Project Manager's Decision Aid for a Radical Project Cycle Reduction

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Abstract: Currently there are no formal decision tools or guidelines to assist owners and project managers in choosing delivery systems and project strategies that would allow significant reductions in the project cycle time. The development of a decision aid that would allow a project manager to prioritize and apply project cycle reduction techniques would be a valuable tool for achieving project cycle time reduction in projects. This paper presents a new high performance project delivery system called "project manager's game planner" (PMGP) designed to assist a decision maker in identifying and utilizing an optimal set of radical reduction techniques (RRTs) with the greatest potential for success in achieving cycle time reduction. Additionally, the PMGP can assist the user in identifying the top RRTs during any of the five project phases: preproject planning, design, material management, construction, and start-up. Most projects can utilize this PMGP to improve the project performance whether to achieve significant cycle time reduction or to simply achieve effective project execution.

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Introduction

Project delivery systems in the construction industry have gone through an evolutionary process to reduce delivery time, while maintaining quality and containing cost. The most commonly utilized project delivery systems prevalent today are traditional design-bid-build; construction managed by a professional construction manager; design-build (lump-sum and guaranteed maximum price); and bridging (a hybrid of two different systems). From the automotive industry to the process industries and from the information technology to e-commerce, today's business relies on just-in-time capacity enhancements and first-to-market product strategies to gain competitive advantages and to enhance profits. Under the situation, owners are requiring contractors to accomplish projects faced with shortened schedules, tight budgets, and technical complexity. This has caused an increased demand for a high performance project delivery system that can achieve significant reductions in project delivery times. However, there are few decision tools or formal guidelines to assist owners and contractors in choosing delivery systems and project strategies to radically reduce the cycle time from the preplanning phase through the start-up phase of the project.

It is evident that the development of a high performance project delivery system designed to assist the owners and project managers in identifying and utilizing an optimal set of radical reduction techniques (RRTs) with the greatest potential for success in achieving a cycle time reduction in a given project would be highly beneficial to the construction industry. Over time, the construction industry has been successful in making incremental reductions to the project schedule. However, the high performance system discussed herein addresses projects that have a need to make a "radical reduction" to the project cycle time. For the purpose of this research, a reduction of 25% or more in the overall project cycle time represents radical reduction as compared to the standard duration for projects of similar size and scope. This research has been conducted under the direction of the Construction Industry Institute (CII) project team 193 (PT 193). The PT 193 has decided that the reduction of 25% or more in the overall project cycle time is defined as radical reduction.

This paper presents the high performance project delivery system called project manager's game planner (PMGP). The PMGP has been designed as a result of the research conducted by the CII, of Austin, Texas. The PGMP has been developed from the data collected through surveys and case study analyses. This system assists a decision maker in prioritizing and utilizing techniques most beneficial for the overall project or specific phases of a project in achieving radical reduction in the project cycle time.

The first part of this paper describes the essence applicability matrix (EAM) developed to prioritize and rank the effectiveness of the project cycle reduction techniques. The techniques include CII best practices (BP), management techniques (MT), and schedule reduction techniques (SRT), identified as being effective through surveys and further validated through case study analyses. Due to editorial constraints, this paper illustrates the development, organization, and utilization of the PMGP, whereas, the detailed discussion of the EAM is a subject of another paper. A

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Table 1. Summaries of Seven Case Studies

Project name	Offered by	Cost (dollars)	Standard duration (months)	Actual duration (months)	Reduction (%)
Project A	R Chemicals	9.0M	12	9	25
Project B	R Chemicals	45M	21	10	52
Project C	S Engineering	335M	28	20	30
Project D	T&M	16M	12	6	50
Project E	AZ Petroleum	13M	18	9	50
F Purification plant	SUV Incorporated	94M	60	36	40
M biotech	LS Construction	25	4	2	50

typical schedule driven project scenario is used to illustrate the application of the PMPG and the relative impact of the RRT during the five project phases.

Essence Applicability Matrices

The research team solicited responses to a questionnaire survey from 104 CII member companies (consisting of owners, engineers, contractors, suppliers, etc.) in order to help identify case studies that have achieved significant reduction in the project cycle time. Twenty-two responses were received identifying 17 potential projects. A total of seven projects (refer to Table 1) were selected for in-depth analysis and site visits with the project teams. The projects varied in scope, location, and duration. However, all had accomplished a "radical" reduction in the project cycle time as defined earlier. Through literature review, questionnaires, and case study analyses, a list of techniques utilized in achieving the project cycle time was compiled. These techniques form the *essence* of a successful project delivery strategy where the project cycle time reduction is the principal objective. The techniques include: 11 CII BP, 46 SRT, and 21 MT. The EAM was devised to assess the impact and/or applicability of each technique on the overall project, and on each phase of the project (see Fig. 1 for project phases). The EAM were sent to CII research team members and the case study participants. Eleven responses were received from the team members and fifteen from the case study participants.

CII Best Practices

The first matrix of the EAM lists the eleven CII BP—preproject planning, alignment, constructability, design effectiveness, material management, team building, partnering, quality management, and change management; and the respondents were asked to indicate either "yes" or "no," whether they felt that the eleven BP could be applied to the twenty-four macro activities (see Fig. 1) of the five project phases, namely: preproject planning (PPP); design (D); material management (MM); construction (C); and start-up (SU). A particular reduction technique could be appli-

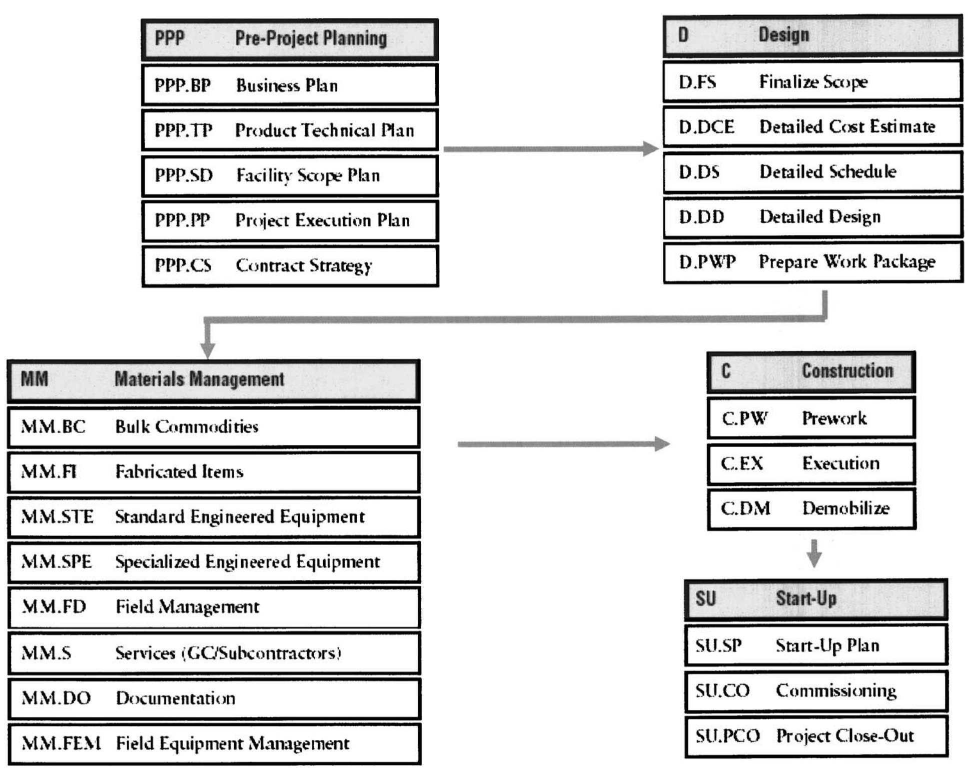

Fig. 1. EPC macro model [adapted from CII 125-11 (1998)]

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cable 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 BPs could be applied to each one of the macro activities.

Schedule Reduction Techniques

The research team also identified 46 SRTs through extensive literature review. Some of the SRTs are as follows: (1) advanced construction equipment; (2) alternative construction methods; (3) avoidance of interruption; (4) craftsmen; (5) specialty crew; (6) construction driven schedule; (7) dual purpose design; (8) expedite payment; (9) frequent inspection; (10) fast track scheduling; (11) incentive; (12) lump sum contract; (13) Pareto's law of management; (14) realistic scheduling; (15) use of electronic media; and (16) well-defined organizational structure, etc. For detailed information on these techniques, refer to CII 193-11 (2004). Similar to the matrices discussed earlier for the BP, EAMs were developed for the SRTs. The respondents were asked to identify the macro activities for which a particular reduction technique was used or could be used. A particular reduction technique could be well applicable to more than one macro activity.

Management Techniques

Management techniques (MT) that have been successfully utilized in other industries for schedule reduction (e.g., time based competitive strategies, just-in-time, etc.) were studied to identify the main essence (or characteristics) that could be applied to the construction industry. This analysis led to the identification of thirteen "essences," such as inventory reduction, elimination of unneeded items, employee involvement, increase output, improve quality, reducing cycle time, safety in workplace, space reduction, reliability, continuous improvement, prevent mistakes, minimal resources, and reducing delivery lead time. As in the previous two matrices, respondents were asked to indicate the applicability of these techniques to the 24 project activities (refer to Fig. 1).

PMGP—Radical Reduction Techniques per Phase

As mentioned before, the PMGP has been developed from data collected through the EAM. As discussed earlier, this data was collected from the case study participants, as well as the research team members. The PMGP was tested and validated through additional case studies. It is divided in two sections: (1) phase wise RRTs; and (2) relative impact of RRTs on the project cycle. The first sec. aims at assisting a user in identifying the top RRTs during any of the five phases (PPP, D, MM, C, and SU: refer to Fig. 1). The second sec. identifies the relative impact that each of these RRTs would have on the five phases over the project life cycle.

Development of PMGP—Radical Reduction Techniques per Phase

Fig. 2 indicates the number of positive responses (or scores) received on each of the macro activities during the data collection phase discussed earlier. The total scores (number of responses) for each of the 11 CII BPs, 46 CII SRTs, and the 13 MTs has been calculated over the five macro phases. Fig. 2 shows a sample of how the total scores for each of the CII BP have been computed. In the same manner, the total scores for all the SRT and MT have been computed over the five macro phases. Underneath each macro phase, there are three divisions: (1) CII BP; (2) SRT; and (3) MT. The top ten (as per scores from EAM) SRT, top five BP, and top five MT are shown under each of these three secs. Fig. 3 illustrates the top reduction techniques for the PPP and D phases.

The top ten SRT, five CII BP, and the five MT are subsequently combined and arranged in descending order of their scores. The ten techniques with the top scores are selected irrespective of their origin (i.e., CII BP, MT, or SRT) and are now called RRT. This is done for all the five macro phases. Fig. 4 shows the top ten RRT arranged in a descending order for each of the five macro phases based on their scores, and it also indicates whether the RRT is a CII BP, SRT, or MT.

CII Best Practices / Macro Activities (CII 125-11)	Pre-Project Planning	Alignment	Constructability
Pre Project Planning	**31**	**29**	**15**
Business plan	7	5	
Product technical Plan	4	3	2
Facility scope plan	7	6	4
Project execution plan	7	8	5
Contract strategy	6	7	4
Design	**21**	**30**	**33**
Finalize scope	3	5	8
Detailed cost estimate	6	7	4
Detailed Schedule	5	8	8
Detailed Design	4	5	8
Prepare Work Package	3	5	5
Material Mgmt.	**27**	**17**	**29**
Bulk Commodities	4	1	4
Fabricated Items	3	1	3
Standard Engineered Equip.	3	1	3
Specialized Engineered Equip.	3	1	2
Field Mgmt.	3	3	4
Services (GC/Subcontractors)	4	3	5
Documentation	4	4	4
Field Equip. Mgmt.	3	3	4
Construction	**16**	**17**	**18**
Prework	8	7	8
Execution	5	7	8
Demobilize	3	3	2
Start-up	**11**	**16**	**6**
Start-up Plan	4	7	2
Commissioning	4	7	2
Project Close-out	3	2	2
TOTAL SCORE	**106**	**109**	**101**

Fig. 2. Total scores for CII best practices (sample view)

Color Coding of Macro Phases

A color coding has been utilized for the project phases for visual appeal and ease of use as follows: PPP—blue; D—tan; MM—yellow; C—green; and SU—purple. Fig. 5 illustrates the color coded macro phases and the respective RRT.

Color Coding for Radical Reduction Techniques

Color coding was also adopted for each of the RRT to help illustrate reduction techniques that repeat in successive steps. Fig. 6(a) shows color blocks on the left side of every RRT. All the RRT under the PPP phase have a blue color box corresponding to the color assigned to the PPP phase. The RRT from the PPP phase that roll over to the other four macro phases are also highlighted in blue [Fig. 6(b)].

Similarly, the RRT under the D phase that have not been previously highlighted in blue are highlighted with the color given to

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PRE-PROJECT PLANNING		DESIGN	
Schedule Reduction Techniques		**Schedule Reduction Techniques**	
Participative Mgmt	34	Use of Electronic Media	50
Well defined Organizational Structure	33	Freezing of project scope	42
Start up driven scheduling	31	Participative Mgmt	37
Use of Electronic Media	29	Start up driven scheduling	32
Pareto's Law Mgmt	29	Construction driven schedule	32
Construction driven schedule	26	Non traditional Drawing Release	31
Single EPC owner	26	Realistic scheduling	30
Avoidance of interruption	21	Productive Working Environment	29
Realistic scheduling	19	Supplier/Engineer Early Information Exchange	28
Reduction of Task scope	18	Pareto's Law Mgmt	23
CII best practices		**Schedule Reduction Techniques**	
Pre project planning	55	Constructability	48
Alignment	50	Design Effectiveness	48
Team building	33	Alignment	43
Constructability	26	Materials Mgmt	28
Partnering	21	Change Mgmt	28
Management Techniques		**Schedule Reduction Techniques**	
Employee involvement	24	Employee involvement	35
Continuous improvement	17	Continuous improvement	21
Increase Output	16	Reliability	17
Safety in workspace	16	Prevent Mistakes	15
Reliability	13	Increase Output	14

Fig. 3. Top reduction techniques per phase

the D phase, i.e., tan. The RRT under the D phase that repeat themselves in any of the subsequent phases are also highlighted in tan. RRT that are first implemented during MM are highlighted in yellow. If these repeat in any of the succeeding project phases, then they are also represented by the same yellow color in those phases. The process is repeated for the remaining two project phases. Fig. 6(c) shows the completed first part of the project manager's game planner with color coding.

Radical Reduction Techniques

Based on phase 1 of the PMGP [refer to Fig. 6(c)], the following 25 RRT were identified over the five project phases. All the RRT have been arranged in alphabetical order. Each technique is mentioned only once. There are no repetitions.

- *Alignment:* in the context of capital projects, alignment is defined as the condition where appropriate project participants

PRE-PROJECT PLANNING

SRT	Startup-Driven Scheduling	34
SRT	Participative Mgmt.	33
BP	Pre-Project Planning	31
BP	Alignment	29
SRT	Use of electronic Media	29
SRT	Well-defined Organizational Structure	26
SRT	Pareto's Law Mgmt	26
MT	Employee Involvement	21
SRT	Realistic Scheduling	19
SRT	Construction-driven Schedule	18

DESIGN

BP	Constructability	33
SRT	Use of electronic Media	31
BP	Alignment	30
SRT	Freezing of project scope	30
BP	Design Effectiveness	29
SRT	Startup-Driven Scheduling	29
MT	Employee Involvement	28
SRT	Non-Traditional Drawing Release	27
SRT	Participative Mgmt.	25
SRT	Supplier/Engineer Early Interaction	25

MATERIALS MANAGEMENT

BP	Material Mgmt.	66
SRT	Startup-Driven Scheduling	46
SRT	Non-Traditional Drawing Release	42
SRT	Material Coordination	39
SRT	Prioritize Procurement of Material	38
SRT	Efficient Packaging for Transportation	37
SRT	Material Id. on Purchase Documentation	35
SRT	Supplier/Engineer Early Interaction	33
SRT	Supplier Submittal Control	32
MT	Employee Involvement	32

CONSTRUCTION

SRT	Startup-Driven Scheduling	22
SRT	Lump-sum Contract	19
BP	Constructability	18
SRT	Participative Mgmt.	18
SRT	Realistic Scheduling	18
SRT	Construction-driven Schedule	18
BP	Zero Accident Techniques	17
BP	Alignment	17
MT	Safety in workspace	17
BP	Pre-Project Planning	16

START-UP

SRT	Startup-Driven Scheduling	23
SRT	Construction-driven Schedule	19
SRT	Use of electronic Media	17
BP	Alignment	16
SRT	Temporary Startup Systems	16
MT	Employee Involvement	15
SRT	Well-defined Organizational Structure	14
BP	Zero Accident Techniques	13
SRT	Participative Mgmt.	12
SRT	Realistic Scheduling	12

Fig. 4. Top ten radical reduction techniques

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PRE-PROJECT PLANNING	DESIGN	MATERIALS MANAGEMENT	CONSTRUCTION	START-UP
Startup-Driven Scheduling	Constructability	Material Mgmt.	Startup-Driven Scheduling	Startup-Driven Scheduling
Participative Mgmt.	Use of electronic Media	Startup-Driven Scheduling	Lump-sum Contract	Construction-driven Schedule
Pre-Project Planning	Alignment	Non-Traditional Drawing Release	Constructability	Use of electronic Media
Alignment	Freezing of project scope	Material Coordination	Participative Mgmt.	Alignment
Use of electronic Media	Design Effectiveness	Prioritize Procurement of Material	Realistic Scheduling	Temporary Startup Systems
Well-defined Organizational	Startup-Driven Scheduling	Efficient Packaging for	Construction-driven Schedule	Employee Involvement
Pareto's Law Mgmt	Employee Involvement	Material Id. on Purchase	Zero Accident Techniques	Well-defined Organizational
Employee Involvement	Non-Traditional Drawing Release	Supplier/Engineer Early Interaction	Alignment	Zero Accident Techniques
Realistic Scheduling	Participative Mgmt.	Supplier Submittal Control	Safety in workspace	Participative Mgmt.
Construction-driven Schedule	Supplier/Engineer Early Interaction	Employee Involvement	Pre-Project Planning	Realistic Scheduling

Fig. 5. (Color) Color coded macro phases with corresponding reduction techniques

are working within acceptable tolerances to develop and meet a uniformly defined and understood set of project objectives (CII 113-1 1997).

- *Constructability:* constructability is the optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives. Maximum benefits occur when people with construction knowledge and experience become involved at the very beginning of a project (CII 34-1 1993a).
- *Construction-Driven Schedule:* scheduling software should be used to prepare and track an integrated engineering/construction schedule. This shall help by putting into focus the construction progress in light of the base schedule (CII 124-11 2000).

Fig. 6. (Color) Development of project manager's game planner

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- *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 (CII 8-1 1986b).
- *Efficient Packaging for Transportation:* this technique involves considerations of dimensional limitation of common transportation modes (length, width, height, volume, and weight) when designing and specifying components so as to minimize the need for special transportation and handling. The handling of oversize components can be expected to add to both cost and delivery time (CII 6-7 1988).
- *Employee Involvement:* one of the essences of 5S is encouragement of employee involvement. 5S, abbreviated from the Japanese words Seiri, Seiton, Seison, Seiketsu, and Shitsuke, are simple but effective methods to organize the workplace. The 5S are prerequisites for any improvement program. The 5S, translated into English are: housekeeping, workplace organization, cleanup, keep cleanliness, and discipline.
- *Freezing of Project Scope:* prior to commencement of detailed engineering, the owner/architect/engineer should have defined the project scope. The owner waives the right to make scope changes after this approval unless attendant cost and schedule impacts are acknowledged. As a control procedure, it is advisable that the date for freezing of the project scope becomes a milestone date on the overall project control schedule. This forces activity planning to target on this date (CII 6-7 1988).
- *Lump-Sum Contract:* these are contracts, wherein, the consideration for the project accomplishment is fixed and not floating with the quantum of work, as is the case in the item rate contracts. With lump-sum contracts, the contractor is interested in getting on and off the job as soon as possible, since there is no incentive to keep the clock running on indirect costs (CII 6-7 1988; CII 124-11 2000).
- *Material Coordination:* this technique suggests establishing a staff position whose primary, if not only, function is to be totally aware of the material situation at all times. This individual will maintain material status, reports, serve as a link between the field construction personnel and procurement personnel, be a key advisor during weekly look-ahead planning meetings, coordinate temporary diversions of materials to meet emergency demands, and otherwise assure the availability of materials when needed (CII 6-7 1988).
- *Material Identification (I.D.) on Purchase Documentation:* this technique promotes a universal company-wide coding system for the material appearing on the purchase order. It suggests including on purchase orders a coding for each item which identifies the item itself plus the working package for which the item is intended, further specifying all tags, stencils, or other identification placed on the item by the supplier. This will facilitate routing of incoming items to laydown areas and minimize potential for misplacement and loss. This technique is practical only for engineered or tagged items. It is not suitable for bulk items or those warehoused on a stock-level basis (CII 6-7 1988).
- *Materials Management:* materials management is defined as the planning and controlling of all necessary efforts to ensure 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 (CII 7-1 1986a).
- *Nontraditional Drawing Release:* allows partially completed drawings to be released for purposes of expediting procurement, construction planning, and execution for the completed and approved portion of the drawing (CII 6-7 1988).
- *Pareto's Law:* the main objective of this technique is to concentrate management attention on those activities that have the greatest potential to adversely affect project schedule, cost, and quality. The famous 80:20 law of management states, "The 80/20 Rule means that in anything a few (20%) are vital and many (80%) are trivial." Concentrate management attention on those activities which have the greatest potential to adversely affect project schedule, cost, and quality (CII 6-7 1988).
- *Participative Management:* this technique involves obtaining worker/employee ideas for reducing inefficiencies and increasing production. Participative management is a process of involving those who are influenced by decisions, in making decisions, where everyone makes certain that everyone gets their needs met. This can be achieved by utilizing techniques such as delay surveys, quality circles, problem solving teams, suggestion programs, and worker discussions to obtain employee/worker ideas for reducing inefficiencies and increasing production (CII 6-7 1988; CII 41-1 1995).
- *Preproject Planning:* CII defines preproject planning as the process of developing sufficient strategic information with which owners can address risk and decide to commit resources to maximize the chance for a successful project (CII 39-1 1994).
- *Prioritize Procurement of Material:* this technique proposes that the prime contractor should consider the purchase of materials for a subcontractor. It also suggests that priorities established for materials acquisition are consistent with the project needs and the vendor capabilities and ensure that these priorities are communicated to purchasing and expediting personnel so that they will concentrate their efforts on the right items (CII 6-7 1988).
- *Realistic Scheduling:* this technique involves regular review and updates of schedules to reflect the realities of the situation. It involves the use of a summary level schedule for overall control, reserving detailed schedules for short-range planning, and regularly reviewing and updating these schedules to reflect the realities of the situation. This approach will permit the schedule to be used as a true planning and controlling document (CII 6-7 1988).
- *Safety in Workspace:* some of the management techniques such as 5S, poka yoke, and visual factory have a primary essence of safety in the workspace. While 5S was discussed earlier, poka yoke is any mechanism that either prevents a mistake from being made or makes the mistake obvious at a glance. It follows that mistakes will not turn into defects. Similarly, the intent of a visual factory is that the whole workplace is set up with signs, labels, color coded markings, etc., such that anyone unfamiliar with the process can, in a matter of minutes, know what is going on, understand the process, and know what is being done correctly and what is out of place, thereby, enhancing safety in workspace.
- *Startup-Driven Scheduling:* on an engineering, procurement, and construction (EPC) project, this technique proposes to develop the schedule based on the logic that the owner's need date governs the start-up activity, start-up activities establish the dates for construction, and construction establishes the need dates for procurement and engineering (CII 6-7 1988).
- *Supplier Submittal Control:* this technique involves making

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sure that the supplier makes the delivery on time (CII 6-7 1988).

- *Supplier/Engineering Early Interaction:* on those procurements where vendor engineering information is needed to permit follow-on design by the detailed engineering staff, it may save time if representatives of that staff visit the vendor's shop and receive advance information on those design features to be incorporated which influence follow-on engineering work. Such information, however, must be labeled as preliminary so that it will not be treated as final (CII 6-7 1988).
- *Temporary Start-Up Systems:* eliminate or reduce the need for temporary systems for start-up by scheduling completion of permanent systems in time to support start-up activity (CII 6-7 1988).
- *Use of Electronic Media:* use of electronic media in project management as a SRT is defined as the use of computer related technology to improve information management and communication in order to achieve higher productivity in developing project documents (e.g., drawings, specifications, procurement documents, instructions, change orders, and procedures) and supporting field operations (CII 124-11 2000; CII 41-1 1995).
- *Well-Defined Organizational Structure:* a well-defined organizational structure is one which clearly establishes all reporting and control lines, also maintains narrative position descriptions which delineate the authority, responsibility, and accountability of each position. This will reduce the potential for delays caused by lack of understanding of who is responsible for what and also clearly establish document control and distribution procedures (CII 124-11 2000; CII 41-1 1995; CII 6-7 1988).
- *Zero Accident Techniques:* zero accident techniques are high-impact zero injury safety techniques that are applicable to small, as well as large owners and contractors (CII 32-1 1993b).

PMGP—Relative Impact of Radical Reduction Techniques on Project Cycle

It is important to recognize that it is difficult and may be even impossible to utilize a set of 25 RRT on a given project. A more practical approach from a project manager standpoint would be to

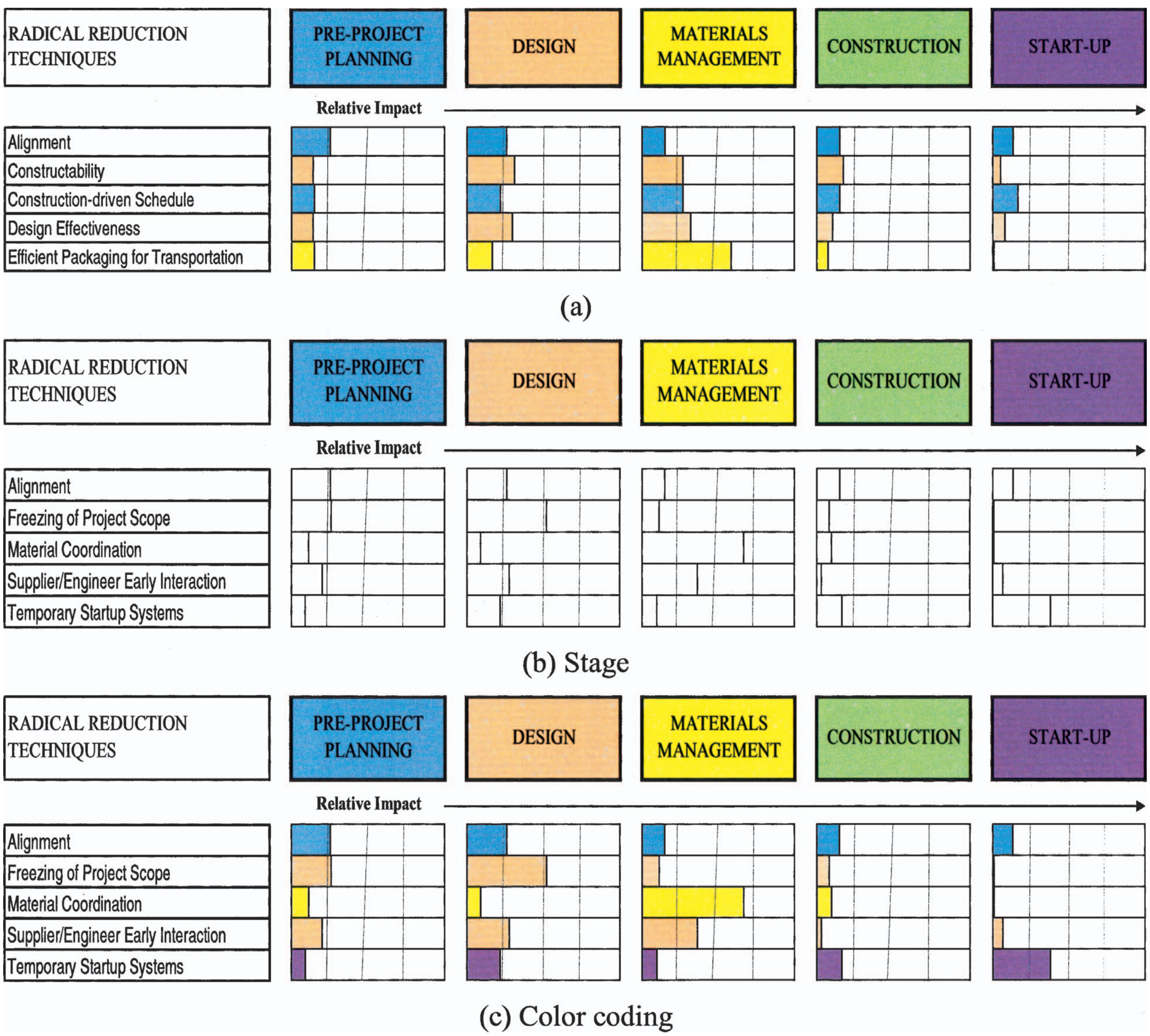

Fig. 7. (Color) Relative impact of radical reduction techniques over project cycle

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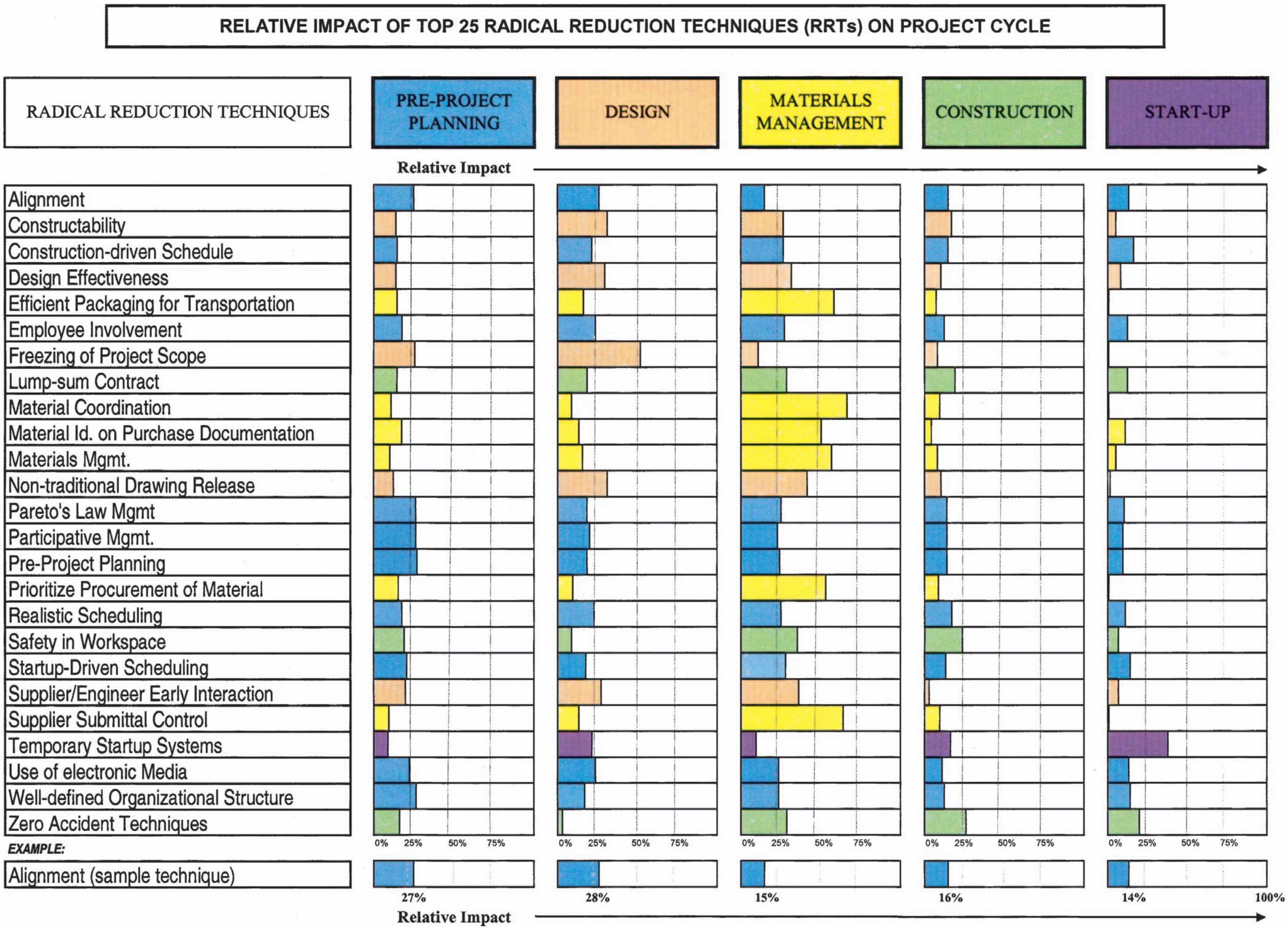

Fig. 8. (Color) Complete version of project manager's game planner

implement a select few of the 25 techniques. While in some instances, the selected techniques could be one that the PM organization has utilized on other projects, in other cases, it may be ones that appear to be easiest to implement. In order to commence the decision of selecting the techniques in a more rational fashion, the concept of relative impact of RRT was developed. The relative impact indicates the impact of the chosen technique by each phase of the project, and cumulatively over the entire project life cycle. The greatest impact of the RRT occurs when the identified technique is selected and implemented from the beginning of the project, however, in many instances a project is accelerated at some point during its execution in which case the PMGP can still be a useful tool in determining the appropriate selection of the RRT based on its impact during the phase that the project is in, and on the subsequent phases.

Development—Relative Impact of Radical Reduction Techniques on Project Cycle

As shown in Fig. 7(a), relative impact is read horizontally and is the impact of a particular technique (expressed in terms of percentage) on each of the five phases. Hence, the total project impact of any RRT over the five project phases will be 100%.

The three dotted vertical lines seen under the relative impact [refer to Fig. 7(a)] divide each box into one-quarter intervals, thus, allowing a quick visual identification of the relative impact in each phase. Fig. 7(b) shows a graphical representation that considers a hypothetical situation in which an organization decides that it can implement only the following five RRTs, e.g., alignment, freezing of project scope, material coordination, supplier/engineer early interaction, and temporary start-up systems. The relative impact of a reduction technique in a particular phase has been projected by using a rectangular box. The logic behind this is that any given RRT has a different degree of effectiveness during different phases of a project. For instance, in Fig. 7(b), the box under PPP indicates approximately 26% of the overall impact of alignment can be achieved during that phase in achieving radical reduction. When applied during the D phase, around 27% of its impact is achieved, similarly, approximately 16% impact during the MM phase and C phase, and finally 15% of the overall impact during the SU phase. It can be seen that these numbers add up to 100%. Similarly, the relative impacts of each of the RRTs during all the phases add up to 100%.

As shown in Fig. 7(c), the horizontal bars representing the relative impacts of a RRT bears the same color coding as the colors of the project phase where it was listed for the first time among the Top Ten lists. For instance, in the case of the hypothetical example, Alignment occurs for the first time in the top ten RRT lists (refer to Fig. 6) during the PPP; therefore, it bears the blue color throughout all other project phases wherever it appears. Correspondingly, in the relative impact chart, the horizontal bars

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representing Alignment in all the five phases have the same blue color. On the other hand, freezing of project scope and quality management occur for the first time in the D phase in the top ten lists (refer to Fig. 6), hence, all the horizontal bars of freezing of project scope and supplier/engineer early interaction bear a tan color as illustrated in Fig. 7(c).

It can also be seen that even though an activity might appear in the top ten list later during the project life cycle, the color coding of the relative bars has been started from the PPP phase. For instance, it can be seen that freezing of project scope and supplier/engineer early interaction have some impact in the PPP phase also, indicating that, although, they are among the top ten during the D phase, they have a certain degree of impact in the earlier phases also, and hence, their implementation should be considered from the PPP phase itself to get the maximum benefit of the RRT. Thus, the color of the bar of the RRT indicates the phase in which it makes it to the top ten RRT list. This can be further clarified by the fact that the color of a horizontal bar for the RRT is the same as that assigned in Fig. 6. The complete version of the PMGP is shown in Fig. 8.

Organization of Project Manager's Game Planner

The PMGP has been organized in a booklet format with the following information.

1. List of 25 RRTs which are ranked among the top ten in one or more project phases;
2. A guide "How to Read The Game Planner" elucidating the color coding employed in the "Top Ten RRTs Per Project Phase" and "Relative Impact of the Top Ten RRTs on Project Cycle;"
3. Flowchart for the development of the Gameplan;
4. Top Ten RRTs per project phase as explained above;
5. Relative impact of the top 25 RRTs on a project cycle;
6. Definitions describing the RRTs and their application methodology in a project; and
7. Radical Reduction Playcard: This is explained in the next subsection.

Radical Reduction Playcard

It is a blank template of the Relative Impact of the Top RRTs on the Project which is designed to help the user develop a strategy that identifies RRTs, which can be most effectively implemented on the project considering the resources at his disposal and the organizational limitations. These organizational and resource constraints restrict the RRTs that can be implemented. Hence, the selection is made from the list of 25 RRTs as mentioned looking at the applicability and resource requirement for each of them, and once finalized, the respective horizontal bars are filled with the appropriate color in the Playcard. This would serve as the Gameplan for achieving radical reduction.

This can be more effectively understood using an example of a project where it is assumed that the organizational and other constraints allow implementation of only five RRTs, namely, alignment, freezing of project scope, material coordination, supplier/engineering early interaction, and temporary start-up systems.

The horizontal bars representing the relative impact of each of these RRTs on the project phases are colored appropriately (refer to Fig. 8). This will serve as a baseline against which the actual schedule reduction impact of each selected RRT would be gauged. Once the project has proceeded through the phases, a new actual playcard can be developed for comparison against the baseline and also for future use on other projects. Thus, this playcard serves the following two objectives: (1) as a tool for developing radical reduction strategies for a given project by assigning ranks (if necessary) and color coding appropriate boxes as explained earlier in this paper; and (2) as a playcard to keep track of reduction achieved during various project phases when implementing the different RRT. It can serve as a reference for future projects.

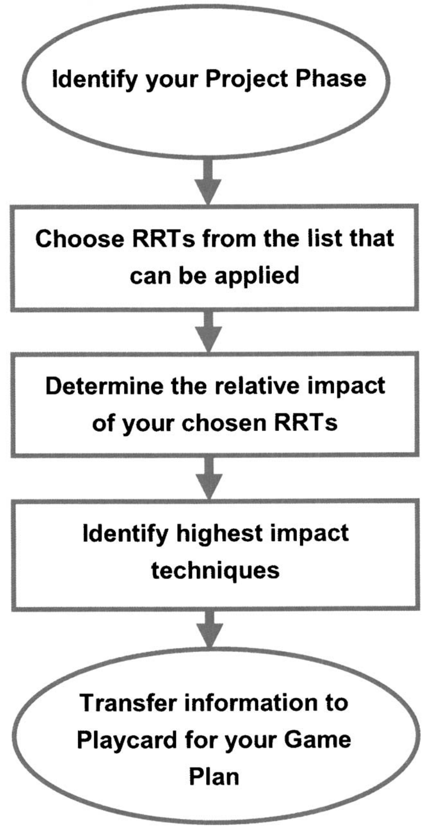

Fig. 9. Flow chart of project manager's game planner

Conclusion

The PMGP has been developed with a focus on creating a strategic tool to assist in development of a radical schedule reduction strategy for the entire project. Fig. 9 shows the flow chart of the PMGP. The tool has crystallized a list of 25 most effective schedule reduction techniques that will allow a project manager to focus on the fewer options that are feasible within the project and the organization. It presents the expected relative impact of each of the RRT during each project phase, thus, giving a guideline for basing the strategy for radical schedule reduction.

It also provides an avenue for future input in the form of Radical Reduction Playcard. The Playcard can be used to create databases for actual results on the schedule reduction, and which in turn can help fine tune the tool for future reference. It can also serve the purpose of a baseline plan against which actual progress or impact could be measured and recorded for future projects.

The data for this research has been obtained from seven case studies (refer to Table 1) which demonstrated reduction in project

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cycle time greater than 25%. The 25 RRTs identified through this study are applicable to all types of industries, as well as different organizations. However, every organization may have its own set of preferred BP that they would like to implement. Currently, the PMGP does not facilitate the addition of user specific reduction techniques. Also, the tool was tested by the research team members at their respective companies. It was determined that while the process was initially cumbersome, it became easier to apply once the tool was utilized by the team and understood. Also, an electronic decision tool should be developed that would help the users in custom designing a "Game Planner" to their specific requirements.

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