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Logic Flow Diagrams for Planning of Building Projects

by

Jeffrey Clinton Furman, B.S.C.E.

Thesis

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Master of Science in Engineering

The University of Texas at Austin

August, 1999

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Logic Flow Diagrams for Planning of Building Projects

Dedication

This thesis is dedicated to my wife Leigh.

Acknowledgements

I would like to thank Dr. Edd Gibson for his direction through the course of this thesis. Also, I would like to thank CII and the members of Research Team 155 for allowing me to participate in the research. Special thanks to the Logic Flow Diagram subgroup members for volunteering their efforts. Finally, I would like to thank the faculty and students at the University of Texas for making graduate school a memorable experience.

August 1999

Abstract

Logic Flow Diagrams for Planning of Building Projects

Jeffrey Clinton Furman, M.S.E.

The University of Texas at Austin, 1999

Supervisor: G. Edward Gibson, Jr.

This thesis details the development and validation of logic flow diagrams for the activities composing the pre-project planning process. Generic in nature, these diagrams utilize the activities found within the Project Definition Rating Index (PDRI) for Building Projects, a scope definition measurement tool developed by the Construction Industry Institute.

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Chapter 1 : Introduction

Pre-project planning is a term used by the construction industry that refers to the activities that occur after idea generation and prior to detailed design on construction projects. As shown in research conducted by the Construction Industry Institute (CII), benefits of pre-project planning include improved predictability of project parameters, cost reduction of design and construction, schedule preservation, reduced risk, improved team communication and customer satisfaction (PDRI for Buildings 1999). Viewing the extensive list of benefits, it would seem the construction industry would take the time and effort to do a good job of planning. However, a number of factors including the unique nature of construction projects and the lack of easy-to-use planning tools has resulted in substandard pre-project planning across much of the construction industry.

One tool that would certainly help the general building industry plan more effectively is a pre-project planning process map. However, reviewing published literature, it seems that a generic process map of the tasks required for effective pre-project planning for building projects does not exist or is viewed by industry members as proprietary. Therefore, the scope of this research is to develop a set of logic flow diagrams (LFD) for the pre-project planning process using the Project Definition Rating Index (PDRI) for Building Projects. Similar to a flowchart, the diagrams show the interconnection between steps of the planning process. Potential uses for the LFDs include use as a:

- 'wayfinding map' for the planning team,

- guide for scope definition using the PDRI for Building Projects,
- gauge for establishing capital budgeting gates,
- education tool for members of project teams
- process improvement tool.

The PDRI for Building Projects is a tool developed by CII for use by a project team to measure the degree of scope development. The term ‘general building projects’ or ‘building projects’ refers to single or multi- story commercial, institutional, or light industrial facilities such as offices, banks, dormitories, warehouses, schools, and apartments.

1.1 SCOPE

A generic logic-flow diagram for the Project Definition Rating Index (PDRI) for Buildings will be developed from the following steps. The first step consists of designing an exploratory framework developed from experience of the building construction process using CII Research Team (RT) 155 expertise and the PDRI for Building Projects as a basis. Next, the prototype will be distributed, analyzed, and improved upon by select members of the research team. After incorporating feedback into the prototype, it will be distributed and analyzed by selected building construction industry points of contact. This feedback will ensure the diagrams are relevant to the current building industry; but due to the size of the sample, it will not be considered an industry wide validation. Summarizing the above work, a final diagram will be included in the PDRI publication as an implementation tool.

1.2 OBJECTIVES

The primary objective of this study is to develop a *generic* logic flow diagram for pre-project planning of buildings. The logic flow diagram is envisioned to be made up of three charts, one for each tier of the PDRI. From general to specific, the tiers are 1) section 2) category and 3) element.

A second objective is to tie the diagrams to the quantitative score of the PDRI for buildings. This chart shows the project's PDRI score as the user progresses through the planning process.

A third objective is to validate the logic flow diagram's usefulness and accuracy. A CII RT 155 subteam and select industry professionals are the entities used to meet this objective.

1.3 THESIS OBJECTIVES

This thesis will detail the development of the LFDs from idea origination to the author's conclusions and recommendations about potential uses. Chapter 2 gives the background of the research including a synopsis of CII's research into pre-project planning as well as other related publications from other entities. Research methodology is presented in Chapter 3. Chapter 4 displays the LFD diagrams and documents the logic used in their creation. A summary of interviews concerning the LFDs is the topic of Chapter 5, Validation. Finally, Chapter 6 contains the author's conclusions about the LFD development and potential uses.

Chapter 2: Background

2.1 INTRODUCTION

This chapter details the organizations, events, and literature providing background for the development of logic flow diagrams for the planning of building projects. In general, this thesis has been part of an overall effort by the Construction Industry Institute (CII) to facilitate front end planning on construction projects. Over the past eight years, CII has funded three pre-project planning research projects that have resulted in numerous publications and implementation tools. Of these publications, two, *The Pre-Project Planning Handbook* (1995) and *The Project Definition Rating Index for Industrial Projects* (1996), are closely tied to the background of this project. Specifically, this project is part of the research by CII Research Team 155, Project Definition Rating Index for Building Projects. In addition to a description of CII and CII publications, mention of other relevant literature to this research are covered in the final section.

2.2 THE CONSTRUCTION INDUSTRY INSTITUTE

Located at the University of Texas at Austin, the Construction Industry Institute (CII) is a research organization whose mission is:

“to improve the safety, quality, schedule, and cost effectiveness of the capital investment process through research and implementation support for the purpose of providing competitive advantage to its members in the global marketplace” (CII 1998).

CII was established in 1983 in order to improve the safety, quality, schedule, and cost effectiveness of the capital investment process. It is a consortium of leading owners and contractors who have joined together to find better ways of planning and executing capital construction programs (CII 1999).

As far as operations, CII is funded by an annual grant from each of its member companies. Each year, research teams are organized by CII's Board of Advisors to explore new areas of study within the six areas of concentration: research, implementation, education, benchmarking, globalization, and breakthrough research. The teams are composed of industry professionals from the member companies as well as an academic expert in the subject area who is the principal investigator for the research team. Since 1985, CII has established over 85 research teams including collaboration with over 35 universities.

2.3 PRE-PROJECT PLANNING HANDBOOK

The *Pre-Project Planning Handbook* was published in April of 1995 as a result of the Pre-Project Planning Research Team that was commissioned by CII in 1991. Geared toward industrial projects, it takes the user through the steps of pre-project planning using a high level process map. The pre-project planning steps as stated in the book are:

1. Organize for Pre-Project Planning
2. Select Project Alternatives
3. Develop a Project Definition Package
4. Decide Whether to Proceed with Project

The first step, Organize for Pre-Project Planning, has a phase that is titled, "Prepare Pre-Project Planning Plan." Here, the text provides a list of suggested components that might make up a pre-project plan. In fact, some of these items are identical to those used to form the basis for this effort. However, the suggested components are assembled in the form of a list, not by logic sequence. Instead of a checklist, LFDs would be an excellent addition to this section to help the user understand the organization of the overall process and get a better feel for how succeeding activities of the planning process are affected by changes.

2.4 PDRI FOR INDUSTRIAL PROJECTS

The Project Definition Rating Index (PDRI) for Industrial Projects was developed in 1995 by a sub-team of the Front End Planning Research Team that was chartered by CII in 1994. Industrial projects include such facilities as chemical, gas production, paper, power and manufacturing plants that range from one or two million dollars to hundreds of millions of dollars. The PDRI for Industrial Projects is a tool for measuring project scope development based on industry best practices and a methodology for benchmarking the degree of scope development through the use of a weighted index (Dumont 1995). The PDRI for Industrial Projects was envisioned to be used from the beginning of initial feasibility studies to the completion of design development.

The PDRI for Industrial Projects consists of a weighted list of 70 scope definition elements. The elements may be scored in one of six definitions from 0 to 5; 0 if not applicable, 1 if perfectly defined, and so on until a score of 5 which represents totally undefined. Therefore, a project could theoretically receive a

score that ranged from 1000 for a totally undefined project to a perfectly defined score of around 70 depending on which elements are not applicable.

The final step of the PDRI for Industrial Projects development was validation. Even though the PDRI weights were based upon the expertise of industry professionals, the research team felt the tool should be tested on a sample of actual projects. For the validation, 40 projects that varied in cost from \$1 million to \$635 million were used. Based on these “after the fact” projects, a ‘par value’ of 200 points was defined that showed a strong delineation of project outcome. Projects that scored below 200 averaged 5% below budget, 1% ahead of schedule and 2% change orders. Projects above 200 averaged 14% above budget, 12% behind schedule and 8% change orders (CII 1997). In summary, this research proved the enormous potential of a tool to quantitatively define scope definition on construction projects and paved the way for further studies about pre-project planning in other construction industry sectors.

2.4 RESEARCH TEAM 155, PDRI FOR BUILDING PROJECTS

In 1998 based on the success of the PDRI for Industrial Projects and industry interest, CII formed Research Team 155, Project Definition Rating Index for Building Projects. The scope of this research was limited to developing a scope definition tool for building projects (excluding residential houses) in the public and private sector (Gibson 1998). Unlike industrial projects that center around process and equipment specifications designed by engineers, building projects are generally designed by an architect for an owner’s specified use. However, both types of projects are similar in the regard that the level of pre-

project planning can have a tremendous impact on project outcomes. The following figure shows the typical parts of a building project's lifecycle where the PDRI is applicable.

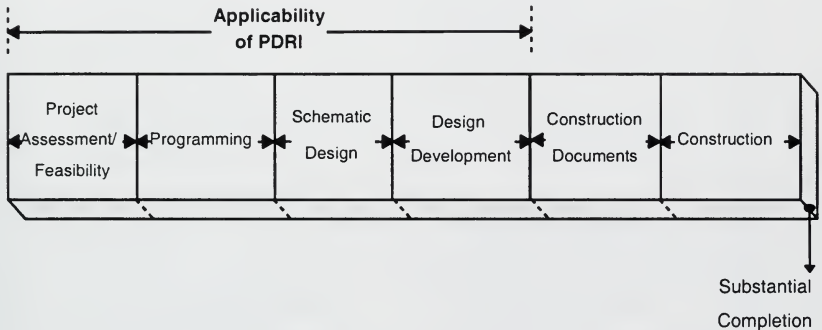


Figure 2.1: Applicability of PDRI in Project Lifecycle

The inner workings of the PDRI for Building Projects are very similar to the PDRI for Industrial Projects. The PDRI for Building Projects is composed of three sections that expand to 11 categories that further expand to 64 elements. These are shown in Figure 2.2 and completely detailed in Appendix B as part of the complete PDRI for Building Projects package.

SECTION I. BASIS OF PROJECT DECISION	E7 Functional Relationship Diagrams/ Room by Room
A. Business Strategy	E8 Loading/Unloading/Storage Facilities Requirements
A1. Building Use	E9 Transportation Requirements
A2. Business Justification	E10. Building Finishes
A3. Business Plan	E11. Room Data Sheets
A4. Economic Analysis	E12. Furnishings, Equipment, & Built-Ins
A5. Facility Requirements	E13. Window Treatment
A6. Future Expansion/Alteration Considerations	F. Building/Project Design Parameters
A7. Site Selection Considerations	F1. Civil/Site Design
A8. Project Objectives Statement	F2. Architectural Design
B. Owner Philosophies	F3. Structural Design
B1. Reliability Philosophy	F4. Mechanical Design
B2. Maintenance Philosophy	F5. Electrical Design
B3. Operating Philosophy	F6. Building Life Safety Requirements
B4. Design Philosophy	F7. Constructability Analysis
C. Project Requirements	F8. Technological Sophistication
C1. Value-Analysis Process	G. Equipment
C2. Project Design Criteria	G1. Equipment List
C3. Evaluation of Existing Facilities	G2. Equipment Location Drawings
C4. Scope of Work Overview	G3. Equipment Utility Requirements
C5. Project Schedule	
C6. Project Cost Estimate	
SECTION II. BASIS OF DESIGN	SECTION III. EXECUTION APPROACH
D. Site Information	H. Procurement Strategy
D1. Site Layout	H1. Identify Long Lead/Critical Equipment and Materials
D2. Site Surveys	H2. Procurement Procedures and Plans
D3. Civil/Geotechnical Information	J. Deliverables
D4. Governing Regulatory Requirements	J1. CADD/Model Requirements
D5. Environmental Assessment	J2. Documentation/Deliverables
D6. Utility Sources with Supply Conditions	K. Project Control
D7. Site Life Safety Considerations	K1. Project Quality Assurance and Control
D8. Special Water and Waste Treatment Requirements	K2. Project Cost Control
E. Building Programming	K3. Project Schedule Control
E1. Program Statement	K4. Risk Management
E2. Building Summary Space List	K5. Safety Procedures
E3. Overall Adjacency Diagrams	L. Project Execution Plan
E4. Stacking Diagrams	L1. Project Organization
E5. Growth and Phased Development	L2. Owner Approval Requirements
E6. Circulation and Open Space Requirements	L3. Project Delivery Method
	L4. Design/Construction Plan & Approach
	L5. Substantial Completion Requirements

Figure 2.2: PDRI for Buildings SECTIONS, Categories, and Elements.

The following figure is a portion of the scoresheet that includes Category G, Equipment, as well as a sample element description of Element G1, Equipment List from the PDRI for Building Projects. Complete versions of the scoresheet and element descriptions are given in Appendix A and Appendix B, respectively.

CATEGORY Element	Definition Level						Score
	0	1	2	3	4	5	
G. EQUIPMENT (Maximum Score = 36)							
G1. Equipment List	0	1	5	8	12	15	
G2. Equipment Location Drawings	0	1	3	5	8	10	
G3. Equipment Utility Requirements	0	1	4	6	9	11	
CATEGORY G TOTAL							

G. EQUIPMENT

G1. Equipment List

Project-specific equipment should be defined and listed. (Note: Building systems equipment is addressed in element F4, Mechanical Design, and F5, Electrical Design). In situations where owners are furnishing equipment, the equipment should be properly defined and purchased. The list should define items such as:

- Process
- Medical
- Food service/vending
- Trash disposal
- Distributed control systems
- Material handling
- Existing sources and characteristics of equipment
 - Relative sizes
 - Weights
 - Location
 - Capacities
 - Materials of construction
 - Insulation and painting requirements
 - Equipment related access
 - Vendor, model, and serial number once identified
 - Equipment delivery time, if known
- Other

Figure 2.3: Sample of Scoresheet and Element Description

The PDRI for Building Projects is completed in a similar manner to the PDRI for Industrial Projects (CII 1999). Each of the applicable 64 elements is scored by project participants according to the element definition level based on an analysis of its description. At the end, the weighted score gives the user a score that corresponds to likelihood of project success. Like the PDRI for Industrial Projects, there is a 'par score' for purposes of benchmarking PDRI scores. This 'par score' was determined by a statistical analysis of 30 completed projects. Figure 2.4 displays the results.

Performance	PDRI SCORE		<i>Difference</i>
	< 200	> 200	
Cost	-1 % below budget	6% above budget	7%
Schedule	1% behind schedule	11% behind schedule	10%
Change Orders	6% of budget (N = 14)	10% of budget (N = 16)	4%

Figure 2.4: Summary of Cost, Schedule, and Change Order Performance for the PDRI Validation Projects Using a 200 Point Cutoff

The purpose of going to such detail explaining the background of the PDRI for Building Projects is because this document is the source of all the activities included in the logic flow diagrams. The fact that the PDRI for Buildings is an industry created and industry validated pre-project planning tool dispenses with the need to generate a unique set of activities for diagramming purposes.

2.6 LITERATURE REVIEW

In addition to the review of pre-project planning publications from CII, a thorough literature review has been performed. The primary intent of this literature review was to identify previously published diagrams of the pre-project planning process for building projects. Excluding the CII publications, five principle sources were found that were related to development of logic diagrams. The following paragraphs describe the parts of each text that contributed to the development of this thesis.

Development Building: The Team Approach by C. W. Griffin (1972) presents a project model in three phases: decision, design, and delivery. This model is similar to the first level of the logic flow diagrams presented in this thesis. Also in Griffin's book, a critical path network of the steps required to prepare a proposal is shown. The individual steps contain similar logic and terminology to the LFDs. Griffin's network is an example of how the generic LFDs presented in this thesis could be customized to reflect a specific process.

Master Planning for Architecture by Keith Billings (1993) describes the four main stages of the planning process as:

1. Needs or program formulation
2. Physical data collection.
3. Designing process
4. Evaluation.

These steps proved to be particularly useful when trying to analyze the parts of the building process that typically belong to the architect. Later in

Billings' text, a generic list of the activities for reengineering an organization's capital facilities is shown. The text following this list goes on to say that the activities could be assembled in the form of a bar chart but they likely overlap. Thus, Billings' bar chart is a high level representation of an LFD diagram without much detail.

Professional Practice in Facility Programming by Wolfgang F. E. Prieser (1993) is a book that describes the planning process for a wide variety of building types. The text contains numerous real world case studies that document the planning procedure and explain architecture terminology. Also, a great number of diagrams and images are presented. Though the diagrams are intended to display specific information such as the collaborative design process or data flow in facility programming, the book is primarily included in the background because of the variety of ways that planning is communicated graphically. This reference helped view the multitude of options showing how to represent the activities contained within the pre-project planning process.

Programming for Design by Edith Cherry, FAIA (1999), is a tutorial about the programming process. Like some of the above books, this text provides excellent working level descriptions of architecture terms, and a number of case studies. The text gives good examples of how graphics often reinforce a concept much better than additional text. Reinforcing concepts with graphics is the underlying motivation that stresses the importance of creating a process map for the pre-project planning process.

A Design-Build Process Map for Air Force Military Construction Projects by Andrew Thornburn is a University of Texas thesis that was published in 1994. Thornburn's thesis documents the design-build process within the United States Air Force. The primary benefit of Thornburn's text is the structure and presentation of a process map development as the central theme of a thesis. The author used Thornburn's thesis extensively when outlining the chapters and sections of the LFD project.

2.7 CONCLUSIONS

CII and others have published numerous books and other literature relating to pre-project planning. However, reviewing the majority of these publications, the lack of a detailed pre-project planning process map for generic building projects is apparent. Many authors have drafted checklists but assembling a detailed pre-project planning map is beyond the scope of any list the author has seen. Perhaps the majority of companies that use pre-project planning maps view them as proprietary.

The most recent efforts by CII RT 155, PDRI for Building Projects, is part of an overall effort by CII to research pre-project planning. The success of the PDRI as well as other tools previously published by CII demonstrates the utility of creating a process map to help communicate the PDRI contents or simply serve as a standalone pre-project planning tool. Specifically, the validated content of the PDRI for Building Projects enables the formation of a comprehensive pre-project planning process diagram. The next chapter details the

development of the logic flow diagrams from a rough idea into meaningful, validated, process maps of the pre-project planning process for buildings.

Chapter 3 : Research Methodology

3.1 INTRODUCTION

The logic flow diagram (LFD) development evolved as part of the overall effort by CII Research Team 155 (RT 155), PDRI for Building Projects. In fall of 1998, diagrams were drafted for the first two parts of the PDRI for Building Projects as a proposal. Once these drafts were presented to RT 155, a decision was made to pursue development, and a subgroup was formed to work on the diagram formation. Over the next 6 months, the author worked closely with the subgroup to gain feedback on the diagram evolution. In early summer of 1999, the diagrams were validated by interviews conducted with building industry professionals. After incorporating validation feedback and the team's final input, the diagrams were finalized in July 1999 and prepared for publication. Figure 3.1 shows the interaction used in the research.

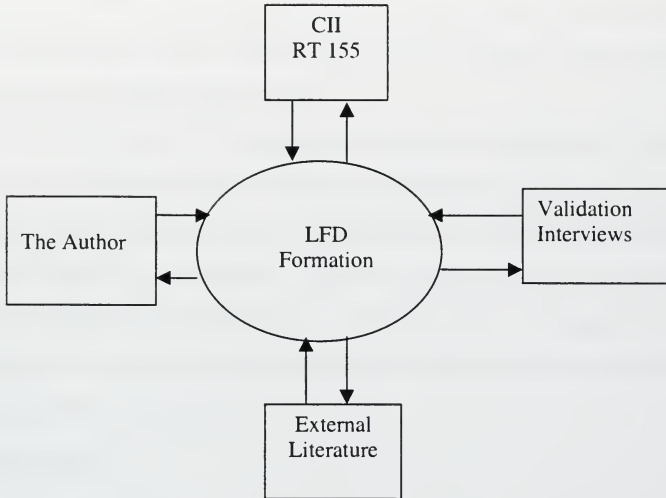


Figure 3.1 LFD Research Sources

3.2 GROUND RULES

Early in the project, ground rules were set to limit the scope of the logic flow diagrams. The first ground rules dealt with the composition of the LFDs. It was decided that the diagrams would only consist of the components of the current PDRI for Building Projects. Also, all definitions and numbering schemes would remain as currently stated in the PDRI for Building Projects.

The next ground rule dealt with the type of diagrams best suited to communicate the objectives. It was decided that the diagrams would be generic flow charts only displaying sequential logic. Recognizing that the planning

process has numerous ‘feedback loops,’ the author decided to only show the path forward for purposes of clarity. Furthermore, none of the diagrams would be time sensitive like a critical path method chart.

The final ground rules concerned the graphical presentation of the diagrams. The LFDs would consist of three charts on separate pages, one for each tier of the PDRI for Building Projects. Ideally, graphical standards would remain consistent throughout the diagrams. Also, the author decided to create the diagrams in Microsoft Office Excel™ due to existing expertise and compatibility with existing software in the research environment. The next section details the path forward from the ground rules.

3.3 DEVELOPMENT

In November of 1998, the ‘first pass’ was performed on the Section and Category diagrams. These drafts were presented in December of 1998 to RT 155 at its Austin meeting. Since RT 155 decided the diagrams would be a beneficial addition to current work in progress, several members of RT 155 volunteered to be part of a working subgroup appropriately named, ‘The LFD Subgroup.’ The members of the LFD Subgroup as well as all the members of RT 155 are included as Appendix C.

In January of 1999, the LFD Subgroup convened at CII’s offices in Austin to discuss the scope, objectives and ground rules of diagramming the PDRI for Building Projects. Also, the subgroup analyzed and improved upon drafts of the section and category diagrams. Soon after this meeting, new drafts of the section and category diagrams were distributed to RT 155 for feedback.

In March 1999, several meetings were held to draft the 'first pass' of the element diagram. Initially, the element diagram was broken up by section in order to phase the diagramming process. Once the draft was complete, the LFD Subgroup convened in May 1999 to finalize the section and category diagrams; and review the element diagrams. As expected, reviewing the element diagrams took considerably more effort than was exerted on the section and category diagrams. Once consensus was reached on the element diagram, it was distributed to RT 155 for comment.

In late May 1999, the internal diagram development was complete. The project was ready for the final phase, validation. The validation process is covered in Chapter 5. However, the diagrams continued to develop as a result of validation feedback and further review by RT 155. In fact, a number of minor changes were made in June and July as a result of validation feedback and RT 155 review at the June 1999 meeting. In mid July 1999, a final version of the LFD diagrams were submitted for CII to be included in other PDRI for Building Projects publications.

3.4 CONCLUSIONS

The LFDs evolved as a result of a collaborative process between academia and industry. Utilizing RT 155 and activities as defined by the PDRI for Building Projects, the author was able to develop generic logic flow diagrams through continuous interaction with a group of building industry professionals. Constrained only by the bounds of the ground rules, the LFDs evolved over the course of nine months into a generic representation of the planning process.

Envisioning the rationale of the LFD end user, an individual may have conflicting ideas about the logic path because it is a complex process and was not validated by an industry-wide sample. However, the LFDs provide a generic example of process flow and due to the large amount of industry interaction that has occurred during the course of this research project, the author feels that they are an effective representation of the process. The next chapter displays the LFDs as finalized for this thesis and gives an overview of the logic.

Chapter 4: The Logic Flow Diagrams

4.1 INTRODUCTION

There are three logic flow diagrams, one for each tier of the PDRI for Building Projects. Unlike “critical path method (CPM)-type” diagrams, the logic flow graphical representation of the activities shows functional relationships rather than defined start and stop times. In varying degrees, activities are often pursued concurrently and as additional information is discovered, upstream elements are revisited (CII 1999).

Generically, the nature of the planning process is such that any new information found while planning an activity must be in alignment with the existing plan or the plan may change. On each of the diagrams, a true representation of the logic would have feedback arrows going out of each activity to all those behind it. However, in order to maximize clarity, feedback loops are not shown on the diagrams themselves.

Full-sized versions of all three diagrams are included as Appendix D. Smaller versions of the diagrams are included within the chapter to help the reader follow the explanation of the logic. The first three sections of the chapter address the individual diagrams. The fourth section is an overlay of the PDRI score on top of the element diagram.

4.2 SECTION DIAGRAM

The logic of the section diagram is fairly simple and shown in Figure 4.1. Section I, Basis of Project Decision, is composed of the business considerations, client (owner) philosophies, and overall project requirements. For the most part, the decision whether or not to proceed is made before progressing with design or execution plan.

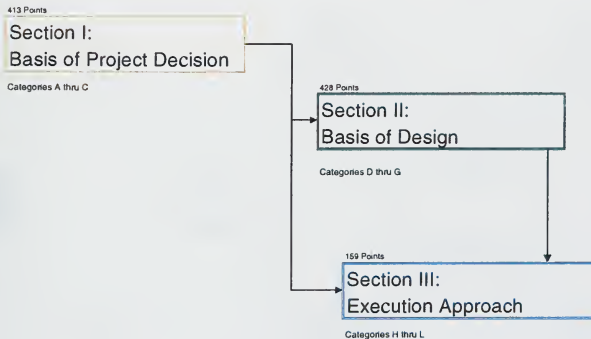


Figure 4.1: Section Diagram

Section II, Basis of Design, relies upon much of the information generated in Section I. Section II consists of all the design components including detailed site information, building programming, design parameters, and equipment. Section III, Execution Approach, begins shortly after Section II. Section III includes the procurement strategy, deliverables, execution plan and project controls. Near the end of Section II, an arrow is shown going into Section III to

represent the information that helps define the procurement strategy and deliverables.

4.3 CATEGORY DIAGRAM

The category diagram is composed of one start box, the 11 categories, and one stop box. It decomposes the section diagram by providing three categories for Section I, four categories for Section II, and four categories for Section III. As shown in the legend, the color of the categories differentiates their respective section. The category diagram is shown in Figure 4.2.

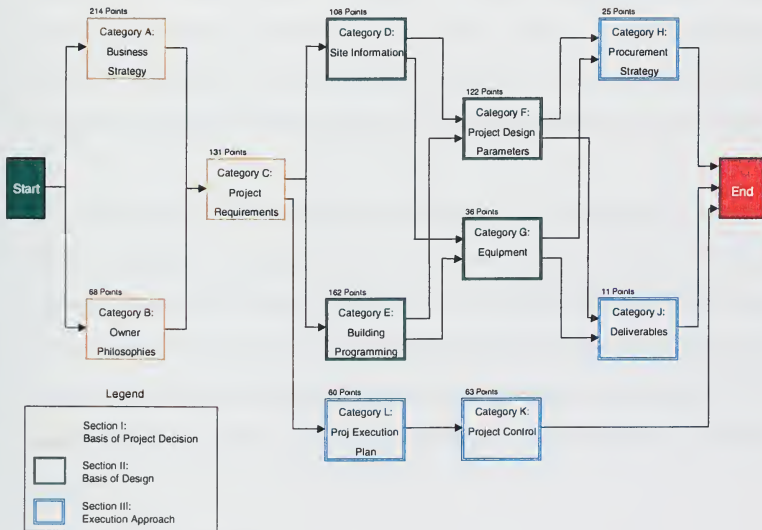


Figure 4.2: Category Diagram

The category diagram is merely a “zoomed-in” view of the section diagram. Coming out of the Start Box, Business Strategy (Category A) and Owner Philosophies (Category B) occur concurrently. They flow into Project Requirements (Category C) which includes such elements as scope of work, schedule and cost estimate.

Project Requirements (Category C) provides the necessary information to begin three categories, Site Information (Category D), Building Programming (Category E), and Project Execution Plan (Category L). Site Information (Category D) which includes all aspects of ‘due diligence’ combines with Building Programming (Category E) to provide inputs to Project Design Parameters (Category F) and Equipment (Category G). At or around the same time, Project Execution Plan (Category L) flows into Project Control (Category K).

After Project Design Parameters (Category F) and Equipment (Category G) are complete, information flows from both into Procurement Strategy (Category H) and Deliverables (Category J). The category diagram is completed by the conclusion of Procurement Strategy (Category H), Deliverables (Category J) and Project Control (Category K). Any specific questions about the logic of the category diagram are best explained by viewing the final diagram, the element diagram.

4.4 ELEMENT DIAGRAM

A reduced element diagram is included on the next page as Figure 4.3. A full sized version is located in Appendix D.

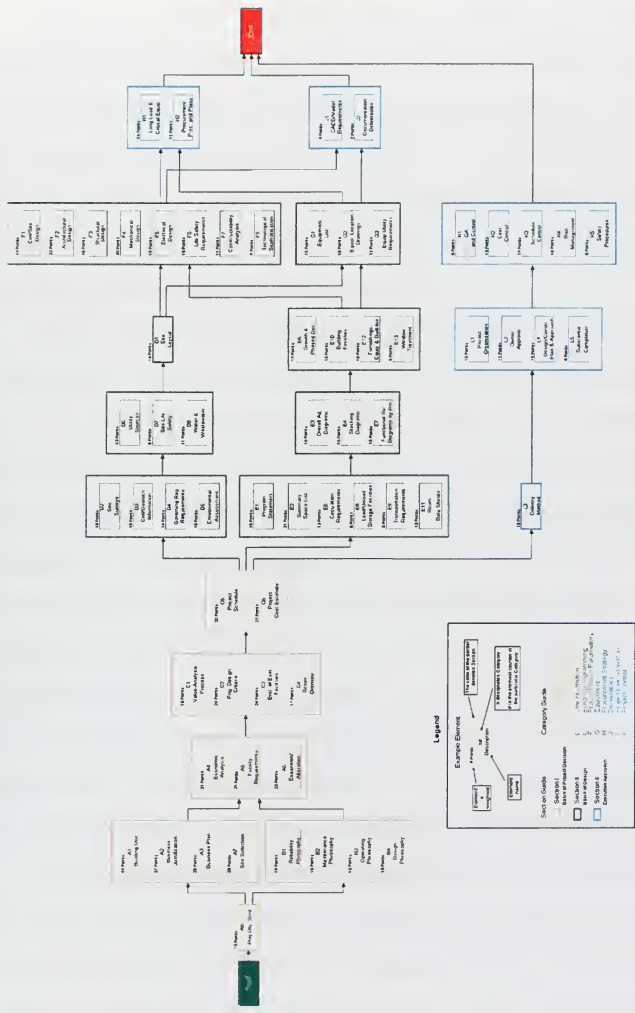


Figure 4.3: Element Diagram

The element diagram is composed of one Start Box, the 64 elements, and one End Box. Like the relationship between the section and category diagrams, the element diagram is the decomposition of the category diagram. For the most part, the element diagram remains consistent with the category diagram but there are a few exceptions as explained in the following paragraphs. A list of the elements with complete descriptions is found in Appendix B and each can be considered a “deliverable” of the planning process.

Coming out of the Start Box, the first element is Project Objective Statement (A8). Once the objectives are set, two sets of concurrent activities begin. These concurrent activities are the elements that make up the business planning: Building Use (A1), Business Justification (A2), Business Plan (A3), and Site Selection (A7); and the Owner Philosophies (Elements B1 through B4). This information flows into the remaining elements of Category A: Economic Analysis (A4), Facility Requirements (A5), and Expansion/Alteration (A6). Once Categories A and B are complete, the first phase of Category C, Project Requirements, begins. This phase includes: Value Analysis Process (C1), Project Design Criteria (C2), Evaluation of Existing Facilities (C3), and Scope of Work Overview (C4). The final phase of Section I on the element diagram, Basis of Project Decision, is Project Schedule (C5) and Project Cost Estimate (C6).

After Section I elements are complete, information flows into two pieces of Section II and Section III. Here it is important to recognize that the graphical alignment of these activities does not necessarily translate to simultaneous start times. The top part of the diagram is the flow into Category D, Site Information.

The middle part is the flow into Category E, Building Programming. The bottom part goes into Category L, Project Execution Plan, which is part of Section III.

The flow through Site Information (Category D) goes in three phases that may be described as data collection, requirements, and layout. The first phase, data collection, consists of Site Surveys (D2), Civil/Geotechnical Information (D3), Governing Regulatory Requirements (D4), and Environmental Assessment (D5). The second phase, requirements, is composed of Utility Sources with Supply Conditions (D6), Site Life Safety Considerations (D7), and Special Water and Waste Treatment Requirements (D8). The third and final step in the Site Information Category is Site Layout (D1). Site Layout (D1) is the actual facility layout on the selected property.

Concurrent to the above activities is the flow of Building Programming (Category E). Like Site Information (Category D), Building Programming (Category E) may be viewed in three phases, data, diagram, and details. The first phase, data, consists of collecting all the needed information for programming. The six Elements that make up this phase are: Program Statement (E1), Summary Space List (E2), Circulation Requirements (E6), Load/Unload Storage Facilities (E8), Transportation Requirements (E9), and Room Data Sheets (E11). The next phase, diagrams, consists of Overall Adjacency Diagrams (E3), Stacking Diagrams (E4), and Functional Relationship Diagrams/Room by Room (E7). The final phase, details, includes Growth and Phased Development (E5); Building Finishes (E10); Furnishings, Equipment, and Built Ins (E12); and Window Treatment (E13).

The bottom part of the element diagram following Section I shows the flow going into Delivery Method (L3). Once the Delivery Method (L3) is planned, the rest of Category L, Execution Plan, can occur. These elements include Project Organization (L1); Owner Approval (L2); Design/Construction Plan and Approach (L4); and Substantial Completion Requirements (L5). Once the execution plan is complete, the project controls may be planned. Project Controls (Category K) is composed of Quality Assurance and Control (K1); Cost Control (K2); Schedule Control (K3); Risk Management (K4); and Safety Procedures (K5).

Moving back to the end of both Category D and Category E, information flows out of both these categories into both Category F, Building/Project Design Parameters, and Category G, Equipment. Category F consists of eight elements that occur in one phase. These elements consist of all the sub-disciplines of site and facility design, as well as safety, constructability and technology. Equipment (Category G) includes Equipment List (G1), Equipment Location Drawings (G2), and Equipment Utility Requirements (G3).

At the conclusion of both Building/Project Design Parameters and Equipment, information flows into Category H, Procurement Strategy and Category J, Deliverables. Procurement Strategy (Category H) is composed of two elements, Identify Long Lead/Critical Equipment and Materials (H1), and Procurement Plans and Procedures (H2). Clearly, procurement follows efforts in design and equipment identification. Deliverables (Category J) is composed of CADD/Model Requirements (J1) and Documentation/Deliverables (J2). These

two elements consist of all the specific information needed for project execution and the steps following (turnover, operations and maintenance, disposal, etc).

The Element Diagram concludes with flows from Category H, Category J and Category K going into the End Box.

4.5 ELEMENT DIAGRAM OVERLAID WITH PDRI SCORE CURVE

The purpose of this section is to display a diagram showing the decreasing PDRI score as the project team progresses through the PDRI. The diagram is composed of the PDRI progress graph overlaid on top of the element diagram. The points on the progress curve were determined by treating the elements that align vertically as if they were part of the same the phase. Assuming the elements were all applicable and perfectly defined, the phases' total score was subtracted from the initial score of 1000 to create the set of data points. Since complete definition results in an element score of zero, one or two, the lowest possible score is 70. The diagram is shown on the next page as Figure 4.4.

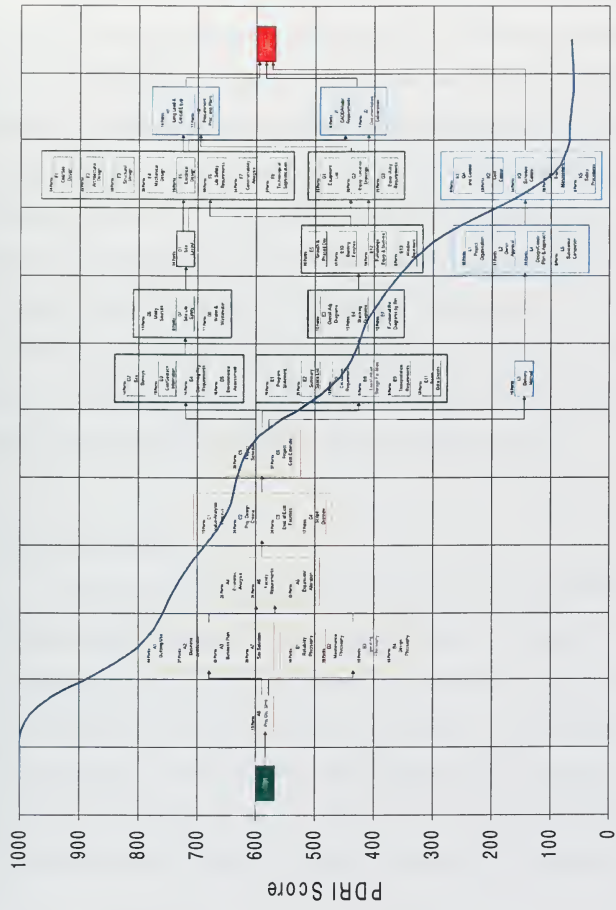


Figure 4.4: Overlay Diagram

The two main points that the overlay curve illustrates are the front-end loading of pre-project planning and the impact of making scope changes once the project planning has started. In terms of front-end loading, by the time the first section is complete approximately half (41%) of the PDRI score has been totaled, thus illustrating the importance of close interaction with business personnel in the planning process. The two latter sections are important but in some ways subservient to Section I, Basis of Project Decision. In terms of scope changes, the diagram illustrates the iteration that must be performed for every major change once the planning has begun particularly late in the process. In summary, this figure is intended to inform and enlighten the PDRI user about the relationship between the logic of the LFDs and use of the PDRI scoresheet.

4.6 CONCLUSIONS

The three LFDs represent each of the three tiers of the PDRI for Building Projects, respectively section, category and element. The intent of the diagrams is to display logic so that the user can see how upstream and downstream activities are affected by the individual parts of the PDRI. All the diagrams portray the same process, it is just that they have different zoom intensities. The fourth diagram, the PDRI score curve overlay, portrays the declining PDRI score in an ideal scenario. This diagram is intended to illustrate the magnitude of the impact created by late scope changes once the planning process has started. The next chapter, Validation, is the third party verification of the each of the LFDs.

Chapter 5 : Validation

5.1 INTRODUCTION

The goal of the validation was to gain feedback on the logic flow diagrams by presenting them to selected professionals in the building industry. However, this was not the first validation. The nature of the LFD development involved continuous validation, during numerous reviews by the 15 individuals making up RT 155. The list of RT 155 members is given in Appendix B.

Up front, it was recognized that the thesis scope would not suffice a true industry-wide sample. However, by the completion of this thesis, 22 highly experienced building industry professionals will have reviewed the diagrams. As far as value added to the LFDs, the validation proved to be useful as individuals outside the process of LFD formation provided suggestions and ideas to improve the diagrams. Many the comments from the interviews have been incorporated into the final diagrams.

5.2 INTERVIEW DEVELOPMENT

The first step of the validation was to come up with a list of interviewees. It was decided that all members of RT-155 should be excluded since they had reviewed the diagrams during the course of the development. Also, a mix of architects, engineers and real estate professionals was desired so that the feedback would encompass the stereotypical strengths of each of these different building project team members. The key strengths for each profession relative to feedback on the diagrams are listed below in Table 5.1.

Table 5.1: Author's Opinion of Key Strengths of Building Industry Professionals

Job Title	Characteristics
Architect	Good eye for flow, color and graphic standards, and knowledge of process.
Engineer	Good at analyzing the logic, knowledge of process.
Real Estate Professional	Good instincts, able to quickly decide on utility

Utilizing industry points of contact from graduate studies and the LFD subgroup, seven interviews were scheduled with individuals from the three targeted groups. Since most of the diagram formulation was performed by engineers, the interviews targeted architects and real estate professionals. The respective 'categorization' follows:

Table 5.2: Specialty Breakout of Interviews

Interview Candidate	Architecture	Engineering	Real Estate
A	✓		✓
B		✓	
C	✓		
D			✓
E	✓	✓	
F			✓
G	✓		

With the list of interviews established, the next task was to establish interview constraints and goals. Considering the interviewee's schedules, a time limit of one hour was set for each interview. The time limit meant that an agenda

would have to cover a complete introduction to the PDRI and allow for feedback on the LFDs. In order to reduce the amount of time needed for introduction to the PDRI and the LFDs, an interview proposal was e-mailed about a week before each interview. The proposal is included in Appendix E.

5.3 INTERVIEW SUMMARY

The interviews were extremely beneficial both in terms of collecting feedback and discussing the interviewees' related thoughts about pre-project planning. Individual summaries for all the interviews are included in Appendix F. Even though the agenda was set for one hour, almost every interview lasted an hour and a half or longer. This was due to engaging conversations about such topics as personal experience with pre-project planning, planning vs profitability, planning responsibilities, current trends in the building industry and so on.

The interviews are summarized by the following agenda items:

1. LFD introduction
2. CII and PDRI for Building Projects background
3. Diagram review
4. Comments on diagram logic and graphic presentation
5. Discussion of potential uses
6. Conclusions

The first two agenda items, introduction and background on CII and the PDRI for Buildings, served as an introduction to the logic flow diagram. Since most of the interviewees had seen the PDRI and were familiar with CII, the introduction consisted of a brief rundown of the study objectives. None of the

interviewees had seen a diagram that mapped the pre-project planning process in a generic fashion. The only related diagrams were those proprietary maps of specific companies' processes.

The intent of the third agenda item, diagram review, was to have the interviewee evaluate the diagrams while the author explained such things as scope, objectives and ground rules. This step captured the interviewee's first impression of the diagrams. The only interviewees who did not immediately grasp the diagrams were the real estate people who were unfamiliar with some of the terminology. Overall, the first impressions were positive resulting in no significant comments or suggestions.

The fourth agenda item was comment on diagram logic and graphic presentation. Here, the author based the interview questions on the interviewees' background. For example, if the interviewee were an architect, this step would focus on diagram presentation. Although there were no major logic suggestions, a number of diagram changes came out of this step. In fact, the element logic of Building Programming (Category E) was partially rearranged. Other changes included the addition of a legend on the category and element diagrams, and minor typographical errors. The only other logic questions centered around terminology which was cleared up by looking at the PDRI for Building Projects element definitions found in Appendix A.

Concerning color, all of the interviews found the color diagrams more effective than those in black and white. No colors were changed from the original

scheme proposed. The interviewees thought that color allowed the LFD user to remain oriented to the big picture while looking at specific steps.

The fifth agenda item was to discuss potential uses of the LFDs. These uses are included in Table 5.3.

Table 5.3: Interviewee's Uses of the LFDs

Number	Description
1	Scope definition tool
2	Way-finding map in the planning process
3	Identification of capital budgeting gates
4	Project team communication and responsibility delineation
5	Process improvement and lessons learned

The LFDs use as a scope definition tool refers to using the LFDs while the project team scores an actual PDRI scoresheet. In this manner, the LFDs keep the user oriented to the big picture of the PDRI while the project is scored. This is similar to the second use, way finding map in the planning process. In this case, the LFDs serve as a process map so that the user can figure out where they are located in the planning process. Upstream and downstream affects of decisions may be better visualized by use of the LFDs.

The third use, identification of capital budgeting gates, involves using the LFDs in conjunction with a pre-determined score to control the budgeting process. In this way, an owner can have a good idea of how well-defined a project should be in order to qualify for a certain level of funding.

The fourth use, project team communication and responsibility delineation, involves the project team using the LFDs to talk about requirements in the planning process and figuring out who is going to perform the work. Graphical representation is much more effective in this regard than a simple checklist.

The final use, process improvement and lessons learned, involves the project team using the LFDs to evaluate where their strengths and weaknesses lie in the pre-project planning process.

5.4 CONCLUSIONS

In accordance with the objectives, the validation consisted of normal reviews by RT 155 and seven interviews set up with selected building industry professionals. These interviews were performed with a spectrum of individuals that would compose a project team. As a result, the interviews yielded a wealth of information used in both fine tuning the LFDs and identifying potential uses. The bottom line is that each interviewee thought the LFDs would complement the PDRI and furthermore, the LFDs could be used by themselves for a variety of tasks.

Chapter 6 : Conclusions and Recommendations

6.1 CONCLUSIONS

The primary objective of the research was to develop logic flow diagrams that display the tiers of the PDRI. The completed LFDs not only display the activities within the PDRI but also allow the user to see the upstream and downstream affects of decisions made on specific activities during the planning process.

The LFD development undertaken in this thesis has created a tool with a variety of applications. Although it canvassed a relatively small sample for validation, development consisted of numerous reviews by the 15 individuals making up RT 155 and seven interviews with selected building industry professionals. Feedback from the validation allowed the diagrams to truly reflect the needs of industry.

The various applications of the LFDs may be performed in conjunction with the PDRI for Building Projects or in a standalone scenario. Used in conjunction with the PDRI, three primary uses have been identified: wayfinding, budgeting and communications. As a wayfinding tool, the LFDs help the user orient himself/herself within the PDRI. As a budgeting tool, the LFDs allow the owner organization to set qualification gates that screen out projects with insufficient scope definition. Finally, as a communications tool, the LFDs can help a project team identify pre-project planning tasks, delineate actions, and

ultimately educate team members about the logic of the pre-project planning process.

6.2 RECOMMENDATIONS

The LFDs are generic by design. Each individual or entity using the diagrams must ensure the validity of all the LFD components before adopting a customized LFD as their process map. In certain situations, some of the activities may shift in the overall flow of planning logic. This is an expected occurrence that will happen in segments of the building industry.

The positive reaction to the LFDs reveals a need for process maps in other segments of the construction industry. Certainly, an obvious candidate for another set of LFDs would be the PDRI for Industrial Projects, but additional areas such as civil and residential projects should be considered.

Through this research and all the work that has proceeded it, the proven success of pre-project planning should positively influence owners to use tools like the PDRI and LFDs to assemble a complete scope definition package to increase the likelihood of a successful building project.

Appendix A: PDRI for Building Projects Scoresheets

PROJECT SCORE SHEET (WEIGHTED)

SECTION I - BASIS OF PROJECT DECISION							
CATEGORY Element	Definition Level						Score
	0	1	2	3	4	5	
A. BUSINESS STRATEGY (Maximum = 214)							
A1. Building Use	0	1	12	23	33	44	
A2. Business Justification	0	1	8	14	21	27	
A3. Business Plan	0	2	8	14	20	26	
A4. Economic Analysis	0	2	6	11	16	21	
A5. Facility Requirements	0	2	9	16	23	31	
A6. Future Expansion/Alteration Considerations	0	1	7	12	17	22	
A7. Site Selection Considerations	0	1	8	15	21	28	
A8. Project Objectives Statement	0	1	4	8	11	15	
CATEGORY A TOTAL							
B. OWNER PHILOSOPHIES (Maximum = 68)							
B1. Reliability Philosophy	0	1	5	10	14	18	
B2. Maintenance Philosophy	0	1	5	9	12	16	
B3. Operating Philosophy	0	1	5	8	12	15	
B4. Design Philosophy	0	1	6	10	14	19	
CATEGORY B TOTAL							
C. PROJECT REQUIREMENTS (Maximum = 131)							
C1. Value-Analysis Process	0	1	6	10	14	19	
C2. Project Design Criteria	0	1	7	13	18	24	
C3. Evaluation of Existing Facilities	0	2	7	13	19	24	
C4. Scope of Work Overview	0	1	5	9	13	17	
C5. Project Schedule	0	2	6	11	15	20	
C6. Project Cost Estimate	0	2	8	15	21	27	
CATEGORY C TOTAL							
Section I Maximum Score = 413							
SECTION I TOTAL							

Definition Levels

0 =Not Applicable 2 =Minor Deficiencies 4 =Major Deficiencies
 1 =Complete Definition 3 =Some Deficiencies 5 =Incomplete or Poor Definition

SECTION II - BASIS OF DESIGN

CATEGORY Element	Definition Level						Score
	0	1	2	3	4	5	
D. SITE INFORMATION (Maximum = 108)							
D1. Site Layout	0	1	4	7	10	14	
D2. Site Surveys	0	1	4	8	11	14	
D3. Civil/Geotechnical Information	0	2	6	10	14	19	
D4. Governing Regulatory Requirements	0	1	4	8	11	14	
D5. Environmental Assessment	0	1	5	9	12	16	
D6. Utility Sources with Supply Conditions	0	1	4	7	10	13	
D7. Site Life Safety Considerations	0	1	2	4	6	8	
D8. Special Water and Waste Treatment Requirements	0	1	3	6	8	11	
CATEGORY D TOTAL							
E. BUILDING PROGRAMMING (Maximum = 162)							
E1. Program Statement	0	1	5	9	12	16	
E2. Building Summary Space List	0	1	6	11	16	21	
E3. Overall Adjacency Diagrams	0	1	3	6	8	10	
E4. Stacking Diagrams	0	1	4	7	10	13	
E5. Growth & Phased Development	0	1	5	8	12	15	
E6. Circulation and Open Space Requirements	0	1	4	7	10	13	
E7. Functional Relationship Diagrams/Room by Room	0	1	3	5	8	10	
E8. Loading/Unloading/Storage Facilities Requirements	0	1	2	4	6	8	
E9. Transportation Requirements	0	1	3	5	7	9	
E10. Building Finishes	0	1	5	8	12	15	
E11. Room Data Sheets	0	1	4	7	10	13	
E12. Furnishings, Equipment, & Built-Ins	0	1	4	8	11	14	
E13. Window Treatment	0	0	2	3	4	5	
CATEGORY E TOTAL							
F. BUILDING/PROJECT DESIGN PARAMETERS (Maximum = 122)							
F1. Civil/Site Design	0	1	4	7	11	14	
F2. Architectural Design	0	1	7	12	17	22	
F3. Structural Design	0	1	5	9	14	18	
F4. Mechanical Design	0	2	6	11	15	20	
F5. Electrical Design	0	1	5	8	12	15	
F6. Building Life Safety Requirements	0	1	3	5	8	10	
F7. Constructability Analysis	0	1	4	8	11	14	
F8. Technological Sophistication	0	1	3	5	7	9	
CATEGORY F TOTAL							

SECTION II - BASIS OF DESIGN							
CATEGORY Element	Definition Level						Score
	0	1	2	3	4	5	
G. EQUIPMENT (Maximum = 36)							
G1. Equipment List	0	1	5	8	12	15	
G2. Equipment Location Drawings	0	1	3	5	8	10	
G3. Equipment Utility Requirements	0	1	4	6	9	11	
CATEGORY G TOTAL							
Section II Maximum Score = 428							
SECTION II TOTAL							

Definition Levels

0 =Not Applicable 2 =Minor Deficiencies 4 =Major Deficiencies
 1 =Complete Definition 3 =Some Deficiencies 5 =Incomplete or Poor Definition

SECTION III - EXECUTION APPROACH							
CATEGORY Element	Definition Level						Score
	0	1	2	3	4	5	
H. PROCUREMENT STRATEGY (Maximum = 25)							
H1. Identify Long Lead/Critical Equip. & Materials	0	1	4	7	10	14	
H2. Procurement Procedures and Plans	0	1	3	6	9	11	
CATEGORY H TOTAL							
J. DELIVERABLES (Maximum = 11)							
J1. CADD/Model Requirements	0	0	1	2	3	4	
J2. Documentation/Deliverables	0	1	2	4	6	7	
CATEGORY J TOTAL							
K. PROJECT CONTROL (Maximum = 63)							
K1. Project Quality Assurance and Control	0	1	3	4	6	8	
K2. Project Cost Control	0	1	4	7	10	13	
K3. Project Schedule Control	0	1	4	8	11	14	
K4. Risk Management	0	1	6	10	14	18	
K5. Safety Procedures	0	1	3	5	7	9	
CATEGORY K TOTAL							
L. PROJECT EXECUTION PLAN (Maximum = 60)							
L1. Project Organization	0	1	3	5	8	10	
L2. Owner Approval Requirements	0	1	4	6	9	11	
L3. Project Delivery Method	0	1	5	8	12	15	
L4. Design/Construction Plan & Approach	0	1	4	8	11	15	
L5. Substantial Completion Requirements	0	1	3	5	7	9	
CATEGORY L TOTAL							
Section III Maximum Score = 159							
SECTION III TOTAL							

PDRI TOTAL SCORE

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(Maximum Score = 1000)

PROJECT SCORE SHEET (UNWEIGHTED)

SECTION I - BASIS OF PROJECT DECISION							
CATEGORY Element	Definition Level						Score
	0	1	2	3	4	5	
A. BUSINESS STRATEGY							
A1. Building Use							
A2. Business Justification							
A3. Business Plan							
A4. Economic Analysis							
A5. Facility Requirements							
A6. Future Expansion/Alteration Considerations							
A7. Site Selection Considerations							
A8. Project Objectives Statement							
B. OWNER PHILOSOPHIES							
B1. Reliability Philosophy							
B2. Maintenance Philosophy							
B3. Operating Philosophy							
B4. Design Philosophy							
C. PROJECT REQUIREMENTS							
C1. Value-Analysis Process							
C2. Project Design Criteria							
C3. Evaluation of Existing Facilities							
C4. Scope of Work Overview							
C5. Project Schedule							
C6. Project Cost Estimate							

Definition Levels

0 =Not Applicable 2 =Minor Deficiencies 4 =Major Deficiencies
 1 =Complete Definition 3 =Some Deficiencies 5 =Incomplete or Poor Definition

SECTION II - BASIS OF DESIGN

CATEGORY Element	Definition Level						Score
	0	1	2	3	4	5	
D. SITE INFORMATION							
D1. Site Layout							
D2. Site Surveys							
D3. Civil/Geotechnical Information							
D4. Governing Regulatory Requirements							
D5. Environmental Assessment							
D6. Utility Sources with Supply C Conditions							
D7. Site Life Safety Considerations							
D8. Special Water and Waste Treatment Requirements							
E. BUILDING PROGRAMMING							
E1. Program Statement							
E2. Building Summary Space List							
E3. Overall Adjacency Diagrams							
E4. Stacking Diagrams							
E5. Growth & Phased Development							
E6. Circulation and Open Space Requirements							
E7. Functional Relationship Diagrams/Room by Room							
E8. Loading/Unloading/Storage Facilities Req'mts							
E9. Transportation Requirements							
E10. Building Finishes							
E11. Room Data Sheets							
E12. Furnishings, Equipment, & Built-Ins							
E13. Window Treatment							
F. BUILDING/PROJECT DESIGN PARAMETERS							
F1. Civil/Site Design							
F2. Architectural Design							
F3. Structural Design							
F4. Mechanical Design							
F5. Electrical Design							
F6. Building Life Safety Requirements							
F7. Constructability Analysis							
F8. Technological Sophistication							

SECTION II - BASIS OF DESIGN							
CATEGORY Element	Definition Level						Score
	0	1	2	3	4	5	
G. EQUIPMENT							
G1. Equipment List							
G2. Equipment Location Drawings							
G3. Equipment Utility Requirements							

Definition Levels

0 =Not Applicable 2 =Minor Deficiencies 4 =Major Deficiencies
 1 =Complete Definition 3 =Some Deficiencies 5 =Incomplete or Poor Definition

SECTION III - EXECUTION APPROACH							
CATEGORY Element	Definition Level						Score
	0	1	2	3	4	5	
H. PROCUREMENT STRATEGY							
H1. Identify Long Lead/Critical Equip. & Materials							
H2. Procurement Procedures and Plans							
J. DELIVERABLES							
J1. CADD/Model Requirements							
J2. Documentation/Deliverables							
K. PROJECT CONTROL							
K1. Project Quality Assurance and Control							
K2. Project Cost Control							
K3. Project Schedule Control							
K4. Risk Management							
K5. Safety Procedures							
L. PROJECT EXECUTION PLAN							
L1. Project Organization							
L2. Owner Approval Requirements							
L3. Project Delivery Method							
L4. Design/Construction Plan & Approach							
L5. Substantial Completion Requirements							

PDR TOTAL SCORE

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(Maximum Score = 1000)

Appendix B: PDRI ELEMENT DESCRIPTIONS

The following descriptions have been developed to help generate a clear understanding of the terms used in the Project Score Sheets. Some descriptions include checklists to clarify concepts and facilitate ideas when scoring each element. Note that these checklists are not all-inclusive and the user may supplement these lists when necessary.

The descriptions are listed in the same order as they appear in the Project Score Sheet. They are organized in a hierarchy by section, category, and element. The Project Score Sheet consists of three main sections, each of which is broken down into a series of categories which, in turn, are further broken down into elements. Scoring is performed by evaluating the levels of definition of the elements, which are described in this attachment. The sections and categories are organized as follows:

SECTION I BASIS OF PROJECT DECISION

This section consists of information necessary for understanding the project objectives. The completeness of this section determines the degree to which the project team will be able to achieve alignment in meeting the project's business objectives.

CATEGORIES:

- A - Business Strategy**
- B - Owner Philosophies**
- C - Project Requirements**

SECTION II BASIS OF DESIGN

This section consists of space, site, and technical design elements that should be evaluated to fully understand the basis for design of the project.

CATEGORIES:

- D - Site Information**
- E - Building Programming**
- F - Building/Project Design Parameters**
- G - Equipment**

SECTION III EXECUTION APPROACH

This section consists of elements that should be evaluated to fully understand the requirements of the owner's execution strategy.

CATEGORIES:

- H - Procurement Strategy**
- J - Deliverables**
- K - Project Control**
- L - Project Execution Plan**

The following pages contain detailed descriptions for each element in the Project Definition Rating Index (PDRI).

SECTION I - BASIS OF PROJECT DECISION

A. BUSINESS STRATEGY

A1. Building Use

Identify and list building uses or functions. These may include uses such as:

- | | | |
|--|---|---------------------------------------|
| <input type="checkbox"/> Retail | <input type="checkbox"/> Research | <input type="checkbox"/> Storage |
| <input type="checkbox"/> Institutional | <input type="checkbox"/> Multimedia | <input type="checkbox"/> Food service |
| <input type="checkbox"/> Instructional | <input type="checkbox"/> Office | <input type="checkbox"/> Recreational |
| <input type="checkbox"/> Medical | <input type="checkbox"/> Lt manufacturing | <input type="checkbox"/> Other |

A description of other options which could also meet the facility need should be defined. (As an example, did we consider renovating existing space rather than building new space?) A listing of current facilities that will be vacated due to the new project should be produced.

A2. Business Justification

Identify the driving forces for the project and specify what is most important from the viewpoint of the owner including both needs and expectations. Address items such as:

- | | |
|---|---|
| <input type="checkbox"/> Possible competitors | <input type="checkbox"/> Need date |
| <input type="checkbox"/> Level of amenities | <input type="checkbox"/> Target consumers |
| <input type="checkbox"/> Location | <input type="checkbox"/> Building utilization justification |
| <input type="checkbox"/> Sales or rental levels | <input type="checkbox"/> Number of lessors/occupant types |
| <input type="checkbox"/> Market capacity | <input type="checkbox"/> Support new business initiatives |
| <input type="checkbox"/> Use flexibility | <input type="checkbox"/> Facility replacement/consolidation |
| <input type="checkbox"/> Other | |

A3. Business Plan

The overarching project strategy should be defined that supports the business justification in relation to the following items:

- Funding availability
- Cost and financing
- Schedule milestones (including known deadlines)
- Types and sources of project funds
- Related/resulting projects
- Other

A4. Economic Analysis

An economic model should be developed to determine the viability of the venture. The model should acknowledge uncertainty and outline the boundaries of the analysis. It should acknowledge items such as:

- Design life
- Building Ownership
- Tax implications of investment including length of ownership
- Long-term operating and maintenance costs
- Resale/lease potential or in the case of institutional buildings, long term use plans
- Analysis of capital and operating cost versus sales or occupancy and profitability
- Other

A5. Facility Requirements

Facility size requirements are many times determined by applicable code and are often driven by occupancy. Note that this analysis is at the macro level. Some considerations are listed below:

- Number of occupants
- Volume
- Net and gross square footage by area uses
- Support infrastructure
- Classroom size
- Linear feet of display space
- Number of laboratory stations
- Occupant accommodation requirements (i.e., number of hospital beds, number of desks, number of workstations, on-site child care, on-site medical care, cot space, etc.)
- Other

A6. Future Expansion/Alteration Considerations

The possibility of expansion and/or alteration of the site and building should be considered for facility design. These considerations consist of a list of items that will facilitate the expansion or evolution of building use including adaptability/flexibility. Evaluation criteria may include:

- Provisions for site space in case of possible future expansion up or out
- Technologically advanced facility requirements
- Are departments or functional areas intended to “grow in place” during the future phase?
- If there will not be a future expansion of the building, how will departments or areas expand?
- Are any functional areas more likely than others to move out of the building in the future to allow others to expand or move in?
- Who will occupy the building in 5, 10, 15, 20 years?
- Flexibility or adaptability for future uses.
- Future phasing plan
- Other

A7. Site Selection Considerations

Evaluation of sites should address issues relative to different locations (i.e., global, country, or local). This evaluation may take into consideration existing buildings or properties, as well as new locations. The selection criteria include items such as:

- General geographic location

- Access to the targeted market area
- Local availability and cost of skilled labor (e.g., construction, operation, etc.)
- Available utilities
- Existing facilities
- Economic incentive zones
- Tax
- Land availability and developed costs
- Legal constraints
- Unusual financing requirements in region/locality
- Domestic culture vs. international culture
- Community relations
- Labor relations
- Government relations
- Political issues/constraints
- Education/training
- Safety and health considerations
- Environmental issues
- Symbolic and aesthetic
- Historic preservation
- Weather/climate
- Permitting Schedule
- Other

A8. Project Objectives Statement

This statement defines the project objectives and priorities for meeting the business strategy. It should be clear, concise, measurable, and specific to the project. It is desirable to obtain total agreement from the entire project team regarding these objectives and priorities to ensure alignment. Specifically, the priorities among cost, schedule, and value-added quality features should be clear. The objectives also should comply with any master plans if applicable.

B. OWNER PHILOSOPHIES

B1. Reliability Philosophy

A brief description of the project intent in terms of reliability should be defined. A list of the general design principles to be considered to achieve optimum/ideal operating performance from the facility/building should be addressed. Considerations may include:

- Critical systems redundancy
- Architectural/structural/civil durability
- Mechanical/electrical/plumbing reliability
- Other

B2. Maintenance Philosophy

A list of the general design principles to be considered to meet building maintenance requirements should be identified. This evaluation should include life cycle cost analysis of major facilities. Considerations may include:

- Daily occupancy loads
- Maximum building occupancy requirements
- Equipment monitoring requirements
- Energy conservation programs
- Selection of materials & finishes
- Requirements for building finishes
- Other

B3. Operating Philosophy

A list of the general design issues that need to be considered to support routine operations should be developed. Issues may include:

- Operating schedule/hours
- Provisions for building rental or occupancy assignments (i.e., by room, floor, suite) including flexibility of partitioning
- Future renovation schedule
- User finish out philosophy
- Flexibility to change layout
- Other

B4. Design Philosophy

A listing of design philosophy issues should be developed. These issues should be directed at concerns such as the following:

- Design life
- Aesthetic requirements
- Compatibility with master plan
- Theme
- Image
- Environmentally sustainable design (internal/external)
- Quality of life
- Other

C. PROJECT REQUIREMENTS

C1. Value-Analysis Process

A structured value analysis approach should be in place to consider design and material alternatives in terms of their cost effectiveness. Items that impact the economic viability of the project should be considered. Items to evaluate include issues such as:

- Discretionary scope issues
- Expensive materials of construction
- Life-cycle analysis of construction methods and structure
- Other

C2. Project Design Criteria

Project design criteria are the requirements and guidelines which govern the design of the project. Any design review board or design review process should be clearly articulated. Evaluation criteria may include:

- Level of design detail required
- Climatic data
- Codes & standards
 - National
 - Owner specific
 - Local
 - International
- Utilization of design standards
 - Owner's
 - Designer's
 - Contractor's
 - Mixed
 - Level of design detail required
- Donor or benefactor requirements
- Sole source requirements for equipment or systems
- Insurance underwriter requirements
- Cultural preferences
- Other

C3. Evaluation of Existing Facilities

If existing facilities are available, then a condition assessment must be performed to determine if they will meet facility requirements. Evaluation criteria may include:

- Capacity
 - Power
 - Fire water
 - Sanitary sewer
 - Security
 - Utilities (i.e., potable water, gas, oil, etc.)
 - Waste treatment/disposal
 - Telecommunications
 - Storm water containment system/filtration
- Access
 - Rail
 - Roads
 - ADA or local standards
- Parking areas
- Type and size of buildings/structures
- Amenities
 - Food service
 - Ambulatory access
 - Medical facilities
 - Recreation facilities including public outdoor spaces
 - Change rooms
- Condition assessment of existing facilities and infrastructure
- Other

C4. Scope of Work Overview

This work statement overview is a complete narrative description of the project that is discipline-oriented and supports development of the project schedule and project cost estimate. It sets the limits of work by each involved party and generally articulates their financial, task, and contractual responsibilities. It clearly states both assumptions and exclusions used to define the scope of work.

C5. Project Schedule

Ideally, the project schedule should be developed by the project team (owner, A/E, and construction contractor). It should include milestones, unusual schedule considerations and appropriate master schedule “contingency” time (float), procurement of long lead or critical pacing equipment, and required submissions and approvals.

C6. Project Cost Estimate

The project cost estimate should address all costs necessary for completion of the project. This cost estimate may include the following:

- Construction contract estimate
- Professional fees
- Land cost
- Furnishings
- Administrative costs
- Contingencies
- Cost escalation for elements outside the project cost estimate
- Startup costs including installation
- Miscellaneous expenses including but not limited to:
 - Specialty consultants
 - Inspection & testing services
 - Bidding costs
 - Site clearance
 - Bringing utilities to the site
 - Environmental impact mitigation measures
 - Local authority permit fees
 - Occupant moving & staging costs
 - Utility costs during construction (if paid by owner)
 - Interest on borrowed funds (cost of money)
 - Site surveys, soils tests
- Availability of construction laydown & storage at site or in remote or rented facilities
- Other

SECTION II - BASIS OF DESIGN

D. SITE INFORMATION

D1. Site Layout

The facility should be sited on the selected property. Layout criteria may include items such as:

- Access (e.g., road, rail, marine, air, etc.)
- Construction access
- Historical/cultural
- Trees and vegetation
- Site massing and context constraints or guidelines (i.e., how a building will look in 3-dimensions at the site)
- Access transportation parking, delivery/service, & pedestrian circulation considerations
- Open space, street amenities, "urban context concerns"
- Climate, wind, and sun orientation for natural lighting views, heat loss/gain, energy conservation, and aesthetic concerns
- Other

D2. Site Surveys

The site should be surveyed for the exact property boundaries, including limits of construction. A topography map with the overall plot and site plan is also needed. Evaluation criteria may include:

- Legal property descriptions with property lines
- Easements
- Rights-of-way
- Drainage patterns
- Deeds
- Definition of final site elevation
- Benchmark control systems
- Setbacks
- Access & curb cuts
- Proximity to drainage ways and flood plains
- Known below grade structures and utilities (both active and inactive)
- Trees & vegetation
- Existing facility locations and conditions
- Solar/shadows
- Other

D3. Civil/Geotechnical Information

The civil/geotechnical site evaluation provides a basis for foundation, structural, and hydrological design. Evaluations of the proposed site should include items such as:

- Depth to bedrock
- General site description (e.g., terrain, soils type, existing structures, spoil removal, areas of hazardous waste, etc.)
- Expansive or collapse potential of soils
- Fault line locations
- Spoil area for excess soil (i.e., location of on-site area or off-site instructions)
- Seismic requirements
- Water table elevation
- Flood plain analysis
- Soil percolation rate & conductivity
- Ground water flow rates and directions
- Need for soil treatment or replacement
- Description of foundation design options
- Allowable bearing capacities
- Pier/pile capacities
- Paving design options
- Overall site analysis
- Other

D4. Governing Regulatory Requirements

The local, state, and federal government permits necessary to construct and operate the facility should be identified. A work plan should be in place to prepare, submit, and track permit, regulatory, re-zoning, and code compliance for the project. It should include items such as:

- | | |
|---|--|
| <input type="checkbox"/> Construction | <input type="checkbox"/> Fire |
| <input type="checkbox"/> Accessibility | <input type="checkbox"/> Unique requirements |
| <input type="checkbox"/> Building | <input type="checkbox"/> Demolition |
| <input type="checkbox"/> Environmental | <input type="checkbox"/> Occupancy |
| <input type="checkbox"/> Solar | <input type="checkbox"/> Structural calculations |
| <input type="checkbox"/> Special | <input type="checkbox"/> Platting |
| <input type="checkbox"/> Building height limits | <input type="checkbox"/> Signage |
| <input type="checkbox"/> Air/water | <input type="checkbox"/> Setback requirements |
| <input type="checkbox"/> Historical issues | <input type="checkbox"/> Transportation |
| <input type="checkbox"/> Other | |

The codes that will have a significant impact on the scope of the project should also be investigated and explained in detail. Particular attention should be paid to local requirements. Regulatory and code requirements may affect the defined physical characteristics and project cost estimate. The project schedule may be affected by regulatory approval processes. For some technically complex buildings, regulations change fairly often.

D5. Environmental Assessment

An environmental assessment should be performed for the site to evaluate issues that can impact the cost estimate or delay the project. These issues may include:

- Archeological
- Location in an EPA air quality non-compliance zone
- Location in a wet lands area
- Environmental permits now in force
- Existing contamination
- Location of nearest residential area
- Ground water monitoring in place
- Downstream uses of ground water
- Existing environmental problems with the site
- Past/present use of site
- Noise/vibration requirements
- Air/water discharge requirements and options evaluated
- Discharge limits of sanitary and storm sewers identified
- Detention requirements
- Endangered species
- Erosion/sediment control
- Other

D6. Utility Sources with Supply Conditions

The availability/non-availability of site utilities needed to operate the facility with supply conditions of quantity, temperature, pressure, and quality should be evaluated. This may include items such as:

- Potable water
- Drinking water
- Cooling water
- Fire water
- Sewers
- Electricity (voltage levels)
- Communications (e.g., data, cable television, telephones)
- Special requirement (e.g., deionized water or oxygen)
- Other
- Instrument air
- Facility air
- Heating water
- Gases
- Steam

D7. Site Life Safety Considerations

Fire and life safety related items should be taken into account for the selected site. These items should include fire protection practices at the site, available firewater supply (amounts and conditions), special safety requirements unique to the site, etc. Evaluation criteria may include:

- Wind direction indicator devices (e.g., wind socks)
- Fire monitors & hydrants
- Flow testing
- Access and evacuation plan
- Available emergency medical facilities
- Security considerations (site illumination, access control, etc.)
- Other

D8. Special Water and Waste Treatment Requirements

On-site or pretreatment of water and waste should be evaluated. Items for consideration may include:

- Wastewater treatment
 - Process waste
 - Sanitary waste
- Waste disposal
- Storm water containment & treatment
- Other

E. BUILDING PROGRAMMING

E1. Program Statement

The program statement identifies the levels of performance for the facility in terms of space planning and functional relationships. It should address the human, physical, and external aspects to be considered in the design. Each performance criteria should include these issues:

- A performance statement outlining what goals are to be attained (e.g., providing sufficient lighting levels to accomplish the specified task safely and efficiently)
- A measure that must be achieved (e.g., 200 foot-candles at surface of surgical table)
- A test which is an accepted approach to establish that the criterion has been met (e.g., using a standard light meter to do the job)
- Other

E2. Building Summary Space List

The *summary* space list includes *all* space requirements for the entire project. This list should address specific types and areas. Possible space listings include:

- | | |
|--|--|
| <input type="checkbox"/> Building population | <input type="checkbox"/> Classrooms |
| <input type="checkbox"/> Administrative offices | <input type="checkbox"/> Laboratories |
| <input type="checkbox"/> Lounges | <input type="checkbox"/> Corridors |
| <input type="checkbox"/> Food Service Cafeteria | <input type="checkbox"/> Storage facilities |
| <input type="checkbox"/> Conference rooms | <input type="checkbox"/> Mechanical rooms |
| <input type="checkbox"/> Vending alcoves | <input type="checkbox"/> Electrical rooms |
| <input type="checkbox"/> Janitorial closets | <input type="checkbox"/> Parking space |
| <input type="checkbox"/> Elevators | <input type="checkbox"/> Entry lobby |
| <input type="checkbox"/> Stairs | <input type="checkbox"/> Restrooms |
| <input type="checkbox"/> Loading docks | <input type="checkbox"/> Data/computer areas |
|
 | |
| <input type="checkbox"/> Dwelling units | |
| <input type="checkbox"/> Other considerations | |
| <input type="checkbox"/> Special technology considerations | |

A room data sheet should correspond to each entry on the summary space list. Room data sheets are discussed in element E11. The room data sheet contains information that is necessary for the summary space list. This list is used to determine assignable (usable) and non-assignable (gross) areas.

E3. Overall Adjacency Diagrams

The overall adjacency diagrams depict the layout of each department or division of the entire building. They show the relationship of specific rooms, offices, and sections. The adjacency diagrams must adequately convey the overall relationships between functional areas within the facility. Note that these diagrams are sometimes known as “bubble diagrams” or “balloon diagrams.” They are also commonly expressed in an adjacency matrix.

E4. Stacking Diagrams

A stacking diagram portrays each department or functional unit vertically in a multi-story building. Stacking diagrams are drawn to scale, and they can help establish key design elements for the building. These diagrams are easily created with space lists and adjacency (or bubble) diagrams. Critical vertical relationships may relate to circulatory (stairs, elevators), structural elements, and mechanical or utility shafts.

Stacking diagrams can establish building elements such as floor size. This type of diagram often combines functional adjacencies and space requirements and also shows how the project is sited.

E5. Growth and Phased Development

Provisions for future phases or anticipated use change must be considered during project programming. A successful initial phase necessitates a plan for the long term phases. The following phasing issues may be addressed.

- Guidelines to allow for additions (i.e., over-design of structural systems, joist layout, column spacing, etc.)
- Technology needs as facility grows and expands or changes (e.g., mechanical systems, water demands, etc.)
- Compare the additional costs involved with making the building “expandable” versus the probability of the future expansion occurring as envisioned.
- Provisions for infrastructure that allow for future expansion
- Other

E6. Circulation and Open Space Requirements

An important component of space programming is common-area open spaces, both interior and exterior. These areas include the items listed and considerations such as:

- Exterior
 - Service dock areas and access
 - Circulation to parking areas
 - Passenger drop-off areas
 - Pedestrian walkways
 - Courtyards, plazas, or parks
 - Landscape buffer areas
 - Unbuildable areas (e.g., wetlands or slopes)
 - Sidewalks or other pedestrian routes
 - Bicycle facilities
 - Lobbies and entries
 - Security considerations (e.g., card access or transmitters)
 - Snow removal plan
 - Postal and newspaper delivery
 - Waste removal
 - Fire and life-safety circulation considerations
- Interior
 - Interior aisle ways and corridors
 - Vertical circulation (i.e., personnel & material transport including elevators and escalators)
 - Directional and location signage
- Other

E7. Functional Relationship Diagrams/Room by Room

Room by room functional relationship diagrams show the structure of adjacencies of a group of rooms. With these adjacency diagrams (also known as bubble diagrams), the architect can convert them into a floor plan with all the relationships. Each space detail sheet should have a minimum of one functional relationship diagram. Rooms are often represented by circles, bubbles, squares, or rectangles. Larger rooms are represented with bigger symbols. They are also commonly expressed in an adjacency matrix.

E8. Loading/Unloading/Storage Facilities Requirements

A list of requirements identifying materials to be unloaded and stored and products to be loaded along with their specifications. This list should include items such as:

- Storage facilities to be provided and/or utilized
- Refrigeration requirements and capabilities
- Mail/small package delivery
- Recycling requirements
- Other

E9. Transportation Requirements

Specifications for implementation of facility transportation (e.g., roadways, conveyers, elevators, etc.) as well as methods for receiving and shipping of materials (e.g., air, rail, truck, marine, etc.) should be identified. Provisions should be included for items such as:

- Facility access requirements based on transportation
- Drive-in doors
- Extended ramps for low clearance trailers
- Rail car access doors
- Service elevators
- Loading docks
- Temporary parking
- Other

E10. Building Finishes

Levels of interior and exterior finishes should be defined for the project. For example, the finishes may include categories such as:

Interior Schedule:

- Type A
 - Floor: vinyl composition tile
 - Walls: painted
- Type B
 - Floor: direct glue carpet
 - Walls: vinyl wall covering
- Type C
 - Floor: carpet over pad
 - Walls: wood paneling

Exterior Schedule:

- Type 1
 - Walls: brick
 - Trim: brick
- Type 2
 - Walls: overlapping masonry
 - Trim: cedar

Finishes and local design standards are further defined in category F.

E11. Room Data Sheets

Room data sheets contain the specific requirements for each room considering its functional needs. A room data sheet should correspond to each room on the building summary space list. The format of the room data sheet should be consistent. Possible issues to include on room data sheets are:

- Critical dimensions
- Technical requirements (e.g., fireproof, explosion resistance, X-ray, etc.)
- Furnishing requirements
- Equipment requirements
- Audio/visual (A/V) data and communication provisions
- Lighting requirements
- Utility requirements
- Security needs including access/hours of operation
- Finish type
- Environmental issues
- Acoustics/vibration requirements
- Life-safety
- Other

E12. Furnishings, Equipment, and Built-Ins

All moveable furnishings, equipment, and built-ins should be listed on the room data sheets. Moveable and fixed in place equipment should be distinguished. Building modifications, such as wide access doors or high ceilings, necessary for any equipment also need to be listed. Long delivery time items should be identified and ordered early. It is critical to identify the utility impact of equipment (e.g., electrical, cooling, special water or drains, venting, radio frequency shielding, etc.). Examples may include:

- | | |
|--|--|
| <input type="checkbox"/> Furniture | <input type="checkbox"/> Material handling |
| <input type="checkbox"/> Kitchen equipment | <input type="checkbox"/> Partitions |
| <input type="checkbox"/> Medical equipment | <input type="checkbox"/> Other |

New items and relocated existing items must be distinguished in the program. The items can be classified in the following categories.

New Items:

- Contractor furnished and contractor installed
- Owner furnished and contractor installed
- Owner furnished and owner installed
- Other

Existing Items:

- Relocated as is and contractor installed
- Refurbished and installed by contractor
- Relocated as is and owner installed
- Refurbished and installed by owner
- Other

E13. Window Treatment

Any special fenestration window treatments for energy and/or light control should be noted in order to have proper use of natural light. Some examples include:

- Blocking of natural light
- Glare reducing windows
- Exterior louvers
- Interior blinds
- Other

F. BUILDING/PROJECT DESIGN PARAMETERS

F1. Civil/Site Design

Civil/site design issues should be addressed to provide a basis for facility design. Issues to address may include:

- Service and storage requirements
- Elevation and profile views
- High point elevations for grade, paving, and foundations
- Location of equipment
- Minimum overhead clearances
- Storm drainage system
- Location and route of underground utilities
- Site utilities
- Earth work
- Subsurface work
- Paving/curbs
- Landscape/xeriscape
- Fencing/site security
- Other

F2. Architectural Design

Architectural design issue should be addressed to provide a basis for facility design. These issues may include the following:

- Determination of metric (hard/soft) versus Imperial (English) units
(Note: The term “hard” metric means that materials and equipment are identified on the drawings and have to be delivered in metric-sized unit dimensions such as 200mm by 400mm. “Soft” metric means that materials and equipment can be delivered using sizes that approximate the metric dimensions given on the drawings, such as 3 inch length instead of 8 cm. It is important to set these dimensions and not “mix and match.”)
- Requirements for building location/orientation horizontal & vertical
- Access requirements
- Nature/character of building design (e.g., aesthetics, etc.)
- Construction materials
- Acoustical considerations
- American with Disabilities Act requirements or other local access requirements
- Architectural Review Boards
- Planning & zoning review boards
- Circulation considerations
- Seismic design considerations
- Color/material standards
- Hardware standards
- Furniture, furnishings, and accessories criteria
- Design grid
- Floor to floor height
- Other

F3. Structural Design

Structural design considerations should be addressed to provide a basis for the facility design. These considerations may include the following:

- Structural system (e.g., construction materials, constraints, etc.)
- Seismic requirements
- Foundation system
- Corrosion control requirements/required protective coatings
- Client specifications (e.g., basis for design loads, vibration, deflection, etc.)
- Future expansion/flexibility considerations
- Design loading parameter (e.g., live/dead loads, design loads, collateral load capacity, equipment/material loads, wind/snow loads, uplift)
- Functional spatial constraints
- Other

F4. Mechanical Design

Mechanical design parameters should be developed to provide a basis for facility design. Items to consider include:

- Special ventilation or exhaust requirements
- Equipment/space special requirements with respect to environmental conditions (e.g., air quality, special temperatures)
- Energy conservation and life cycle costs
- Acoustical requirements
- Zoning and controls
- Air circulation requirements
- Outdoor design conditions (e.g., minimum and maximum yearly temperatures)
- Indoor design conditions (e.g., temperature, humidity, pressure, air quality, etc.)
- Building emissions control
- Utility support requirements
- System redundancy requirements
- Plumbing requirements
- Special piping requirements
- Seismic requirements
- Other

F5. Electrical Design

Electrical design parameters provide the basis for facility design. Consider items such as:

- Power sources with available voltage & amperage
- Special lighting considerations (e.g., lighting levels, color rendition)
- Voice, data, and video communications requirements
- Uninterruptable power source (UPS) and/or emergency power requirements
- Energy consumption/conservation and life cycle cost
- Ability to use daylight in lighting
- Seismic requirements
- Lightning/grounding requirements
- Other

F6. Building Life Safety Requirements

Building life safety requirements are a necessity for building operations. They should be identified at this stage of the project. Possible safety requirements are listed below:

- Fire resistant requirements
- Explosion resistant requirements
- Area of refuge requirements in case of catastrophe
- Safety and alarm requirements
- Fire detection and/or suppression requirements
- Eye wash stations
- Safety showers
- Deluge requirements and foam
- Fume hoods
- Handling of hazardous materials
- Isolation facilities
- Sterile environments
- Emergency equipment access
- Personnel shelters
- Egress
- Public address requirements
- Data or communications protection in case of disaster or emergency
- Fall hazard protection
- Gas hazard detection
- Other

F7. Constructability Analysis

CII defines constructability as, "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."

Is there a structured approach for constructability analysis in place? Have provisions been made to provide this on an ongoing basis? This would include examining design options and details of construction that minimize construction costs while maintaining standards of safety, quality, and schedule. Elements of constructability during pre-project planning include:

- Constructability program in existence
- Construction knowledge/experience used in project planning
- Early construction involvement in contracting strategy development
- Developing a construction-sensitive project schedule
- Considering major construction methods in basic design approaches
- Developing site layouts for efficient construction
- Early identification of project team participants for constructability analysis
- Usage of advanced information technologies
- Other

F8. Technological Sophistication

The requirements for “intelligent” or special building systems should be evaluated. Examples of these systems may include:

- Video conferencing
- Internet connections
- Advanced audio/visual (A/V) connections
- Personnel sensing
- Computer docking stations
- “Smart” heating or air-conditioning
- Intercommunication systems
- Security systems
- Communication systems
- Conveyance systems
- Other

G. EQUIPMENT

G1. Equipment List

Project-specific equipment should be defined and listed. (Note: Building systems equipment is addressed in element F4, Mechanical Design, and F5, Electrical Design). In situations where owners are furnishing equipment, the equipment should be properly defined and purchased. The list should define items such as:

- Process
- Medical
- Food service/vending
- Trash disposal
- Distributed control systems
- Material handling
- Existing sources and characteristics of equipment
 - Relative sizes
 - Weights
 - Location
 - Capacities
 - Materials of construction
 - Insulation and painting requirements
 - Equipment related access
 - Vendor, model, and serial number once identified
 - Equipment delivery time, if known
- Other

G2. Equipment Location Drawings

Equipment location/arrangement drawings identify the specific location of each item of equipment in a project. These drawings should identify items such as:

- Plan and elevation views of equipment and platforms
- Location of equipment rooms
- Physical support requirement (e.g., installation bolt patterns)
- Coordinates or location of all major equipment
- Other

G3. Equipment Utility Requirements

This evaluation should consist of a tabulated list of utility requirements for all major equipment items such as:

- Power and/or all utility requirements
- Flow diagrams
- Design temperature and pressure
- Diversity of use
- Gas
- Water
- Other

SECTION III - EXECUTION APPROACH

H. PROCUREMENT STRATEGY

H1. Identify Long Lead/Critical Equipment and Materials

Identify engineered equipment and material items with lead times that will impact the design for receipt of vendor information or impact the construction schedule with long delivery times.

H2. Procurement Procedures and Plans

Procurement procedures and plans include specific guidelines, special requirements, or methodologies for accomplishing the purchasing, expediting, and delivery of equipment and materials required for the project. Evaluation criteria may include:

- Who will perform procurement?
- Listing of approved vendors, if applicable
- Client or contractor purchase orders
- Reimbursement terms and conditions
- Guidelines for supplier alliances, single source, or competitive bids
- Guidelines for engineering/construction contracts
- Who assumes responsibility for owner-purchased items?
 - Financial
 - Shop inspection
 - Expediting
- Tax strategy
 - Depreciation capture
 - Local sales and use tax treatment
 - Investment tax credits
- Definition of source inspection requirements and responsibilities
- Definition of traffic/insurance responsibilities
- Definition of procurement status reporting requirements
- Additional/special owner accounting requirements
- Definition of spare parts requirements
- Local regulations (e.g., tax restrictions, tax advantages, etc.)
- Incentive/penalty strategy for contracts
- Storage
- Other

J. DELIVERABLES

J1. CADD/Model Requirements

Computer Aided Drafting and Design (CADD) requirements should be defined. Evaluation criteria may include:

- Software system required by client (e.g., AutoCAD, Intergraph, etc.)
- Will the project be required to be designed using 2D or 3D CADD? Will rendering be required?
- If 3D CADD is to be used, will a walk-through simulation be required?
- Owner/contractor standard symbols and details
- How will data be received and returned to/from the owner?
 - Disk
 - Electronic transfer
 - Tape
 - Reproduces
 - Full size mock-ups

Physical model requirements depend upon the type needed for analysis, such as study models or design checks.

J2. Documentation/Deliverables

Documentation and deliverables required during project execution should be identified. If electronic media are to be used, format and application packages should be outlined. The following items may be included in a list of deliverables:

- Drawings & specifications
- Project correspondence
- Permits
- Maintenance and operating information/startup procedures
- Facility keys, keying schedules, and access codes
- Project data books (quantity, format, contents, and completion date)
- Equipment folders (quantity, format, contents, and completion date)
- Design calculations (quantity, format, contents, and completion date)
- Spare parts and maintenance stock (special forms)
- Procuring documents/contract documents
- Record (as-built) documents
- Quality assurance documents
- Project signage
- Guarantees/warranties
- Inspection documents
- Certificates of inspection
- Shop drawings and samples
- Bonds
- Distribution matrix
- Other

K. PROJECT CONTROL

K1. Project Quality Assurance and Control

Quality assurance and quality control procedures need to be established. Responsibility for approvals needs to be developed. Electronic media requirements should be outlined. These issues may include:

- Responsibility during design and construction
- Testing of materials and workmanship
- ISO 9000 requirements
- Submittals and shop drawing approach
- Inspection reporting requirements
- Progress photos
- Reviewing changes and modifications
- Communication documents (e.g., RFI's, RFQ's, etc.)
- Commissioning tests
- Lessons-learned feedback
- Other

K2. Project Cost Control

Procedures for controlling project cost need to be outlined and responsibility assigned. Electronic media requirements should be identified. These may include cost control requirements such as:

- Financial (client/regulatory)
- Phasing or area sub-accounting
- Capital vs. non-capital expenditures
- Report requirements
- Payment schedules and procedures
- Cash flow projections/draw down analysis
- Cost code scheme/strategy
- Costs for each project phase
- Periodic control check estimates
- Change order management procedure, including scope control
- Other

K3. Project Schedule Control

The project schedule is created to show progress and ensure that the project is completed on time. The schedule is necessary for design and construction of the building. A schedule format should be decided on at the beginning of the project. Typical items included in a project schedule are listed below.

- Milestones
- Unusual schedule considerations
- Required submissions and/or approvals
- Required documentation and responsible party
- Baseline vs. progress to date
- Long lead or critical pacing equipment delivery
- Critical path activities
- Contingency or "float time"
- Permitting or regulatory approvals
- Activation and commissioning
- Liquidated damages/incentives
- Other

The owner must also identify how special project issues will be scheduled. These items may include:

- Selection, procurement, and installation of equipment
- Design of interior spaces (including furniture and accessory selection)
- Stages of the project that must be handled differently than the rest of the project
- Tie-ins, service interruptions, and road closures
- Other

K4. Risk Management

Major project risks need to be identified, quantified, and management actions taken to mitigate problems developed. Pertinent elements may include:

- Design risks
 - Expertise
 - Experience
 - Work load
 - Teamwork orientation
 - Communication
 - Integration and coordination
 - Other
- Construction risks
 - Availability of craft labor and construction materials
 - Weather
 - Differing/unforeseen/difficult site conditions
 - Long lead item delays
 - Strikes
 - Inflation
 - Scope growth
 - Other
- Management risks
 - Availability of designers
 - Critical quality issues
 - Bidders
 - Human error
 - Cost & schedule estimates
 - Timely decisions
 - Team chemistry
 - Other
- Insurance considerations

K5. Safety Procedures

Safety procedures and responsibilities must be identified for design consideration and construction. Safety issues to be addressed may include:

- Hazardous material handling
- Interaction with the public
- Working at elevations/fall hazards
- Evacuation plans & procedures
- Drug testing
- First aid stations
- Accident reporting & investigation
- Pre-task planning
- Safety orientation & planning
- Safety incentives
- Other special or unusual safety issues

L. PROJECT EXECUTION PLAN

L1. Project Organization

The project team should be identified including roles, responsibilities, and authority. Items to consider include:

- Core team members
- Project manager assigned
- Project sponsor assigned
- Working relationships between participants
- Communication channels
- Organizational chart
- Approval responsibilities/responsibility matrix
- Other

L2. Owner Approval Requirements

All documents that require owner approval should be clearly defined. These may include:

- Milestones for drawing approval by phase
 - Comment
 - Approval
 - Bid issues (public or private)
 - Construction
- Durations of approval cycle compatible with schedule
- Individual(s) responsible for reconciling comments before return
- Types of drawings/specifications
- Purchase documents/general conditions & contract documents
 - Data sheets
 - Inquiries
 - Bid tabulations
 - Purchase orders
- Vendor information
- Other

L3. Project Delivery Method

The methods of project design and construction delivery, including fee structure should be identified. Issues to consider include:

- Owner self-performed
- Designer and constructor qualification selection process
- Selected methods (e.g., design/build, CM at risk, competitive sealed proposal, bridging, design-bid-build, etc.)
- Contracting strategies (e.g., lump sum, cost-plus, etc.)
- Design/build scope package considerations
- Other

L4. Design/Construction Plan and Approach

This is a documented plan identifying the specific approach to be used in designing and constructing the project. It should include items such as:

- Responsibility matrix
- Subcontracting strategy
- Work week plan/schedule
- Organizational structure
- Work Breakdown Structure (WBS)
- Construction sequencing of events
- Site logistics plan
- Safety requirements/program
- Identification of critical activities that have potential impact on facilities (i.e., existing facilities, crane usage, utility shut downs and tie-ins, testing, etc.)
- Quality assurance/quality control (QA/QC) plan
- Design and approvals sequencing of events
- Equipment procurement and staging
- Contractor meeting/reporting schedule
- Partnering or strategic alliances
- Alternative dispute resolution
- Furnishings, equipment, and built-ins responsibility
- Other

L5. Substantial Completion Requirements

Substantial Completion (SC) is defined as the point in time when the building is ready to be occupied. The following may need to be addressed:

- Have specific requirements for SC responsibilities been developed?
- Have warranty, permitting, insurance, tax implications, etc., been considered?
- Commissioning
 - Equipment/systems startup and testing
 - Occupancy phasing
 - Final code inspection
 - Calibration
 - Verification
 - Documentation
 - Training
 - Acceptance
- Landscape requirements
- Punchlist completion plan and schedule
- Substantial completion certificate
- Other

APPENDIX C: PDRI FOR BUILDING PROJECTS RESEARCH TEAM (CII RT 155)

George Abikhaled, The University of Texas System
Dennis Bayon, NASA
Ronald P. DiLustro, NASA
G. Edward Gibson, Jr., The University of Texas at Austin*
Mark Hanchar, ADP Marshall, Inc.
Thomas R. Hodges, U.S. Department of State
Schiller Liao, The University of Texas System*
Tom Lyons, H.B. Zachry, Research Team Chairman
Ezel Silver, Jr., U.S. Department of State
Gary T. Steinmetz, General Motors Corp.

Other Contributing Participants:

Gary M. Boyd, 3D/International
Sidney L. Henson, BECK Program Management*
Robert D. Morris, 3D/International
Ron Ohm, HC BECK
John A. Oualline, 3D/International*

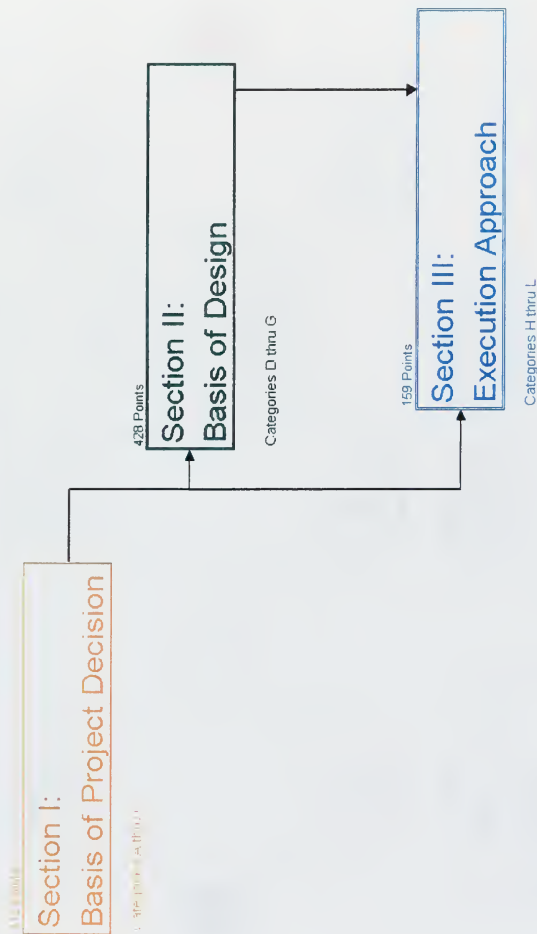
Past Membership:

James A. Broaddus, The University of Texas System
Jerry Pitzrick, M.A. Mortenson Co.
Walter W. Morton, Metric Constructors, Inc.

* Member of LFD Subteam

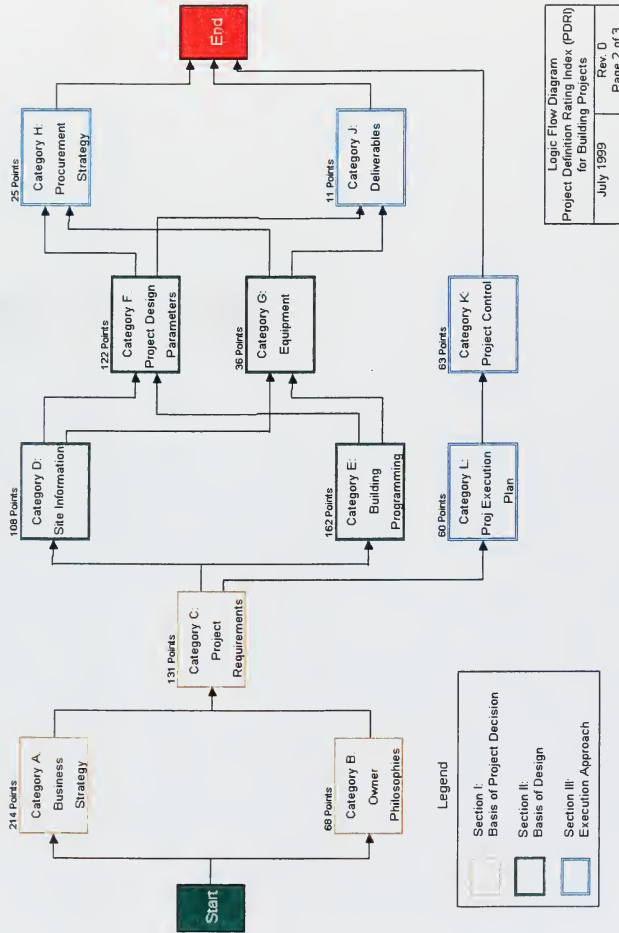
Appendix D: LFD Diagrams

Section Diagram



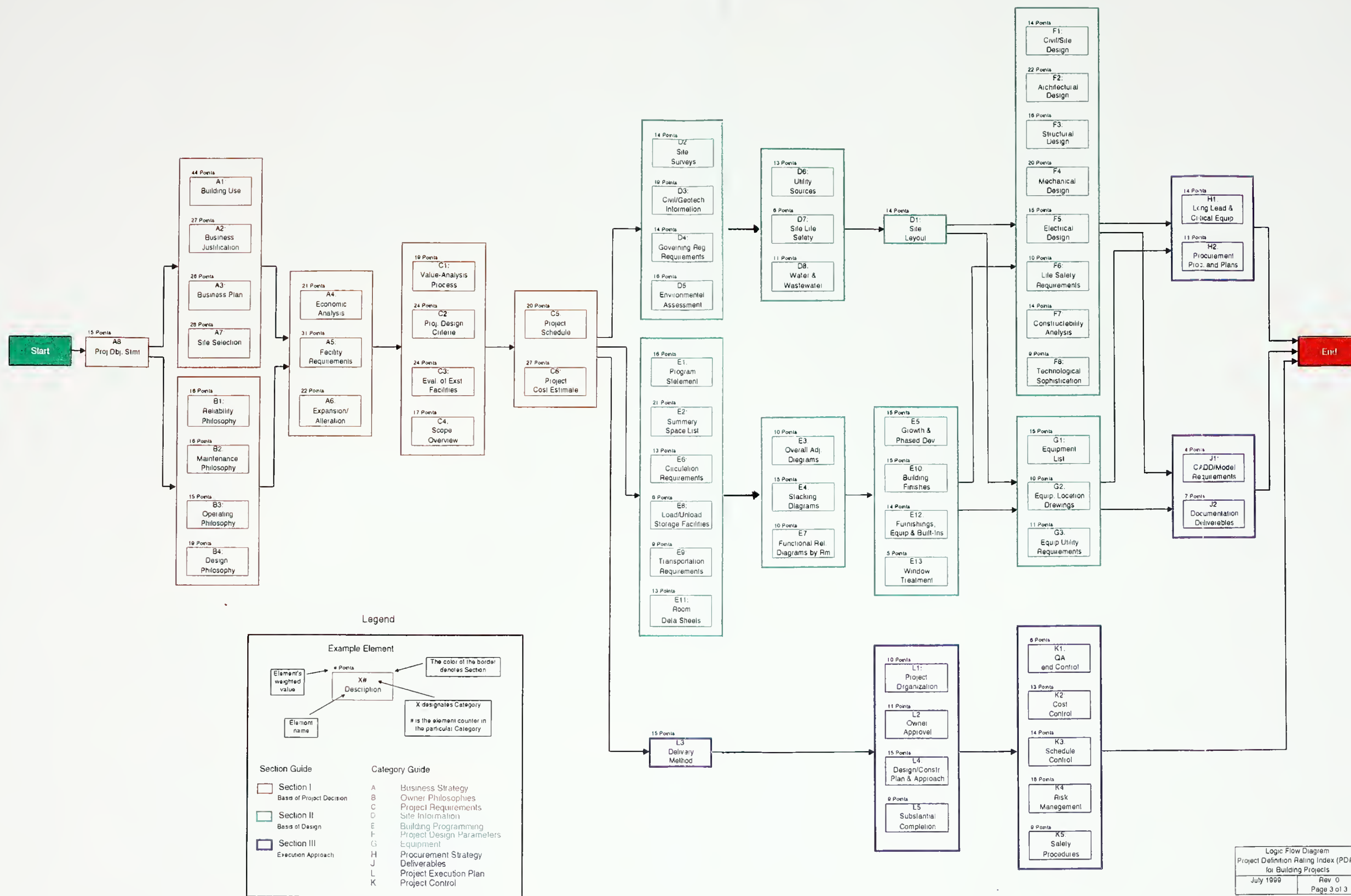
Logic Flow Diagram Project Definition Rating Index (PDR) for Building Projects	
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Category Diagram



Logic Flow Diagram
Project Definition Rating Index (PDRi)
for Building Projects
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Element Diagram



Appendix E: Proposal for PDRI Logic Flow Diagram Interviews

Background

The Project Definition Rating Index (PDRI) for Building Projects is a tool developed by the Construction Industry Institute (CII) to measure the degree of scope development on building projects. As validated in the earlier PDRI for Industrial Projects, the greater the scope development (or front end planning), the greater the likelihood that the project will be a success.

Until now, the PDRI for Buildings has been in the form of a categorized scoresheet. The score sheet is composed of 64 elements supported by detailed descriptions. A list of the elements is included in the following table.

SECTION I. BASIS OF PROJECT DECISION	
<ul style="list-style-type: none"> A. Business Strategy A1. Building Use A2. Business Justification A3. Business Plan A4. Economic Analysis A5. Facility Requirements A6. Future Expansion/Alteration Considerations A7. Site Selection Considerations A8. Project Objectives Statement B. Owner Philosophies B1. Reliability Philosophy B2. Maintenance Philosophy B3. Operating Philosophy B4. Design Philosophy C. Project Requirements C1. Value-Analysis Process C2. Project Design Criteria C3. Evaluation of Existing Facilities C4. Scope of Work Overview C5. Project Schedule C6. Project Cost Estimate 	<ul style="list-style-type: none"> E7. Functional Relationship Diagrams/ Room by Room E8. Loading/Unloading/Storage Facilities Requirements E9. Transportation Requirements E10. Building Finishes E11. Room Data Sheets E12. Furnishings, Equipment, & Built-Ins E13. Window Treatment F. Building/Project Design Parameters F1. Civil/Site Design F2. Architectural Design F3. Structural Design F4. Mechanical Design F5. Electrical Design F6. Building Life Safety Requirements F7. Constructability Analysis F8. Technological Sophistication G. Equipment G1. Equipment List G2. Equipment Location Drawings G3. Equipment Utility Requirements
SECTION II. BASIS OF DESIGN	
<ul style="list-style-type: none"> D. Site Information D1. Site Layout D2. Site Surveys D3. Civil/Geotechnical Information D4. Governing Regulatory Requirements D5. Environmental Assessment D6. Utility Sources with Supply Conditions D7. Site Life Safety Considerations D8. Special Water and Waste Treatment Requirements E. Building Programming E1. Program Statement E2. Building Summary Space List E3. Overall Adjacency Diagrams E4. Stacking Diagrams E5. Growth and Phased Development E6. Circulation and Open Space Requirements 	<ul style="list-style-type: none"> H. Procurement Strategy H1. Identify Long Lead/Critical Equipment and Materials H2. Procurement Procedures and Plans J. Deliverables J1. CADD/Model Requirements J2. Documentation/Deliverables K. Project Control K1. Project Quality Assurance and Control K2. Project Cost Control K3. Project Schedule Control K4. Risk Management K5. Safety Procedures L. Project Execution Plan L1. Project Organization L2. Owner Approval Requirements L3. Project Delivery Method L4. Design/Construction Plan & Approach L5. Substantial Completion Requirements
SECTION III. EXECUTION APPROACH	

Progress

The central aim of my thesis is to take the existing scoresheet and create logic-flow diagrams that will enable the user to see how the individual pieces of the PDRI are linked. To date, logic-flow diagrams have been developed from the

following steps. The first step consisted of designing an exploratory framework from experience of the building construction process using research team expertise. Next, the prototype was distributed, analyzed, and improved upon by selected members of the research team. Currently, I'm setting up about 7 interviews with building industry professionals outside of the research team to gain feedback on my work. Once the interviews are complete, I'll write up the remainder of my thesis. The projected completion date is July 15, 1999.

Agenda of the Interview

Item	Description	Time
1	Provide a brief background on the PDRI.	15 min
2	Review most current diagrams.	10 - 25 min
3	Comment on the logic of the diagrams.	15 - 30 min
4	Discuss the potential uses of the diagrams.	15 min
5	Discuss graphical representation.	5 min

Additional Information

Construction Industry Institute
www.construction-institute.org

PDRI Virtual User Group
www.cii-pdri.org

Appendix F: Interview Summaries

Tom Howard Project Manager Beck Program Management
Perry Lorenz Commercial and Investment Real Estate
Mike Managan, AIA Vice President, 3D/International
Darrel McGehee, AIA Director of Design-Build Beck Group
Jeff Pace Vice President, CarrAmerica
Kirby W. Perry, AIA Instructor, UT School of Engineering
Steve Ross, MSAS, BBA Lecturer, UT School of Architecture

The following notes are transcripts of the interviews in chronological order (does not correspond to the above listing).

Interview A

Background of interviewee:

Experience across a broad spectrum of real estate and land development. Very knowledgeable about published material on architecture/design/development.

Notes on Agenda Items

1. PDRI Background

This was the first exposure to CII and the PDRI. Initial discussion about flexibility/complexity. Seems like the PDRI would try to eliminate this. Maybe the architect/designer should try to 'design in' flexibility.

2. Diagram Review

The legend is helpful. Might consider putting it on every page.

3. Diagram Logic

From an architect's perspective, program exists at inception and is present until conclusion. Didn't see any glaring errors.

4. Potential Uses

Scoring the PDRI has the potential to facilitate communication within the project team. We discussed the 'gate' concept of the PDRI. He thought it would be especially useful at the corporate level.

5. Graphical Representation

Understandable, but I should read Tufte's book. It might help display the continuous iteration in the process. Color is helpful.

Conclusion:

He suggested I try to meet with Larry Speck, Andy Vernoooy, and Steven Moore. He thought Larry would be particularly interested in the diagrams since he spends time educating public/private entities about the building process. Also, Robert Poth, builder/contractor/developer, would be a knowledgeable person. Applicable text includes: Ranko Bon, "Building as an Economic Process" and Edward Tufte, "Visual Display of Information".

Interview B

Background of interviewee:

20 years with engineering corporation. Started as a field engineer. About 10 years experience with CM. Projects include highrise, campus, interior finish and overseas. Both public and private ventures.

Notes on Agenda Items

1. PDRI Background

Has experience with the PDRI. Not much time spent on the introduction.

2. Diagram Review

We went over all three levels of the diagrams. No major issues.

3. Diagram Logic

Didn't point out any major logic deficiencies. A couple questions regarding terminology having to do with site selection.

4. Potential Uses

Uses include owner education, budgeting and an 'exercise' for project team communication.

5. Graphical Representation

He thought the diagrams should be bordered. Also, if possible, the font should be increased. He also identified two graphical corrections I have already made.

Conclusion:

The interview was very productive. We discussed using the PDRI and LFD diagrams from a CM/program management point of view. In order to be successful, the tools must help achieve the owner's needs. Specifically, the LFD diagrams should help the user understand how the PDRI links together.

Interview C

Background of interviewee:

Bachelor's and Master's in Architecture from Rice University. Extensive experience in programming and master planning.

Notes on Agenda Items

1. PDRI Background

He had heard of the PDRI and was familiar with the terminology.

2. Diagram Review

Stick with color. Diagram should be labeled throughout. Elements should be numbered according to their placement in the chart.

3. Diagram Logic

Overall, he thought the logic was sound. A couple of questions involving site selection.

4. Potential Uses

Refine scope of work, educate the client, checklist to make sure everything is done. Probably most applicable with corporate clients.

5. Graphical Representation

Need to focus on pattern recognition.

Conclusion:

Overall, he thought the diagram's logic was sound. The diagrams should help the PDRI user understand the influences of each line item.

Interview D

Background of interviewee:

Commercial developer who has spent time selling real estate, land speculating and teaching auto mechanics.

Notes on Agenda Items

1. PDRI Background

He was neither familiar with the PDRI nor the terminology.

2. Diagram Review

We went over the diagrams in limited detail. If the user has problems with the terminology, the diagrams don't mean too much.

3. Diagram Logic

Good. We talked about the importance of the business decision.

4. Potential Uses

He thought the diagrams would help the client understand the process to build a facility. In his spectrum, the developer is concerned about the government constraints and the customers' demands.

5. Graphical Representation

Good.

Conclusion:

He thought the diagrams would be useful to those individuals/entities that thrive on structure. From his perspective, the architect could use the diagrams to help educate the client.

Interview E

Background of interviewee:

Large amount of industry and academic experience including work as an expert witness involving code compliance, consulting and design.

Notes on Agenda Items

1. PDRI Background

Familiar with the PDRI so we didn't spend too time on intro material.

2. Diagram Review

We went over all the LFD's. Overall, he thought the presentation was readable. Maybe the elements should be numbered how they appear?

3. Diagram Logic

He thought the logic was sound. We discussed several areas he thought could be different depending on how you approached the process. No big changes

4. Potential Uses

We discussed uses of the LFDs and the PDRI including use as a tool for and budgeting, and as a checklist for the architect/client.

5. Graphical Representation

Good.

Conclusion:

The interview with was productive. We discussed A/E services from his perspective as A/E business owner on projects mostly from \$1M to \$5M. As far as pre-project planning, he does a 'mental PDRI' with the client to build a long-lasting relationship. We also discussed other related issues such as owner's self image, market drivers, disposal influencing design, codes, politics, and the danger of scoring a project too early.

Interview F

Background of interviewee:

Vice President of major corporation responsible for the Austin market. BS from UT at Austin and an MBA from UT at Arlington. Extensive experience in real estate marketing. Currently working on a proposed 23 story office building in downtown Austin.

Notes on Agenda Items

1. PDRI Background

He had neither seen nor heard of the PDRI.

2. Diagram Review

3. Diagram Logic

4. Potential Uses

5. Graphical Representation

Conclusion:

Hard for a real estate professional to pick up the LFDs and use them. Probably the largest hurdle to overcome is the terminology.

Interview G

Background of interviewee:

Bachelors and Masters of Architecture from Oklahoma State University. Lots of program management including extended experience with both Southwestern Bell and AT&T

Notes on Agenda Items

1. PDRI Background

He was familiar with the PDRI and the terminology.

2. Diagram Review

Overall, he thought the diagrams were well put together. This was the first time any of the interviewees had seen all the elements on one page. He thought the elements should be numbered like they appear on the diagrams.

3. Diagram Logic

He had suggestions about reorganizing the Building Programming category. We discussed other items such as the true starting point of 'program' and what reliability philosophy encompassed.

4. Potential Uses

We didn't discuss potential uses other than those I laid out as part of the introduction for the interview. He showed me a couple planning process diagrams from other companies.

5. Graphical Representation

Overall, pretty good but he had some comments aimed at making the big element diagram easier to understand.

Conclusion:

The interview went very well. The interviewee's experience and familiarity with the PDRI made for a meaningful discourse and in depth analysis of the entire set of diagrams. I've recorded his specific recommendations about changes and will go over them with Dr. Gibson.

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Vita

Jeffrey Clinton Furman was born in Yuma, Arizona on August 6, 1972, the son of John Edward Furman and Janet Ruth Furman. He graduated from New Bern Senior High School in 1990 and accepted an appointment to the United States Naval Academy. In 1993, he left the Naval Academy and worked for Fluor Daniel before resuming his studies at North Carolina State University. He graduated Magna Cum Laude with a Bachelor of Science in Civil Engineering in May 1995. After attending Officer Candidate School, he was commissioned as an Ensign in the US Navy's Civil Engineer Corps in September 1995. In January 1996, he assumed duties as the Public Works Production Officer at Naval Air Station Key West, Florida. In August 1998, he entered The Graduate School at the University of Texas.

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