Design Engineer's Role in Managing Front End Planning Information

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Abstract

The front end planning process is known to be fundamental to project success. Successful planning, as the shared responsibility of a project team, is dependent on the provision of information that is complete, correct, and timely. Numerous authors have described the process and statistically validated its relevance and importance. However, few investigations have been conducted on the subject of how early project information is actually managed through the planning process. This paper summarizes a two-phased research investigation that examines how information supports the front end planning process. Based on the expertise of a group of industry members from major owner and contractor organizations, an extended front end planning process model is first developed. Based on surveyed data and through the front end planning activities in the process model, this research indicates engineers play an important and integral role in front end planning and therefore have significant influence on the likelihood of project success. Also, the information requirements for front end planning efforts leading to successful projects are indicated, and the front end planning activities for which information is commonly non-available are also identified.

Keywords: engineering, construction, front end planning, project management

1. Introduction

The process of planning the design and construction of large commercial and industrial capital facilities is both information intensive and information dependent. Additionally, the design and construction process may also be characterized as being both multi-disciplinary and multi-organizational. Given these inherent complexities, it is no surprise that the construction engineering industry faces enormous challenges in any attempt to create an uninterrupted, error-free flow of project information and data across such a high number of organizational boundaries. However, it is readily acknowledged that when the communication of information is timely, unambiguous, and easily understood, downstream activities are more efficiently and effectively performed.

As such, the identification and removal of process barriers to a seamless flow of information will likely benefit all measures of project performance.

All project planning and design activities, either directly or indirectly, interact with information. Participants may generate information, modify or amend information, utilize information, validate it, or transmit it to other project team members. Information may be formal or informal and may be stored in computer databases, filing cabinets, print rooms, text messages, email attachments, or simply kept in the minds of individuals. Information may be captured manually or automatically. It may be shared electronically in integrated systems, communicated in an unread email, transferred by word of mouth, conveyed graphically in a drawing, exist buried in a complex written document, or lost in the notes scribbled on a file folder or meeting minutes. Regardless of whether these methods are considered good or poor examples of information management, they are all common in the design and construction process of capital facilities. In reality, information has its own life and exists in various forms throughout the project lifecycle.

Information management is not a process with an easily defined beginning and end. It is a continuous process intrinsic to the normal workflow of a company. The process of managing any one piece of information begins when that information is created internally or introduced from an outside source. The management process continues as that information is shared and used. Unfortunately, it is often the case that as information is shared across functional, disciplinary, or organizational boundaries, there are significant efficiency losses resulting from utilizing information that is late, inadequate, incomplete, or erroneous. The ultimate goal of this research was to identify how supervisory design engineers can positively influence information management during the process of front end planning.

2. Background

Front end planning is dependent on gathering sufficient information to ensure project success and is considered an important process in capital project delivery. Cleland and Ireland (2002) expand upon this by stating that front end planning is the process of thinking through and making explicit the objectives, goals, and strategies necessary to bring the project through its life cycle to a successful termination when the project's product, service, or process takes its ultimate place in the execution of project owner business strategies. While there are different definitions or varied vocabulary employed in discussions of front end planning, most authors agree that it is a key element to overall project success (Gibson et al. 1995, Smith 2000, and Hartman and Ashrafi 2003, Webster 2004). Cleland and Ireland (2002) identify that decisions made early in the project process will, "…set the direction and force with which the project moves forward as well as the boundaries within which the work of the project team is carried out." Previous research has demonstrated that effective front end planning increases the likelihood of improved overall project performance (Hamilton and Gibson 1996; Johansen and Wilson 2006, Weerasinghe et al. 2007; Wang and Gibson 2010).

Of particular interest is an investigation into the role of design engineers in a well executed front end planning process. Often a design engineer operates within an engineering design discipline for which she/he has particular education, training, and professional practice experience and responsibility. Typically, such design engineers provide the management, coordination, leadership and strategic direction for respective discipline activities on assigned projects. Although the technical responsibilities and duties of discipline design engineers may be understood, their role in the front end planning process is not well defined. However, it is acknowledged by nearly every project participant that the design engineers have a key role in the creation and dissemination of project information. The project information may be in the form of discrete data or formatted data into documents. However, inasmuch as the design process is iterative, the information is in a constant state of movement and change.

So how is information managed during the front end planning process? What is the role of the design engineer and how do they contribute to the overall planning process? Back and Moreau (2001) state that information management is, "the use of all agency personnel, processes, policies, and technologies that define and comprise the information infrastructure in order to coordinate the use on information from the time it is created until it is no longer useful and eliminated." Krings and Hantikainen (1996) identify that an effective information management system allows users to compile, access, and analyze critical information in an efficient manner. In other words, information management is a system to control the information resources of a company.

Often, engineers spend countless hours locating, deciphering, and using information. Every time information is used, company resources are consumed and time is expended (Back, Moreau, and Toon, 1996). Furthermore, when information is used, accessed, or manipulated, such information may result in new information. Without an effective information management system, information has the potential to be lost or misused. Therefore, it is imperative that information is managed in a manner to allow quick dissemination by the users. Furthermore, Gelle and Karhu (2003) has stated that businesses are receiving too much information that is scattered, unreliable, and obsolete. They also cite work by Marien (1999) that this oversupply of useless information results in a decreased value of the information. Several authors have validated the concept that good decisions, and hence good engineering, is predicated on project based information that is generated, manipulated, shared, revised, and managed by engineers within their respective project teams (Walker and Shen 2002, Oloufa et al. 2004, Menches et al. 2008).

3. Objectives

We sought to find an improved understanding of the contributing role of discipline design engineers in managing the flow of information in the front end planning process. Additionally, we sought to identify how information management practices can be improved to optimize the front end planning efforts that are already encouraged and/or recommended within the industry. In order to achieve these objectives, the following research steps were defined:

- Identify the information requirements for the principal front end planning activities and to document their interrelationship.
- To better define the responsibilities of discipline design engineers in the execution of a robust front end planning process.
- Suggest recommendations for improving information flow to support front end planning by identifying activity requirements critical to planning success and by communicating areas of engagement and opportunity for design engineering.

4. The Front End Planning Process Model

Previously published project planning research by the authors (Back and Moreau 2000, CII RR # 125-11, 1998) presented a logic driven process model for the project planning process. The baseline model (1998) consists of 30 activities identifying the steps required to successfully execute project planning. This diagram was utilized as a baseline for the research reported herein and was updated to reflect current planning techniques and practices. A research team comprised of 12 industry practitioners, representing both contractor and owner organizations, worked with three academics to revise the front end planning model. The revised model consists of 33 distinct activities within the front end planning process. The 33 activities are identified in Table 1.

Table 1. Information flow activity list

BP Business Plan	
BP.01	Define Business Plan
BP.02	Identify/Select Project Alternatives
BP.03	Conduct Market Research and Analysis
BP.04	Establish Image and Public Relations
BP.05	Finalize Project Alternative
BP.06	Address Regulatory Issues
BP.07	Develop Funding Plan
BP.08	Raw Material Sourcing/Source Building Materials
BP.09	Develop Labor Plan and Address Human Resource Issues
BP.10	Define Start-Up Requirements
BP.11	Risk Mitigation Analysis
BP.12	Refine Public Relations
CS Contracting Strategy	
CS.01	Develop Contract Strategy
CS.02	Develop Bid Package
CS.03	Review Potential EPC Contractor Bidders
CS.04	Select EPC Contractor Team
PP Project Execution Plan	
PP.01	Develop Preliminary Design Criteria, Including PFD's and P&ID's
PP.02	Formulate Preliminary Organization
PP.03	Complete Preliminary Estimates
PP.04	Establish Master Project Schedule
PP.05	Address Quality and Safety Issues
PP.06	Develop Preliminary Execution Plan
PP.07	Compile Project Scope
PP.08	Develop Start-Up Plan
SD Site Development Plan	
SD.01	Process and Facility Planning
SD.02	Develop Utilities and Offsite Scope
SD.03	Develop Environmental Scope
SD.04	Develop Site Plan
SD.05	Detail Work Breakdown Structure
TP Technical Plan	
TP.01	Conduct Technical Surveys and Process Analysis
TP.02	Product Development/Identify Certification and Testing Procedures
TP.03	Obtain License Agreements
TP.04	Establish Security and Secrecy Agreement

Figures 1a-1c present the updated front end planning process model as an activity based logic diagram (the model is one continuous logic model divided into three sections for illustration purposes). The model is based upon Critical Path Method (CPM) logic and can be explained as follows:

- Each box represents an activity
- Logic flow is identified by the arrows. Flow is from left to right.
- An activity cannot be executed until all predecessor activities have been completed.
- Activities may be executed in parallel if all predecessor activities have been completed.

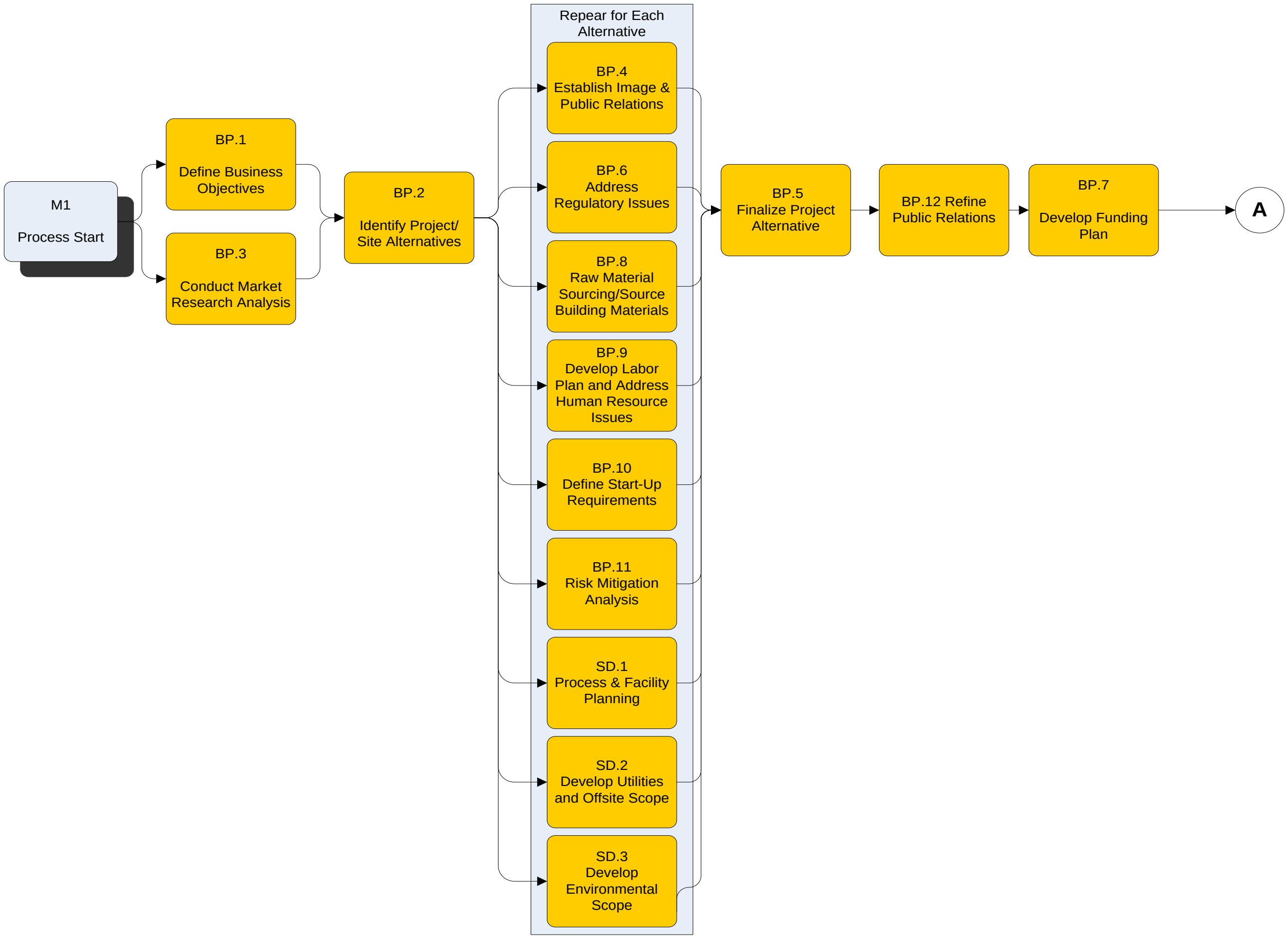

Figure 1a. Project planning process model

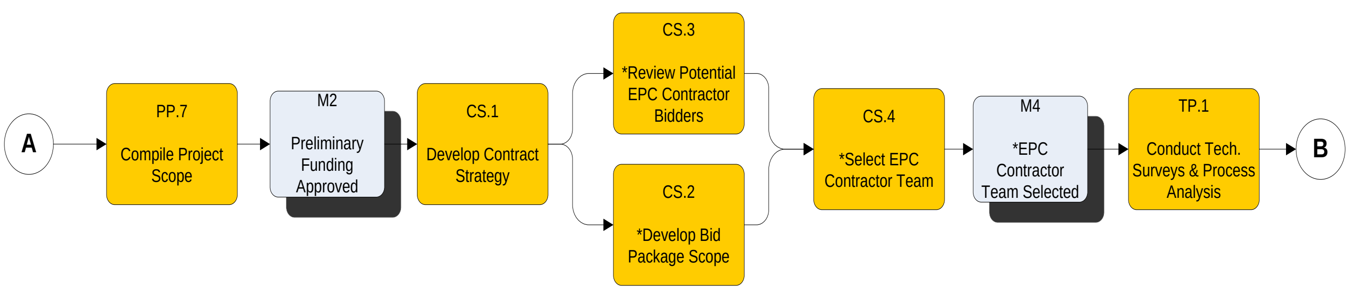

Figure 1b. Project planning process model

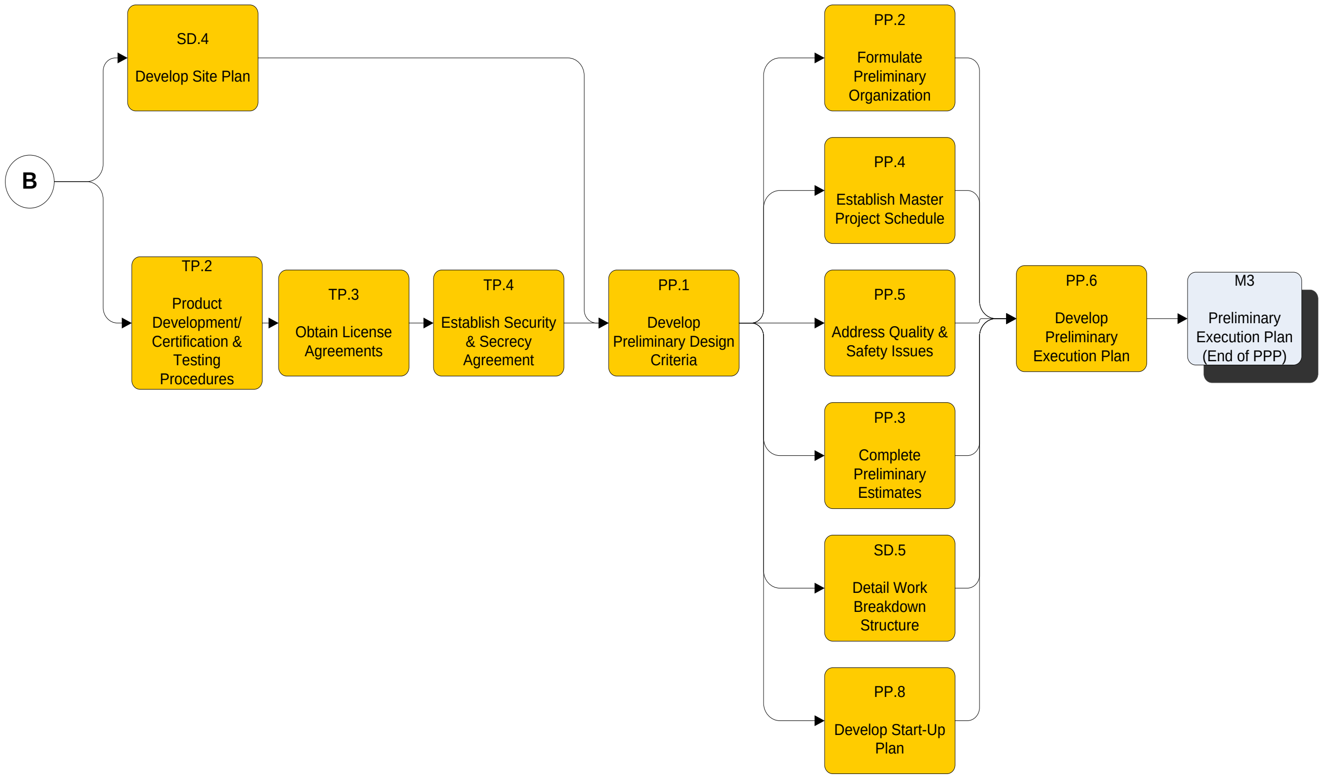

Figure 1c. Project planning process model

The Front End Planning logic diagram consists of the broad categories of Business Plan, Contract Strategy, Project Execution Plan, Facility Scope Plan, and Product Technical Plan. Additionally, each category is associated with an identification code to allow for easier referencing when performing the data analysis. Milestones are depicted to indicate the progressions through the planning process and are not identified themselves as an activity. Activities associated with the Business Plan have the identifier BP, CS for Contract Strategy, PP for Project Execution Plan, SD for Facility Scope Plan, and TP for Product Technical Plan.

The Business Plan, or strategic plan, involves the goals and objectives of a business entity. The activities included in this category help to provide a comprehensive structure to identify the business objectives of the company, and to ensure that the project(s) is in line with these objectives.

The Contracting Strategy category is comprised of the activities needed to identify the contract strategy to execute the project. This plan reviews the business and project objectives, identifies any partnerships the company is involved with, and selects contractors and/or service providers. Activities may also include the creation of a list of potential bidders for execution of the project.

The Project Execution Plan is a detailed plan identifying how the project will be executed once approved. Information related to the estimate, schedule, execution strategies, start-up plans, and safety plans are addressed by activities within this category.

The Facility Scope Plan is the category of activities which addresses the identification of necessary components needed during the design phase (which starts after front end planning). The scope of work for the facility and engineering services are documented. Additionally, utility requirements are identified, governmental environmental restrictions documented, and the initial site plan formed. The generation of Work Breakdown Structures (WBS) is also included. The final category of front end planning activities is identified as those related to the creation of the Product Technical Plan.

These activities identify the technical requirements of the project and include the identification of license agreements, testing procedures, and any security/secrecy requirements that may be needed for the project. These activities are more commonly executed on industrial projects, but have applicability in other types of construction.

5. Information Requirements for Front End Planning

A survey instrument was created and distributed to project professionals and key managers within large owner and contractor companies. Survey respondents were asked to identify the overall duration (in days) it took to complete each activity for an individual project. Similarly, the number of internal man hours and external (contractor or external source) man hours expended to complete the activity were also collected. These questions were specifically designed to capture the time (duration) and resources (labor hours) required to complete project planning for any given project. It should be noted that this data collection process was relatively lengthy and detailed and required direct facilitation by the research team and considerable preparation by the survey respondents.

In order to separate the data into positive and negative response samples, the survey asked if project planning was successfully executed for the project. Projects indicating they were successfully planned were placed into the positive response sample. Similarly, non-successfully planned projects were identified and placed into the negative response sample. 51 respondents contributed to this research. In some instances, the same company provided several project surveys from differing projects. The surveys contained information from projects summing to a value exceeding $2.9 billion in total installed costs. The distribution for the project total installed costs (TIC) is depicted in Figure 2. As illustrated, the majority of the projects are in the $10-50 million dollar range. In addition, the distribution identifies that the sample was distributed among varying project costs.

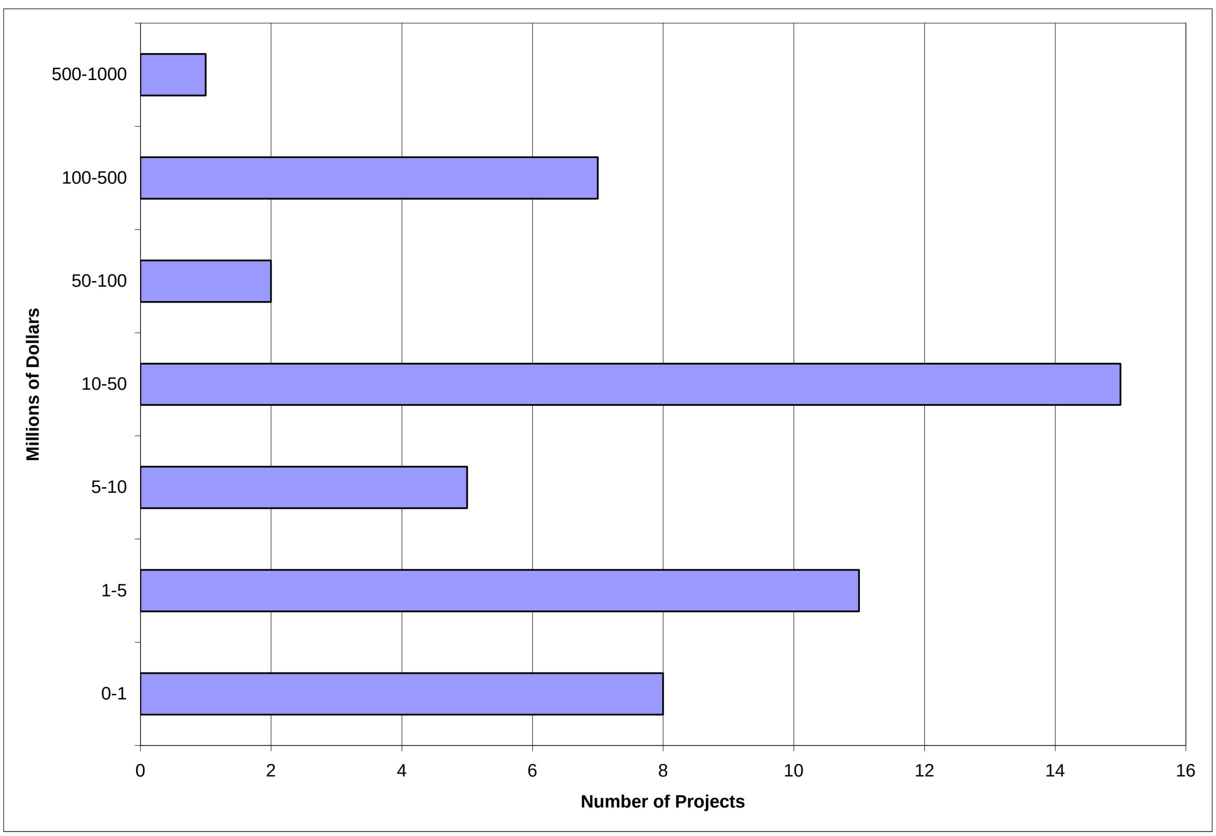

Figure 2. Distribution of projects by total installed cost

All market sectors are represented within the database of project surveys. However, the majority of the surveys are from industrial / manufacturing projects. The distribution of the project sectors is illustrated in Figure 3. Additionally, the types of construction were divided between new construction projects and maintenance / renovation / retrofit type projects. There was a small percent of projects that were a combination of the previous two groups. This is more clearly illustrated in Figure 4.

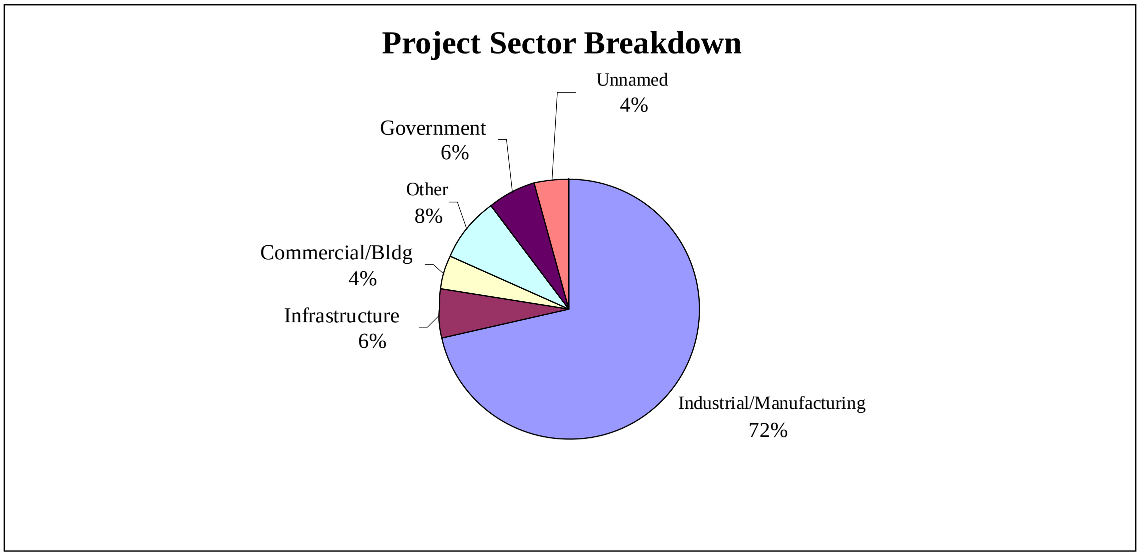

Figure 3. Distribution of projects by industry sector

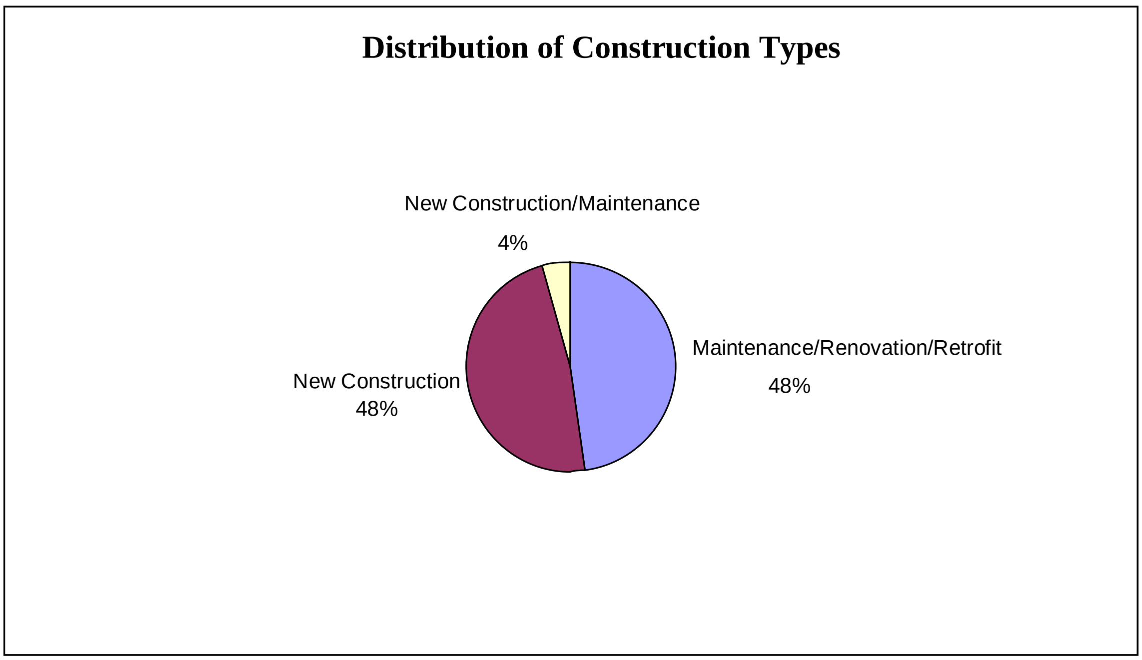

Figure 4. Distribution of projects by construction type

The projects evaluated in this research all vary in cost, and duration of front end planning. It was evident through analyzing the data that the surveys needed to be normalized to allow comparison of differing sized projects; the time and resource requirements to perform front end planning on a $20 million project would be different than a $150 million project. The process for normalization involved summing up the total value for each of the quantitative data values from all 33 activities. Next, the individual value for a particular activity was divided by the total time. This provided the percent effort value for the specific activity. For example, if the total elapsed time for the entire project planning process from one survey equals 100 days, and one activity has a single duration of seven days. Then, the normalized value is 7/100 or 7% perceived effort. This process was repeated for all internal and external resource values. All the data values identified were presented in percent effort of the total planning process. In other words, the values analyzed represented the amount of time (in percent) needed to complete each activity. Once the data were normalized, the mean values for the duration, internal resources expenditure, and external resource expenditure was calculated for the two samples for each activity. Then, a standard T-Test identified which activities have statistically different mean values.

A level of significance of 0.05 (ά = 0.05), was used to determine which means were significantly different.

The statistical analysis identified seven front end planning activities that are particularly critical to achieving overall project success. Originally reported in an article by George et al. (2008), seven important front end planning activities were identified by statistically correlating them to several measures of project success criteria. The statistical analysis was the first step of a multi-year research project. Additional activities, not yet reported, include a detailed process diagramming effort of information flow patterns at high levels of detail; and the creation of an interactive database software program that provides users with the capability of tracking important front end planning data and documents. To establish continuity in the discussion, it is important to recap a few significant findings from the earlier publication (George et al. 2008). As noted, certain activities were identified as being statistically significant in comparing successful vs. less successful projects. Seven critically important front end planning activities are known to be:

- BP.04 Establish image and public relations
- BP.10 Define start-up requirements
- BP.12 Refine public relations
- PP.05 Address quality and safety issues
- PP.06 Develop preliminary execution plan
- PP.07 Compile project scope
- SD.02 Develop utilities and offsite scope

However, in an attempt to better comprehend the overall data set, and to extend the research to a new level of understanding, a number of additional data queries have been completed. Table 2 lists the most utilized information documents used during the front end planning process as indicated by the data.

Table 2. Most utilized information requirements

No.	Activity	Description	Number of Activities that Utilize the Information	Percent Used
1	BP.5.7	Final Project Objectives List	15	45%
2	BP.1.14	Business Objectives Letter	13	39%
3	PP.7.6	Preliminary Project Scope	13	39%
4	BP.2.6	Project Alternatives Report	11	33%
5	SD.2.8	Utilities & Offsite Scope Document	10	30%
6	SD.1.12	Process & Facility Planning Scope	9	27%
7	BP.11.8	Risk Management Plan	7	21%
8	SD.1.13	Conceptual Schedule & Estimate Document	7	21%
9	SD.3.19	Environmental Scope	7	21%

The data also showed conclusively that successful projects tend to spend more, not less, time on front end planning activities. Several activities had significantly longer durations than the less successful projects and still others acknowledged a high dependency on outside (contractor) resources to achieve success (George et al. 2008). A disappointing finding was that it is not uncommon for necessary front end planning information to be missing, unavailable, or inadequate. Table 3 identifies the activities that most commonly experienced an information need that was unfulfilled (George et al. 2008).

Table 3. Activities for which information is mostly unavailable

Activity	Percent responding information was not readily available
BP.07 Develop Funding Plan	49
PP.03 Complete Preliminary Estimates	43
BP.02 Identify Project Alternatives	43
PP.01 Develop Preliminary Design Criteria	41
SD.01 Process and Facility Planning	41
BP.01 Define Business Objectives	39
PP.06 Develop Preliminary Execution Plan	39

Another finding of the research was that much of the front end planning documentation is generated by, shared, modified, or utilized by contractor personnel. Most notably, it was evident from the data that the discipline design engineer is integral to a successful front end planning process.

6. Role of the Discipline Design Engineer in Front End Planning

For purposes of this discussion, a discipline design engineer (DDE) is defined as being in a management role within a contractor organization that engages in engineer, procure, and construct (EPC) projects. Discipline design engineers are at the level where technical knowledge, management, and communication skills are essential tools to effectively complete project roles. The DDE is focused on one engineering discipline area within a specific project and is tasked with managing a group of engineers in the same discipline. Items such as meeting budget, schedule, and quality targets are each large components of the DDE's profession. Moreover, the DDE provides management, coordination, leadership, and strategic direction for respective discipline activities on assigned projects. The DDE must complete all activities with high regard to cost, innovative engineering service, safety standards, and schedule to meet the goals and objectives of the company. In this research, six individual design disciplines were considered. These are:

- Architectural, Civil, Environmental, and Structural (ACES)
- Electrical
- Instrumentation and Controls (I&C)
- Mechanical
- Piping, and
- Process.

A total of 75 discipline design engineers were surveyed and a total of 47 surveys were completed, providing a 63% response rate for the analysis. The respondents represented the six core engineering disciplines previously listed and had a range of professional experience from 4 to 35 years. The engineers were located in different regions of the United States. The breakdown by discipline can be seen in Figure 5.

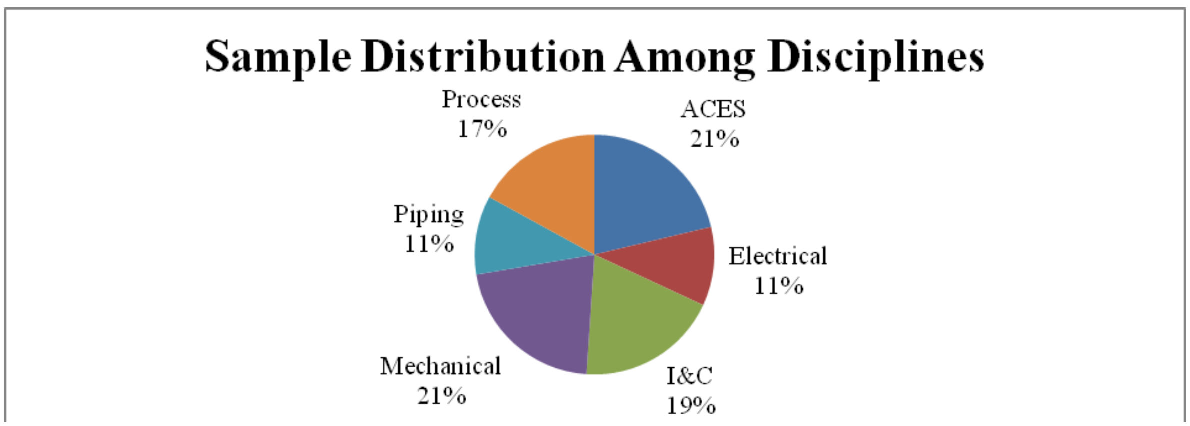

Figure 5. Distribution of participants by engineering discipline

The survey respondents were asked to individually assess their level of participation in the various phases of the front end planning process. Rather than focus on information exchange activities per se, this model identifies the key steps in the process in a categorical and hierarchical organization. The front end planning process is defined as having three principal phases, namely the feasibility, concept and detailed scope phases. Of interest here is that the model assumes a multi-disciplinary approach to front end planning. The feasibility phase is the first phase of the front end planning process. The primary objectives of this phase are to define business objectives, identify potential alternatives, and to outline steps and resources necessary to continue concept phase development. Its primary output is a decision about whether the potential project is economically and technically feasible for the organization. It is also known as business planning, and strategic planning (CII, 2006). The concept phase is the second phase of the front end planning process. It is primarily concerned with defining, evaluating, and selecting the best alternative(s) for site, technology, and acquisition strategy. It is also known as alternative selection, conceptual design, and programming (CII, 2006).

The detailed scope phase is the third phase of the project front end planning process. The primary objectives of this phase is to define the technical scope of the project, further develop project execution plans, and develop a definitive cost estimate and schedule suitable for project authorization for detailed design and/or construction. Its primary output is the design basis for the facility. It is also known as schematic design and design development, scope finalization, preliminary engineering, definition phase, and sanctioning process (CII, 2006). These three phases are outlined by CII and given in Table 4 and Table 5.

Table 4. Front end planning outline: feasibility phase and activities

Phase	Activity	Detailed Activity
Feasibility		
	F.1 - Initiate Phase	
		1. Understand Alignment
		2. Understand Business Objectives
		3. Understand project assumptions
		4. Generate early design basis and parameters
	F.2 - Generate Options	
		1. Generate Assumptions/Drivers
		2. Generate Alternatives for Site(s)
		3. Generate Alternatives for Technology
		4. Generate Reliability, Maintainability, and Operability Guidelines
		5. Generate Intellectual Property
		6. Prepare Initial Feasibility Scope
		7. Develop Order of Magnitude (OOM) Estimate / Schedule
	F.3 - Filtering Options	
		1. Develop Economic Model
		2. Develop Funding Strategies
		3. Consider Significant Risks
		4. Develop Initial Roles and Permit Analysis
		5. Develop EHS Considerations
		6. Develop Go/ No-Go Analysis
		7. Develop Sensitivity Analysis
	F.4 - Develop Recommendation Report	

Table 5. Front end planning outline: concept and detailed scope phases and activities

Phase	Activity	Detailed Activity
Concept		
	C.1 - Initiate Phase	1. Understand Team Alignment 2. Review and Understand Business Objectives 3. Validate project assumptions 4. Review design basis
	C.2 - Analyze Alternatives	1. Review and Identify Alternatives 2. Analyze Site Alternatives 3. Analyze Acquisition strategies 4. Analyze Technology 5. Identify Short List of Alternatives
	C.3 - Develop Conceptual Scopes and Estimates	1. Develop Conceptual Scopes 2. Develop Conceptual Estimates
	C.4 - Evaluate and Select Best Alternatives	
	C.5 - Develop Concept Phase Report	
Detailed Scope		
	S.1 - Initiate Phase	1. Understand Team Alignment 2. Review and Understand Business Objectives 3. Validate project assumptions 4. Review conceptual design basis
	S.2 - Develop Preliminary Design/Engineering	
	S.3 - Develop Preliminary Design/Engineering Review	
	S.4 - Finalize Scope Definition Package	
	S.5 - Develop Cost and Schedule Control Estimate	
	S.6 - Compile Project Definition Package	1. Compile Project Definition Package 2. Compile Authorization Package 3. Prepare Oral presentation

For each step in the front end planning model, the survey participants were asked to identify their perceived level of involvement in the process. The potential responses and the corresponding numeric value for the survey are as follows: 1 = *Very Little*, 2 = *Little*, 3 = *Moderate*, 4 = *Much*, and 5 = *Very Much*. The mean, median, and mode values were calculated and analyzed. The researchers found it useful to present the information as "box whisker" plots. The box whisker plots illustrate the lower quartile, minimum, median, maximum, and upper quartile values. It is fairly evident that the respondents have differing views on their involvement in the front end planning process by observing the skewness and dispersion within the data set. Figures 6 and 7 illustrate the findings from the DDE surveys. Tables 6 and 7 present the design discipline summary by front end planning activity.

Table 5. Feasibility phase: level of DDE's involvement matrix

Category/Statistical Method	Group	ACES	Electrical	I&C	Mechanical	Piping	Process
Feasibility							
F.1 - Initiate Phase							
1. Understand Alignment	Much	Much	Much	Moderate	Much	Moderate	Moderate
2. Understand Business Objectives	Moderate	Much	Moderate	Moderate	Moderate	Moderate	Moderate
3. Understand project assumptions	Much	Very Much	Much	Much	Very Much	Much	Much
4. Generate early design basis and parameters	Very Much	Much	Very Much	Much	Very Much	Moderate	Very Much
F.2 - Generate Options							
1. Generate Assumptions/Drivers	Much	Much	Very Much	Moderate	Much	Much	Much
2. Generate Alternatives for Site(s)	Moderate	Very Much	Much	Moderate	Moderate	Moderate	Much
3. Generate Alternatives for Technology	Much	Moderate	Much	Moderate	Much	Much	Very Much
4. Generate Reliability, Maintainability, and Operability Guidelines	Much	Moderate	Much	Moderate	Much	Much	Much
5. Generate Intellectual Property	Moderate	Moderate	Much	Moderate	Much	Little	Moderate
6. Prepare Initial Feasibility Scope	Much	Much	Much	Much	Much	Much	Much
7. Order of Magnitude (OOM) Estimate/Schedule	Much	Much	Very Much	Much	Much	Very Much	Moderate
F.3 - Filtering Options							
1. Develop Economic Model	Little	Little	Moderate	Little	Little	Little	Moderate
2. Develop Funding Strategies	Little	Little	Moderate	Little	Little	Little	Little
3. Consider Significant Risks	Much	Much	Much	Moderate	Much	Moderate	Much
4. Develop Initial Roles and Permit Analysis	Moderate	Much	Much	Moderate	Moderate	Little	Moderate
5. Develop EHS Considerations	Moderate	Moderate	Much	Moderate	Much	Moderate	Much
6. Develop Go/ No-Go Analysis	Moderate	Much	Moderate	Little	Moderate	Little	Moderate
7. Develop Sensitivity Analysis	Moderate	Moderate	Moderate	Little	Moderate	Little	Much
F.4 - Develop Recommendation Report	Moderate	Moderate	Moderate	Little	Moderate	Much	Much

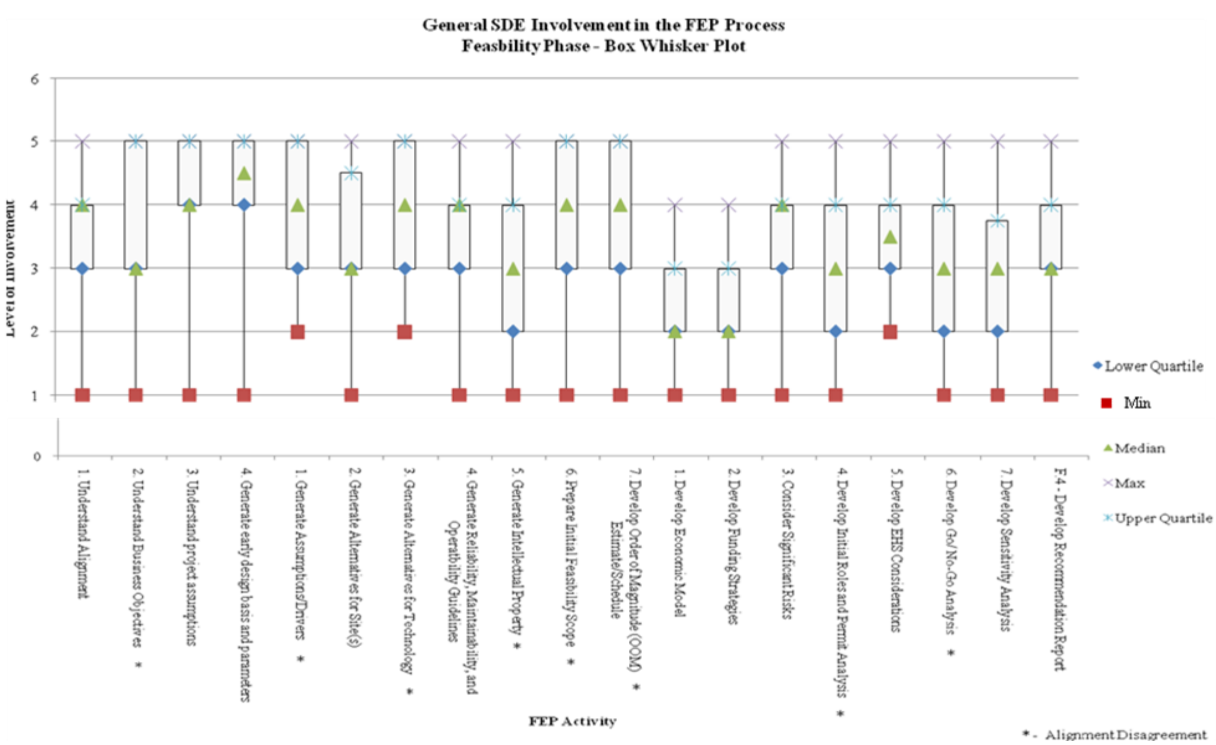

Figure 6. Feasibility phase: level of DDE's involvement box whisker plot

Table 6. Concept and detailed scope phases: level of DDE's involvement matrix

Category/Statistical Method	Group	ACES	Electrical	I&C	Mechanical	Piping	Process
Concept							
C.1 - Initiate Phase							
1. Understand Team Alignment	Much	Very Much	Much	Much	Very Much	Much	Much
2. Review and Understand Business Objectives	Much	Much	Moderate	Moderate	Much	Much	Moderate
3. Validate project assumptions	Much	Very Much	Very Much	Much	Much	Much	Much
4. Review design basis	Very Much	Very Much	Very Much	Much	Very Much	Much	Very Much
C.2 - Analyze Alternatives							
1. Review and Identify Alternatives	Much	Much	Very Much	Much	Much	Much	Very Much
2. Analyze Site Alternatives	Moderate	Very Much	Much	Moderate	Moderate	Much	Moderate
3. Analyze Acquisition strategies	Moderate	Moderate	Much	Moderate	Moderate	Much	Moderate
4. Analyze Technology	Much	Very Much	Much	Much	Much	Much	Very Much
5. Identify Short List of Alternative(s):	Much	Much	Much	Much	Very Much	Much	Very Much
C.3 - Develop Conceptual Scopes and Estimates							
1. Develop Conceptual Scopes	Much	Much	Very Much	Much	Much	Much	Much
2. Develop Conceptual Estimates	Much	Much	Very Much	Much	Much	Much	Moderate
C.4 - Evaluate and Select Best Alternatives	Much	Much	Very Much	Much	Much	Much	Much
C.5 - Develop Concept Phase Report	Much	Moderate	Much	Much	Much	Much	Much
Detailed Scope							
S.1 - Initiate Phase							
1. Understand Team Alignment	Very Much	Very Much	Very Much	Very Much	Very Much	Very Much	Much
2. Review and Understand Business Objectives	Much	Much	Very Much	Much	Much	Very Much	Moderate
3. Validate project assumptions	Very Much	Very Much	Very Much	Very Much	Very Much	Very Much	Much
4. Review conceptual design basis	Very Much	Very Much	Very Much	Very Much	Very Much	Very Much	Very Much
S.2 - Develop Preliminary Design/Engineering	Very Much	Very Much	Very Much	Very Much	Much	Very Much	Very Much
S.3 - Develop Preliminary Design/Engineering Review	Very Much	Very Much	Very Much	Much	Very Much	Very Much	Very Much
S.4 - Develop Finalize Scope Definition Package	Very Much	Very Much	Very Much	Very Much	Much	Very Much	Much
S.5 - Develop Cost and Schedule Control Estimate	Much	Much	Much	Very Much	Very Much	Much	Moderate
S.6 - Compile Project Definition Package							
1. Compile Project Definition Package	Much	Much	Very Much	Much	Much	Much	Much
2. Compile Authorization Package	Moderate	Moderate	Moderate	Much	Moderate	Moderate	Moderate
3. Prepare Oral presentation	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

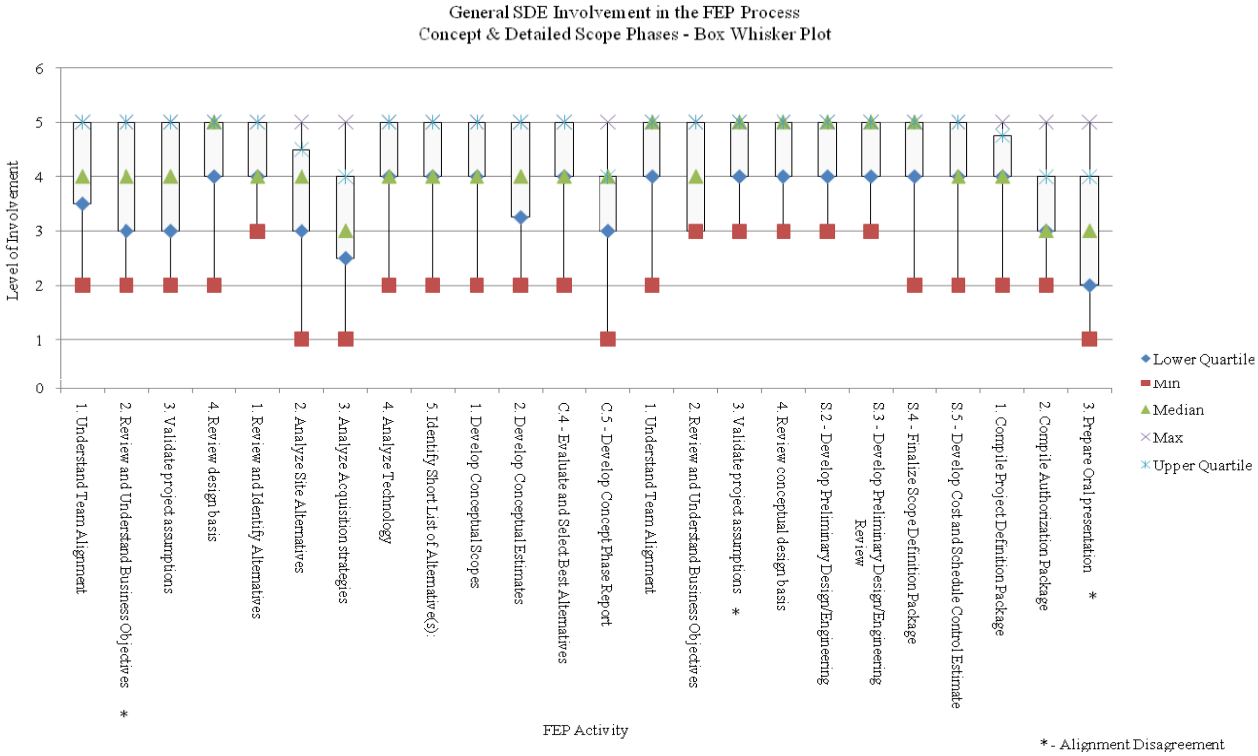

Figure 7. Concept and detailed scope phases: level of DDE's involvement box whisker plot

7. Discussion

Clearly, the front end planning process is dependent on discipline design engineering for the generation and provision of critical information. The first phase of this research involved diagramming and understanding the role information management plays in executing the front end planning process. The data indicates that there is still work to be done with frequent occurrences of inadequate or unavailable project data. Furthermore, the data leads to the conclusion that successful projects spend more, not less, time developing information. Successful projects also had a high reliance on interdisciplinary teams that engaged fully during the planning process.

As demonstrated in the second phase of the data collection, discipline design engineers understand the importance of their involvement in the process and acknowledge the comprehensive role they play. As expected, design engineers have a high level of engagement in the technical roles of discipline design activities and project scope development. This was seen in the detailed scope phase where the corresponding percentage of high involvement areas is much greater than those of the feasibility and concept phases. The general activities with lower levels of involvement were those less technical roles as seen in the data. The activities were primarily based on economics and general business in which the DDE would be generally less likely to play a leadership role. However one can be encouraged by the relatively high level of involvement that DDE's perceive they should contribute to the planning effort overall.

Another insight from this research is the potential lack of alignment between the design disciplines. As shown, there are certain front end planning activities where there is statistical disparity between perspectives regarding level of involvement. As a general statement, the data indicates that front end planning is dependent on multi-disciplinary participation. Focus should continue to be placed on the development of process models that better define the information requirements and hold participants accountable for ensuring the information is complete, correct, and timely. The front end planning process is information intensive and information dependent for success. Every participant on the project team must understand and commit to the important role they play in the complex process of project planning and execution.

8. Conclusions

Front end planning undeniably improves the probability of project success. However, the front end planning process for capital projects requires significant information to be generated that is utilized by multiple project participants across organizational and discipline boundaries. As a result, discipline design engineers should have meaningful and active involvement in the front end planning process. Their discipline expertise has influence on many project related decisions and the extent of their involvement may have fundamental influence on the effectiveness of the overall planning effort. While there are some appropriate differences between the various design disciplines as indicated in this research, all design engineers should have an active, participatory engagement with respect to supporting the planning process and should proactively manage the generation and communication of project critical planning information for which they are most responsible and knowledgeable.

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