing representative, project engineer and process control representative. All projects originate from a division and a project manager is assigned to each division depending on the market conditions. A typical project goes through different stages and could be cancelled at any stage/time. The following are the different stages in a project life cycle:

Stage I – Pre planning: expense, preliminary economics to see if the job is feasible
Stage II – Detailed work, purchasing, engineering.
Stage III – Material management, design and construction
State IV – Start-up, wrap up and completion.

The contract was Hard Bid and innovative techniques were used for detailed design as well as construction phase of the project. The construction schedule and master project schedule are initiated at stage I and sometimes can start as long as five years before construction. The typical duration of these types of projects from historical data is 15 months.

The construction manager and project engineer get involved only at stage II of the project. Constructability was very important to R Chemicals and many unique techniques were used during this project. One of them being a technique called “Value Improvement Package (VIP)” in which a dedicated individual is assigned to learn about all the new team building and management exercises. This person then trains the others in these new exercises. To show a sense of harmony, the entire crew was treated to lunch once in a while. The other technique being “Global Project Methodology” is a detailed process used on all projects. It included Contracting Strategies, Master Plan Schedule, Procurement Plan, Construction Plan etc.

“SWAT Team” is R chemicals terminology for a dedicated management team with the specific task to resolve problems quickly. It is essentially comprised of individuals at the level of project managers.

“Multiple parallel contracts” were initiated to realize radical reduction in project cycle time. The project was judged to be easy from an engineering as well as construction point of view. Safety was the main concern and was stressed throughout the project. It was suggested that the techniques used for radical reduction would have been equally effective on a more complex project.

Factors that helped in reduction cycle time were as follows:

- Detailed construction plan.
- Selection of labor contractor early.
- Ordered pipe, valve & other long lead items early.
- Followed a different method of welding to reduce welding time by 50%.
- Pre-fabrication and standardization of pipe racks and pipe loop elements.
- Pre-assembly of bridge support in river crossing, transported to site and raised in place.
- Improved material staging.
- Sticking with the plan and making the plan work.
- Project steering team met weekly and had good communication between them.

4.2 Case Study II: R Chemicals

There were 4 different engineering companies (names withheld) involved in the project. Co-location of over 100 engineering personnel mobilized to do detailed engineering work at one location at a cost of $1 million. Engineering hours were greater than budgeted hours but savings came from negotiating a better (lower) rate. MicroStation was used for all drawings. No liquidated damages clause for the project.

There was no formal constructability program in project management. Since the project involved extensive demolition and reconnecting of conduits and wires, everything had to be strategically planned. Lot of energy and teamwork was required and a dedicated team was employed for this project. Material Management was carried out along with priority alignment. Problems were handled through the SWAT team approach.

This cost of such a project is not more than an average project of this kind. One Senior Project Manager (PM) and four others were employed for this project. They conclude that the strategies and techniques use for this project could be used on another project, even if it was not in a crisis mode.

4.3 Case Study III: S Engineering

There were more than 1,200 people working on the project. 6,000 S Engineering drawing and 14,000 Vendor prints were created. 85 Vendor contractors were signed. The start-up took about 275,000 man-hours, while construction required 1.9 million man-hours. The total project cost including land and utilities came to about $650 million, of which $335 million were invested in Engineering & Construction, and $200 in Equipment.

Although the S Engineering team from the Michigan office had no prior experience working with Z Construction, the Joint Venture relationship worked very well. S Engineering was the lead on the project, which was a 50 – 50 partnership.

Regarding factors that helped in reducing cycle time, modularization saved SZ (S engineering + Z construction) a lot of times as well as money. They are committed to trying it on other projects as well. Start up engineers participated in 4 weeks of factory testing of various control systems before shipping it out. This reduced failure rate. Also, a joint venture approach helped facilitate the ability to accelerate and take on the extra work. Also more than typical on-site engineering support was considered a contributing factor for radical reduction. Insights identified in this case study were as follows:

- Owner sponsored partnering
- No liquidated damages
- Early advances in engineering (till before equipment came in)
- BPA (Blanket Project Agreement)[2)] – Faster procurement
- Personnel devoted exclusively to procurement

4.4 Case Study IV: T Incorporated

Active Project Management was pursued with Front End Loading being one of them. There were a lot of known as well as unknown factors. The contingency plan was to keep the acquired facility running and production going. Feasibility study was started in the months of December/January and went all the way through February. Four months of work was crammed into 2 months.

As per the integrated plan, every single down time was used constructively; focus was 80/20 cost items as the key to achieving schedule. Also "known" and "unknown" bins were established and each was dealt separately. The organization held off the strong desire to jump into "execution" and instead waited until conceptual design was complete and sourcing decisions were made before getting into action.

Increased safety was observed on this project. Some of the steps initiated were having a safety orientation. Onsite drug testing, implementing safety task assignments (STAs) and conducting behavior observation surveys. There were safety technicians to provide support for all the shifts. Besides all these, job safety analysis was started during the planning phases itself. A valuable technique followed was Multi Cause Analysis (MCA), which helped in identifying near misses, first aids, recordables, and define follow up and action steps. In addition, factors that helped in reducing cycle time were as follows:

- Plant safety resources involved in the design review process.
- Single points of contact – Tech Engineers lead the process, vs. plant contact.
- Designated days to work on specific projects - Engineering, Construction, PM, Operations.
- Single point – dedicated contact for all purchasing.
- Cell phones for quick communication.
- Schedule driven decisions, all upper management available.
- Weekly overall project integration meeting that includes Engineering, PM, Construction key resources.
- Co-location of T Incorporated Tech Engineer and Construction

Insights identified in this case study were as follows:

- Material Steering Team
- Drug testing
- Safety Task Assignments (STAs)
- Behavior Observation Survey
- Multi Cause Analysis (MCA)

4.5 Case Study V: AZ Petroleum

The job was awarded to an EPC contractor as a Cost-Plus contract and they were involved with the project right from

[2)] S Engineering had a Blanket Project Agreement (BPA) with vendors, which helped in faster procurement. As per this approach, they selected vendors even before the start of the project and worked with them from the engineering viewpoint. With this technique suppliers were decided months in advance, which saved them considerable time once the actual construction had started.

the start. The team skipped the Preliminary Estimate (since AZ Petroleum had done similar projects earlier they were confident about doing this one also without any additional risk; the same integrated team was used for other projects). Having had an alliance with AZ Petroleum for almost 12 to 13 years, the F Construction crew knew everybody on the team.

Regular team building exercises were conducted with lunches, recognitions etc. An electronic access program was used for daily roll calls. There was no use of Personal Digital Assistants (PDAs), because the inspectors were technology aware, but not 'Tech Savvy'. Construction time was not changed, and there was no fast tracking. Neither was the schedule altered or modified in any ways.

The project team had work together on similar projects and was able to use previous design as a reference. The preliminary estimates were skipped on this project since the owner had worked on similar projects with the same team. Also, the team was confident that they could repeat a similar performance on other similar projects, but any further improvements in cycle time would be almost impossible.

Factors that helped in reducing cycle time were as follows:

- Skipped preliminary estimate
- No increase in cost
- Good support by supplier (working with them for a long time)
- Very favorable terrain for work and good weather
- All contractors work overtime (preferred method of working)

Insights identified in this case study were as follows:

- Skip preliminary estimate
- Same team for years (very little change)
- Dedicated crew available on demand
- Selected list of contractors allowed to bid

4.6 Case Study VI: UV Incorporated (UV)

A team of dedicated and experienced people were assembled from various office locations like Cleveland, Houston, Florida, and California. Rest of the team moved out of regular offices to a special suite of offices to avoid distractions. There were weekly web based net meetings and conference calls. Other people were flown in from other locations for "Team Building" exercise. Micro-station Intergraph – 3D CAD design was the software of choice due to favorable feedback from prior smaller projects. Most team members were not familiar with 3D CAD and real time design. This caused some learning curve issues in the beginning.

The instrumentation, architecture, and electrical was done at satellite locations. Brainstorming sessions were conducted to evaluate potential for risk at every stage of the project. A risk management strategy was developed and a formal Risk Evaluation was undertaken using Monte Carlo simulation e.g. tunneling for intake structure (differing site condition clause not allowed), alignment for transmission lines (all easements had not been acquired), and dewatering and foundation issue. Regulatory Agencies were brought on board very early to better understand their needs & concerns and incorporate a solution in design that would speed up permissions.

Factors that helped in reducing cycle time were as follows:

- No bonus or incentive, high liquidated damages
- Dedicated Team
- 3D Design
- Formal Risk Evaluation
- Web based net meetings
- Regulatory agencies consulted early into the design phase itself, hence few hold ups later.

4.7 Case Study VII: M Biotech Facility (LS Construction)

Initially, the project was being handled by a construction company T. The owner had a particular product, they thought, was key to their business model. They had a tight budget, and the owner decided to accelerate the project even though it would cost more money. But the current team of T construction thought that it was impossible to complete the project in owner's timeframe and were replaced by LS. Based on the criteria the owner had given, LS performed Value Engineering and came to a conclusion that they could achieve the construction in two months time.

When LS came on board, engineering was only about 30-40% done, though in the first meeting with M Biotech, they were told otherwise. Termination of contractor T was handled by LS. Later when LS agreed to the scenario it was found that work was only 35 % complete and the plans were without any details since the owner had little construction experience. LS team was put together with people selected based on their skills and previous experiences of meeting challenges. After mobilization, the LS team had 58 days to finish the project.

T construction had purchased some major mechanical equipment and systems for the job. The owner purchased all the laboratory equipment. The project was divided into two phases. Only phase 1 had to be completed under this time frame. Advance payments were made for all activities and this was a very attractive option for the subcontractors.

For phase I, most of the work was modularized construction. LS came in when almost all of the pre-project planning was done. The location was also helpful as many subcontracting parties had their offices in that area. Subcontractor relations were good and most had past experience.

Drawings were all standard 2D drawings. Modeling was done only for the second phase. Work was done 7 days a week performed in two ten-hour shifts each day. A five hundred activity schedule using Primavera was developed and updated weekly. Under normal circumstances, the project would have taken eight months utilizing a forty-hour week. The quality was a bit compromised because of the accelerated schedule.

There were to be no liquidated damages, however, there was a bonus if work was finished early. Work was completed a day in advance and hence no substantial bonus was received. Work was monitored daily with subcontractor coordination meetings. There was a full time person on site to strictly enforce and ensure safety. There were no serious problems on the project. Also there were not many change orders as a 'not to exceed contract value' was issued to the subcontractors. Critical items were the long lead items like HVAC equipment. The only risk to LS was that if they failed to perform, they would not get the next phase. Also at stake was the company's reputation.

The most important factor was to be able to put together a good project team with engineering and construction together to complete the schedule in time. A similar type of project from concept to operation would take six months if done on fast track and eight to ten months, in a reasonably controlled environment. The owner found the work quality satisfactory and well worth the money invested.

Factors that helped in reducing cycle time were as follows:

- Value Engineering
- Ten-hour shifts, seven days a week
- Advance payment to subcontractors
- Modularized Construction

5. CONCLUSION AND SUMMARY

A comprehensive literature review that assisted the research team in identifying a set of criteria that was important to establish the state-of-practice and state-of-art for project cycle time reduction techniques. The data obtained from the literature reviews assisted in developing Questionnaire I that helped to identify companies which had implemented methods and techniques to radically reduce project cycle time. Questionnaire II was a follow-on questionnaire after responses to Questionnaire I were received and Questionnaire III was a follow-up to Questionnaire II and the seven case studies that were conducted.

Project delivery systems in the construction industry have gone through an evolutionary process to reduce delivery time while maintaining quality and containing costs. The most commonly utilized project delivery systems prevalent today are traditional design-bid-build; construction managed by a professional construction manger; Bridging; Design-Build (Lump-sum & Guaranteed Maximum Price). Today's business puts greater performance requirements on capital project delivery systems used to maintain competitiveness. For the risks associated with a fast track approach to be justified, there have to be significant benefits from reduction in project cycle time. These benefits will naturally vary with the industry and also circumstances of the company. There are usually financial benefits of increased profit or reduced loss from early use of the asset. The client may also have other reasons for the achievement of reduced project duration, such as to improve the financial standing of the company, minimize disruption to customers or to reduce period of adverse publicity where new or modified equipment is needed to solve a problem.

In summary, radical reduction in project cycle time is achievable. The necessary techniques and practices are readily available to the contracting community with sufficient resources available for study, training, and implementation. The following conclusions were identified in projects that successfully achieved greater than 25% reduction in project cycle time.

1) Radical reduction in project cycle time requires four key drivers
    a. A compelling need
    b. Owner commitment
    c. High performance team
    d. Detailed project planning and execution

2) Use of CII best practices are key components to radical reduction in project cycle time. This was conformed through case studies that utilized 7 of 11 best practices

3) The CII best practices most frequently and successfully used in the case studies are:
    a. Alignment
    b. Material management
    c. Pre-project planning
    d. Constructability
    e. Design Effectiveness

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