THE STRATEGIC POTENTIAL OF DESIGN-BUILD IN THE INFORMATION AGE

by

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Submitted to the Department of Civil and Environmental Engineering in Partial Fulfillment of the Requirements for the Degree of

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ABSTRACT

Design-build while one of the oldest project delivery methods, offers a current strategic advantage in meeting changing needs of design and construction industry clients. These benefits are centered on a team focus that will create savings in the project cost and schedule. Knowledge concerning the owner's viewpoint on factors that are important to them with projects being considered for design-build, motivations for using design-build, and factors for judging success upon project completion, will offer insight to the needs of our client. The authors of the book *Competing in the Third Wave* have developed new guidelines in the area of management for future business strategies. These changes in management styles will impact the design and construction industry. These managers will be our future clients, and understanding their changing environment provides insight to their future needs as they move through a turbulent state of informational flux. The strategic potential of design-build in this changing economy is considered to offer improvements to delivering projects as well as practices within the design and construction industry. That is, with efforts from the owners, designers, and constructors, improvements will occur in supporting and enhancing a team approach to every project. It is the intent of this thesis to inform and create discussions concerning the future of the design and construction industry. This industry provides a vitally important function to our society. Discussions must be occurring at all levels throughout our industry to focus the attention in creating value-added changes in the way we deliver our services. The goals should include advancing our professional industry in a positive direction that will involve increasing our professional worth to our clients, therefore increasing our perceived value.

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1.0 Introduction

The essence of the design and construction industry, although not always the focus of conversations, is teamwork. As a highly fragmented, project oriented industry teams are formed in the beginning of every project, possibly never to be seen again, as a team, when the project is completed. The project orientation of the industry is an obvious point in which the next project will never be the same whether differing in scope, location, details, or any other facet within a project.

The design and construction industry is highly fragmented. Michael Porter, in his book *Competitive Strategy,* defines a fragmented industry as 'an industry in which no firm has a significant market share and can strongly influence the industry outcome.' (18, p.191) The fragmentation of the design and construction industry can be shown by combining the financial data from the top four contractors of the *Engineering New Record's Top 400 Contractors*[1] (20) coupled with the *U.S. Census 1998 Annual Value of Construction Put in Place in the United States* (2). The financial data for the first, second, and fourth companies on the *Engineering New Record's Top 400 Contractors* were examined[2]. This conveyed an approximation for the construction work completed in the United States for these companies in 1998. The *Engineers News Record* magazine rank these companies by construction revenue in prior year dollars. Therefore, although the ranking includes overseas projects, the three referenced companies separated out U.S. work. It was found that these organizations performed between $4.6B and $5.1B in U.S. construction for an aggregated total of $14.6B (5,6,9). The U.S. Census report titled the *1998 Annual Value of Construction Put in Place in the United States* documented $665B in construction. Therefore it is supported that 3 of the top 4 contractors in the industry only command 2.2% of the industry. Furthermore, the fragmentation is exaggerated with differing types of construction; public and private residential, industrial, commercial, institutional, utilities, and infrastructure. Finally, anyone with experience in this industry is well

[1] These top contractors typically have in-house design capabilities. Therefore, contractor is interpreted as being involved in the design and construction industries.

aware of the positive characteristic in which many small size companies can respectably win and complete projects in the design and construction industry.

Therefore, a fragmented industry with many contractors attempting to win the opportunity to complete a unique project is a fair statement. How will an owner decide how to begin the project and complete this daunting task insuring focus on finances, scheduling, and quality of the finished product among other items unique to each project? The area of project delivery methods complicates this decision by also being inundated with options. The basic delivery methods are 1) the 'traditional approach' - in recent times defined as design-bid-build with a General Contractor 2) Construction Management 3) Design-Build 4) Turnkey 5) Build-Operate-Transfer and 6) Multiple Primes. These again are the fundamental delivery methods and variations and combinations of these six methods are available, however each method of delivery being exercised in practice can be analyzed and classified under one of these main categories. (10)

This thesis will focus on the design/build delivery method. Design-Build is one of the oldest methods and it offers benefits to the owner with compatible projects. These benefits, as well as concerns, will be discussed. The owner's perspective with respect to factors that the owners perceive as important in selecting projects for a design-build delivery, the owner's motivation is using design-build, and factors judging success upon completion will be specified. The authors of the book *Competing in the Third Wave* have developed guidelines in the area of management for future business strategies. These managers will be the future clients of the design and construction industry. These management areas will be explained and referenced to the current state of the design and construction industry. Finally, this thesis will show the strategic potential of design-build in a changing economy and how this method, with efforts from the owners, designers, and constructors, could improve the industry by enhancing a team approach to every project.

[2] The third rank contractor for 1999 was Kellogg Brown & Root. A merger between Brown & Root parent Halliburton Co. and Kellogg parent Dresser Industries Inc occurred in September 1998. The Financial Reports since the time of merger was not readily available to substantiate revenues.

2.0 Design-build defined

'Despite its increasing acceptance in the past years, design/build still sparks heated debate among architects. Advocates claim that it helps control costs, increases efficiency, and promotes accountability within the construction industry. Detractors maintain that it raises serious and as yet unresolved legal and ethical problems. Both sides agree, however, that design/build as a project delivery method represents a significant departure from the way in which American architects, owners, and contractors have structured their legal relationships for most of the century.' (22, p.107)

2.1 History

The current increasing popularity of design-build as a formidable delivery method has been related, in concept and practices, to ancient Mesopotamia (1800BC) where the master builders were held accountable for design and construction. In relatively more recent times, design-build was used by the Egyptian, Greek, and Romans, again using the 'Master Builder.' (1)

The Egyptian and Greek architects spent most of their time on the construction or building site, directing stone cutters and sculptors. 'The Romans honed their engineering skills on site, designing and solving problems in a practical manner. During Gothic[3], Renaissance[4] and Barogue[5] times, reliance on drawings increased, yet many architects were sculptors, painters, or members of other guilds. In England, the source of many early American attitudes, architects frequently were talented amateurs. Much of early America was built by 'architect builders' who traveled through a region designing and building houses, churches, schools, and stores'. (15, p.22)

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[3] The Gothic style began with the Architecture of the 12th century (1140-1500)
[4] The name 'Renaissance' meaning 'rebirth' is given to a period of broad cultural achievement spanning three centuries (1400-1700)
[5] The name has no formal meaning however it has been identified with connoting the ridiculous or the strange. It is 'neither a rise not a decline from classic, but a totally different art.' (1600-1750)

'The separation of design and construction began to take place during the Industrial Revolution. Mechanical Production, the division of labor, the publication of plan books and the sheer demand for more buildings redefined the nature of architectural services. Later architectural schools were founded at M.I.T. (1865) and Columbia (1881), where design was institutionalized and the *Beaux-Arts* (fine-arts) approach emphasized art as the prime goal of the architect. (15, p.22)

The traditional method involves a separation of roles between the designer and the builder, with each being retained by the owner. This method was first used in the 18th century and became institutionalized in the 19th and 20th centuries. (1)

'In the early 19th century, architects were engaged in fierce competition for clients with design/builders who called themselves 'package dealers.' Like their modern-day counterparts, package dealers provide both design and construction services to owners. To create a legitimate distinction between them and package dealers, architects adopted a system of professional ethical principles that, among other things, placed the client's interests above those of the architect. (22, p.107) In 1909, the American Institute of Architects (AIA) formalized this distinction by adopting a code of ethics that forbade architects from engaging in building construction. This code would not be seriously challenged for more than a century thereafter. (15) The code adopted by the AIA formally ended the single point of responsibility that owners have become accustomed to at that time. 'From this point forward an owner needed to enter into two separate contracts: a design contract with the architect and a construction contract with the contractor.' (22, p.107)

'By the 1970's, however, dissenting voices from both inside and outside the (architectural) profession began to argue that the ethical prohibition against design/build was an anachronism. In 1978, the AIA authorized a three-year trial period during which members would be permitted to engage in design/build work. Before the trial period was over, antitrust questions encourage the AIA to drop its mandatory code of ethics (including its prohibition of design/build) in favor of a purely voluntary statement of ethical principles. In 1986, the AIA

again adopted a mandatory code of ethics. The new code does not prohibit design/build, but nonetheless targets it as a *potential* conflict of interest.' (22, p.107)

However, 'increasing pressures are prompting many architectural firms to consider alternatives to the traditional method of *separate contracts in* design and construction *from the owners perspective*. These pressures include: the unprecedented scope and complexity of projects today, the need for shorter construction times, and the balancing of project excellence against cost and function. Also contributing are more involved and sophisticated clients, greater participation by specialist consultants and review agencies, and fewer available skilled trades people and managers. To meet these growing pressures, the AIA recognized the trend and issued the first edition of design/build contract forms in 1985.' (15, p.22)

2.2 Definitions used in this thesis

'Traditional Method - The architect–engineer (A/E) and contractor are retained separately by the owner. The owner selects an A/E based upon qualifications to develop a project concept defined by the owner's needs and goals. At the completion of the design phase, the project will be described by a complete set of plans and specifications. The contractor, on the other hand, has a different relationship with the owner: a contractor is not expected to represent the owner's desires; rather, the qualified low bidder agrees to construct the facility efficiently and in accordance with the design intent (represented by the plans and specifications). The A/E function during construction is usually limited to a supporting role, on behalf of the owner, to ensure the integrity of the final product. Responsibilities are fragmented and shared (although not equal) under the traditional method, and the owner is placed in the position of being arbiter of disputes and claims' (1, p.7)

'Design-Build – The owner retains a single entity that provides both A/E design and construction services for a project. The Design-Build entity (contractor) may be one of four types: A/E as prime contractor; constructor as prime contractor; joint venture of A/E and constructor; and Design-Build organization. There are two major differences recognized between design-build and the 'traditional' method. 'First, with design-build, project

responsibility and control is the hands of a single entity from concept through design and construction to completion. A second important difference of design-build is the early design level at which a construction contract price is agreed upon. For example, with design-build, the price is often set at concept or early schematic designs (10% to 30% design document completion levels). By contrast, with construction management, the price may be set at 50% to 80% (could be earlier depending on risk the construction manager will assume) of design completion. The 'traditional' method requires 100% completed design documents, and the contract price is not known until bids or negotiated prices are submitted.' (1, p.7)

To compare the definitions above relative to the process; a 'traditional facility design typically evolves through various phases; project definition and programming, concept design, schematic design, design development, and construction documents; culminating in a complete set of plans, specifications and other project documents. A design-build project at nominal 20% design completion may be comprised of different portions of the facility design at different degrees of completion.' (1, p.7) As an illustrative example; for a project to construct a new office building project, the civil site drawings may be at the design development phase; architectural drawings at the concept and early schematic phase, structural drawings at the schematic phase, and mechanical, electrical, and plumbing at the concept phase. (1)

2.3 Benefits and concerns

The following section is a qualitative, although not exhaustive list, of benefits and concerns from the perspectives of the owner, design professional, and the constructor. This list provides an insight into the issues being addressed in recent publications. The writer believes that opportunities for success will increase if a process can be defined in a manner that all issues, positive and negative, could be understood. In other words, people should take the time to investigate all relevant sides of an issue. Once completed, with the good as well as the bad being captured from each perspective, then viable modifications or solutions can be developed that will support the positive and explain the negative. Therefore, the following list is provided to show the common benefits of design-build as well as those issues that will need to be overcome to have others begin to support this delivery method.

'The design-build approach works with most forms of contracts, including lump sum, cost plus fixed fee, cost plus an incentive fee, and guaranteed maximum price. The pros and cons depend upon the individual owner and the expertise of the design-build firm.' This thesis assumes the reader understands the intricacies of each of these contract types inasmuch as they each offer many advantages and disadvantages in and among themselves. Design-build is not being supported as the only delivery method that would fit every project. To the contrary, design-build works well with the proper projects just as the other delivery methods mentioned best fit a project with certain other characteristics. Therefore, once again, both the benefits and concerns with using design-build will be offered to complete the understanding of this method.

2.3.1 Benefits

2.3.1.1 Owner's benefits: (1,15)

1. Establishes a single source of responsibility – this element eliminates disagreements over project responsibility with the team efforts of the designer and builder. The owner's administrative duties are reduced also because of this team. That is, the owner has one contract to administer.
2. Offers protection from liability – the A/E does not have the legal obligation to perform as an agent of the owner, therefore, if the owner detects any defects or omissions in design or construction, the owner is able to hold the design-build team liable. This is a benefit inasmuch as the team is not able to point fingers toward the other entity in a traditional method, nor are problems able to be turned toward the owner for restitution.
3. Can reduce total project duration – the A/E and contractor can work together on current relevant issues and come to a mutual understanding, therefore reducing the documentation needed to detail these issues. Construction of early phases of work can begin while later phases are still within the design phase. Schedule delays may also be reduced because time will not be taken to clarify completeness or constructability issues within the drawings and specifications inasmuch as the team develops them. Instead, the design-build entity will solve the problems as they arise, usually without the owner even being aware that a potential problem existed.

4. Lowers number of formal change orders – because design and construction is teamed together. Quick and informal communication will occur in which problems can be solved which may have grown into adversarial change orders under the traditional delivery method. This modification process during the project is streamlined which also adds to the possibilities of timesaving.
5. May reduce total project costs – there is an inherent relationship by reducing the project duration that will reflect in overall project cost savings. The savings will be experienced in costs incurred by the owner within the overhead and project financing costs. Furthermore, the design-build team has the ability to define the project from the design perspective combined with the 'how-to' knowledge of the constructor early in the process, therefore less time will be spent on administrative duties later in the project.
6. Promotes innovative solutions – the design-build team will be able to develop together creative designs and construction solutions that will benefit the professional as well as the owner. That is value engineering in an implicit part of the process.
7. Can improve overall design – the interaction of both the design professional and the construction professional can add to the final design because of their respective experience. This may improve the design by ensuring constructability.

2.3.1.2 Design professional's benefits: (1)

1. Offers more control over quality – within a design-build team, the A/E gains first-hand appreciation for construction, and the contractor gains similar appreciation for design issues. Field changes will include input and control from both the A/E and contractor, which improves the results with a more informed quality-versus-cost decision.
2. Improves A/Es business options – an A/E may be able to increase potential profits within the design-build team by designing with input from the contractor that will allow a reduction in design production cost. That is, there will be less documentation needed from the designer when the contractor is involved in the decision process to define the design intent. An A/E can also develop different clients, which will be other than owners that only need professional design services. The designer and builder teamed together will be able to attract owners needing more conceptual involvement in defining and developing obtainable needs.

3. Reduces adversarial claims – the traditional delivery method developed a perfect scenario that promotes an adversarial relationship between the designer and the builder. The design-build team is legally bound together and is working toward the same goal, thus claims due to improper or lack of communication and trust are greatly reduced.
4. Increased owner confidence – Owner may place greater confidence in an A/E who is knowledgeable of both the science of design and the skill of construction. Owners may more readily support design decisions from design-builders because of their more balanced attention to design, cost, constructability, and facility performance.
5. Improves inter-disciplinary design decisions – the team approach is also extended among the design professionals, and with the similarity in goals, provides for a more equal participation of the various design disciplines in project design decisions. This results in more efficient decision-making and greater project value. That is the engineers teamed with the architect are making design decisions in concert with each other and the construction contractor.
6. Rewards innovation – the design-build team has the increased ability to incorporate innovation or new technology (and possibly proprietary systems or processes to achieve a competitive advantage) which can result in financial rewards.

2.3.1.3 Constructor's benefits

1. Improves contractor's business performance – with the ability to offer early input into design, the contractor is able to promote systems, methods, and materials in which the firm is experienced and has expertise and historical cost data to improve cost estimates
2. Increases project control – for contractors, design-build gives the opportunity to participate in the technical discipline of design prior to construction. A single person (such as the master builder previously discussed) has to be skilled in defining an idea in two dimensions (design) and carrying it through to three dimensions (construction). This is one of the reasons why contractors are attracted to design-build. That is, this method provides the opportunity of the builder to be involved and responsible for a project from conceptualization to completion.
3. Lower project risk – the contractor traditionally has very little opportunities, if any, to meet directly with the owner or designer prior to estimating and bidding a project. In consultation with the designer, the contractor has the ability to define some of the unknowns within a project and the solution becomes a mutual concern of the design-build team

4. Rewards innovation – the ability of the design-build entity to incorporate innovative construction procedures or systems and innovative technology to achieve competitive advantage can result in financial rewards.

2.3.2 Concerns and disadvantages

2.3.2.1 Owner's concerns: (1, 15)

1. Loss of fiduciary relationship with the A/E – the A/E is part of a design-build team and the owner may not receive the same type of guidance and advice received in the traditional method. The A/E also has gained a direct financial interest in the construction of the project, rather than a service fee gained as a sole designer. Furthermore, this loss of relations with the A/E will detract from project field investigations. The owner is accustomed to a field representative, the A/E, out on the site looking out for the sole interest of the owner in the overall integrity of the project. The owner may need to provide another independent entity in order to perform these services inasmuch as the A/E is tied directly to the financial concerns of completing the project.
2. Substituted materials – if the owner does not have the project sophistication to develop a full project needs and scope, a contractor-dominated design team may drive the owner to accept lower first-cost materials. This concern will not provide for the consideration of system and material life-cycle cost and performance.
3. Firm costs are unknown - typically, a firm cost is not agreed upon until construction has progressed well into the project. This increases the risk to the owner that the future negotiations that will define these costs will continue until the price exceeds the original organizational budget and construction will be well under way. Since competitive bidding is not generally used, the owner is not assured of the lowest price. A strong relationship between the owner and its lender or financing source can alleviate the potential risk inherent in the design-build context.' (7, p.22)
4. Unaware of important issues - there are few checks or balances within the design-build team and the owner may not be made aware of issues that could affect the costs or schedule.

2.3.2.2 Design professional's concerns: (1)

1. Responding to an RFP is costly – owners may ask design professional to submit designs that are 5 to 35 percent complete. These initial costs are significant and not attractive to design firms that are accustomed to the traditional method and being paid for services rendered.
2. 'Perceived difficulty in obtaining liability insurance and/or performance and payment bonds – Some insurance carriers will insure for acts of omission by the design professional, but want no responsibility beyond traditional A/E services. Each party within the design-build entity needs to make sure that adequate coverage exists in both the design liability and construction bonding arenas.' (1, p.14)
3. Decreased importance of design issues – cost tradeoff discussions are held early in the design stage, possibly circumventing design concerns or material selection in favor of cost efficiency.

2.3.2.3 Constructor's concerns (1, p.14-15)

1. 'Inability to shift responsibility for errors or omissions – the entire design-build entity assumes responsibility for errors and omissions, including the contractor. Under a design-build prime contract, the A/E may not be recognized separately from the contractor. Rather, responsibility for the projects rests with both parties jointly and severally.
2. Increased obligation to the owner – under traditional project delivery, the owner gives the contractor and implied warranty that the design documents are complete, free from errors and fit for the purpose. Subsequently, if during construction a code-required item is required but not shown in the design documents, the contractor can expect the owner to pay for the 'additional work'. With design-build the contractor cannot hold the owner responsible for incomplete or erroneous design documents.
3. Complexity of design-build may make organizing and assigning roles within a design-build entity difficult – the parties not only must select a legal arrangement (joint venture; prime-subcontractor, separate corporation), but it must develop decision-making procedures allowing either dominance by one party (A/E or contractor) or balance among the parties on various project decisions.'

These benefits and concerns illustrate the perspectives of each of the parties within a project using design-build. A common theme could be argued that all of the concerns above could be overcome with a properly developed team atmosphere with open and free communications. The members will inherently have there own issues and some will be directly related to the business outcomes of the project. However, the emphasis on a common goal and the efficient transfer of information provides an opportunity to benefit all to an agreeable level relative to their perspective.

3.0 Owners perspective on current design-build projects

3.1 Introduction

With so many delivery methods available to an owner, how is one to decide which to use for a given project. 'Design-build has experienced extraordinary growth in recent years. Since 1986 there has been continued growth in design-build construction in terms of previous volume and as a percentage of total construction ('Top' 1994). Current projections suggest continued growth of design-build. The U.S. Department of Commerce predicts that design-build will account for half of all non-residential construction by the year 2001 (Rosenbaum 1995). An inevitable outcome of this growth is the increased entry into the market by both contractors and architect-engineers (AE's) possessing little or no design-build experience. Additionally, such growth suggests an increase in owners selecting design-build for the first time. Continued success of the design-build method requires documentation and dissemination of fundamental design-build knowledge to these new participants. Therefore, to enhance owner selection of appropriate projects and to provide appropriate design-build services, the AE, construction, and owner communities must improve their understanding of owner attitudes toward selecting design-build as a preferred delivery method.' (21, p.1)

Past perceptions within the construction industry has been that there is no single reason why owners would select design-build as a delivery method. In fact, even though there may be many intuitive reasons why an owner may choose this method, (e.g. perceived cost and schedule savings discussed in the previous section), limited research has been conducted to substantiate any of these reasons (7). However, researchers at the University of Colorado have conducted several surveys that give a full view of many characteristics within the design-build projects, the factors of a successful completion, and the selection criteria that defines owners evaluations. Defining these characteristics will assist an owner in establishing the grounds to choose design-build to support a project.

This research was formed in 1995 and as stated the research was undertaken to assist owners in selecting projects that are appropriate for using design-build as the delivery method. The following sections are presented as a synopsis of this research and are included in this thesis in order to help the reader understand the factors that are currently important to an owner wanting to use design-build. The thesis provides a look at the owner's changing business perspectives in later chapters. The most important factors given by owners at the time of the study in selecting a project type, motivation to use design-build and factors defining a successful completion were:

1) Project type selection - a well-defined scope.

2) Motivation - shorter duration.

3) Successful completion - on budget.

It will be shown later in this thesis that the changes our clients are currently going through in management and informational areas will effect the focus of these characteristics. These changes will provide insight into a possible future focus of design-build. That is, although these were important at the time of the study, given the rapidly changing business environment of the information age, design-build may in fact be the delivery method that is best positioned to fill emerging owners requirements in the future.

The original study was designed to look at public projects in the hope of developing an automated selection tool for public sector design-build projects (17). However, the researchers later studied the similarities in the area of the selection process between owner attitudes in the public and private sectors (20, 21). The researchers found that there was little difference between the two. The public and private sectors considered the same characteristics as most important and there was only slight variation in the less important factors (21). Therefore, although the first two sections below were intended for public sector design-build, they also approximate the characteristics that would be established in a similar study focusing on the private sector.

3.2 Owners chosen project characteristics that promote using design-build

The initial study (17) identified fifteen characteristics listed in Table #1 that were rated (1 to 6, 6 being the highest) by various organizations throughout the public sector. There were 88 qualified responses from organizations included local, state, and federal offices. This section asked the respondents to rate these fifteen project characteristics in terms of importance that would promote using design-build as the delivery method.

Characteristic Description	Mean	Rank
Well Defined Scope	5.41	1
Shared Understanding of Scope	5.22	2
Owner's Construction Sophistication	4.62	3
Adequate Owner Staffing	4.57	4
Established Budget	4.35	5
Established Completion Date	4.16	6
Availability of Design-builders	3.79	7
Willingness to Forgo Design Input	3.78	8
Owner's Risk Aversion	3.72	9
Standard Design Specifications	3.56	10
Technologically Advanced	3.20	11
Type of Contract	3.17	12
Size of Project	3.16	12
Current State of the Market	2.97	14
Alternative Financing Options	1.78	15

Table 1: Project Characteristics (17)

While the organizational responses were recorded in several ways, this thesis shows only the mean value and relative rankings that were derived by the researchers. The three columns

labeled Characteristic Description, Mean, and Rank were imported directly from the study without adjustments.

Figure #1 is a graphical representation of Table #1 taken from the original study. The first item that is noticeable is the apparent grouping of the data points. The author of the original study, Kieth Molenaar also noticed these and referred to them as plateaus. The author of this thesis added value to the original analysis by redrafting the figure and coordinating the columns to develop the classification to identify functional groups.

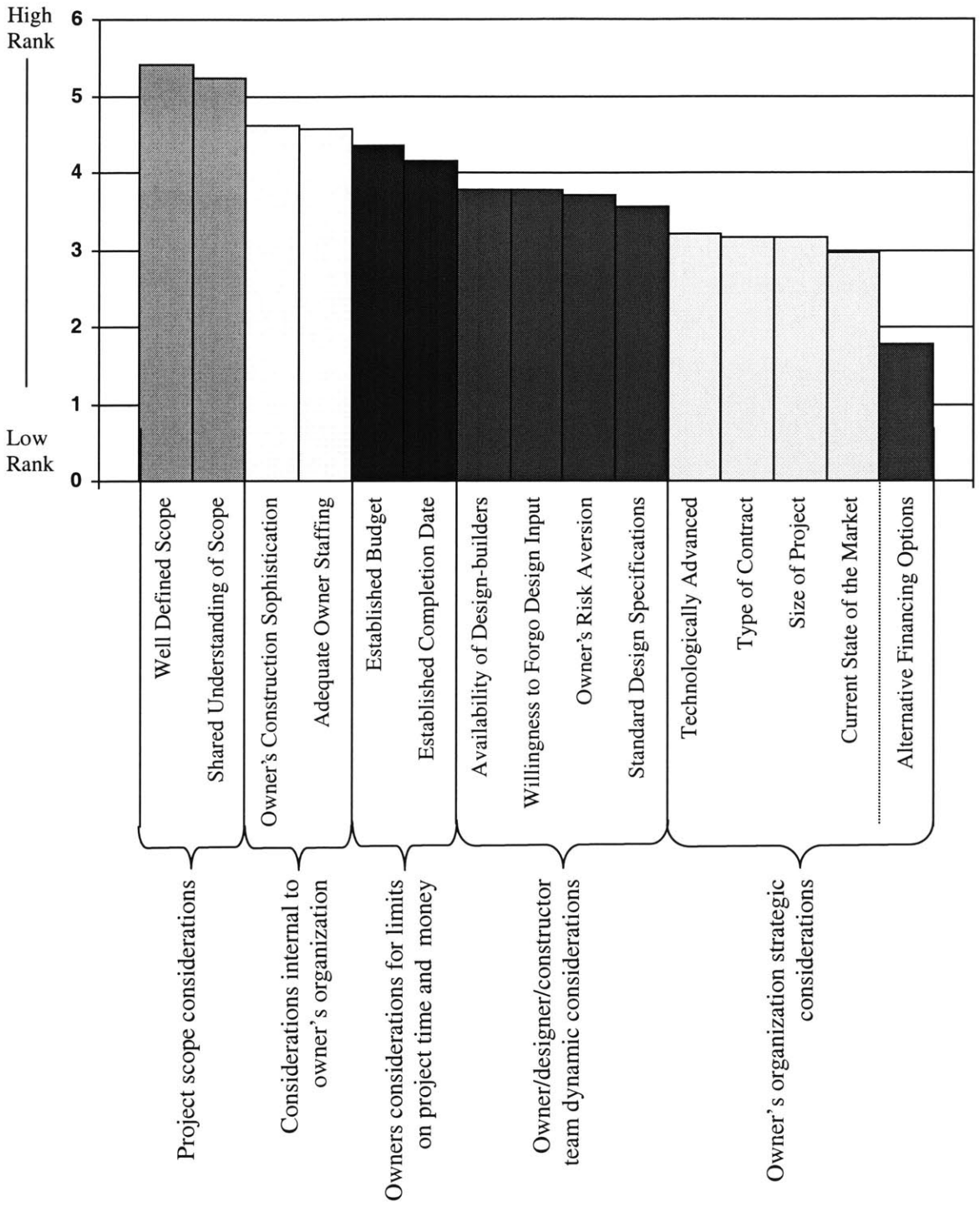

Figure 1: Project Characteristics Ranking by Mean Score

The first two characteristics are defined as project scope considerations. This is considered relevant to the owner as well as a prospective design-build team and shows the importance of having a finite scope for a design-build project. The next two characteristics are defined as factors that the owner must consider and that are relevant to the internal functions of

his or her organization. These factors are rarely similar between organizations or within the same organization over time. That is, no two organizations have identically experienced (construction related) staff members; and, over time people leave organizations, taking experience with them. The importance of these factors to the owner alerts a potential design-build team to the need to customize the make up of its own team to complement and supplement the skills in the owner's organization. The next noticeable group is concerned with the owner's business considerations of cost and time. That is, what are the desired budget and time constraints for a project? A design-build team will be able to satisfy the owner in these areas with the ability to fast-track and reduce time to completion.

The next four items relate to the dynamics of a prospective team and raise issues such as the following. Are the constructors or the design-build team available to accept the project? What is the owner's perception and attitude towards allowing the design-build team to take control of the design? Is the owner willing to loose some of the availability of the input towards final design attributes? Is the owner willing to accept risk; or is the goal of the owner to avoid risk as much as possible? Is the owner willing to accept and does the design-build team advocate the use of standard specification? Is customization an important consideration?

The last items have been grouped together to show the factors tied to the owner's business strategy. Questions raised include the following. Will there be advancement in the technology; and if so, will it apply to the firm or to the structure of the industry? (18) Will this type of contract best serve the strategy of the organization in executing the project? That is, will this project and its method of implementations support the organization's generic strategy as an industry cost leader or as an organization that has differentiated itself within the industry? (19) Is the size of project appropriate to this method of project delivery? What is the current state of the market? Is the market behaving commensurate with the goal of the project (as either a cost saver or as a differentiation enhancer)? The last item, Alternative Financing Options was significantly lower than the previous items. However, rather than perceiving it as a new plateau, it was classified as being a strategic consideration of the organization.

The fifteen characteristics were further consolidated to illustrate that there is a pattern in the way the study showed the data in which owners characterized projects. The most important characteristics to the owners can be taken as the top three consolidated sets (or the top six individual characteristics). That is, the project scope (top two characteristics), the internal scrutiny (16) of the organization at the time the project is being considered (items 3 and 4), and the defining parameters of this project relative to time and cost (items 5 and 6).

These top ranked sets will be used later in this thesis in considering the owners changing business practices. Will these factors remain in the same precedence with the owners of the information age?

3.3 Owners motivations for using design-build (21)

The previous section helps the owner identify a project with characteristics that make design-build an appropriate method, however the question still remains, why use design-build? This section presents the study findings concerning public and private sector owners' attitudes towards this question. The factors outlined are the owner's motivations for using design-build as the delivery method for projects with the characteristics discussed in the previous section.

To fully understand the selection factors shown in Table #2, the original researchers provided the following description of each factor and perceptions given by the owners in the questionnaire. These are equally applicable in this thesis and are repeated for clarification and accuracy of interpreting the results. In the questionnaire the owners were asked to assign the most important selection factor a '1' and the least important a '7'. There were 108 qualified responses. (21, p.3-4)

Selection Factor	Definitions
Establish Cost	Secure a project cost before the start of the detailed design.
Reduce Cost	Decrease the overall project cost as compared to other procurement methods (design-bid-build, construction management, etc.).
Establish Schedule	Secure a project schedule before the start of detailed design.
Shorten Duration	Decrease the overall project completion time as compared to other procurement methods (design-bid-build, construction management, etc.).
Reduce Claims	Decrease litigation due to separate design and construction entities.
Larger Project size/ Complexity	The project's shear magnitude is too complex to be managed through multiple contracts.
Constructability/Innovation	Introduce construction knowledge into design early in the process.

Table 2: Selection Factors and Definitions (20)

Establish Cost: Some owners choose design build to secure a fixed construction cost. By allowing one entity total control over design, scope and budget, there is less opportunity for

scope-related change orders. Additionally, improved relations among A/Es and contractors reduce liability issues associated with increasing project cost.

Reduce Cost: Although very little empirical data exists which identifies a specific amount of cost savings produced through design-build, there is sound reasoning for expecting an overall cost reduction. This cost reduction stems from two main sources, the shortening of project duration, and the introduction of the contractor's knowledge into the design.

Establish Schedule: For the same reasons that some owners choose design-build to establish cost, they can and do choose it to establish a fixed schedule. A majority of the schedule growth in the traditional method stems from communication problems between the A/E and the contractor (i.e. requests for information, design errors, design omissions, etc.). By allocating responsibility to one entity, these issues are minimized.

Reduce Schedule: Design-build promotes schedule reduction. Communication is greatly improved when design and construction are controlled under one contract. This results in reduced design and construction cycle times and also encourages fast tracking.

Reduce Claims: Implicit in the design-build process is an owner's shelter from liability. The A/E does not perform as an agent of the owner. Design errors and omissions are solely the responsibility of the design-builder. Design-build is not a magic cure for the construction industry's litigation problems, but it does inherently promote a non-adversarial relationship between designer and builder.

Large Project Size/Complexity: Dealing with one entity reduces administrative burden. Many owners do not have the staff or experience to manage the traditional triad of owner-designer-builder. Taking one player out of the game lessens managerial tasks on large or complex construction projects. It should be noted, however, that the owner's involvement early in the process is often increased (17) and there is a loss of the A/E as an independent professional (1).

Constructablity/Innovation: Inherent in the design-build process is early involvement of the contractor. Interjecting contractor knowledge early into design fosters creative design and construction solutions. If used correctly, design-build promotes constructablity and innovation in the same manner as a value-engineering plan.

An interesting point is the fact that as the researchers excluded from the list of factors the 'concept that owners select design-build because it establishes a single source of responsibility' (21, p3). This phrase is what many use to define as well as describe an advantage of design-build. This definition as the researchers noted encompass all the factors listed in Table #2. They determined early in the study 'not to use single source as a reason for selecting design-build because it is too general and would not offer insight into the true motivation for choosing design-build' (21, p3).

The final results were tabulated in several forms however the mean value and rank are shown below in Table #3.

Selection Factor	Mean	Rank
Shorten Duration	2.48	1
Establish Cost	3.26	2
Reduce Cost	3.82	3
Constructability/Innovation	3.94	4
Reduce Claims	3.99	5
Establish Schedule	4.58	6
Larger Project size/ Complexity	5.92	7

Table 3:Selecting Factor Survey Results (21)

This data shows an obvious motivation by owners to select design-build for the purpose of shortening project duration. As the researchers also noted there is distinctive data that shows owners do not choose design-build because of the size or complexity of the project scope. (21).

The data indicated that each of the selection factors was chosen at least once to be the most popular reason in selecting design-build. However, the frequency histograms showed a definite trend that even though the two distinctions mentioned earlier at either end of the spectrum were apparent, it was also apparent the remaining five selection factors were relatively equally important. That is, each of the selection factors could be the primary reason for selecting design-build for any given singular project.

These are the factors at the time of the study that the owners saw as motivating reasons to choose design-build as the delivery method for a certain project. Later these factors will be revisited to see if they still apply to owners as their practices continue to change in response to the information age.

3.4 Owners factors for judging success in design-build (20)

This section provides the study results related to the analysis of how owners judge a project to be successful upon completion. The original research conducted was targeted at the United States (U.S.) and the United Kingdom (U.K.). The researcher's intentions were to compare the reasons for selecting design-build to how does an owner judged it to be successful. The researchers also noted that design-build as a delivery method has matured more rapidly in the U.K. as compared to the U.S. From this point of view, the validity of the results is increased. The U.K. had relatively more experience and more time to develop design-build as a viable delivery method. The final results showed that the U.S. has the same selection and success criteria as the U.K., with only one difference in ranking. The top three in order for the U.K. were On Budget, On Schedule, and Conforms to Expectations. As shown in Table #5, the U.S. ranking was On Budget, Conforms to Expectations, and On Schedule. These three factors were consistently ranked among the top factors for judging success.

Two items were statistically differentiated between the U.K. and the U.S. They are 'On Budget' and 'Quality Workmanship'. The U.K. had stronger weightings placed on the 'On Budget' item. According to the researchers, this could be 'explained by external differences in the Construction Markets of the U.S. and U.K. The very strong weighting by the U.K. owners is indicative of the economic pressures on owners in a slow market.' The second difference was the 'Quality Workmanship'. In the list of selection criteria for using design-build, the U.K. had Construction/Innovation ranked 6th whereas the U.S. had it ranked 4th in importance. 'This difference explains in part why U.S. owners are more concerned with High Quality of Workmanship as a success criterion. Allowing increased innovation transfers much of the risk for quality to the design-build entity. To balance this risk transfer, owners emphasize quality as an important consideration of success.' (20, p.9)

The researchers noted, 'Contrary to the inherent differences in U.S. and U.K. design-build procurement procedures, design-build success criteria and selection attitudes can generally be treated as equivalent. These findings should be encouraging for design-builders seeking work

in the global marketplace. Motivations for choosing the design-build procurement process as well as the criteria for judging the projects success appear to be similar.' (20, p.10)

However, with the above aspects in the original research defined, this thesis includes the information related to the U.S. market. Table #4 contains a list of success criteria as well as the definition of each factor as it was interpreted for the study. Using this list, owners were asked to assign the most important criteria a '1' and the least important a '6'. Therefore, a lower mean score indicates greater importance. There were 137 qualified responses.

Success Criteria	Definition
On Budget	The project is completed at or under the contracted cost.
On Schedule	The project is completed on or before the contracted finish date.
Meets Specifications	The completed project meets or exceeds all technical performance specifications provided by the owner.
Conforms to User's Expectations	The completed project meets or exceeds the user's envisioned functional goals (fitness for purpose).
High Quality of Workmanship	The completed project meets or exceeds the accepted standards of workmanship in all areas.
Minimizes Construction Aggravation	The construction process does not unduly burden the owner's project management

Table 4: Design-Build Success Criteria (20)

The results of the responses are shown in Table #5. Again these are the mean and rank in the U.S. responses only. The values the U.S. responders assigned the criteria seemed to be interesting. With a high value of '1' and a low value of '6', a centerline could be established at a rating of '3.5'. This is graphically represented in Figure #2. To be noted is the proximity of the ranked criteria to this centerline. Although, the budget is the strongest and the minimization of construction aggravation is the weakest, the criteria are close enough to the centerline to suggest that any of these criteria could be ranked differently with more experience using design-

Success Criteria	Mean	Rank
On Budget	2.25	1
Conforms to User's Expectations	2.65	2
On Schedule	3.03	3
Meets Specifications	3.69	4
High Quality of Workmanship	4.29	5
Minimizes Construction Aggravation	5.11	6

Table 5:Success Criteria Results (US only) (20)

build. That is, as companies gain experience in operating with the design-build method, these criteria could be rearranged and have a different relative ranking.

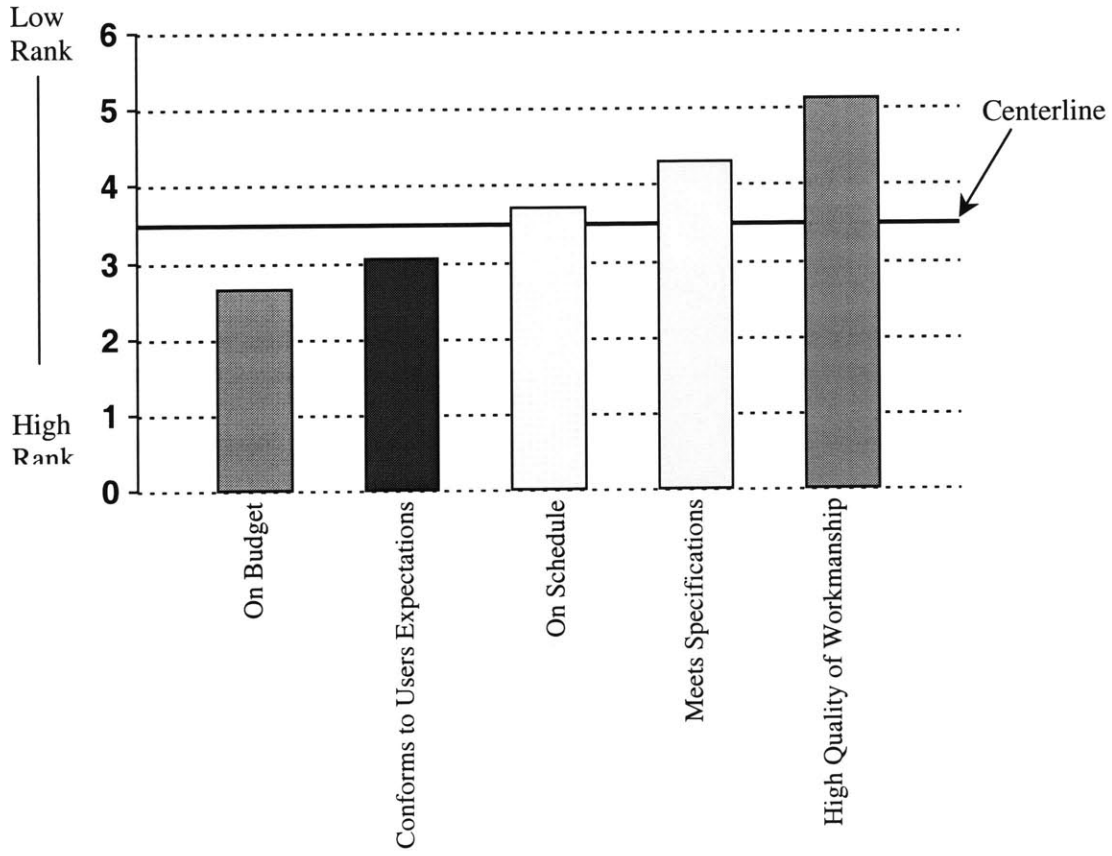

Figure 2:U.S. Success Criteria

It could be expected that 'on budget' will remain the most important factor and possibly might even be given a heavier weight to separate it from the pack. However, with the ability of design-build to fast-track, the schedule will continue to be important. However, it may loose weighting and move down the rank with proper execution of the delivery method and a proven record that overlapping design and construction increases the possibility of the project finishing on or before schedule. Therefore, it will become an expectation rather than a unique level of success.

With changing owner business practices, a combination of the factors may be required to allow an owner to judge a project successful and give them confidence to use design-build for future projects. This will be examined in later chapters.

The combination of all the studies above were listed in the original documentation and provided in Table #6 as a concise method to combined the results. (17)

PROJECT CHARACTERISTICS
PROJECT
A. Well Defined Scope - The owner has a precise understanding of the project scope before it is submitted to the design-build team.
B. Established Budget - The project has a fixed cost before the it is submitted to the design-build team.
C. Established Completion Date - The project has a fixed schedule or finish date before it is submitted to the design-build team.
D. Standard Design Specifications - The project can utilize design specifications similar to existing projects.
E. Technologically Advanced - The project uses unique or specialized building techniques (e.g., a sewage treatment plant or industrial production plant).
OWNER
F. Owner's Construction Sophistication - The owner has the ability to precisely define the project scope, either with in-house staff or with a preconstruction consultant.
G. Adequate Owner Staffing - The owner has a project manager or staff that can be dedicated to this specific design-build project.
H. Owner's Risk Aversion – The owner prefers to shift some of the traditional risks (e.g., design errors and omissions) to the design-builder.
I. Owner's Willingness to Forgo Design Input - The owner is willing to give up a large amount of design input after design-builder selection.
MARKET
J. Current State of the Market - The amount of work available in the area and the bidding climate therein.
K. Availability of Design-builders - The number of local designers, contractors, and design-build firms with experience.
L. Size of Project - The size and dollar amount of a project as compared to others available for design-builders.
RELATIONSHIP
M. Type of Contract – Whether the project is being awarded as lump sum, unit price, cost-plus, guaranteed maximum price, fixed fee, or other.
N. Shared Understanding of Scope - The owner and design-builder share a clear understanding of functional and technical performance required in the finished project.
O. Alternative Financing Options - The project is using or can utilize third-party financing (e.g., build/operate/transfer

Table 6: Definitions of Appropriate Design-Build Project Characteristics (17, p.11-12)

4.0 An owner's changing perspective

4.1 The Information Age defined

Peter F. Drucker writes, 'Every few hundred years in Western history there occurs a sharp transformation.... Within a few short decades, society rearranges itself – its world view; its basic values; its social and political structure; its arts; its key institutes. Fifty years later there is a new world. And the people born cannot even imagine the world in which their grandparents lived and into which their own parents were born.' (13, p.1) Hope and Hope write 'Two hundred years after the industrial revolution dramatically changed the established world order, we are once again in the midst of a sharp transformation, the likely effects of which will be a period of dislocation followed by a period of prosperity.' (13, p.1)

There have been three waves of economic change and we are currently in the Age of Information, otherwise known as the 'Information Wave'. (13, p.2) The pattern of transforming

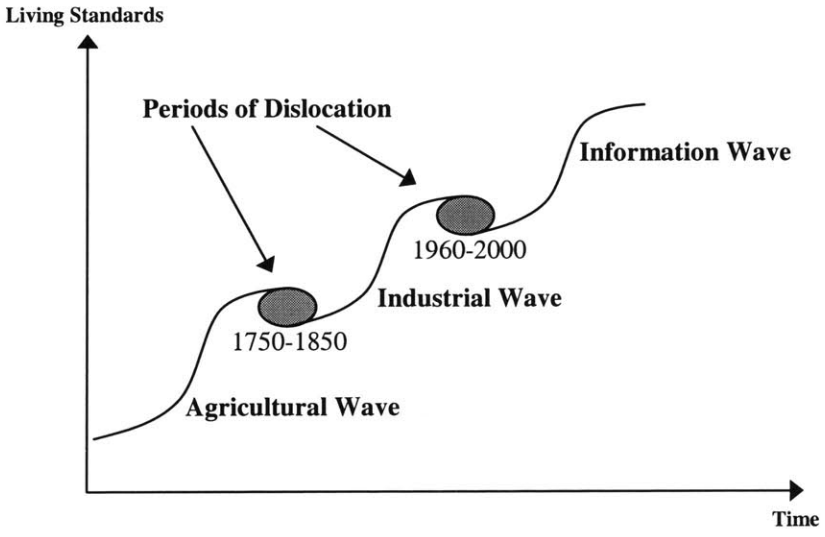

Figure 3: The Three Waves of Economic Change (13, p.2)

from economic wave to the next is best shown in Figure #3. The basic concept is that each wave is in the shape of an 'S' curve showing the progression of the period. Each period begins with

time of dislocation followed by a time of rapid development and then the eventual end of the wave as new technologies begin to emerge and shape the next wave (13). As Hope and Hope in their book *Competing in the Third Wave* stated, '(T)he first wave was driven by physical labor, the second wave by machines and blue-collar workers, and the third by information technology and knowledge workers.' (13, p.2) Peter Drucker first used the term 'knowledge worker' in 1960 (13). However, this term seems to be becoming much more defined with the fast pace of technological changes. Along with the knowledge worker gaining momentum, the economic times of the information wave is dominated by service organizations. In the current society, the ones that know how to solve a problem, not necessarily the ones who must perform the physical labor, are the ones becoming more in demand.

4.2 Service and technology drive the Third Wave

The service sector of the economy has grown to provide the greatest contribution in 'terms of value-added per job' compared to the manufacturing sector (13, p.3). This growth of the service sector has grown 200% from 1960s to the 1990s with respect to the real value added in terms of the increase in the U. S. national income. In comparison the manufacturing sector has grown approximately 150% and the agricultural, mining, and construction sector has grown by 75%. (13) This change can be attributed to 'the real engine of the third wave economy, the high-tech sector, which is now accelerating at a rapid rate.' 'Moreover, many so-called manufacturers no longer consider production to be an essential core competence.' (13, p.3)

'The rapid pace of technological change is creating a wide array of new business opportunities. The development of the Internet, for example, with its global reach and tens of millions of users, is opening up possibilities for electronic banking, education on demand, digital photography, virtual shopping, and virtual factories; ultimately it has the potential to change almost every aspect of business life.' (13, p.5) Technology is also changing the face of business. In the manufacturers' day, owning more of a process could prove to be beneficial. However, with the formulation of 'information-based networks' (13, p.5) organizations are able to coordinate informational systems. This coordination has allowed companies to focus on a core competency and out source functions that do not meet their current business plan. (13)

These previous statements apply to emerging trends in the business of the manufacturer. However, the design and construction industry has been performing in an information age for quite some time. The flow of information discussed in the next chapter (Figure #3) could be applied to any projects arbitrarily over the last hundred years. The flow of information will be recognizable as depicted in this model. The flow of information in construction has been key since the industry's inception. The owner must communicate a need to a separate individual to build a structure, and the builder must further translate this to an unrelated entity that may have the labor force to accomplish the task. The manufacturing industry contained most of these functions within the same organization. Communication is still essential, however as mentioned earlier manufacturers are able to reduce levels of employment and use the information-based network to accomplish tasks not in line with core business strategies.

4.3 The client's changing management issues

Understanding the client of the future is essential to the planning and implementation of appropriate design and construction services. The book, *Competing in the Third Wave*, focuses on the manufacturers and the customers in the economy of the future. It therefore provides insight to the nature and perspectives of future clients of the design and construction industry. For example, the book states that, '(W)ith sophisticated customers in charge of the marketplace and technology at their fingertips, firms must chose their strategies carefully. Whether they select technical leadership, opt for low cost and convenience buying, or pursue specialized niche markets and customization, complexity is likely to be the order of the day.' (13, p.14)

The 'Ten Key Management Issues of the Third Wave' as set forth by the authors of the book are as follows:

Issue 1: Strategy: Pursue Renewal, Not Retrenchment

- Learn to think 'outside the box.'
- Trust people to think and act strategically.
- Build core competencies and avoid core rigidities.
- Leverage value through strategic alliances and economic webs.

Issue 2: Customer Value: Match competencies to Customers

- Choose the right value proposition and build the right operating model.

- Evolve the model continually

Issue 3: Knowledge Management: Leverage Knowledge for Competitive Advantage
- Learn how to define and acquire knowledge.
- Learn how to learn.
- Leverage knowledge for competitive knowledge.

Issue 4: Business Organization: Organize around Networks and Processes
- Move from hierarchies to the networks and emphasize process and teams.
- Recognize the organization as a social structure.

Issue 5: Market Focus: Find and Keep Strategic, Profitable, and Loyal Customers
- Build the value of customer capital.
- Find out which customers are worthwhile and keep the right customers.

Issue 6: Management Accounting: Manage the Business. Not the Numbers
- Know how to analyze product and service profitability
- Use accounting to help improve processes.
- Move toward more relevant accounting systems.

Issue 7: Measurement and Control: Strike a New Balance Between Control and Empowerment
- Beware of the behavioral implications of budgets.
- Strike a new balance between control and empowerment.
- Implement a strategic measurement system.

Issue 8: Shareholder Value: Measure the New Source of Wealth Creation – Intellectual Assets
- Understand the changing shape of share values.
- Note the users of accounting information and the problems of valuing intellectual assets.
- Note the changes needed in capital expenditure appraisal.

Issue 9: Productivity: Encourage and reward Value-Creating Work
- Beware of the second wave model – in pursuit of the lowest unit cost.
- Adopt the third wave model – in pursuit of value-adding work.
- Look for new measurement systems.

Issue 10: Transformation: Adopt the Third Wave Model
- Question the effect of the second wave model.
- Migrate to the third wave model.
- Question the value of management education.

The overall lesson that can be derived from these issues is that the way of doing business is undergoing fundamental changes from the mass production focus of the past. The design and

construction industry should view these issues as characteristics of future clients so that they can be more informed and understand their needs. Those in design and construction organizations should be given more latitude to define and offer value-added functions. Moreover, the ability to learn and acquire competitive advantages will become increasingly important. Customers will become the primary focus rather than the construction process itself. That is, our clients will need facilities that meet the changing needs of their customers and our (design and construction) services will need to provide solutions.

The ability to look at a business within the framework of these ten management issues will allow the professional in the design and construction industry to understand what future clients will be facing. This understanding will facilitate the formation of teams that include the owner, which are capable of enhanced definition of owner needs and the production of end products that fully meet owner expectations.

Issue 4, which is the need to organize around networks and processes, is particularly important now and even more so in the future. Manufacturers are striving to be able to provide ever changing custom products to different customers. This requires the ability to easily transmit information about customer requirements to the manufacturing process and facilities that are extremely flexible. The design and construction of such facilities require similar flexibility and information exchange capabilities on the part of the designer and constructor.

The design-build delivery method provides maximum flexibility and encourages the formation of informational joint ventures or an internet of professional intranets. A design-build team can be established as a dynamic organization that calls upon specialized disciplinary skills on an 'as-needed-basis.' The design-build approach is far superior to other delivery methods in that it provides closer and continuous collaboration with the client throughout all project life-cycle phases. Figures #4 and #5 illustrate the dynamic nature of a design-build team. Figure #4 is the team for a mechanical and electrical focused project. Figure #5 is the team for an architectural, structural steel and concrete focused project. The solid lines indicate a contract for the specified project and the dotted lines represent an ongoing relationship without a contract. The relationship between the design-build team and the specialty layer below can continue

through sharing information in anticipation of future projects. The design-build team will continuously, through these informational relationships, have a sense of the working capacity available to pursue a project. For example, is the design-build team's current structural engineer overloaded with other projects? If this happens, and the specialty is not available to pursue a desired project, an alternate layer could be shown in these diagrams depicting flexibility with relationships.

In an information age environment characterized by change, flexibility, and the paramount importance of knowledge, the design-build approach is a natural choice for both clients of designers and constructors and for the design and construction industry itself. The next chapter expands upon the knowledge intensive nature of the industry.

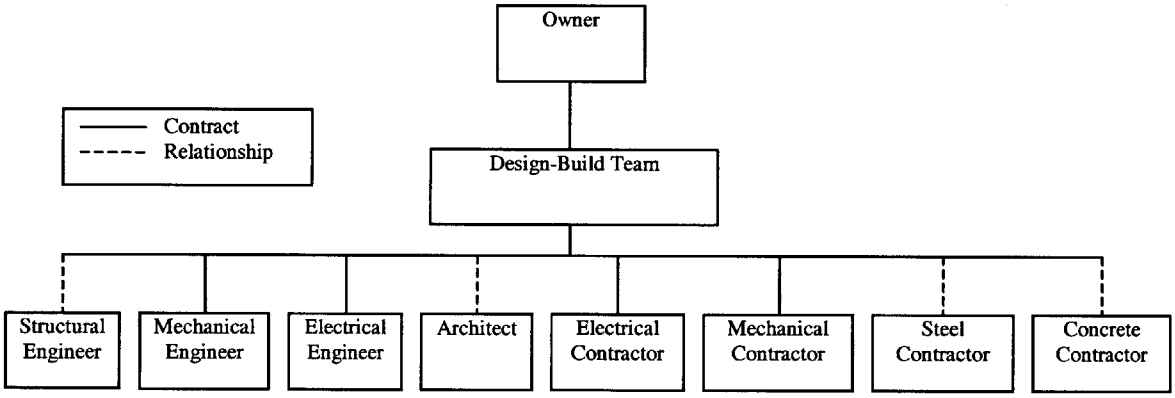

Figure 4: Design-Build Team 1

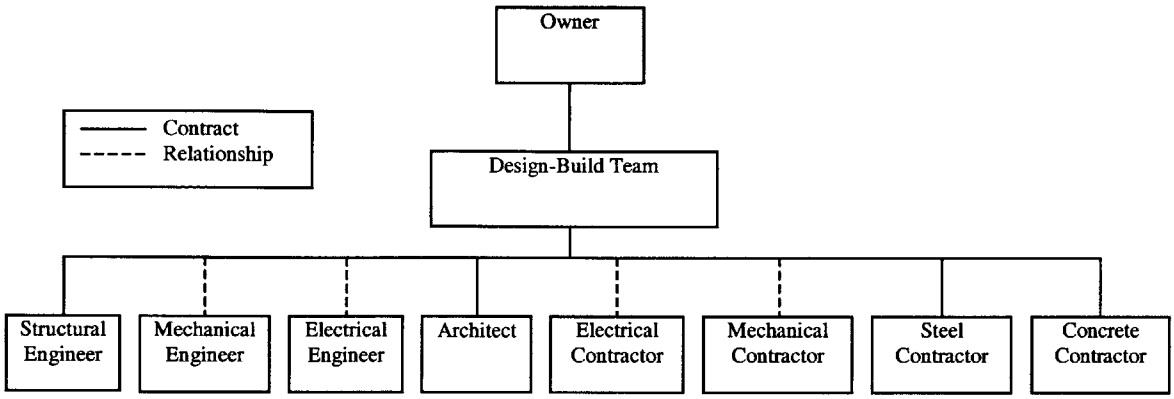

Figure 5: Design-Build Team 2

5.0 The vital role of information in design and construction

The term 'construction' immediately brings to mind visions of buildings, and infrastructure systems, the end products of complex design and construction processes. The flow of information in these processes is the key to being successful in meeting the needs and expectations of the clients that are paying for these facilities.

The following analysis and figures had their origins in the book *Project Management for Construction* (12). As the thesis author closely examined the information flow in the light of personal experience, it seemed necessary and appropriate to make changes in both flows and groupings, particularly as they applied tot he design-build approach.

Figures #6, #7, #8 represent the flow of information during the life cycle of a facility. The design and construction processes have their own uniqueness with respect to information. However, it is necessary to understand the broader spectrum of the entire cycle to fully understand the concepts and recommendations set forth in this thesis.

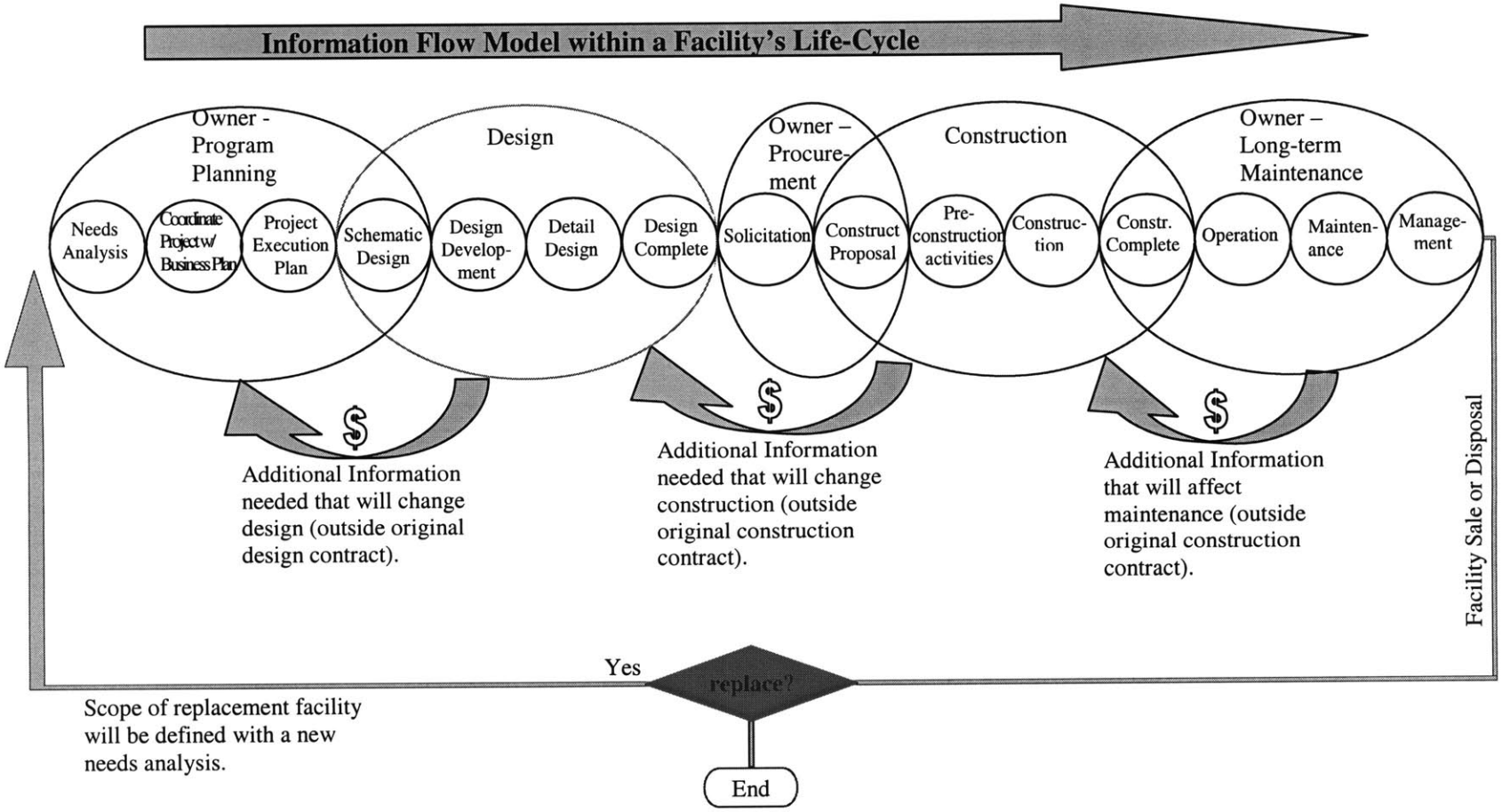

Figure 6: Information Flow Model within a Facility's Life-Cycle

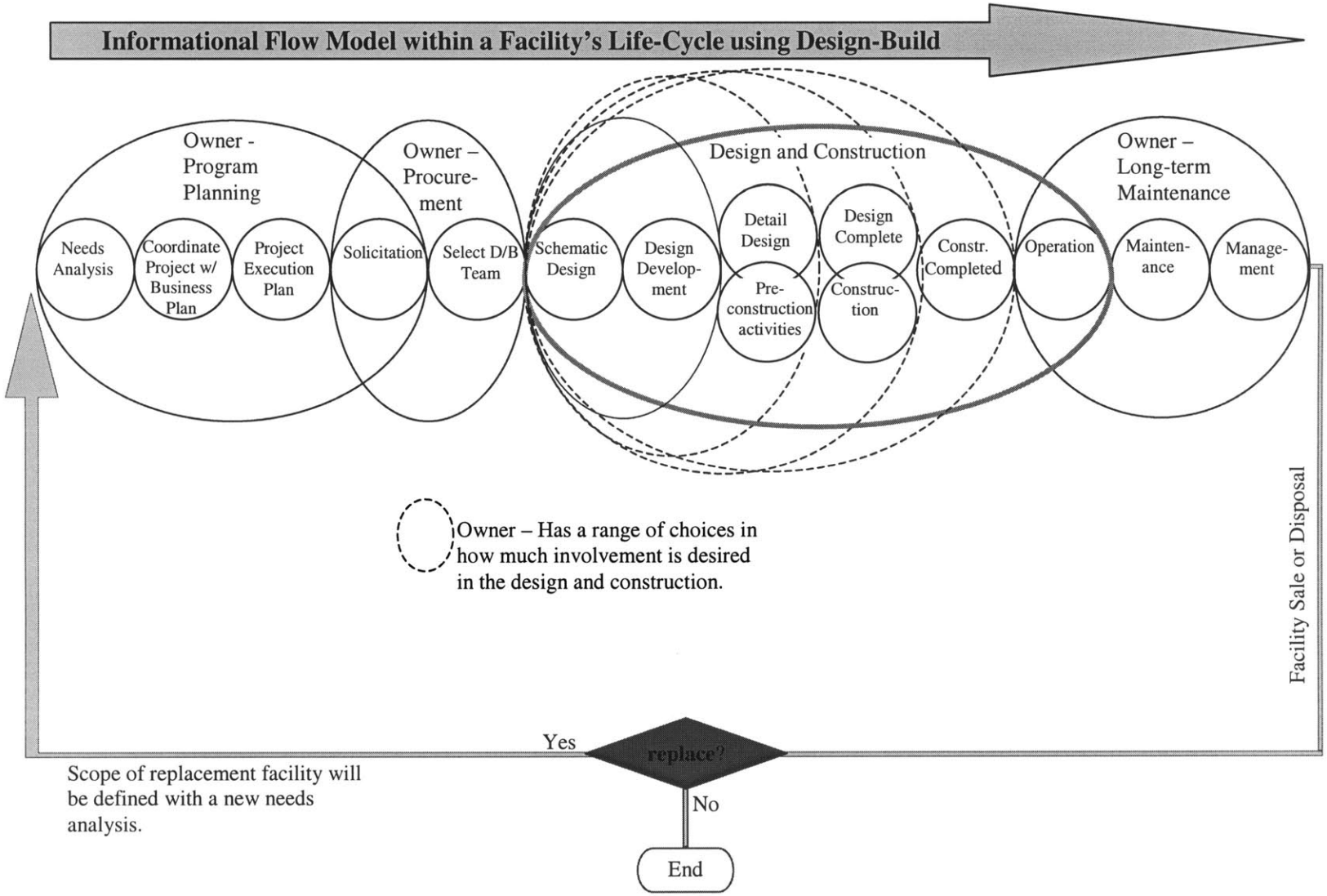

Figure 7: Informational Flow Model within a Facility's Life-Cycle using Design-Build

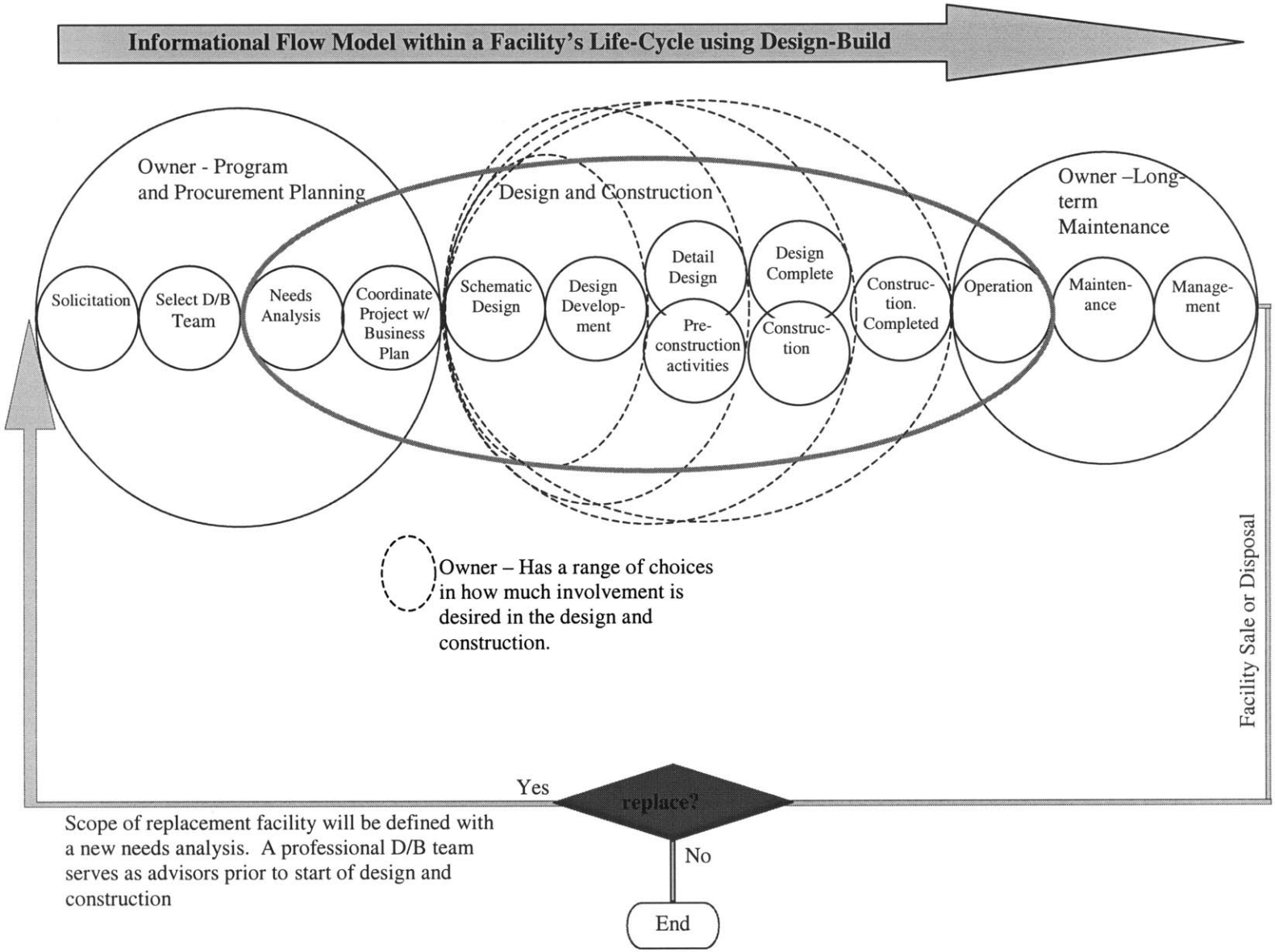

Figure 8: Proposed Informational Flow Model within a Facility's Life-Cycle using Design-Build

5.1 Facility life-cycle information

Figure #6 represents the basic flow of information in the life cycle of a typical[6] facility. The owner initiates the information stream with an analysis of the organizational business needs. The owner must then analyze the project to ensure it fits into the strategic plans of the business. For example, it may not be the best time to create a new facility if the organization is about to invest its capital in other ventures or activities. The owner must also look at how this project is to be executed. Although design-build has benefits that may fit into the owner's plan, other delivery methods should be examined and discarded to ensure that the best plan is being used (10). This figure assumes the owner decided to use the design-bid-build method. The owner hires the design professional and a schematic design is developed. The designer then adds to the flow of information by developing the design, complete details, and specifications. The owner at this point must reenter the flow of information and essentially form a wedge between design and construction. The owner will solicit the project, contractors will prepare proposals, or bids, and the lowest bidder will typically be chosen. The contractor then proceeds to set up the organization to complete the project. Construction is undertaken with sole reliance on the plans and specifications received during the solicitation phase. As construction is nearing completion, the owner will begin to focus on the long-term operations of the facility. Information with respect to operation and maintenance (O&M) manuals will begin to flow from the contractor to the owner. Once the owner has assumed control of the facility, personnel will monitor and update information on maintenance cycles, major repairs, and renovations. The final step is to demolish or sell the facility. Obviously demolition will end the flow of information. However, if the owner is to continue business and a new facility is to be constructed, the flow of information will start over with a new strategic analysis and definition of future needs.

In this typical pattern, all information flows from left to right. There is a strong transfer of information at the beginning of each of the phases, for example at the overlap of design with the owner and with construction's overlap with the owner. These overlap points signify the points at which needs are defined for the following phase. Once this definition is formulated,

any information that is needed by the previous phase will have a price attached to it. For example, if the contractor wins a bid for a building that was specified in a set of plans and specifications, then any changes to these documents will cause the contractor to incur extra costs. These costs will be passed to the owner. If the plans and specifications are not well prepared and the contractor is faced with ambiguities, any clarifications may also cost the owner money. Any changes in the O&M requirements that were not originally included in the construction contract may also cost the owner additional money. The owner will also pay extra if any of the original design criteria are changed. Therefore, the left-to-right information flow in the model makes it extremely important that the information be correct the first time in order to avoid a reverse flow in informational needs. Although not all information that moves right to left or in the reverse direction, will cost the owner, it is safe to say that it will in a majority of cases.

5.2 Facility life-cycle information using design-build

Design-build changes the flow of information within the life-cycle of a facility. Figure #7 highlights the major improvements. The flow of information within the design-build team has also changed the operations of a project. The designer is now contractually related to the constructor. This allows the constructor to input value engineering changes during design as well as to understand the intent of the design in a way that will produce a large advantage during construction. This also allows the designer to become more involved in the construction practices. The internal communication between these two will inherently improve the construction process. As can be seen in figure #7 the flow of information is changed in the life-cycle of the facility.

This figure assumes the owner has not developed any schematic design and that the design-build team will perform this task. The flow of the information is similar to the previous figure with the following exceptions. The procurement activity occurs early in the information stream and thus the owner must now choose a team of professionals that will develop a design to

[6] Typical is used relative to the writers experiences as an owner's representative responsible for each of the section shown in the figures as well as experience in the design and construction process and profession.

meet the needs defined by the owner. Once the team has been chosen, the owner has several options. The dashed lines signify the extent of these choices. It can be argued that the owner could, in theory, hire a professional team, define the scope and reduce direct involvement[7] from that point on. However, this model assumes that the owner will remain involved in the schematic and preliminary design development. Then the owner has choices. The design and construction has now been overlapped to show the benefit of design-build but also to show where the owner has choices. An owner can stay involved through design that will cover the start and potentially advanced stages of construction. Or, the owner may desire to stay involved during the entire construction period. Obviously as shown in the model, if the owner decides not to be involved to a great extent in the early stages, the owner must come in before the constructor leaves the site in order to deal with any long-term issues. The reverse communication issues have been eliminated using design-build. The team will essentially build the facility identified early in the process. However, confusions from the designer and/or constructor will be dealt with prior to incurring actual additional costs. Questions can be asked and resolved even while construction is proceeding. It is understood that at some time the final costs will need to be determined. However, settling later in the process and allowing issues to be defined prior to locking in a price may save money. Informational flow is key within this process. Communications must be open and information widely accessible. That is, the information must flow up and down stream, from the owner to the designer and constructor, and back.

5.3 Proposed changes in the facility life-cycle information using design-build

The prior two figures have presented the authors understanding of the information flow within a typical project. However, changes can be made that may be advantageous to the owner and the design-build team. Figure #8 shows the author's proposed flow of information using design-build in a different and more effective way.

In this model the owner can exercise greater flexibility in his or her involvement and at the same time ensure that the design-build team fully understands the owner needs and the

[7] The term 'involved' is being used relative to the flow of information and not meant to be related to design and/or construction activities.

reasons why they are essential to the business plan of the organization. This insight to the owner's organization allow the design-build team to develop informed project alternatives that not only fill current needs, but may also contain the flexibility to serve future needs as well. For example, since the owners are not usually design and construction professionals, they have no ability to use current design and construction technologies to arrive at solutions that best fit the needs and serve the business plan. An owner will gain this advantage with selecting a highly professional design-build team.

Once the needs have been defined the owner again has a choice to make. Has a professional relationship been developed well enough to allow the design-build team to continue with minimal involvement by the owner? If so the owner can direct the corporate resources that had been earmarked for administering the project, to focus on other issues closely to the business plan. This does not imply that the owner should not remain involved at some level. However, the depth or extent of this involvement can certainly be lessened if a solid relationship as been established and.

Is moving the design-build team up the information flow stream a value-added option? The answer to this proposed flow of information rests on trust and teamwork. The traditional adversarial relationships that place the owner in the middle as a wedge (also shown in figure #6) have been eliminated. However, this design-build team must earn the trust of the owner by demonstrating its total commitment to the owner's needs and priorities and its understanding of the organization's key issues. Having a professional design-build team involved in the upstream activities and analysis provides for a fresh look at the needs from different disciplinary perspectives. It places all parties on the same playing field at the same time, thus eliminating second-guessing up front decisions. Therefore value is added by the proposed change in the flow of information and chances for a successful project are greatly increased.

6.0 The strategic potential of design-build

The design-build delivery method is ideally positioned to offer Information Age clients[8] a focused team that has the design and construction expertise required for a project's entire project life-cycle. Clients are experiencing a time of change as they develop methods to move knowledge workers into more value-adding positions. Clients who have made this transition will be more informed on two levels. The client will either be reassured of what the customer[9] desires in a product, or the client will be aware the customer will require customization and continual improvements of the product. This translates directly into the types of constructed facilities it will need for production purposes.

The design and construction industry has always been aware of the importance of information and knowledge in its processes and products. Some see the design and construction industry as not transferring information very effectively or efficiently. However, this author would like to present an answer to this argument from another view. From the days of onsite coordination to the more recent days when the designers and constructor are not even in the same geographical area, communication is based on getting the information to the right place. Coordination issues have always had equal importance and the design and construction industry has been able to transfer information effectively with the tools that were available e.g. the mail or phone systems. That is, when mail was the only form of communication, it was understood to be an obstacle and responses were not expected to be immediate. When phones and faxes were developed, issues became more time sensitive. Geographic dislocation between designers and constructors could now be managed with relatively shorter response times. Currently communication has progressed to transferring information in real-time. Communication capabilities are undergoing radical changes experienced much like that when the phone system enabled significant decreased response time compared to the mail system. Current technology in wide use today allows people to be immediately reached anytime and anywhere with personal

[8] Clients are defined as the provider of a product or service that will require the design and construction industries to construct a facility. Synonymous with owner in this thesis.
[9] Customers are the ones receiving the product or services from the clients. Customers are not directly related to the design and construction industry, however have indirect affects via the demands on the clients.

pagers and cell phones, for example. This instantaneous access to the decision-makers in the design and construction industry will shorten response times to current and urgent issues on the project site and will allow them to be solved before they become major problems.

In the beginning of the Information Age, the clients of the design and construction industry have increased their access to information flow as well. Customers have increased levels of information available to them via the Internet for example. They can research and define product needs better than any time in the past. They are also becoming more attentive to the direct desires of their customers and this awareness translates directly for facilities that are efficiently able to adapt to the organization's business plan.

Design-build offers advantages in all these aspects. The relationships a design-build team is able to build with owners and other professionals will only be enhanced with the ability of real time information exchange. As owners' needs become more defined through the design process, again, real time information capabilities will allow all parties to ensure the product is going to meet the clients requirements.

6.1 Future owner preferences

Since the owner will have increased knowledge about their customers' needs, the owner will need to increase the potential flexibility of any new facility. The essential functions and use of a facility could be less understood than ever before. Owners need to spend adequate resources and define what prospective customers need, whether in a niche or mass production market. The owners will need to take these findings and build a facility that will provide an area to produce or serve these markets.

Customers also have an incredible access to information. The client's ability to adapt to future needs is essential to sustaining relative success. That is, an owner may loose competitive advantage if a product offering increased technology attributes would come to the market. However, if an owner is able to quickly adapt its facility to accommodate new operations required to support new technologies, then the advantage may not be lost. This is not to say that

an owner of a production operation should change practices with every new market technology. This emphasizes the instance where a technological advancement in a product can improve current operations. Or, if a production owner forecasts an increased market in advancing technology, then changing current operations to support new technologies will better position their organization in the future.

As an example, there are many current machines that need to be isolated from motion in order to operate properly. These machines may be isolated using current structural dynamic theory. Technology and motion requirements could advance to the point that the owner must completely isolate a room or the entire structure itself. A typical owner will not know this technology exists. However, with a design-build team in place prior to project definition, the team could offer these technological advancements as solutions to current and future problems. Imagine a building completely isolated from affects of external motion e.g. wind, train passing by, or even an earthquake, regardless of increasingly stringent requirements being developed in the future for machines needing less disturbance, this forward thinking owner will be able to accommodate all prospective machine restrictions within the same facility. This example of an increased flexibility theme will be used later to support changes to the owner's preferences for using the design-build method.

The first of the owner's perspectives presented in this thesis in Chapter 3 were the project characteristics by which the owners in which they identify projects that are ideal for design-build. Will the same characteristics hold true for the information age client's changing business interest and operating methods?

The top three consolidated characteristics were: 1) Project scope considerations, 2) Considerations internal to the owner's organization, and 3) Owner's considerations with cost and schedule.

The isolation example previously described, indicates a need for changes in these characteristics. An owner will look at projects with an increased emphasis on schedule and cost. However, cost will not be bottom line construction costs. Other factors such as completion

timeframe, and technological innovations in the project will be joined with costs. Also, the life-cycle costs rather than just construction costs will drive future projects. Adaptability and flexibility aspects will also become important to owners. In the past, an owner might set up a relatively fixed assembly line to mass-produce a product. However the increasing market demand for product customization and alternatives will require flexible production facilities and spaces.

Therefore, in the new economy project characteristics that indicate the use of design-build will be schedule coupled with cost issues, along with issues of market demand and manufacturing facilities for the client's product? Design-build provides flexibility and access to a team of design and construction professionals early in a project's inception that can greatly assist in defining the scope, functions, and requirements of the intended manufacturing plant.

The second area of owners perspectives addressed in this thesis was motivating factors for choosing design-build. The factors included: 1) Shorten Duration, 2) Establish Cost, 3) Reduce Cost, 4) Constructability/ Innovation, 5) Reduce Claims, 6) Establish Schedule, and 7) Larger Project size/ Complexity. In reference to the structural vibration and isolation example, the first three of these may remain in the same order of preference with future owners. However, establishing a schedule and project complexity might well increase in importance again. Design-build, with its early input from the professionals will enable owners to think even farther outside of the traditional construction parameters. A professional design and construction team will be able to offer solutions to the owners problematic requirements. This in essence could increase the initial conceptual complexity and at the same time develop a more accurate definition of what an owner desires in a facility.

The characteristic of reducing claims will move further down the list. As many other delivery methods are attempting to focus on partnering and teamwork, the relative importance of reducing claims will decline. All rational sides of a construction project are increasingly realizing that claims and adversarial relationships benefit no one, and should be avoided at all cost.

The last area of owner perspective described in the thesis were the criteria by which an owner judged the success of a design-build project. These criteria were: 1) On budget, 2) Conforms to users expectations, 3) On schedule, 4) Meet specifications, 5) High quality of workmanship, and 6) Minimizes construction aggravation. The future more enlightened owner may be more realistic about the inherent uncertainty of budgets and the detriment that strict adherence to them might cause. Design and construction is inherently full of unknowns from site conditions, to design and construction issues, as well as unknown owner issues. However a capable design-build team can work closely with the owner to develop a project that is within the "scope of the business budget". This collaboration will go along way towards increasing confidence and reducing conflicts regarding the budget.

The future owner's judgement of project success will rely heavily on conformance to his expectations. Design-build will greatly enhance this aspect with its up front involvement in helping the owner be realistic, not only with respect to cost, but also with respect to the function, architecture, quality, and other expected features of the building.

Schedule will also remain a key determinant of success especially in an environment characterized by the high profits associated with being first in the market. For example, the manufacturers of microchips are able to make hundreds of thousands if not millions of dollars a day in production. Each day in the design and construction process will severely cost this type of business.

6.2 Design-build evaluated

The previous section discussed possible changes in the future owner's perception of project characteristics. The design-build delivery method seems ideally suited to these changing owner needs and priorities. This observation is confirmed by a study completed in early 1998 that compared design-build against two other principle project delivery methods, construction management at risk and design-bid-build. (14) The study included evaluations of the three methods relative to cost, schedule, and quality related variables. The variables pertained only to the design and construction phases of the projects. They were: 1) Unit cost, 2) Construction

speed, 3) Delivery speed, 4) Cost growth, and 5) Schedule growth. In order to relate these variables to delivery methods, the design-bid-build method was set to be a value of 1.0. The design-build and construction management at risk was compared to each through the percentage differences in from the base line value as shown in Figure #9. It is clear that design-build has an advantage in addressing each variable within a given project.

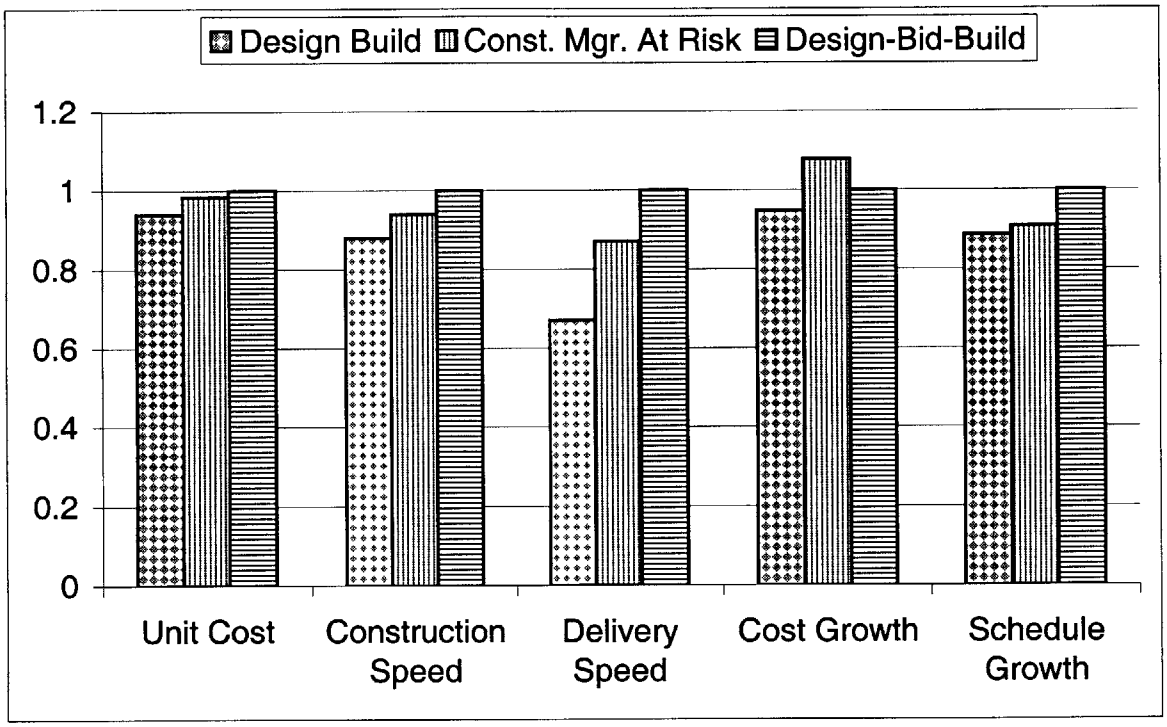

Figure 9: Percentage of Average Differences between Project Delivery Methods

This thesis has tried to highlight the increasing importance on cost, speed, and control of projects. The results in Figure #9 support the strategic advantage of design-build in these areas. If design-build can be shown to owners to be superior with respect to these variables, than the potential for this method improves with every successful project completion. The increase ability to complete a project in a team atmosphere and at the same time have effects on these strategic factors will be extremely attractive to the owners and clients of the future.

6.3 Strategic Considerations

Design and construction services are increasingly seen as becoming commodities. This prospect is not appealing for the industry. The individuals and organizations within engineering and construction professions have too many value-added services to offer to future clients. It is understandable how standard materials and routine subcontracting activities can be based solely on price. However in other areas, such as management and coordinating the collaborations among design and construction professionals and owners, investigating and adopting technical advances and innovations, and systems engineering integration, there are significant opportunities for the industry to provide distinctive value-adding services.

The remainder of the Chapter describes the use of strategic management tools that could assist design and construction industry firms to define and offer value-adding services to the information age clients of the future.

The first of these is the market segmentation matrix shown in Table #7developed by Michael Porter in his book *Competitive Advantage.* The matrix gives an example of this

		Buyer Types					
Service Types		Residential	Industrial	Commercial	Institutional	Utilities	Infrastructure
	Traditional Approach						
	Construction Management						
	Design-Build						
	Turnkey						
	Build-Operate-Transfer						
	Multiple Primes						

Table 7: Design and Construction Market Segmentation Matrix

strategic tool as applied in a more general sense to the delivery of construction projects. The columns of the matrix are labeled with different types of buyers and the rows are labeled with the types of services (delivery methods). The buyer types and service types are taken from chapter 1 of this thesis. Market segmentation is useful to identify focused views of buyers needs and alternative ways an organization can move to meet these needs.

The cell shaded in Table #7 is highlighted in order to apply another strategic tool that can be used to show the potential of design-build within the commercial construction segment of the design and construction market. This tool is called the Five Forces Analysis.

Michael Porter defines five competitive forces that determine industry profitability. These forces are applied to a given market segment in order to judge their influence. The five forces as applied to the design and construction industry would be:

1) The level of threat of entry by new firms
2) The negotiating power of the owners
3) The level of threat of substitution, that is using different delivery methods
4) The negotiating powers of the contractors with the design-build team
5) The rivalry within the industry focusing on design-build projects.

Figures #10 and #11 are graphical representation of the five forces, as they would apply to the design-build commercial market segment. Figure #10 presents the current market level with a medium-to-high threat of new entries. This is interpreted to men that the design-build method of delivery is unique to a limited number of design and construction organizations and therefore does not have a threat of entry as does the traditional design-bid-build method. The threat is higher in the traditional method service type inasmuch as all it takes to get in is the technical skills to complete the job. The barriers to entry (18) into the design-build method are increased due to the needed team or joint venture of design and construction professionals.

The owners negotiating power can be tied to the level of the threat of new entrants. In this example, as more and more organizations discover the benefits of using the team approach, the threat of new entrants will increase, and therefore owners bargaining power will also increase. That is, the owner will have more firms that offer design-build to choose from and thus will have a stronger bargaining position.

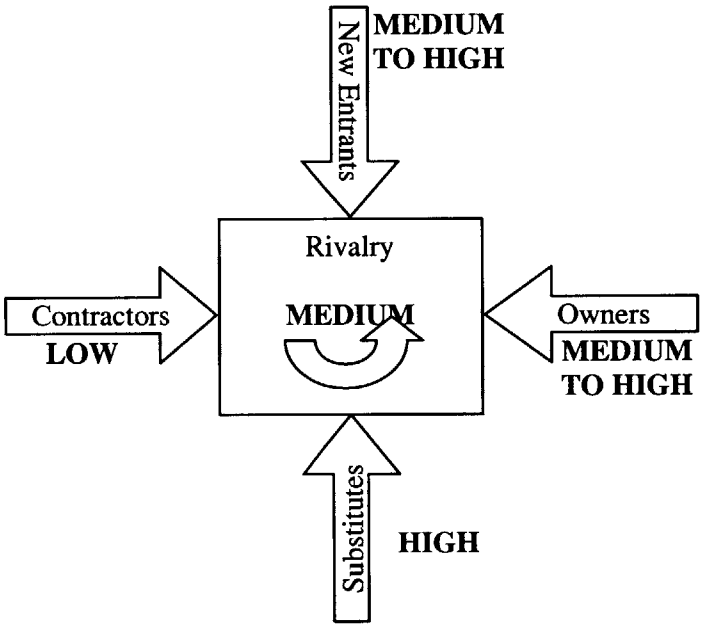

Figure 10: Five forces applied to a current design-build team (18)

The threat of substitution is high. With so many other types of delivery methods, an owner can choose one that they have used in the past; or they may have professionals in their employ who have experienced other delivery methods. The owners need to be shown the team approach supported by design-build is beneficial to all parties within a project. The negotiating power of the contractors is relatively low because the service provided by a contractor is considered a commodity. There are so many plumbing contractors for instance that a project manager will typically choose one based on price factors only. This will not change and therefore, this power will always remain relatively low. The rivalry among current design-build team is judged as a medium level inasmuch as many firms are still not attempting these types of projects.

Figure #11 presents an analysis of these same five forces, after the application of the changes offered in this thesis with respect to the flow of communications in a design-build project, and the application of ideas of an internet of intranets of various design firms and construction contractors. As a design-build firm moves upstream and begins to assist the owner in defining business needs and projects, they will gain unique professional experience that will be hard to duplicate, thus gaining a "first mover" advantage. The firm must internalize the changes and develop differentiated services in order to sustain success in this delivery method.

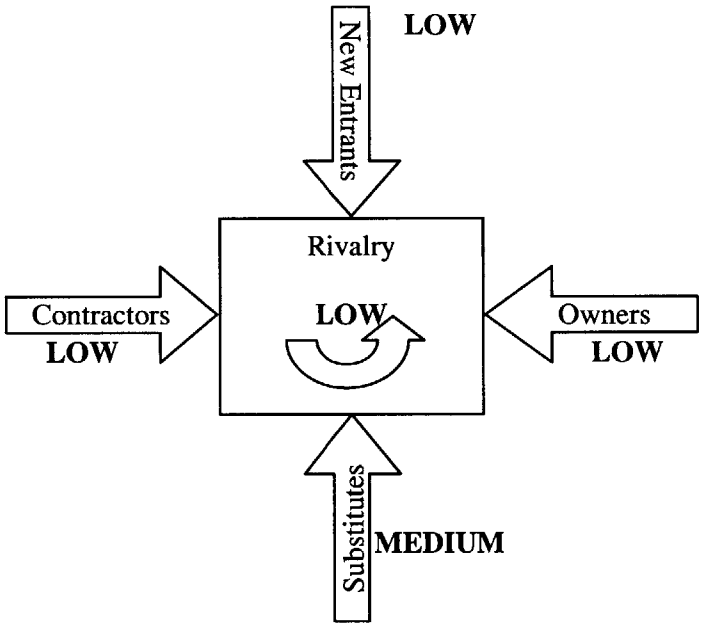

Figure 11: Five forces applied to a future design-build team (18)

If the design-build team develops efficient relationships with owners, and others begin to see the strong benefits in such a team approach, the forces shown in Figure #11 would apply to the industry. The more experienced firms will be able to raise barriers to entry and therefore lower the risk of new entrants. As mentioned earlier in this thesis, this delivery method is not perfect for every project nor is it perfect for every design and construction firm. Therefore, firms that accept the method and develop a connected internet of design and construction intranets will have the opportunity to create winning teams for various types of construction. Firms in the future that will want to move into this segment will have to create these teams and develop experience in this area. The formation of an internet of intranets is accessible to any firm, however the teams with experience will invest in time and money to develop and mold themselves into an efficient model, which will deter some firms from entering. Firms practicing

in design-build will need to develop and institutionalize knowledge and expertise within the organization that would give them a competitive advantage. In this example, and relating the level of rivalry to the number of competent firms, the level of rivalry will decrease in magnitude with fewer entrants into the industry. The atmosphere of the rivalry will also change relative to the traditional model. In the traditional model, price is the factor creating the rivalry. However, in the professional design-build team atmosphere the level of service will become the driving factor. This will improve the product delivered as well as delivery the process to the owner and at the same time raise the level of professionalism in the industry.

The owners negotiating power will decrease with fewer choices of experienced and professional teams. The power will also decrease as the industry validates the value-added functions that are offered by this method, thus convincing owners that paying more for an increase level of service is acceptable and makes good business sense.

The threat of substitutes will remain essentially the same as before, however an argument could be made that when the owners see innovative services in the design and construction process, they will increasingly promote the use of design-build. This might reduce the chances of using a substitute method to a medium level; however, the threat will always be there. The negotiating power of the contractors remains the same as previously discussed.

7.0 Summary and Conclusions

The design-build method of project delivery offers many benefits that could serve as a vehicle for enhancing the prestige and professionalism of the design and construction industry. The days of the traditional adversarial relationships between professionals are rapidly coming to an end. These relationships are self-destructing to the industry and must be avoided by all parties involved in a project.

This thesis has given a historical perspective of the design-build concept as related to the master-builder of past civilizations, and its use as a single point of responsibility on a project. This began to change at the turn of the 20th century when the owner with separate documents contracted with the designer and constructor. This change was the catalyst for the adversarial relationships between the professionals. Many benefits and concerns were listed to support the current thinking that the design-build delivery method is not perfect. However, identifying problems or issues is the first step in finding solutions. The analysis of the lists showed that the benefits outweigh the concerns; and furthermore that the concerns can be overcome with proper pre-project development in creating correct documentation and incentives for all parties.

In order to define current owner perspectives on design build, previous studies were reviewed and summary information presented to provide insight into important factors from an owner's perspective. These studies showed how an owner ranks issues in a project that will point towards using design-build; how an owner ranks factors related to the motivation for using design-build versus other delivery methods; and how an owner would judge a project as successful once design-build was used.

The changing viewpoints of an owner were presented using a management model that is emerging in the Third Wave or Information Age of our economy. This model illustrated drastic changes from the past mass production mentality of industrial age management styles. Managers are beginning to recognize the importance of the knowledge worker within their organizations. It was shown that on one hand these managers, which are clients of our profession, are becoming more in tune with what is needed to satisfy their customers. On the

other hand, these needs are changing so rapidly, that future but unknown production processes must be provided for in constructed facilities being designed and constructed today. Our clients will no longer accept a standard defined by the manufacturing industry, they are demanding customization at some level. This uncertainty must be dealt with by the design and construction industry in helping owners to define and procure projects. Design-build offers a team atmosphere that will foster the best alternatives to meet an owner's future needs.

Design-build provides the capability to change and improve the flow of information between the professional team and owner. The phase at which the design and construction professional enter a project's life-cycle can change the industry and add value to the project earlier with experience and professionalism. These activities will give the owner a project that is more responsive to their current business needs as well as flexibility to make future modifications to complete facilities.

The owner's perspectives on design-build projects were revisited and tested in the context of management in the under the information age. This revealed several changes that the design and construction professional could exploit to better anticipate future requirements. Knowledge of the owner's business decisions will increase the efficiency of projects. Understanding these issues will give the design-build team the ability to ensure the project meets the functional needs of the owner as well as the intent of the business plan. The owner will be able to judge the project more accurately with respect to meeting the initial idea in creating a project.

Design-build is more advantageous in addressing issues the owner will become increasingly concerned with on future projects. That is, speed, cost and schedule growth. While these are currently important to owners, given the speed of business today, these issues can only increase in importance. The proper mix of these issues can better be served in a service-focused segment rather than one seen as a commodity.

A major intent of this thesis is to stimulate and inform and create discussions concerning the future of the design and construction industry. The view of the industry services as commodities must be changed. Buildings, infrastructure, utilities, and of course residences will

always need to be constructed. People do not currently choose doctors, lawyers, or even various products based solely on price related factors. There is a level of service by these professionals that is important and seen as value-added activities by clientele.

Providing roads, hospitals, schools, office buildings, utility and manufacturing plants should not be seen as commodity operations. Design-build promotes the idea of teamwork in order to provide the most applicable and useful product to our clients.

Although this thesis focused on design-build as a delivery method, it is this team atmosphere that is most intriguing. This team, however, is based on communications between the design, constructor, and the owner. An important factor is never to exclude any part of this triangle. A properly formed team will be much more efficient and productive than relationships experienced in the past. The time and cost savings experienced in various projects could be directly linked to this new teaming relationship

This industry provides a vitally important function to our society. Discussions must take place at all levels throughout our industry to focus the attention on creating value-added changes in the way we deliver our services. The goals should include advancing our professional industry in a positive service-oriented direction that will involve increasing our professional worth to our clients, and therefore increasing our perceived value to society.

Appendix

References:

1. American Society of Civil Engineers (1992). *Design-Build in the Federal Sector*, a Report of the Task Committee on Design-Build, American Society of Civil Engineers
2. *Annual Value of Construction Put in Place in the United State: 1995-1999*. United States Census Bureau. Obtained via the Internet page www.census.goc/pub/const
3. Art History obtained via the Internet page www.arthistory.about.com
4. Barogue obtained via the Internet page www.uib.no/ped/baroque.html
5. Bechtel 1999 Global Report obtained via the Internet homepage www.bechtel.com
6. CENTEX Corporation 1999 Annual Report Financial Information obtained via the Internet homepage www.centex-annual.com/1999annual
7. de St. Aubin, Mark C. (1997) '*The Risk and Benefits of Design-Build Contracting.*' Construction Business Review, Volume 7 Number 4, 22-25.
8. Drucker, Peter F., *Post-Capitalist Society* (Oxford: Butterworth-Heinemann, 1993), 1
9. Flour Corporation 1999 Annual report obtained via the Internet homepage www.flour.com/investor
10. Gordon, Christopher. Instructor of Course 1.472 Innovative Project Delivery Methods in the Public and Private Sector, Massachusetts Institute of Technology Spring 2000.
11. 'Gothic Painting (1280-1515' obtained via the Internet page WebMuseam, Paris located at www.metalab.edu
12. Hendrickson, Chris, Au, Tung. *Project Management for Construction*. Prentice Hall, 1989.
13. Hope , Jeremy, Hope, Tony. *Competing in the Third Wave*, Harvard Business School Press, 1997
14. Konchar, Mark, Sanvido, Victor (1998). '*Comparison of U.S. Project Delivery Systems.*'435-444. Jouranal of Construction Engineering and Management, Nov/Dec 1998.
15. Lund, Philip J. '*The Design/Build Alternative.*' 22-23. Original and publishing information unknown. Obtained copy attending Course 1.472, Massachusetts Institute of Technology, Spring 2000
16. Macomber, John D. (1991) 'Eight Steps to Success' Construction Business Review, 31-35, 70-71. HLK Global Communications, Inc.
17. Molenaar, K.R. (1995) '*Appropriate project Characteristics for public sector design-build projects.*' MS thesis, University of Colorado at Boulder CO.
18. Porter, Michael E. *Competitive Strategy in Fragmented Industries*, Competitive Strategy, 191-214. Free Press
19. Proter, Michael E. *Competitive Advantage, Creating and Sustaining Superior Performance*, New York: The Free Press, 1985.
20. Songer, Anthony D., Molenaar Kieth R., and Robinson Graham D. (1997), '*Selection Factors and Success Criteria for Design-Build in the U.S. and U.K.*' University of Colorado at Boulder, CO.
21. Songer, Anthony D., Molenaar Kieth R. (1997), '*Selecting Design-Build:Public and Private Sector Owner Attitudes.*' University of Colorado at Boulder, CO.
22. 'The Top 400 Contractors.' (1999) Engineering News Record Vol. 242, No. 21
23. Wist, Christopher (1987). '*Design/Build Methods Mature,*' Architecture (October, 1986) 107-109