

CONSTRUCTION INDUSTRY INSTITUTE®

RADICAL REDUCTION
IN PROJECT CYCLE TIME

PURDUE UNIVERSITY

MARK HASTAK

KARTIK GOYANI

TAEHOON HONG

BHAVIN SAFI

VANDERBILT UNIVERSITY

SANJIV GOKHALE

Research Report 193-11

 **Documents**
Document Sharing Hub

RADICAL REDUCTION IN PROJECT CYCLE TIME

by

Mark Hastak, Kartik Goyani, TaeHoon Hong, Bhavin Safi
Purdue University

Sanjiv Gokhale
Arizona State University

A Report to
Construction Industry Institute
The University of Texas at Austin

Under the Guidance of
CII Project Team 193
Radical Reduction in Project Cycle Time

CII Research Report 193-11
June 2004

© 2004 Construction Industry Institute®.

The University of Texas at Austin.

CII members may reproduce and distribute this work internally in any medium at no cost to internal recipients. CII members are permitted to revise and adapt this work for the internal use provided an informational copy is furnished to CII.

Available to non-members by purchase; however, no copies may be made or distributed and no modifications made without prior written permission from CII. Contact CII at <http://construction-institute.org/catalog.htm> to purchase copies. Volume discounts may be available.

All CII members, current students, and faculty at a college or university are eligible to purchase CII products at member prices. Faculty and students at a college or university may reproduce and distribute this work without modification for educational use.

Printed in the United States of America.

EXECUTIVE SUMMARY

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. Very few decision tools and guidelines exist to assist owners and contractors in choosing delivery systems and project strategies to radically reduce the cycle time from the preplanning stage through start up. This research surveys the owner and construction industries, identifies projects that have achieved a greater than 25% reduction in overall project cycle time when compared to current industry standard, and evaluates and ranks the Best Practices, Management Techniques, and Schedule Reduction Techniques employed on the projects. The research also catalogs the barriers to radical schedule reduction. The result of the research is that radical schedule reduction well in excess of 25% can be achieved through the selective employment of Management Techniques, Schedule Reduction Techniques and Best Practices. Almost every project can utilize this research to improve project performance whether radical reduction or simply more effective execution is the goal. These techniques and practices, as well as the optimal deployment time, are described in this research.

Blank Page

TABLE OF CONTENTS

EXECUTIVE SUMMARY	iii
LIST OF FIGURES	x
CHAPTER 1 INTRODUCTION	1
1.1 Introduction.....	1
1.2 Definition of Radical Reduction	1
1.3 Purpose of Research.....	2
1.4 Scope of Research.....	2
1.5 Objectives	2
1.6 Research Approach	3
1.7 Report Organization.....	4
1.8 Research Team.....	5
CHAPTER 2 RESEARCH METHODOLOGY	7
2.1 Data Collection Modes	7
2.2 Literature Review.....	9
2.3 Design of Questionnaires.....	9
2.3.1 Questionnaire I.....	10
2.3.2 Questionnaire II	11
2.3.3 Questionnaire III.....	14
2.4 Essence Applicability Matrices.....	15
2.5 Case Studies.....	17
CHAPTER 3 LITERATURE REVIEW	19
3.1 Need For Radical Reduction.....	19
3.2 Contractor Benefits	21
3.3 Current Status and New Trends in Construction Industry	21
3.4 New Trends in Project Delivery Systems in Other Industries	25
3.5 Engineering Procurement Construction (EPC) Macro Model	27
3.5.1 Pre Project Planning Phase	28
3.5.2 Design Phase.....	28
3.5.3 Materials Management	29
3.5.4 Construction.....	30
3.5.5 Start-Up.....	30
3.6 CII Best Practices.....	32
3.6.1 Pre Project Planning.....	32
3.6.2 Alignment	33
3.6.3 Constructability.....	34
3.6.4 Design Effectiveness	35
3.6.5 Materials Management	36
3.6.6 Team Building	37

3.6.7 Partnering.....	38
3.6.8 Quality Management.....	39
3.6.9 Change Management	41
3.6.10 Disputes Resolution	41
3.6.11 Zero Accidents Techniques	43
3.7 Schedule Reduction Techniques	44
3.7.1 Advanced Construction Equipment.....	44
3.7.2 Alternative Construction Methods.....	45
3.7.3 Avoidance of Interruption.....	45
3.7.4 Craftsmen.....	45
3.7.5 Crew (Specialty Crew).....	46
3.7.6 Critical Equipment Contingency Planning	47
3.7.7 Concurrent Engineering.....	47
3.7.8 Constructability Analysis During Construction.....	48
3.7.9 Construction Driven Schedule	48
3.7.10 Crew.....	48
3.7.11 Dual Purpose Design	49
3.7.12 Efficient Packaging for Transportation.....	50
3.7.13 Empowerment.....	50
3.7.14 Expedite Payment	50
3.7.15 Fast Track Scheduling	50
3.7.16 Field Rework Index Implementation	51
3.7.17 Frequent Inspection.....	51
3.7.18 Freezing Project Scope	51
3.7.19 Incentives.....	52
3.7.20 Job Site Preassembly	52
3.7.21 Just -In -Time Material Deliveries.....	53
3.7.22 Lay Down Area Assignment.....	53
3.7.23 Lump Sum Contract.....	54
3.7.24 Material Coordinator.....	54
3.7.25 Material Identification on Purchase Documentation	54
3.7.26 Minimize Owner's Involvement.....	55
3.7.27 Non- Traditional Drawing Release.....	55
3.7.28 Pareto's Law of Management	56
3.7.29 Participative Management	56
3.7.30 PEpC (Procurement Engineering, Procurement & Construction Implementation).....	57
3.7.31 Prioritize Procurement of Material	57
3.7.32 Productive Working Environment.....	57
3.7.33 Realistic Scheduling	58
3.7.34 Repetitive Task Scheduling	58
3.7.35 Single Engineering Procurement and Construction (EPC) Contractor.....	58
3.7.36 Staged Pre-Positioning.....	58
3.7.37 Standard Off the Shelf Design.....	59
3.7.38 Start Up Driven Scheduling.....	59
3.7.39 Temporary Start Up System	59

3.7.40 Use of Electronic Media	60
3.7.41 Use Of Float Flexibilities.....	60
3.7.42 Vendor Submittal Control.....	60
3.7.43 Well- Defined Organizational Structure	61
3.8 Management Techniques	61
3.8.1 5S	61
3.8.2 Activity-Based Costing.....	62
3.8.3 Agile Manufacturing.....	64
3.8.4 Demand Flow.....	65
3.8.5 Just in Time (JIT).....	65
3.8.6 Kaizen	66
3.8.7 Kanban.....	67
3.8.8 One Piece Flow	68
3.8.9 Poka Yoke.....	70
3.8.10 Policy Deployment	71
3.8.11 Quality function development	71
3.8.12 Quick response Manufacturing.....	72
3.8.13 Six Sigma.....	72
3.8.14 Single Minute Exchange of Dies (SMED)	74
3.8.15 Statistical Process Control (SPC)	75
3.8.16 Theory of Constraints	75
3.8.17 Total Productive Maintenance (TPM)	76
3.8.18 Value Streams	76
3.8.19 Visual factory.....	77
CHAPTER 4 DATA COLLECTION AND ANALYSIS	79
4.1 Introduction.....	79
4.2 Questionnaire I.....	79
4.3 Questionnaire II	81
4.3.1 Section I: General Information	82
4.3.2 Section II: Project Cycle Reduction – Part I.....	85
4.3.3 Section II: Project Cycle Reduction – Part II	95
4.4 Questionnaire III	97
4.4.1 Part A	97
4.4.2 Part B	103
4.5 Essence Applicability Matrices.....	105
4.5.1 Essence Applicability Matrices-Team responses	106
4.5.2 Essence Applicability Matrices-Case Study	109
4.5.3 Essence Applicability Matrices - Combined	112
4.5.4 Essence Applicability Matrices-A Comparison.....	115
CHAPTER 5 CASE STUDY BACKGROUND AND ANALYSIS.....	127
5.1 Introduction.....	127
5.2 Case Study I: R Chemicals	128
5.2.1 Company Profile	128
5.2.2 Project Details.....	128
5.2.3 Interview Details.....	129

5.2.4 R Chemicals Organizational Structure	129
5.2.5 Interview Highlights/Observations	130
5.2.6 Factors that helped in reducing cycle time	131
5.2.7 CII Best Practices Identified	132
5.2.8 Insights Identified	132
5.3 Case Study II: R Chemicals	133
5.3.1 Company Profile	133
5.3.2 Project Details	133
5.3.3 Interview Details	133
5.3.4 Interview Highlights/Observations	134
5.3.5 Factors that helped in reducing cycle time	134
5.3.6 CII Best Practices Identified	135
5.3.7 Insights Identified	135
5.4 Case Study III: S Engineering	136
5.4.1 Company Profile	136
5.4.2 Project Details	136
5.4.3 Interview Details	136
5.4.4 Interview Highlights/Observations	137
5.4.5 Factors that helped in reducing cycle time	141
5.4.6 CII Best Practices Identified	141
5.4.7 Insights Identified	142
5.5 Case Study IV: T Incorporated	142
5.5.1 Company Profile	142
5.5.2 Project Details	142
5.5.3 Interview Details	143
5.5.4 Interview Highlights/Observations	144
5.5.5 Factors that helped in reducing cycle time	147
5.5.6 CII Best Practices Identified	147
5.5.7 Insights Identified	148
5.6 Case Study V: AZ Petroleum	148
5.6.1 Company Profile	148
5.6.2 Project Details	149
5.6.3 Interview Details	149
5.6.4 Interview Highlights/Observations	150
5.6.5 Factors that helped in reducing cycle time	152
5.6.6 CII Best Practices Identified	152
5.6.7 Insights Identified	152
5.7 Case Study VI: UV Incorporated (UV)	153
5.7.1 Company Profile	153
5.7.2 Project Details	153
5.7.3 Interview Details	154
5.7.4 Interview Highlights/Observations	154
5.7.5 Factors that helped in reducing cycle time	158
5.7.6 CII Best Practices Identified	158
5.7.7 Insights Identified	158

5.8 Case Study VII: M Biotech Facility (LS Construction).....	159
5.8.1 Profile.....	159
5.8.2 Project Details.....	159
5.8.3 Interview Details.....	160
5.8.4 Interview Highlights/Observations.....	160
5.8.5 Factors that helped in reducing cycle time.....	163
5.8.6 CII Best Practices Identified.....	163
5.8.7 Insights Identified.....	163
CHAPTER 6 IMPLEMENTATION RESOURCE – ‘PROJECT MANAGER’S GAME PLANNER’	165
6.1 Introduction.....	165
6.2 Development of ‘Project Manager’s Game Planner’ – Radical Reduction Techniques per Phase.....	165
6.2.1 Color Coding of Macro Phases.....	170
6.2.2 Color Coding for Radical Reduction Techniques.....	170
6.3 Radical Reduction Techniques.....	172
6.4 ‘Project Manager’s Game Planner’ – Relative Impact of Radical Reduction Techniques on Project Cycle.....	174
6.4.1 Development.....	174
6.5 Organization of Project Manager’s Game Planner.....	179
6.5.1 Radical Reduction Playcard.....	180
6.6 How To Read “Project Manager’s Game Planner”: A Summary.....	182
CHAPTER 7 CONCLUSIONS.....	185
7.1 Summary.....	185
7.2 Benefits of the Research.....	187
7.3 Results of the Research.....	187
7.4 Recommendations of the Research.....	189
7.5 Limitations of the Research.....	191
7.6 Electronic Decision Tool.....	191
LIST OF REFERENCES.....	195
APPENDICES.....	205
Appendix A: Research Team.....	207
Appendix B: Questionnaire I.....	211
Appendix C: Questionnaire II.....	215
Appendix D: Questionnaire III.....	227
Appendix E: Essence Applicability Matrices (EAM) - Blank.....	233
Appendix F: Essence Applicability Matrices – PT 193 Team Responses.....	245
Appendix G: Essence Applicability Matrices – Case Study Responses.....	255
Appendix H: Essence Applicability Matrices (EAM) - Combined.....	265
Appendix I: Project Manager’s Game Planner.....	275

LIST OF FIGURES

Figure	Page
Figure 2.1: Research Methodology	8
Figure 3.1: Project Delivery Systems	22
Figure 3.2: Radical Reduction in Power Plant Construction Cycle	25
Figure 3.3: EPC Macro Model	31
Figure 4.2: Breakdown of Responses	81
Figure 4.3: Respondent profile	82
Figure 4.4: Types of Organizations Responding	83
Figure 4.5: Size of the firm	84
Figure 4.6: Types of Projects Undertaken by the Respondents	84
Figure 4.7 Drivers for Cycle Time Reduction	86
Figure 4.8 Barriers to Cycle Time Reduction	86
Figure 4.9 Cycle Time Extensions	87
Figure 4.10 Preferred Contracting Strategy	88
Figure 4.11 Typical Long Duration Activities	89
Figure 4.12 Lesson Learned from Crisis Situations	94
Figure 4.13: Projects that would benefit most from cycle time reduction techniques	96
Figure 4.14: Overall Safety on Case Study Project	98
Figure 4.15: Lost workday injury and illness cases	99
Figure 4.16: Total Recordable Incidences	100
Figure 4.17: Overall Quality on case study project	100
Figure 4.18: Amount of Rework required	101
Figure 4.19: Overall cost of project	102
Figure 4.20: Cost Commitment	102
Figure 4.21: Technical Objectives	103
Figure 4.22: Insights	104
Figure 4.23: Applicability of Radical Reduction Techniques	105
Figure 4.24: Top 10 CII Best Practices – Team Responses	107
Figure 4.25: Top 10 Schedule Reduction Techniques - Team Responses	107
Figure 4.26: Top 10 Management Techniques - Team Responses	108
Figure 4.27: Macro Phase Comparison	109
Figure 4.28: Top 10 CII Best Practices – Case Studies	110
Figure 4.29: Top 10 Schedule Reduction Techniques – Case Studies	110
Figure 4.30: Top 10 Management Techniques – Case Studies	111
Figure 4.31: Macro Phases Comparison	112
Figure 4.32: Top 10 CII Best Practices - Combined	113
Figure 4.33: Top 10 Schedule Reduction Techniques - Combined	113
Figure 4.34: Top 10 Management Techniques – Combined	114
Figure 4.35: Macro Phase Comparison	115
Figure 4.36: Essence Applicability Matrices-Team Responses Summary	115
Figure 4.37: Essence Applicability Matrices-Case Study Responses Summary	116
Figure 4.38: CII Best Practices	116
Figure 4.39: Schedule Reduction Techniques	117

Figure 4.40: Management Techniques.....	117
Figure 4.41: CII Best Practices-Phase wise comparison	118
Figure 4.42: Schedule Reduction Techniques-Phase wise comparison.....	119
Figure 4.43: Management Techniques- Comparison by phase.....	119
Figure 4.44: CII Best Practices Rank wise comparison.....	120
Figure 4.45: CII Best Practices- Graphical Comparison	121
Figure 4.46: Schedule Reduction Techniques Rank wise comparison.....	122
Figure 4.47: Schedule Reduction Techniques-Graphical Comparison.....	123
Figure 4.48: Management Techniques-Comparison by rank.....	123
Figure 4.49: Management Techniques-Graphical Comparison.....	124
Figure 4.50: Top 15 Radical Reduction Techniques	125
Figure 5.1: Case Study Summaries.....	128
Figure 6.1: Total Scores for CII Best Practices (sample view).....	166
Figure 6.2: Top Reduction Techniques per Phase	167
Figure 6.3: Top 10 Radical Reduction Techniques (Sample View)	168
Figure 6.4: Top ten Radical Reduction Techniques.....	169
Figure 6.5: Top ten Radical Reduction Techniques-Formatted.....	169
Figure 6.6: Color Coding of Macro Phases	170
Figure 6.7: Color Coded Macro Phases with corresponding Reduction Techniques	170
Figure 6.8: Development of 'Project Manager's Game Planner' – Stage 1	171
Figure 6.9: Development of 'Project Manager's Game Planner' – Stage 2	171
Figure 6.10: Development of 'Project Manager's Game Planner' – Stage 3	172
Figure 6.11: Phase wise Radical Reduction Techniques	172
Figure 6.12: Relative Impact of Radical Reduction Techniques on Project Cycle	175
Figure 6.13: Relative Impact of Radical Reduction Techniques on Project Cycle – stage 1 ..	175
Figure 6.14: Relative Impact of Radical Reduction Techniques (RRT) on Project Cycle	176
Figure 6.15: Relative Impact of Radical Reduction Techniques over Project Cycle	178
Figure 6.16: Radical Reduction Playcard: Example	181
Figure 7.1: Structure for Proposed Electronic Decision Tool.....	193

Blank Page

CHAPTER 1 INTRODUCTION

1.1 Introduction

Global competition and reduced project life cycle ultimately put 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. However, the 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 delivery systems with an aim to reducing capital facility planning and construction time.

1.2 Definition of Radical Reduction

Radical reduction is defined as a reduction of 25% or more in overall project cycle time (pre-planning through start-up) 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 project.

1.3 Purpose of Research

The purpose of this research is to investigate methods and processes, and to develop a CII Best Practice related to shortened cycle times including supply chain, design and contractual changes for capital project delivery systems.

1.4 Scope of Research

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.

1.5 Objectives

This research has five main objectives:

- (i) Identify practices that can improve project delivery time.
- (ii) Identify barriers to radical reduction in cycle time.

- (iii) Prioritize the changes or improvements based on their potential for cycle time reduction and identify techniques for radical reduction.
- (iv) Develop a user friendly implementation resource to assist in the evaluation and execution of radical reduction techniques.
- (v) Develop a list of topics for follow-on research aimed at removing or eliminating barriers to significant cycle time reductions.

1.6 Research Approach

The overriding hypothesis of this research is that a study of high performing projects will lead to the discovery of delivery practices, which, if applied broadly and routinely, would improve delivery time across the general construction industry. Data were collected through questionnaire surveys, personnel interviews, site visits, and literature review. The research approach to define and test this hypothesis includes the following tasks:

1. Extensive literature review, including information available in the CII Knowledge Structure and management techniques employed by other industries to achieve cycle time reduction.
2. Questionnaire I: Short survey developed and distributed to CII member companies for the purpose of identifying projects that have achieved radical reduction that could be candidates for a more extensive study.
3. Questionnaire II: Survey developed and distributed to CII membership and Case Study participants for the purpose of collecting data regarding application of reduction techniques.

4. Case Studies: Conduct several case study evaluations of successful projects to identify practices that can improve project delivery time and barriers to radical reduction in cycle time. Incorporate these findings into the overall development effort.
5. Questionnaire III: Short survey developed and distributed to participants of the case studies to gather data in order to develop the final metrics for radical reduction of project cycle time.
6. Develop a prioritization hierarchy for successful reduction techniques based on their potential for cycle time reduction.
7. Develop a user-friendly implementation resource to assist in the evaluation of techniques for accelerated project delivery cycle.
8. Develop publications and presentations and disseminate information to industry through development of an implementation resource.

1.7 Report Organization

The need for the research has already been discussed above. Chapter 2 describes the research methodology followed in this research. It also explains various assumptions and criteria of the research. Chapter 3 gives an overview of the background literature for radical reduction techniques. Chapter 4 discusses data gathered from various questionnaire surveys and the Essence Applicability Matrices (EAM) during the research and gives analysis of the data thus obtained. Chapter 5 discusses results and findings of the case studies. Chapter 6 discusses the framework of the implementation resource – Project Manager’s Game Planner and describes how it has been developed. Chapter 7

briefly discusses the conclusions made from the questionnaire surveys, essence applicability matrices, case studies, and the implementation resource. Recommendations are made along with limitations of the research and direction for future work.

1.8 Research Team

This research has been conducted under the direction of the CII Project Team 193 (PT 193): Radical Reduction in Project Cycle Time. The CII members of the research team have played a significant role in the development of the questionnaire, case studies, identifying metrics, and in developing the framework of the decision aid. A complete listing of team members is provided in Appendix 1.

Blank Page

CHAPTER 2 RESEARCH METHODOLOGY

2.1 Data Collection Modes

As described in the previous chapter, the major objective of this research is to find methods of achieving radical reduction in project cycle time. To achieve this objective, four specific data collection modes were used, namely: (i) Literature review, (ii) Questionnaire surveys targeting the CII membership and case study respondents, (iii) Essence Applicability Matrices to be completed by PT 193 team and the case study respondents and (iv) Case studies of selected projects. These modes of data helped in establishing the current methods used for project cycle time reduction. The results of this research have been used to develop a decision tool called ‘Project Manager’s Game Planner’ which is described in Chapter 6. This chapter describes, the methodology used for each of the above mentioned four tasks. Figure 2.1 illustrates the overall methodology in a brief conceptual format. Some key/major issues were identified by analyzing Management Techniques, CII Best Practices, and Schedule Reduction Techniques, which then led to the development of a combined matrix of applicability called the “Essence Applicability Matrices.” Section 2.4 of this chapter describes the Essence Applicability Matrices in detail. This matrix helped identify radical reduction techniques to be adopted at each project phase. These have been integrated together to develop the implementation resource called “Project Manager’s Game Planner.”

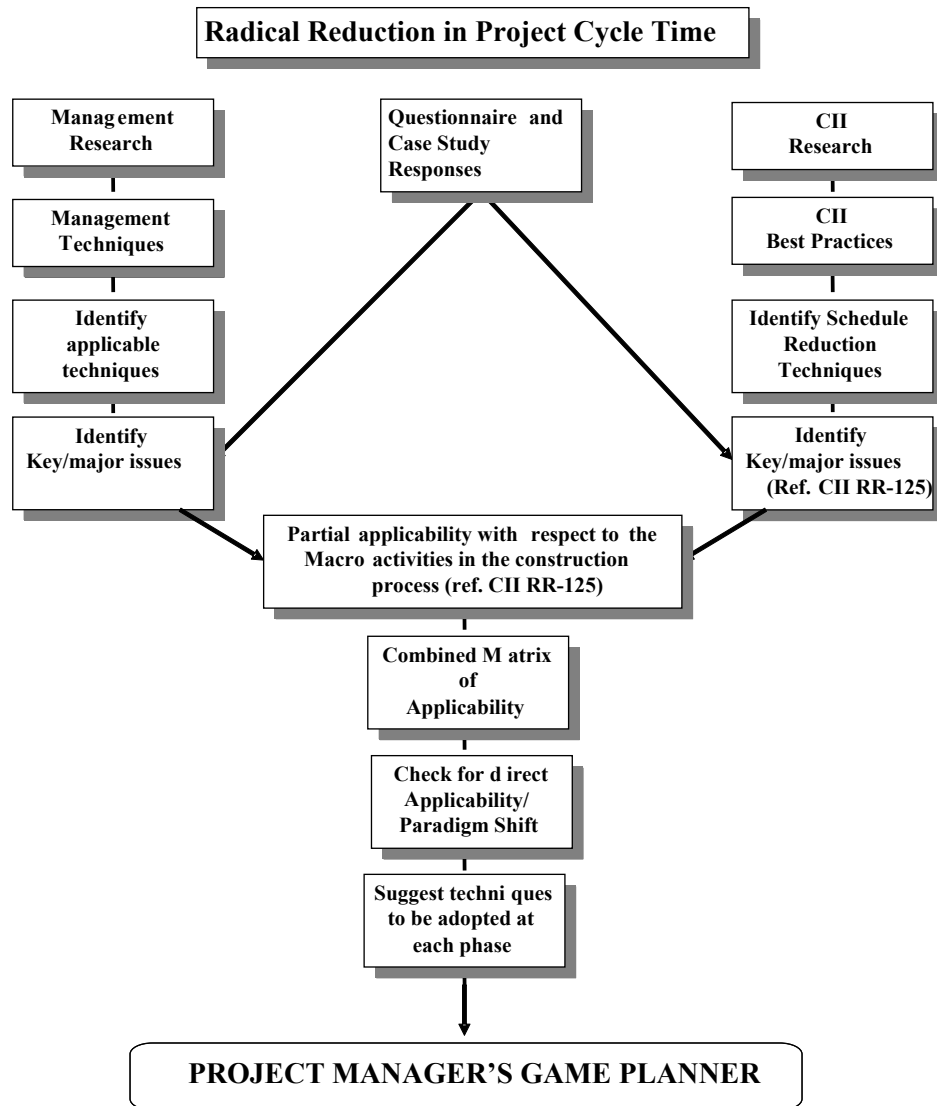


Figure 2.1: Research Methodology

2.2 Literature Review

The literature review helped in identifying the various Schedule Reduction Techniques (SRTs) as well as CII Best Practices currently used in the construction industry. The Literature review 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. As many as 20 management techniques like Kaizen, Kanban, 5S, Six Sigma, Just-in-Time, Time Based Competition and others were studied. Out of these, the ones which had more relevance to civil engineering and the construction industry were studied in detail. These techniques are discussed in Chapter 3. 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 ‘Essence Applicability Matrices’, details of which are included in section 2.4 of this chapter.

2.3 Design of Questionnaires

The literature review, which included academic research, technical reports, CII references, news 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. This chapter summarizes the questionnaires, whereas the data collected through the questionnaires are illustrated in Chapter 4.

2.3.1 Questionnaire I

Questionnaire 1 (refer to Appendix B) was developed to identify companies that have been successful in implementing methods and techniques to radically reduce project cycle time. This questionnaire was mailed out to all CII member organizations (104 in number). This questionnaire has been divided into 3 basic sections:

(1) Company Profile:

This section identifies the respondents' position in the organization, besides collecting information about the name of the company and the respondents' contact information such as e-mail, fax and telephone numbers.

(2) Techniques for Radical Reduction:

The questionnaire asked the respondent to identify if their company had implemented any techniques for radical reduction in project cycle time. If they indicated yes, they were asked to briefly describe what techniques were used for achieving radical reduction. This section further asked them to give other details like the project name, location of project, estimated project cost, actual project cost, estimated project duration and actual duration after achieving reduction. Also, they were asked to indicate if they had used any standard benchmarking such as the one conducted by the Construction Industry Institute (CII) and Independent Project Analysis (IPA).

(3) Conclusion:

This section asked the respondent to indicate whether they/their company would be willing to share this information with PT 193 and were asked to provide the contact name and addresses of people in their organization who could be approached. Also, the

respondents were asked if they were aware of any other companies that may have achieved radical reduction in their projects.

2.3.2 Questionnaire II

This was a follow on questionnaire after responses to Questionnaire I were received. Questionnaire II was completed by two sets of respondents: the CII membership and the case study respondents. The data have been analyzed and compiled in Chapter 4. The questionnaire also provided the definitions of radical reduction in project cycle time and other important terms. The objective of this questionnaire was to investigate methods, processes, and CII Best Practices related to shortened cycle times for project delivery systems. This questionnaire helped the team identify best practices of recently completed projects with unusual success in reducing cycle time.

For the purpose of this questionnaire survey, the following definitions hold:

- **Radical Reduction:** Radical reduction is defined as a reduction of 25% or more in overall project cycle time (pre-planning through start up) when compared to current industry standard for projects of similar size and scope. Of particular interest are projects with cycle time reduction greater than 25% (in the range of 25-50% or even higher).
- **Project Cycle:** 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 project.
- **Front End Loading (FEL):** According to Independent Project Analysis (IPA), the front-end loading process is made up of the critical planning

phases of any project. The effective commitment of time and resources at this point dictates the future success of the project.

Questionnaire II is divided into the following sections:

(1) General Information

This section asked the respondent to fill out their name, company details such as address, e-mail, fax, phone etc. Also, the respondents were asked to indicate the type of organization (AEC/ contractor/vendor) and the number of professional staff employed by their company/organization.

(2) Project Cycle Reduction-Part I

This section has been divided into ten different questions with the foremost being whether radical reduction in project cycle time was important to the respondents' organization. If it was not, then the respondents were asked to skip this section and proceed to the next section of the questionnaire.

If the respondent indicated that radical reduction in project cycle time was important to their organization, they were asked to explain the techniques (like cost/benefit analysis, risk analysis, or other) that they would consider in determining when reduction in cycle time would be possible. Information about the drivers and barriers for cycle time reduction was also collected. The respondents were asked to rate on a scale of 1 to 4 (1-strongly agree, 2-agree, 3-disagree, 4-strongly disagree) some specific drivers and barriers that were short listed in the questionnaire. The respondents also had the option of mentioning any other drivers/barriers they felt were important.

Respondents were also asked to rank the problems/issues that caused cycle time extensions (on a similar scale of 1 to 4 as mentioned above). A list of problems/issues that were identified during the literature review was included in this question for the respondents to rank. Similarly on a scale of 1 to 4, the respondents were asked to rank the contracting strategies that they would prefer to achieve radical reduction, and then to indicate the advantages/disadvantages of those contracting strategies. The respondents were asked to list the top five typical long duration activities in a standard project.

As a next question, the questionnaire provided a list that included but was not limited to CII Best Practices and asked the respondents to identify practices that they would modify in their organization for the purpose of achieving radical reduction. They were also asked to explain in brief how they would do these modifications. This section also asked the respondents if in their opinion, they felt that ‘lessons learned’ from crisis situations in the past could be transferred to every day projects in a sustainable, systematic manner. If ‘yes’, what would be the trade-offs? They were also asked to mention the cause of the crisis and what steps could have been taken to prevent those.

As a concluding question of this section, the respondents were asked to indicate the communication technologies (internet/dedicated project website/net meetings, e-drawings etc.) used by their project teams/organization.

(3) Project Cycle Reduction: Part II

This second part of the questionnaire asked the respondents to identify what size and what type of projects would benefit most from radical reduction. The projects have

been categorized as under \$50M, \$50M-\$100M, \$100M-\$300M and over \$300M. Also, they were asked to identify what type of projects would least benefit from the use of project cycle time reduction techniques. This questionnaire ends by asking if they would be interested in participating in a CII case study and if yes, to provide details of the contact person in their organization.

2.3.3 Questionnaire III

This was a follow-up to Questionnaire II was mailed to the project team as well as those participating in the case study. The questionnaire has been divided into two sections: part A deals with three important project parameters-safety, cost and quality, and part B is a tabular list of 'Insights' essential for radical reduction of project cycle time as obtained through the case studies that were conducted. Responses to section A helped in understanding if there was any adverse impact on the aforementioned aspects of the project due to squeezing of cycle time.

Part A of this questionnaire starts with the general section, which was used to gather information regarding responsibility in the organization and contact information of the person answering the questionnaire. The respondent was asked to rate the 'overall safety' and 'overall quality' (on a scale of Superior, Better, Same, Reduced, and Inferior) of the case study project compared to other projects (where schedule reduction was not a driver). The questionnaire further asked them to identify any lost workday injury and illness cases. The questionnaire then tries to identify how much 'rework' was required and also, how would they rate the 'overall cost' of the case study project (on a scale of

Lot more, Slightly more, Same, Slightly less and Lot less) compared with other comparable projects where radical reduction was not a driver. Part A concludes by asking the respondents if they met the cost commitment for the project and, if not, whether they exceeded the costs or came in below the target cost. These responses have been analyzed and compiled in Chapter 4.

Part B of this questionnaire includes the ‘Insights Matrix’, which asks the respondents to rate the ‘Insights’ obtained through case studies (on a scale of SA-strongly agree, A-agree, D-disagree, and SD-strongly disagree). Also, the respondents were asked to identify if these ‘Insights’ could be applied to any type of project within their organization and to give their comments.

2.4 Essence Applicability Matrices

The Essence Applicability Matrices (refer to Appendix D) were sent to PT 193 members and also to the case study participants. These matrices include (i) CII Best Practices, (ii) Schedule Reduction Techniques and (iii) Management Techniques. The objective of these matrices was to collect responses on the applicability of reduction techniques under different project phases. Responses obtained from PT 193 have been analyzed and compiled. Also, responses from the case study participants have been analyzed and both set of responses are discussed in Chapter 4.

The following describes the three matrices:

(1) CII Best Practices

The first matrix (refer to Appendix D) lists all the eleven best practices as identified by CII, and the respondents were asked to indicate either 'yes' or 'no', whether they felt that the eleven best practices could be applied to any of the 24 macro activities (identified from previous CII research RR125-11) of the five project phases. A particular reduction technique could be applicable to more than one macro activity and hence the maximum responses that a single person could give to this matrix is $11 \times 24 = 264$ responses, assuming he/she felt that all the Best Practices could be applied to each one of the macro activities.

(2) Schedule Reduction Techniques

After an exhaustive literature review of all the previous CII documents, 46 schedule reduction techniques were identified as explained in Chapter 3. This is similar to the earlier CII Best Practice matrix, but is spread over four pages (refer to Appendix D). The respondents were asked to identify the macro activities for which a particular reduction technique was used or could be used. As mentioned earlier, a particular reduction technique could be very well applicable to more than one macro activity.

(3) Management Techniques

As mentioned earlier, various management techniques were studied to identify the main characteristic (essence) that could be applied to the construction industry. Since each management technique had more than one essence, all those were taken together and combined to make a list of the 13 'essences' that were common to all management

techniques that were evaluated (refer to Appendix E). As in the previous two matrices, respondents were asked to indicate for which activity a particular essence was applied or in their opinion could be applied.

2.5 Case Studies

The case studies were conducted to compliment and clarify certain issues and to identify new ‘insights’ or practices. The data collected from Questionnaires I and II was pre-analyzed to compile interview questions. Twenty candidate projects were identified from Questionnaire I and out of this seven case studies were conducted to get a better understating of the decision-making process used by the project teams to radically reduce project cycle time. The case studies also reflect the limitations and barriers as well as the cost and safety issues. The major objective of the case studies was to identify reduction techniques that were successfully applied in achieving radical reduction in project cycle time. The case studies short listed reduction techniques (from the list identified earlier in the essence applicability matrices) as well as identified some new techniques. These successful techniques have been called ‘insights’ and were compiled as the ‘Insights Matrix’ and included with Questionnaire III, which was sent to the case study participants as well as to PT 193 members. The seven case studies have been illustrated in detail in Chapter 5.

Blank Page

CHAPTER 3 LITERATURE REVIEW

3.1 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. There are usually financial benefits of exceptional increased profit or reduced loss from early use of the asset as a result of one or more of the following:

- 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, e.g., 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 competition.
- 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.

3.2 Contractor Benefits

From the contractors' 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 a tight completion date that the only way to achieve it is to adopt a fast track strategy. It is still the case that many contractors only become involved following receipt of bid documents, and then they are unable to influence the 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.

3.3 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:

1. Traditional design-bid-build.

2. Construction managed by a professional construction manager.
3. Bridging.
4. 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 contract is awarded halfway through design (refer to Figure 3.1).

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.

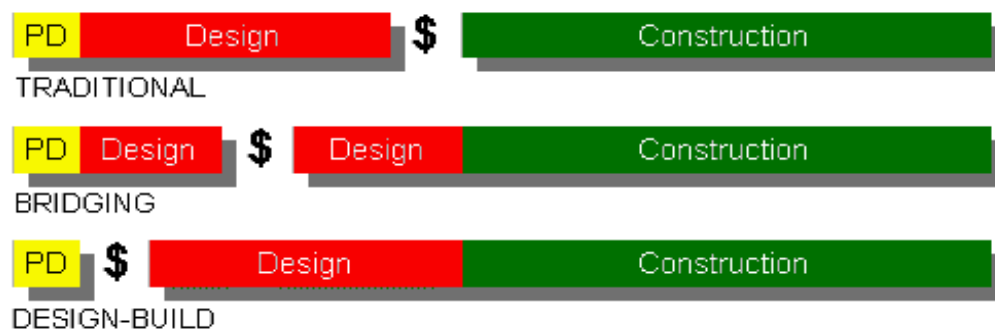


Figure 3.1: Project Delivery Systems
(Lean Project Delivery System LCI White Paper-8, September 23, 2000,
by Glenn Ballard, © Lean Construction Institute, 2000.)

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 reintroduce 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 41-11 (Sanvido et al. 1998), used data from 351 building projects that showed Design-Build to be superior to traditional design-bid-build due to:

- Reduction in unit costs (avg. of 6.1%)
- Increase in construction speed (12%)
- Reduction in overall project delivery (as much as 33.5%)
- 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. The Business Roundtable (*The Business Stake* 1997) states that "Companies that have managed to perform above average in capital efficiency have all maintained some form of central organization that is responsible for front-end loading."

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.

Another innovation in project delivery system is alliancing, a new form of project delivery developed by BP for North Sea oil and gas projects (Badger et al. 1993). The alliance partners are jointly responsible for total project results, and work cooperatively in an integrated team to achieve agreed cost, time and quality targets. The agreement provides financial rewards to encourage and reward outstanding performance. There are also financial penalties if the targets are not achieved. The success of this system is evidenced in some of the recent international projects, including:

- Northside Storage Tunnel Project, Sydney Water Company, Cost: A\$375 million.
- Woodman Point Waste Water Treatment Project, Western Australian Water Corporation, Cost: A\$130 million.

- The National Museum of Australia, Estimated Cost: A\$1 billion (Introduction to Project Alliancing, Jim Ross, Proceedings of the Alliance Contracting Conference, Sydney, Australia, April 30, 2003).

3.4 New Trends in Project Delivery Systems in Other Industries

Technological changes and increased competitive pressures arising from the deregulation of markets have caused much upheaval during the 1990s. Nowhere has this been more evident than in the construction of thermal power plants. Over the past ten years, the average cost and construction time of "greenfield" fossil fuel-fired power plants has been reduced by approximately 50% (refer to Figure 3.2), even as their performance has improved. The key factors contributing to this are: standardization of scope, modularization, automation of design, and technological improvements.

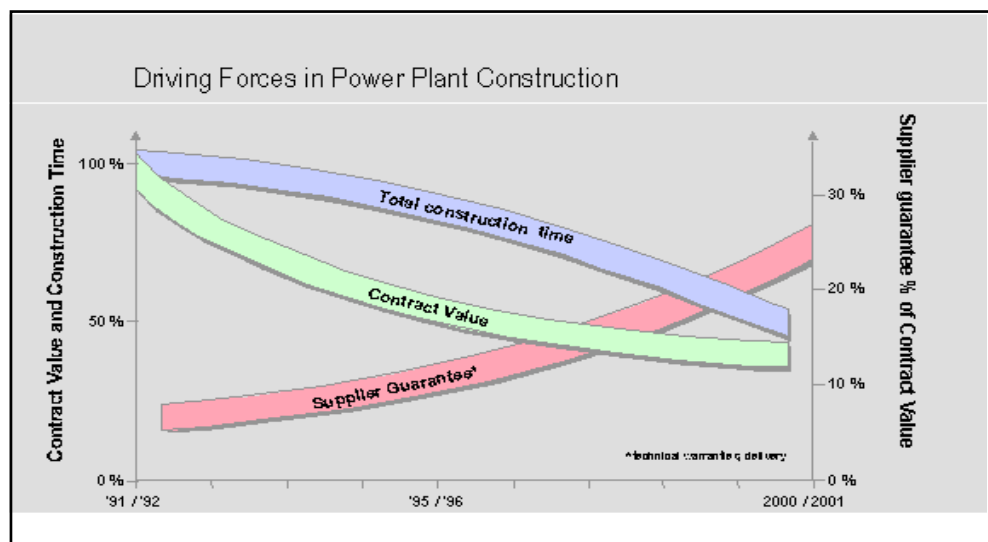


Figure 3.2: Radical Reduction in Power Plant Construction Cycle
<http://www.eere.energy.gov/troughnet/opportunities.html>

Similar success stories abound in the cutting edge businesses such as e-commerce and information technologies. Expedited delivery of products and services is at the very essence of these modern industries. Automated Product Methodology (APM) has allowed e-businesses to significantly accelerate and enhance deployments of large-scale information technology projects, often by cutting the delivery time in as much as half (Berg 1999). APM is designed to meet the needs of implementation team members, project managers and project sponsors - enabling all three to effectively communicate with each other throughout the project life-cycle. It consists of three primary components: a project modeling tool, a project task monitor/workflow engine, and a graphical user interface for the project team. This strategy is particularly appealing in light of the continuing emphasis on rapid solutions delivery in the midst of an intense shortage of skilled IT staff.

Of course, not every innovation is a success story, case in point being the much touted NASA's New Millennium Program: Faster, Better, Cheaper. The concept of "faster, better, cheaper" was based on the interconnection of decreased mission costs and increased risk. To be able to do significant missions with less money, NASA was willing to accept increased risk through the use of untried or otherwise risky techniques or equipment that promise to do more for less money. The dramatic failure of the Mars Surveyor Probe and has caused NASA to reexamine the validity of the entire strategy.

One has to look beyond the construction industry to find new and innovative methods to help reduce project cycle. Time-Based-Competition (TBC) (Hastak et al. 1993) is one such lean manufacturing process. The TBC strategies have been successfully

applied by manufacturing and service companies such as Motorola, General Electric, Harley-Davidson, Citicorp, and American Express in drastically reducing order-to-delivery time for their customers. An analysis of the various case studies from these industries will help bring understanding regarding the success of these methods and help identify barriers to significant cycle time reductions.

3.5 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 (Beck 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 the five primary phases of project execution in an EPC process:

- Pre-Project Planning (PPP)
- Design (D)
- Materials 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 3.3)

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 study, only the first two levels are required and hence, information about level three has not been mentioned here.

3.5.1 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). It also encompasses the development of a product technical plan, facility scope plan, project execution plan, and a contract strategy.

3.5.2 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. In addition,

permitting, codes, design standards, and other legal or regulatory issues are addressed. Based on a finalized scope, a detailed estimate of 109 equipment, materials, and services is developed as well as a detailed schedule for design, materials management, construction, and start up. The design phase also includes the reviews and approvals obtained from within design disciplines, between disciplines, and from the owner as well as all efforts to finalize design deliverables. Work packaging, or the development of logical, well-defined divisions of construction tasks based on construction specialty, location within the project site, and ease of contract administration is also an important part of design (Russell et al. 1992).

3.5.3 Materials Management

Materials 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. General contractor or subcontractor services are also required for materials management. In addition, field equipment management and materials related documentation have been incorporated into this phase.

3.5.4 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.

3.5.5 Start-Up

Start-up is composed of all requirements, procedures, and tests necessary for initial facility or system component production. (Mathews and Ashley 1986, Smith and Pritchett 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 code '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 3)

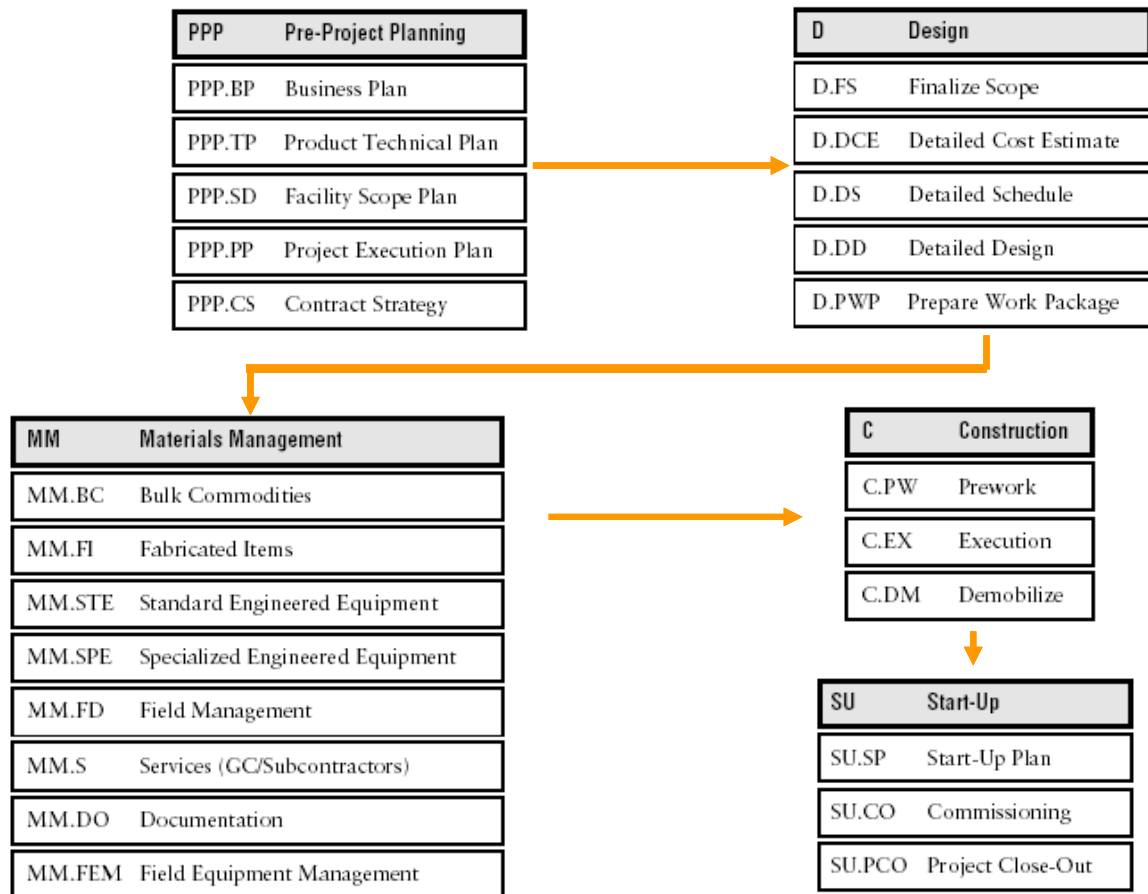


Figure 3.3: EPC Macro Model
(Determining the Impact of Information Management on Project Schedule and Cost.,
June '98, by Back, Moreau, Toon, © Construction Industry Institute,)

3.6 CII Best Practices

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

3.6.1 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. Well performed pre-project planning can lead to:

- Improved cost predictability
- Improved schedule predictability
- Better attainment of operational and production goals in the first six months of operation
- Better achievement of business goals
- Better definition of risks
- Fewer scope changes
- Greatly reduced probability of project failures and disasters.

Pre-project planning represents a significant opportunity for owners to improve all aspects of project performance. Statistics and feedback from companies who embrace these practices indicate that there is an opportunity to reduce project costs by as much as

20 percent, while also achieving significant improvement based on other business and operations criteria. It must be stressed that the work that is being advocated will take place at some point in the life cycle of every project—the most cost-effective time for it to occur is during pre-project planning.

3.6.2 Alignment

In the context of capital projects, alignment is defined more specifically as:

“The condition where appropriate project participants are working within acceptable tolerances to develop and meet a uniformly defined and understood set of project objectives” (Front End Planning Research Team 1997).

Alignment is a relatively new concept in the capital investment process. As owner organizational structures continue to flatten, more projects are pursued using multi-disciplined teams and alliance partners. Alignment is needed to improve projects in this environment. There is a positive correlation between increased efforts to gain alignment in pre-project planning and project success. The following issues have the greatest effect on team alignment:

- 1) Culture: The attitudes, values, behavior, and environment of the company and the pre-project planning team.
- 2) Execution Processes: Project systems, processes, and procedures.
- 3) Information: The data elements, including business objectives, used to define the scope of the project.

- 4) Project Planning Tools: Tools such as software programs, checklists, and aide-memoirs that are typically used to develop and manage projects.
- 5) Barriers: The obstacles to creating and maintaining alignment.

By taking action on these issues, the team will increase its chances of achieving alignment of the diverse project requirements, which will result in a successful planning effort.

3.6.3 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. Six basic constructability concepts are generally applicable to the conceptual planning phase of any project:

- 1) Constructability programs are made an integral part of project execution plans.
- 2) Project planning actively involves construction knowledge and experience.
- 3) Early construction involvement is considered in development of contracting strategy.
- 4) Overall project schedules are construction-driven.
- 5) Basic design approaches consider major construction methods.
- 6) Site layouts promote efficient construction as well as efficient operation and maintenance.

Implementation of a constructability program with early construction involvement results in better projects, lower costs, better productivity, and earlier project completion. At the same time, there are certain barriers to implementing constructability such as reluctance to invest additional money and effort in early project stages; limitations of lump-sum competitive contracting; and lack of construction experience in the design organization.

3.6.4 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. Effective design is the product of effective teamwork among the owner, the designer, and the construction contractor.

The input variables that have the highest influence on design effectiveness often occur before design is initiated. Therefore, the owner is the primary source of input variables. The designer, certain key suppliers, and the construction contractor also supply

input variables to the design function, but to a lesser extent. Design input variables influence all projects whether designed by in-house or full service companies.

The following ten input variables are identified as having the greatest impact on design effectiveness:

- Scope Definition
- Owner Profile and Participation
- Project Objectives and Priorities
- Pre-Project Planning
- Basic Design Data
- Designer Qualification and Selection
- Project Manager Qualifications
- Construction Input
- Type of Contract
- Equipment Source

3.6.5 Materials Management

Materials 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” (Materials 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.