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PRODUCTION PLANNING METHODOLOGY FOR LARGE HOMEBUILDING FIRMS

By

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ABSTRACT

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This report provides a production planning methodology for large homebuilding firms. Production planning, a key component of the business planning process, is the managerial function of planning and controlling the conversion of organizational resources into goods and services. The production planning methodology (PPM) illustrated by this report is designed for the specific characteristics of the homebuilding industry. The methodology includes planning processes and an information system modeling method for the following planning systems; estimating, scheduling, cost and progress control, financial and accounting, subcontracting, and material acquisition. The literature review was conducted to identify research related to construction management, production planning, and structured analysis. Traditional production planning techniques were also identified. Evaluation was conducted through the application of the proposed methodology on an example production homebuilding firm. Additionally, two production homebuilding firms were examined to further evaluate the research findings.

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CHAPTER ONE

INTRODUCTION

1.1. Overview

Today's homebuilding industry is highly competitive. In order to gain a competitive advantage, homebuilding firms must select the right strategy based on their market and available resources, and then direct their efforts toward the selected strategy. This is the process of selecting and developing a strategic plan. The strategic plan encompasses the core purpose of a company through the integration of mission, product, and values. Substantial work has been conducted related to strategy selection and implementation. Kotler, et.al, (1997) and Treacy, et.al, (1995), categorized strategies differently. Kotler, et.al, (1997) categorized strategies by cost leadership, differentiation, and focus. Treacy, et.al, (1995) categorized strategies by operational excellency, product excellency, and customer intimacy. Kotler, et.al, (1997) argued that the foundation for cost leadership or operational excellent business strategy is efficient production. The production concept holds that consumers will favor those products that are widely available and low in cost. It is the author's opinion that the majority of large homebuilding firms, as defined later in this section, have embraced the production concept as a component of their strategic plan. These homebuilding firms are known as production homebuilding firms. Hence, it is essentia

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essential for production homebuilding firms to practice production planning within their organization.

This study presents a methodology for production planning within large homebuilding firms. The production planning methodology is intended to support the growth and survival of large homebuilding firms, increase trade partnering, and facilitate business system integration.

Homebuilding firms can be classified as large, medium, and small according to their construction output. Large homebuilding firms, making up only 2% of the 107,495 residential general contractors, performed over 18% of the total construction work in 1992. Large homebuilding firms, defined by the 1992 Census of Construction Industries (U.S. Department of Commerce, 1992) have 20 or more employees. The 400 largest homebuilding firms, in 1997, captured 23.5% of the market (Professional Builder, 1998). Most large homebuilding firms implement the production concept through product standardization. Product standardization allows for greater production efficiency and volume buying power (Kotler, et.al, 1997). For the purpose of this research, large homebuilding firms that have implemented the production concept through product standardization will be referred to as production homebuilders.

The longevity of successful production homebuilding business models are in question. Increased resistance to new residential development will contribute to product differentiation. Product differentiation is the evolution from standard product lines (limited number of standard home plans) to diverse plan offerings. The phenomenon of product differentiation is described below.

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The author conducted research related to the impact of housing development on Michigan communities, (Seidel et.al, 1998). During the course of this research, the author observed that in many Michigan communities there is an increased resistance to new land development. Residential land development is the process of converting one or more parcels of land into residential parcels, which homes can be constructed upon. A home is a specific residential unit, either single-family (one home per building) or multi-family (two or more homes per building). The author observed that many large residential homebuilding firms also engage in residential land development in their market area. It is the author's opinion that many large homebuilding firms have met the increased resistance to new residential development by employing some or all of the land development techniques listed below.

- Brown-field or urban redevelopment – A development technique that converts land located in an existing urban area to a new use. For example, converting an existing warehouse facility to residential lofts, or construction of multi-family units on urban in-fill sites.
- Planned unit development (PUD's) – A development technique that converts one or more parcels of land into a mixed use community that includes single-family units, multi-family units, commercial uses, schools, and churches.
- Neo-traditional or new urbanism development – A development technique that employs community specific design criteria, often solicited form existing residents and local architectural precedents, to the new proposed

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development. This development technique often employs traditional land-use patterns.

Many land development techniques, such as those described above, result in increased product differentiation. For example, a large production homebuilding firm that historically constructed a limited number of home types with standardized options now must construct a wider range of product in order to meet municipal demands. This phenomenon is driven by many factors such as: increased municipal control or involvement in the land development process and the success of past projects that employed the land development techniques described above. Increased product differentiation has a dramatic impact on production homebuilding firm's business systems and the business planning functions of managers.

A business is a system and managers perform managerial functions within the system. Business planning is the foremost managerial function. Business planning is made up of a sub-set of business planning processes, which include production planning.

Production planning is the process in which managers plan the use of organizational resources in order to meet the demand projected in the market plan. How well managers perform managerial functions impacts the level of managerial proficiency at which a business operates. Managerial proficiency is a measurement of the proficiency of managerial functions and business systems.

Music (1985) defined managerial proficiency as a measure of the characteristics that are readily identifiable within any homebuilding firm. The characteris

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characteristics are management systems, management technique, educational attitude, and organizational structure. Music (1985) demonstrated that a given level of managerial proficiency can support a range of construction output at a fixed level of effort. Homebuilding firms planning to increase construction output must increase either managerial proficiency or effort. The underlying premise is that it is mor3e efficient to increase managerial proficiency then effort.

This study presents a methodological approach to production planning for large production oriented homebuilding firms, taking into account the outlook for increased product differentiation. The production planning process is approached from management systems and information perspectives in order to present a comprehensive production planning methodology. This methodology is intended to increase the managerial proficiency of production homebuilding firms.

1.2. Residential Construction Industry

There are over one hundred thousand residential general contractors constructing homes in the United States. Residential general contractors, defined by the Census of Construction Industries (U.S. Department of Commerce, 1992), performed over 48 billion dollars worth of construction work in 1992. Of the total value of construction work performed by residential general contractors (homebuilders), 81.4% was single-family detached home construction and 6.6% was multi-family construction.

Large homebuilding firms can be classified as either large or giant. For the purpose of this study, large and giant homebuilding firms are those firms that produces

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produced greater than 5 million and 10 million dollars of construction output in 1992, respectively. In 1983, there were 452 giant homebuilding firms, as of 1992, the total was reduced to 206, although the total market share of the giant homebuilding firms remained the same (Census of Construction Industries, U.S. Department of Commerce, 1992). It is the author's opinion that large and giant homebuilding firms are typically production oriented. Production homebuilding firms historically offer a limited selection of home plans for each market segment they operate in. This assumption is based on Treacy's description of production orientation (Treacy, et.al, 1995):

> *"Achieving and sustaining operational excellence requires more than cloning hyper-efficient assets. Today, as in Henry Ford's era, variety kills efficiency. Operationally excellent companies reject variety, because it burdens the business with cost. They produce no-frills products for the middle of the market where demand is huge and customers are more interested in cost than in choice."*

Subsequently, production homebuilding firms are defined as production-oriented organizations that offer standard plans, options, and upgrades. Limited selection allows for greater control of the production process, increased construction efficiency, and volume buying power. It is the author's opinion that due to the outlook of increased product differentiation, described above in section 1.1, this business model must change. Production homebuilding firms must evolve to a foundation based not only on product standardization but system standardization as well. System standardization, fueled by information technolo

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technology, will allow large production homebuilding firms to maintain production efficiency in an environment of increased product differentiation.

1.3. Need Statement

The majority of production planning research has focused on manufacturing environments. The variables related to production homebuilding exclude conventional production planning methodologies from being applied to this industry. For example, material resource planning (MRP) models and software are designed for a controlled environment with minimal tolerance levels. Construction is certainly not conducted in a controlled environment. Also, tolerance levels are wide since no two homes are ever the same. Pheng, et.al, (1997) compared the manufacturing sector with the construction industry:

> *"Unlike the manufacturing sector, the construction industry is a more complex and fragmented industry. Construction activities are generally complex due to the vast number of tradesmen, materials, machineries, and construction methods used in any construction project. The industry is also highly fragmented with different transient builders and suppliers entwined in different procurement and contractual arrangements."*

The levels of fragmentation and unpredictability within the homebuilding industry are high. The fragmentation of the homebuilding industry is attributed to three characteristics: (1) The large number of residential construction firms (107,495 according to the 1992 Census of

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Construction Industries, U.S. Department of Commerce, 1992), (2) the large portion of sub-contracted labor (over 30% according to the 1992 Census of Construction Industries, U.S. Department of Commerce), and (3) the impact of highly fragmented municipal control. For example, in Michigan, interpretation and implementation of building codes varies from one local government to another. Unpredictability in the homebuilding industry is attributed to three primary factors; (1) changing government controls at the federal, state, regional, and local levels, (2) unpredictable weather, and (3) fluctuation of material and labor costs. For example, lumber, a volatile commodity, made up 94% and 89% of all material used in single-family and multi-family low-rise construction, respectively (Census of Construction Industries, U.S. Department of Commerce). Fluctuation in lumber costs dramatically affects the total proportion of material costs to the sales price of homes contracted prior to lumber price fluctuations. Also, a large commercial construction project may commence in a given market area, therefore drying up the labor supply of certain trades, subsequently increasing the cots of those trades. Hence, it is difficult to apply a production-planning methodology to the production homebuilding industry developed without the specific characteristics of this industry in mind.

It is the author's opinion that the production concept, as currently implemented by many large homebuilding firms, is based in its entirety on product standardization. Considering the likeliness of increased product

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differentiation, over time, as described in Section 1.1, it is necessary to revise existing production planning approaches, taking into account the impact of product differentiation. Advancements in information technology contribute new solutions for production homebuilding, given product differentiation.

Information technology is rapidly advancing. The amount and quality of information available to managers today dramatically exceeds what was available before the information revolution. Large homebuilding firms have implemented planning and control software solutions for financial, accounting, estimating, and scheduling functions. Based on the author's experience in the industry, the applications used for the planning activities of managers are often "stand alone" applications. The tasks associated with stand alone applications lack efficiency.

The production planning process utilizes information generated from estimating, scheduling, cost and progress control, finance and accounting, and sub-contracting and material acquisition (Dasso, 1988). For example, the amount of work in progress is a direct result of the number of units in production and the total cycle time necessary to construct each unit. Cash flow constraints must be communicated to production before work in progress exceeds the available cash resources. Limiting the number of job starts or decreasing cycle times can reduce work in progress. Increasing crew size or crew productivity can reduce cycle times.

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A production planning methodology that takes into account the characteristics of large production homebuilding firms is needed. Such a methodology would contribute to the managerial proficiency of a production homebuilding firm, in an environment of increased product differentiation. A production planning methodology should include:

- Method designed to take into account the characteristics of the production homebuilding industry.
- Method that accommodates product differentiation as opposed to a method based on product standardization.
- Method to identify the information system requirements, taking into account system integration.

1.4. Thesis Focus Area – Production Planning

This study will focus on production planning for large production homebuilding firms. The production process for homebuilding firms utilizes both internal and external resources such as management, cash, sub-contractor labor, and material to build homes. The majority of large homebuilding firms are production homebuilders and the production process is their core competency. It is the construction process in which they create the greatest value with the least input. The production process for production homebuilding firms encompasses product development, procurement, and construction activities.

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The three characteristics of core competencies defined by Kotler, et.al, (1997), are; (1) they are a source of competitive advantage, (2) they have potential to span a breadth of applications, and (3) it is difficult for competitors to imitate them. Therefore production planning is a vital component to management of large production homebuilding firms.

Production planning involves the following systems: estimating, scheduling, cost and progress control, finance and accounting, and sub-contracting and material acquisition. Each system is complex in nature and affects many other systems in a production homebuilding firm. During interaction with several homebuilding firms, the author found that many of these systems are developed independently and maintained by different departments. When one considers the hundreds of components that make up a new home multiplied by hundreds of units constructed annually, then the magnitude of the various production planning systems and subsequent production planning processes becomes evident.

Comprehensive production planning can lead to higher quality, improved customer service, increased production efficiency, lower cycle times, improved cash flow, improved work force loyalty, increased job-site safety, and efficient site management. This study first examines production planning in terms of management systems and management functions. Next, the role of information systems in production planning is examined conceptually through the decomposition of management systems.

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1.5. Research Objective

The objectives of this research consist of the following:

- To develop a production-planning methodology (PPM) for homebuilding firms classified as large homebuilders. This methodology should be applicable to the majority of homebuilding firms producing greater than 10 million dollars of construction output annually.
- To include a modeling method that will allow managers to identify the detailed information system requirements necessary for proficient production planning within their firm.
- To evaluate the research findings of the proposed production planning methodology. Evaluation will be conducted through the application of the proposed methodology on an example production homebuilding firm. Additionally, managers of two production homebuilding firms will be interviewed to further evaluate the research findings.

1.6. Methodology

This study was conducted in four phases. A comprehensive literature review was conducted in phase I. A production planning methodology was modeled and the information system requirements were developed in phase II. An industry analysis, designed to evaluate the applicability and essentiality of the work, was conducted in phase III. Finally, a report was developed in phase IV.

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PHASE I

Phase I of the research encompassed the development of an understanding of the focus area and a comprehensive literature review. Any study directed toward a specific industry should begin with the intent of developing an understanding of the focus industry. This was accomplished through the author's diverse work experience related to production planning for large homebuilding firms.

Next, an understanding of business planning was developed before production planning, a sub-set of the business planning process, was investigated. Also managerial proficiency, as related to production homebuilding, was examined. This understanding was partially developed through previous academic work conducted by the author. The author, as part of his work with the Housing Education and Research Center at Michigan State University, developed a guide to business planning for Michigan's residential construction industry, which includes a detailed analysis of managerial proficiency (Seidel, et.al, 1997).

The literature review was directed toward production planning and the role of information systems in production planning. It encompassed the identification and evaluation of information related to the following categories; residential construction management, production planning, and information system design and development. The author's graduate course work was directed toward residential construction management and i

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and information system design with an emphasis on conceptual database modeling.

PHASE II

A production planning methodology and subsequent information system modeling method was developed in phase II of the research. The production planning methodology was derived through the literature review and the researcher's related experience. The information system modeling method was developed through the literature review and the author's course work. The identification of the information system modeling method was accomplished through business system decomposition. Business system decomposition is the process of examining an organization's processes at varying levels of abstraction.

All companies can be examined at different levels of abstraction. The three levels of abstraction are the value chain level, resource-event-agent level, and task level (McCarthy, et.al, 1997). The value chain level of abstraction is utilized to model an organization at the highest and most abstract level. This is accomplished by modeling the value-added series of exchanges a firm engages in. A value-added series of exchange is a representation of a give and take relationship at a highly abstract level. For example, the process of utilizing employee service, materials, and equipment to produce goods. The resource-event-agent level of abstraction is the level of abstraction at which managers plan, monitor,

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and control (McCarthy, et.al, 1997). For example, closing a purchase order, debiting a cash account, and issuing a check to a vendor are representative of the resource-event-agent level of abstraction The lowest and most organizational specific and detailed level of abstraction is the task level. This level of abstraction is representative of the daily tasks employees of a firm engage in to operate the business processes. For example, physically attaching an invoice to the appropriate purchase order. Information processing functions are also considered representative of the task level of abstraction.

The production planning methodology provides models for two of the three levels of abstraction within a typical large homebuilding firm, the value-chain level and the resource-event-agent level. The information system modeling method is directed toward the resource-event-agent level of abstraction because this is the level of abstraction at which managers plan, monitor, and control (McCarthy, et.al, 1997).

Phase III

Evaluation was conducted through the application of the proposed methodology on an example production homebuilding firm. Additionally, two production homebuilding firms were analyzed in order to further evaluate the production planning methodology and information system modeling method developed in phase II. The qualitative evaluation was conducted through the use of a standard format. The information syst

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systems, as related to production planning, utilized by both homebuilding firms were evaluated.

1.7. Expected Output

A final report was developed and presented in phase IV of the research. The report is directed toward owners and managers of large homebuilding firms, affiliated industries, and residential construction management educators. The proposed production planning methodology was presented in the form of a model. The production planning methodology includes a modeling method to identify the information system modeling requirements necessary for proficient production planning. Evaluation of the methodology is presented through illustrative examples resulting from the application of the proposed methodology on an example production homebuilding firm "Big Builder". Additionally, inferences drawn from the evaluation of two existing production homebuilding firms are presented.

1.8. Organization of Report

This report is organized into seven chapters. Chapter One presents the research focus area and objectives. Chapter Two provides a literature review of previous work related to residential construction management, production planning in construction, and business system modeling techniques. Chapter Three discusses business planning.

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Chapter Four provides a discussion on structured analysis, including modeling of the production homebuilding industry. A production planning methodology including a method to identify subsequent role of information systems is presented in Chapter Five. Additionally, Chapter Five includes a running example illustrating the application of the proposed methodology. The evaluation of two production homebuilding firms, intended to further evaluate the research findings, are presented in Chapter Six. The report is concluded with Chapter Seven, a summary of the research findings.

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CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

The literature review was conducted with a focus on three distinct categories, residential construction management, production planning, and structured analysis. Residential construction management is discussed with an emphasis on managerial proficiency. Various approaches to production planning are presented. Modeling techniques associated with structured analysis are presented in terms of varying levels of abstraction in section three. This chapter is organized into the three categories described above.

2.2. Residential Construction Management

A limited amount of research has been conducted related to residential construction management. Music (1985) and Dasso (1988), approached residential construction management from managerial proficiency and management functions perspectives. Willenbrock (1994), assimilated and expanded Music's (1985) and Dasso's (1988) work in terms of management guidelines for growth oriented homebuilding firms. Music (1985), developed "Management Growth Model" (Figure 2.1) which illustrates the relationship between managerial proficiency and effort in terms of construction output. In doing so, he identified four management plateaus at which construction output remains constant, at a given level of effort, without

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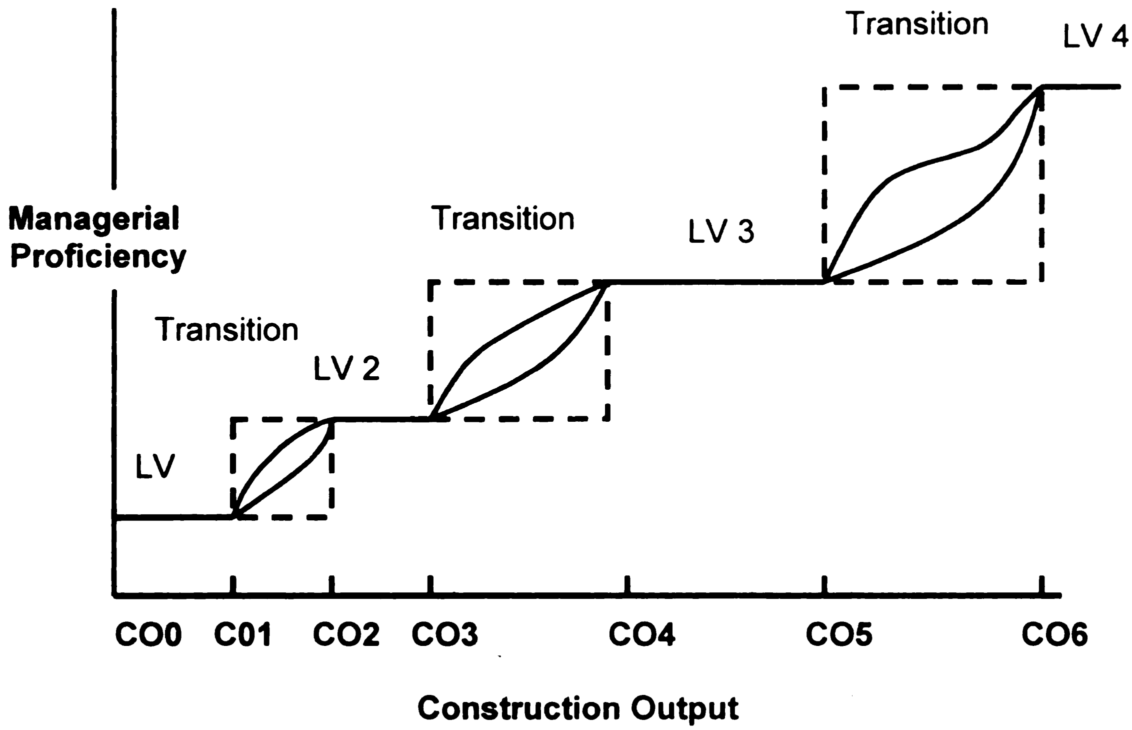

Figure 2.1 Management Growth Model
(Souce: Music, 1985)

changing the educational attitude, organizational structure, management technique, and management systems of homebuilding firms.

Dasso (1988), expanded the growth model by defining the specific characteristics of homebuilding planning systems for each plateau of managerial proficiency. The specific characteristics of managerial proficiency, identified by Dasso (1988), are provided in detail in Appendix B. Willenbrock (1994), presented the Management Growth Model in terms of internal management system analysis, in order to plan for growth. The proposed production planning me

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methodology is built upon the residential construction management foundation established by these authors in terms of planning systems for production, concentrating on large production oriented homebuilding firms (Levels III & IV on the Management Growth Model).

2.2.1. Management Growth

Music (1985), defined residential construction management in terms of business systems. This was accomplished by defining the performance of a business system in terms of management systems and management functions. Management systems were defined as a sub-component of managerial proficiency. Management functions were defined as the activities mangers must perform within the business system. Managerial proficiency, a measurable characteristic of a homebuilding firm's business systems, is impacted by the level at which management functions and systems are utilized within a homebuilding firm.

Music demonstrated that there are four measurable characteristics of managerial proficiency; management systems, management technique, educational attitude, and organizational structure. Music (1985), defined the relationship between a homebuilding firm's managerial proficiency and effort in terms of construction output and potential for growth (construction output represents the total annual retail dollar volume of construction work in place for a particular year). This relationship is illustrated graphically with the Management Growth Model (Figure 2.1.).

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The Management Growth Model identifies four levels of construction output that can be achieved by a homebuilding firm, depending on the level of managerial proficiency and effort within the firm. The model demonstrates that homebuilding firms reach a maximum level of construction output for the given level of managerial proficiency. In order for a firm to achieve a higher level of construction output the firm must go through a transition period. This transition period occurs when a builder makes a conscious decision to increase construction output by increasing managerial proficiency or effort. Music (1985), defined the characteristics of each component of managerial proficiency for homebuilding firms at four levels of construction output (Levels I – IV, small, medium, large, and giant).

The evolution of managerial proficiency within an organization is directly related to the construction output of a firm. According to Music (1985), in order for a home building company to reach a higher level of construction output, it must either increase effort or managerial proficiency. A slight increase in managerial proficiency produces a greater increase in construction output than a similar increase in effort, Music (1988). The evolution of managerial proficiency within a firm is the result of the cumulative effect of the evolution of educational attitude, management technique, organizational structure, and management systems. Large homebuilding firms operate at the highest level of construction output but not necessarily high levels of managerial proficiency. Therefore, large homebuilding firms who want to increase construction output without increasing effort, or maintain the same level of construction output with less effort, must incr

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increase one or more of these management characteristics. This study is based on the assumption that an increase in the proficiency of management systems, through production planning, will increase a firm's managerial proficiency, subsequently contributing to a firm's growth and production efficiency.

2.2.2. Ideal Classification of Management Systems

Dasso (1988), expanded the management systems component of managerial proficiency. First, the author clearly defined management systems required for homebuilding firms, at each of the four levels defined by Music (1985). Second, the author classified the various management systems for each level of managerial proficiency defined by the Management Growth Model. The ten management systems utilized by Dasso (1988) were business planning, office management, estimating, scheduling, cost control, subcontracting, quality control, customer service, safety, and accounting and financial systems.

Dasso (1988), emphasized the management function of planning and noted how it is critical to business success. Planning is very important to the Management Growth Model because planning establishes the need for proper management systems and helps to insure the efficient and effective performance of company activities, (Dasso, 1988). Dasso (1988), noted that "efficient and effective" performance of company activities could not be achieved without integration of management systems.

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2.2.3 Summary

The author's identified above each approach residential construction management from the management system and function perspectives. Managers perform managerial functions within the business system. Music (1985), explained that the level of proficiency at which management systems are implemented directly affect the construction output of a firm. Dasso (1988), expanded Music's (1985) argument by providing a detailed classification of what specific management systems are required for each level of managerial proficiency. Although the authors described various management systems required for maximized managerial proficiency, the specifics of system selection and implementation were not presented. In order to develop a production planning methodology it is necessary to ensure: (1) The methodology will yield a production plan applicable to the production homebuilding industry and, (2) the process undertaken to develop a production plan will yield information required for maximized managerial proficiency.

2.3. Production Planning

In order to develop a comprehensive production planning methodology for the homebuilding industry, it is necessary to examine and define the context from which production planning will be approached. Ballard, et.al, (1997) defined production control in terms of construction with an emphasis on commitment planning. Warszawski (1996), developed a methodological procedure for strategic planning in construction companies. Methods were presented for

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analysis of a company's mission, business environment, and resources which include construction, procurement, marketing, organizational infrastructure, personnel, finance, and knowledge. Artiba, et .al, (1997), illustrated the history and evolution of production planning systems. Following the evolution discussion, a detailed methodology for developing an integrated production planning system including information system conceptual modeling was presented (Banjaree, 1993). Pheng, et.al, (1997), discussed just-in-time philosophy in terms of production planning for construction including a comparison of the manufacturing and construction environments. Kotler (1997), described the production planning process and its interdependent relationship with market analysis and planning. A combination of the above noted research is used as the foundation for the production planning methodology presented in this study.

2.3.1. Strategy Selection in Construction

Warszawski (1996), developed a formal methodology for strategic planning in large commercial building companies based on strategy selection literature and an industry survey of large construction companies. This methodology of strategic planning is founded on management systems. Warszawski (1996), defined a construction company as a system located in an environment with environmental parameters, organizational criteria, constraints, and decision variables. Figure 2.2 illustrates a construction company as a system.

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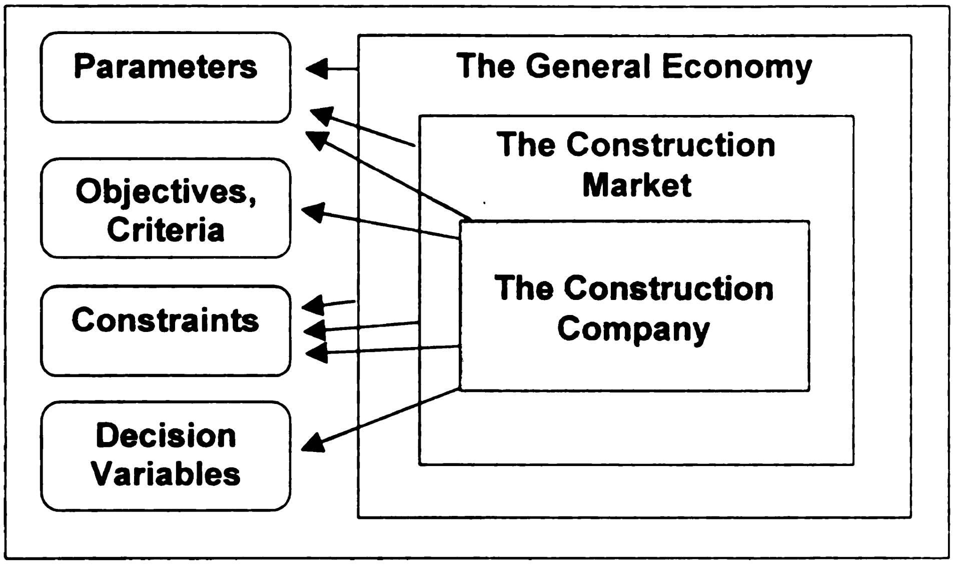

Figure 2.2. Construction Company as a System
(Source: Warszawski, 1996)

Warszawski (1996), provided a number of parameters that must be examined when developing each component of a strategic plan, including company resources. Detailed parameters were presented for resource analysis organized by construction, procurement, marketing, organizational infrastructure, personnel, finances, and knowledge. This methodology further substantiates the use of the systems approach to planning.

Production builders have selected a strategic plan, to be production oriented. To be production oriented is to direct company resources toward management systems that yield efficient production. Efficient production results in "no-frills" products targeted toward the middle of the market where there is the greatest demand. The parameters presented for resource analysis, by

Warszawski (1996), provide a framework for production builders to analyze their business as a system, focusing directly on production capabilities.

2.3.2. Review of Production Planning Methods

There are seven planning and control methodologies prevalent in industry today. These methodologies are: (1) material requirement planning (MRP), (2) manufacturing resource planning (MRP II), (3) just-in-time (JIT), (4) total quality control (TQC), (5) hierarchical production planning, (6) trade partnering, and (7) integrated manufacturing planning and control. The following sections provide a review of these methodologies.

2.3.3. Material Requirement Planning (MRP I)

Material requirement planning (MRP I) is considered a "push based" approach to production planing. This is a demand driven production planning methodology able to accommodate market fluctuations and production options. The major shortcoming of this methodology is its lack of shop floor order and control. The result is either over stocked or under stocked production stages (Artiba, et.al, 1997). For example, a production homebuilder scheduling production, based on the MRP I methodology, would control job starts at the point of sale. With sales fluctuating weekly, say from one to six, an uneven work-flow would result. Seven or eight units would be ready for the electrician at once, and on the same week, no work would be ready for the drywall sub-contractor. In order to schedule even-flow production, project managers would be forced to de

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delay activities in certain units therefore increasing cycle-times and work in progress.

2.3.4. Manufacturing Resource Planning (MRP II)

Manufacturing Resource Planning II was developed as a result of the shortcomings of MRP I. (Artiba, et.al, 1997), identified four assumptions of MRP I that are contradictory. First, the assumption that the market can be forecasted contradicts the assumption that demand should be managed. Second, the assumption that lead-time is know in advance contradicts the assumption that lead-time is controlled by priorities. Third, the assumption that MRP I is a tool for decision support contradicts the assumption that its plans will be executed. Finally, the assumption that material management and master production scheduling are organizational functions contradicts the assumption that MRP I is neutral with respect to organizational structure.

Both Materials Requirement Planning (MRP I) and Manufacturing Resource Planning (MRP II) are inventory driven production planning methodologies. These methodologies are limited in scope, that is, the primary objectives is to reduce inventory. Both methodologies were developed as a result of foreign competition and high interest rates in the 1970's (Pheng, et al., 1997). The MRP systems were designed for the manufacturing environment and are not applicable to construction in whole. For example, inventory is rarely a factor on construction sites. The majority of material is supplied and installed simultaneously by sub-contractors and billed together as a single unit.

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2.3.5. Just-In Time (JIT)

The just-in–time production planning methodology is a "pull based" method of planning. Pull based systems are triggered by the stock level of a finished product. When the stock level of a finished product drops below a pre-defined threshold, typically zero in construction, then the last workstation receives authorization to produce another batch. JIT requires demand to be stable, the product to be standard, and the workshop to be organized according to material flow. This methodology works well for products with a low value-added labor portion and high material costs (Artiba, et.al, 1997).

2.3.6. Just-In-Time for Construction

Pheng, et.al, (1997), applied the just-in-time concept developed by the Japanese automotive industry to the construction industry as a whole. Three case study projects were utilized to develop an implementation method. The projects included a school, public housing project, and a private condominium project. The authors' support of JIT is not, however, a result of low value-added labor and high material costs, such as the adoption of JIT in the manufacturing sector, but premised on reducing waste. The authors argue that by tracking time, material, and process waste through traditional accounting procedures, inefficiencies and bottlenecks will surface. Management can then make use of this data to localize the bottlenecks and inefficiencies in order to suggest and implement necessary solutions to reduce the time waste for a particular task.

The primary method employed by the researchers was to implement the just-in-time management philosophy within the business system by accounting for material, labor, and machinery waste. Therefore, by applying a quantitative measure for JIT, construction processes can be performed at higher efficiency levels (Pheng, et.al, 1997).

The authors identified three categories of time waste in construction. Transportation waste is a result of an item being moved temporarily or rearranged. Waste of motion is a result of poorly planned workspace, such as inadequate tool locations. Inventory waste is a result of excessive material handling. Four categories of process waste were identified: (1) over-production waste, (2) construction method waste, (3) waste from product defects, and (4) poor optimization in carrying out tasks.

2.3.7. Total Quality Control (TQC)

Total quality control (TQC) is also a production planning methodology. TQC is designed to immediately force quality issues to the surface, bringing them to management's attention for immediate corrective action. Ballard, et.al, (1997), best describe this system. Total quality planning, similar to just-in-time, is a pull based production planning methodology. The TQC approach for commercial building defined by Ballard, et.al, (1997) utilizes shielding to produce maximum production efficiency by eliminating uncertainty in a construction environment.

2.3.8. Hierarchical Production Planning (HPP)

Artiba, et.al, (1997), identified three levels of decision making related to production planning; strategic, tactical, and operational. These levels of decision making are known as hierarchical production planning (HPP). The problems of production planning are addressed by solving production problems at each of the three levels. First, production planning addresses problems related to the type of products. Secondly, product types are broken down into families of products, which are again decomposed into the planning problems related to the individual items that make up a product. The primary weakness of HPP is that it is not a stand-alone production planning methodology. It must be used in conjunction with a decision support mechanism.

2.3.9. Trade Partnering

Traditional production planning methodologies view trade-contractor labor as a resource. Trade partnering addresses trade-contractors as partners, as well as resources. Under this methodology, the profitability of trade-partners is an important component of the production plan. Trade partners become part of the item level of production planning in the HPP model. For example, they participate on product development teams with the builder and address item specific production related issues. Suppose a large production homebuilding firm is developing a new entry-level production line. If this organization utilizes trade partnering, then it will invite key trades such as HVAC, plumbing, or rough carpentry to evaluate the plans and make efficiency related suggestions.

2.3.10. Integrated Manufacturing Planning

Integrated manufacturing planning is a methodology for production planning that places emphasis on the particular needs of an enterprise, first on market demands, secondly on product, and finally on the individual characteristics of the production capabilities. This method is based on market projections although it takes into account variable handling capabilities. Variable handling capabilities are designed into the production system through resource flexibility. Banjeree (1997), proposed this methodology to accommodate the dynamics of the modern business environment. This production planning methodology is based on a fundamental principle. In order to yield a specific domain architecture that exhibits appropriate interconnectivity, coordination, and communication with other business practice functions and processes, to fulfill a predetermined set of domain objectives.

- Interdomain relationships exist between various elements, both within and outside the system. Therefore it is necessary to consider a system in this context of integrated system design.
- Historically, organizations have attempted to become more dynamic in operations through decentralized structures. Decentralized structures often evolve into diverging and autonomous production departments or units.
- When attempting to optimize the functional efficiency of a particular unit one may lose sight of the organizational strategies and goals. Therefore coordination of organizational units is essential.

- The process of designing a production planning system should be based on a clear understanding of the interdependencies that exist among the functional groups or domains within the enterprise.

Banjaree (1997), identified the following characteristics any production planning methodology should exhibit:

- Method to match proposed production planning system with the ever-changing needs of a company's market, manufacturing tasks, and manufacturing process, architecture, and layout
- Method to map the integration of the various domains
- Process to select modeling tools and techniques to facilitate the representation of both the existing system and desired system
- Process to identify the difference between the existing and desired physical systems
- Process to construct a conceptual model of a desired system
- Provision for expressing system requirements is a formal language, which can be used as a means for selection of the appropriate decision support tools for a particular system and its unique business needs.

Banjaree (1997), developed a process for production planning methodology development that exhibits the above characteristics. This methodology is divided into four stages; diagnostic stage, characterization stage, customization stage, and concept design stage.

2.3.10.1 Diagnostic Stage

This is the process of business analysis or business specification. It is very similar to the definition of the business process performed in high level strategic planning. This process includes the following:

- Review of the current and intended customer and market segments targeted by the enterprise, their present and projected needs with regard to products and services.
- Assessment of competition
- Review of manufacturing task statement in terms of volume, delivery flexibility, critical product cost and quality, and other manufacturing dimensions, in terms of consistency with the adopted marketing strategy.

2.3.10.2. Characterization Stage

The characterization stage is intended to identify natural product groupings based on similarities in market, product, or process characteristics. Such product groupings form the basis for the production planning system design. Banjaree (1997), suggested an analysis of each product grouping within each of three levels of abstraction, long range, medium range and short range. These levels of abstraction fall into the same classification of the value chain, resource-event-agent, and task level of abstraction described in section three.

2.3.10.3. Customization Stage

The customization stage provides a generic production planning model for the business. The intent of the customization stage is to optimize the generic model for each product type. A conceptual production planning system for each product type will be developed in this stage, although the intent is one model for the enterprise. Therefore it is necessary to develop an aggregate model of the various conceptual production planning models developed for each product type.

2.3.10.4. Concept Design Stage

Now that a conceptual production planning model has been developed for the enterprise it is necessary to employ tools that will facilitate implementation for the various domains. Banjaree (1997), utilized the following modeling techniques in order to develop an information system implementation design; IDEFO, DFD (Data Flow Diagrams), and ERA (entity-relationship-attribute) diagrams are the same as resource-event-agent modeling technique described in Chapter 3.

2.3.11. Shielding – Production Planning

Ballard, et al.,(1997), defined production control for the commercial building industry. The authors clearly illustrated the difference in production control between the construction and manufacturing industries. They described a component of production management known as "shielding" for construction companies. The underlying premise of shielding is to improve the quality of directives, or task assignments, therefore reducing work flow uncertainty and immediately improving productivity in work groups. As applied to construction, shielding is the process of having a detailed scope of work for each phase of construction, including, if necessary detailed tasks, sub-tasks, and sub-sub-tasks. The process of shielding is adopted from "pull" methodologies of production planning.

Pull methodologies, such as just-in-time and total quality planning, are dependent on the level of finished goods. No inventory of finished goods is maintained. Additionally, no inventory buffers exists between the various production processes. If no buffer exists between processes than defects immediately rise to the surface and must be addressed. For example, if a sub-floor has been installed improperly construction will stop prior to the finish floor being installed causing te affected unit's production to remain idol until the sub-floor is repaired. Pheng, et al., (1997), also applied the "pull" philosophy of production planning to construction through application of just-in-time principles.

2.3.12. Summary

Pheng (1997) and Ballard (1997) both illustrated the importance of a "pull" based production planning system. A "pull" based system is a production planing system designed to yield finished goods, as finished goods are required (just-in-time), with no inventory between production processes and no finished inventory. Pheng (1997), emphasized the importance of shielding in construction. Shielding is the process of preparing quality directives for a crew prior to that crew commencing on a particular construction activity. In homebuilding firms, this would entail the preparation of a detailed scope of work for each activity. Just-in-time production homebuilding is the process of scheduling consecutive construction activities with no lag time between predecessor and successor activities, either for a specific unit or another unit within the same project. In order to implement these production planning techniques, a production planning methodology is required. The six properties that a production planning methodology should exhibit were presented by Banjaree (1997).

2.4. Business Systems

The production planning process utilizes information generated from estimating, scheduling, cost and progress control, finance and accounting, and sub-contracting and material acquisition (Dasso, 1988). Through interaction with the industry, the author observed that the applications used by large homebuilding firms for these systems are often "stand alone". McCarthy, et.al, (1997), presented a structured methodology for the design of accounting transaction systems in a shared data environment. This methodology utilizes logical modeling techniques in order to develop conceptual views of an organization at various levels of abstraction. Two modeling techniques are utilized to represent two corresponding levels of abstraction within a typical production homebuilding firm. The Porter Value Chain represents an organization from the highest level of abstraction, the value chain level. The Resource-Event-Agent level (R-E-A) of abstraction is the level of abstraction at which managers must plan, monitor, and control. Data-Flow-Diagrams are utilize

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utilized to decompose the functional areas represented on the value chain into business processes and sub-processes represented by R-E-A modeling. This study will utilize the above noted modeling techniques in order to illustrate the interdepartmental integration of production planning information.

2.4.1 Functional Areas

Gale, et al., (1996) described a business as a system from three distinct levels of abstraction. The authors used Porter's Value Chain (Porter, 1985) to illustrate an organization at the highest level of abstraction. A sample value chain is provided in Figure 2.3. The processes a firm engages in at this level of abstraction are functional areas. Functional areas create value and have

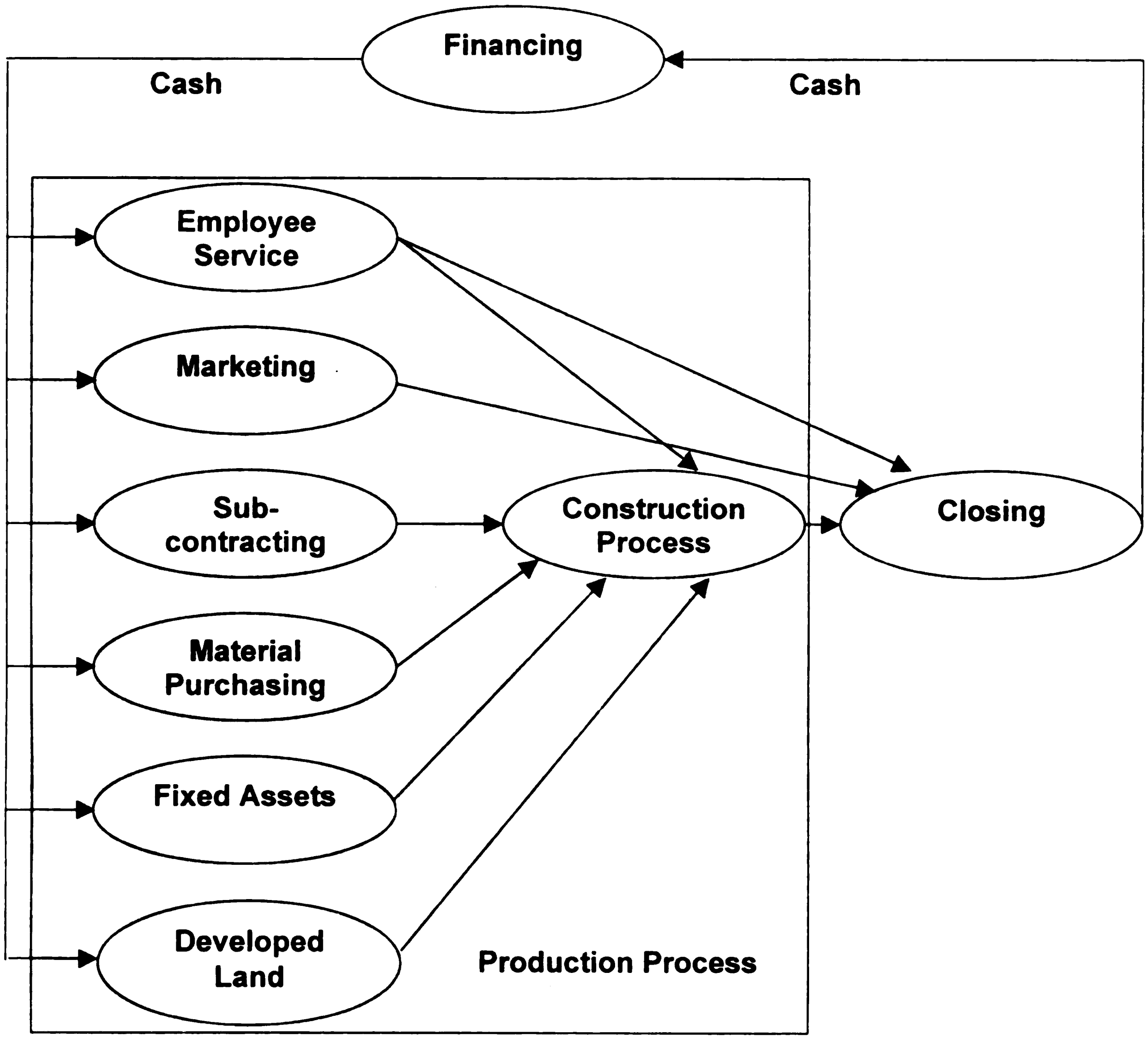


Figure 2.3
Sample Value Chain Depicting the Value-Added Processes of a Typical Production Homebuilding Firm

interdependent relationships. For example, in production homebuilding a functional area would be considered land acquisition. Land acquisition has an interdependent relationship with its predecessor functional area, financing, and its successor functional area, development. Next, the authors illustrated how functional areas can be further decomposed into business processes and sub-processes, noting that processes are decomposed to the physical level or the desired level for modeling. This is typically the level at which managers want to plan, monitor, and control. This level of abstraction is the resource-event-agent (R-E-A) level of abstraction. For example, the difference between the value chain level of abstraction and the R-E-A level of abstraction is similar to the difference between, (A) acquiring material to build homes and (B) acquiring twenty 2x4"s for unit 129. Before a functional area modeled with a value chain can be decomposed to the R-E-A level of abstraction, multiple processes, sub-processes, and sub-sub-processes need to be modeled as well. Data-Flow-Diagrams (DFD's) are utilized to bridge this gap. The process of "bridging the gap" will be referred to as organizational decomposition throughout the remainder of this study.

2.4.2. Business Systems

Kendall, et al., (1996), presented Data Flow Diagrams (DFD's) as a modeling technique to illustrate business processes, sub-processes, and the inter-relatedness of a system and it's sub-systems. Structured analysis is the process of decomposing organizational processes, beginning with functional areas defined with the value chain, into a level of abstraction at which managers can plan, monitor, and control. Structured analysis offers an orderly approach to the problem of analyzing and defining information systems, enabling users, analysts, and designers to obtain a logical (non-physical) view of the system and it's interfaces (McCarthy, et.al, 1997).

The authors provided a sequential process for developing a DFD for business system based on organizational decomposition. Both the logical and physical methods were described. Logical DFD's represent the conceptual view of an enterprise's information system. Physical DFD's represent the implementation view of an enterprise's information system. This study utilizes structured analysis techniques within the proposed production planning methodology in order to fulfill Banjaree's (1997) objectives.

2.4.3. System Development

McCarthy, et.al, (1997), presented a system development methodology that combines both structured analysis and database design methodologies. The authors described the implementation of these methodologies in a complimentary fashion. The following steps to traditional system development were presented; (1) requirement analysis, (2) information analysis and definitions, (3) implementation design, and (4) physical design. The new combined system development methodology presented by the authors includes the following processes; (1) requirement analysis, (2) view modeling and modification, (3) view analysis and integration, (4) system specification, (5) schema refinement, (6) structured design, and (7) implementation. This study will utilize steps 1,2, and 3 of the revised system. Steps 4,5,6, and 7 depend on specific characteristics and implementation compromises of a specific organization, therefore the output from these processes could not be applied to an entire industry (production homebuilding).

2.4.4. Summary

McCarthy, et.al, (1997) illustrated a method for information system development that integrates logical approaches to structured analysis and database design. This methodology serves as a foundation for the information system modeling method presented by this research. A combination of Porter's Value Chain, DFD modeling, R-E-A modeling and Structured analysis are utilized to develop a modeling method that identifies the information system requirements necessary proficient production planning for large homebuilding firms. Also this methodology is utilized to define the shared data among the various production planning management systems.

2.5. Chapter Summary

Residential construction management research has focused on management systems and management functions. Music (1985), developed the Management Growth Model which defines the level of managerial proficiency at which a homebuilder must operate in order to reach a given level of construction output. Managerial proficiency is defined in terms of a homebuilding firm's management systems, management technique, organizational structure, and educational attitude. Dasso (1988), expanded and defined the specifics of management systems for homebuilding firms at each level of construction output. This research will be utilized to define the context in which management systems will be approached from a homebuilding perspective.

The majority of production planning research has focused on manufacturing environments, Ballard, et.al, (1997). Warszawski (1994), developed a strategic planning methodology for large construction companies including a structured methodology for analysis of construction procurement processes. Ballard, et.al, (1997), focused directly on production planning for commercial building companies within the context of "pull" based production planning methodologies, to the construction industry through the development and implementation of just-in-time philosophy. Banjaree (1997), developed a methodology for integrated manufacturing planning system design. This methodology includes system design methods for the physical system and the information system in the context of a shared data environment. A combination of this research is utilized to develop an integrated production planning methodology.

McCarthy, et.al, (1997) illustrated a method for information system development that integrates logical approaches to structured analysis and database design. This methodology is utilized to develop and model the information system requirements for proficient production planning for large homebuilding firms. Also this methodology is utilized to define the shared data among the various production planning management systems.

A combination of the above literature is utilized in the development of a production planning methodology for large production homebuilding firms. The residential construction management research illustrates the context in which production planning will be approached. The production planning literature is utilized to define the unique characteristics of production planning for construction. Finally, the structured analysis literature provides a conceptual framework for the development of a conceptual model illustrating the role of information systems in production planning for large production homebuilding firms.

CHAPTER THREE

BUSINESS PLANNING – PRODUCTION PLANNING

3.1. Managerial Aspects of Residential Construction

Music (1985), performed an analysis of residential construction management and developed the "Management Growth Model" as a result. The model illustrates managerial proficiency in terms of construction output. Managerial proficiency is the result of the cumulative effect of a homebuilding firm's educational attitude, organizational structure, management technique, and management systems (Music, 1985).

The "Management Growth Model" identifies the relationship between managerial proficiency and effort in terms of construction output. Managerial proficiency implies that there are different levels of management skills, techniques, and awareness that are required to achieve various levels of construction output (Music, 1985). Managerial proficiency is defined as the set of management characteristics, that when refined and developed, enable a builder to increase construction output. An increase in managerial proficiency will increase construction output far greater than an equal increase in effort. Effort is defined as the amount of work required to increase construction output, assuming no change in managerial proficiency. Construction output is defined by the following formula.

Construction Output =C1 f(Effort) + C2 f(Managerial Proficiency)

Figure 3.1 displays how the management systems, management techniques, educational attitude, and organizational structure of a homebuilding firm must go through a transition period and reach a higher level of managerial proficiency in order for a firm to increase construction output. The level periods represent the range of construction output the given level of managerial proficiency (LV I - LV IV) can support. An increase in the level of managerial proficiency of any of these four characteristics will increase the overall managerial proficiency of the firm.

3.2. Managerial Proficiency

The concept of managerial proficiency for homebuilding firms, identified by Music (1985), applies the systems approach to residential construction management. Managerial proficiency is described in terms of a homebuilding firm's educational attitude, management technique, organizational structure, and management systems (Music, 1985). Each element of managerial proficiency is a vital component of a firm's growth and survival. A firm's educational attitude is reflected by the individuals employed and is also evident in a firm's ability to expand into new challenging areas and to implement innovation. Management technique is measured by the quality of information used in decisions, proportion of time spent managing in relation to operational work, and the

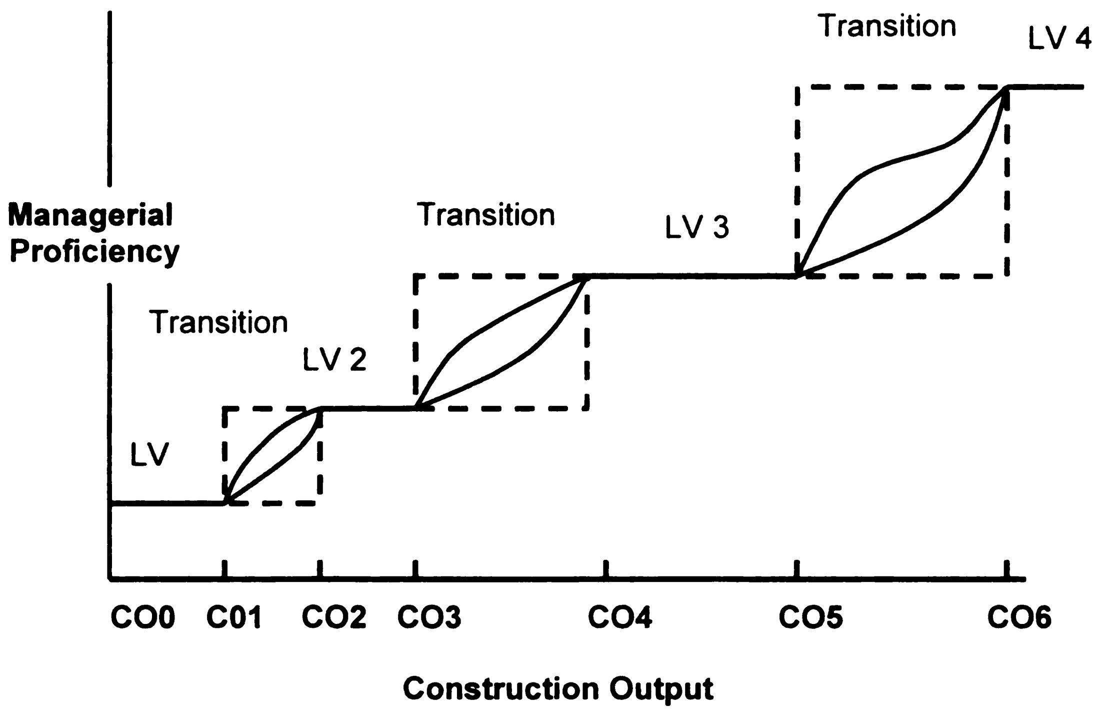


Figure 3.1 Management Growth Model
(Souce: Music, 1985)

level of control within an organization. Organizational structure is defined by the distribution of responsibility, accountability, and authority therefore identifying the level of department integration and employee specialization. Finally management systems are a combination of constraints, people, and theory, that interact to produce goods and services (Music, 1985).

3.3. Management Systems

A management system is the context in which a builder converts internal and external inputs from the environment into a workable set of strategies, plans, and controls. Inputs into the home building industry are; society requirements; market constraints, demand, demographics, land and infrastructure availability, and general market area; government controls; federal, state, regional, and local; financial parameters both for the builder and the consumer. Many of the inputs into the residential construction process are fragmented and unpredictable. Managers of home building firms must transform these inputs into their products through management systems. Management systems, along with organizational structure, educational attitude, and management technique contribute to the level of managerial proficiency a home building firm operates at. Willenbrock (1994), describes management systems in terms of a business system operating in an environment with environmental constraints.

> *"A management system is a combination of internal and external environmental constraints, management theory, and people that interact to produce goods and service."*

Residential construction management systems can be divided into three categories; planning, control, and service (Dasso, 1988). Business planning and office management are planning systems. The control systems at use in home building firms are estimating, cost control, scheduling, financial, accounting, and subcontracting. Quality control and customer service make up the service systems. The detailed systems for each of the four levels of managerial proficiency are provided in Appendix A.

Management systems are executed through management functions. Managers of home building firms perform seven management functions, within the management system, to produce goods and services. Figure 3.2 provides a graphical overview of a management system.

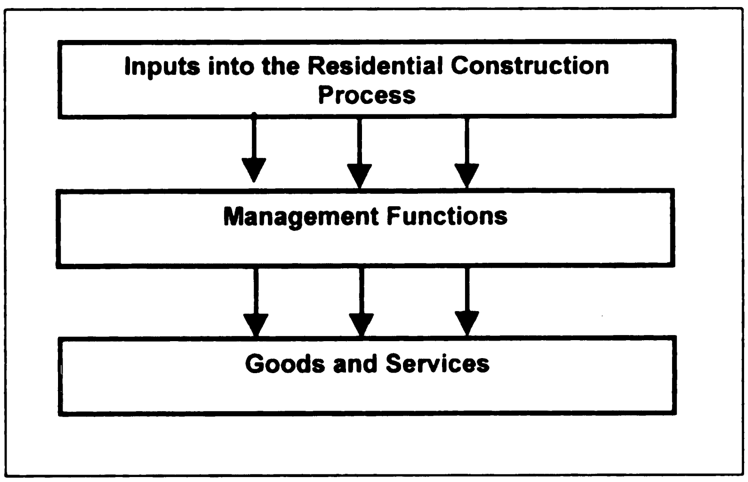


Figure 3.2.
Overview of A Management System

3.4. Management Functions

The process of transforming inputs from the environment into products and customer satisfaction, performed by managers within the management system, can be categorized into management functions. The seven management functions critical to the building industry are planning, organizing, staffing, leading (also known as directing), controlling, innovating, and coordinating. Figure 3.3. illustrates the seven management functions. Koontz, et.al, (1984) defined five management functions. The author expanded the five management functions utilized by Koontz (1984), and later Music (1985), who applied them to residential construction management, into the seven functions displayed in Figure 3.3. Planning is highlighted in the model because it is the focus area of this research. The author added the management functions of innovating and coordinating. Rapid developments in information technology over the past decade have compelled managers to adapt to a dynamic and changing business environment. Therefore managers must be innovative in order to reap

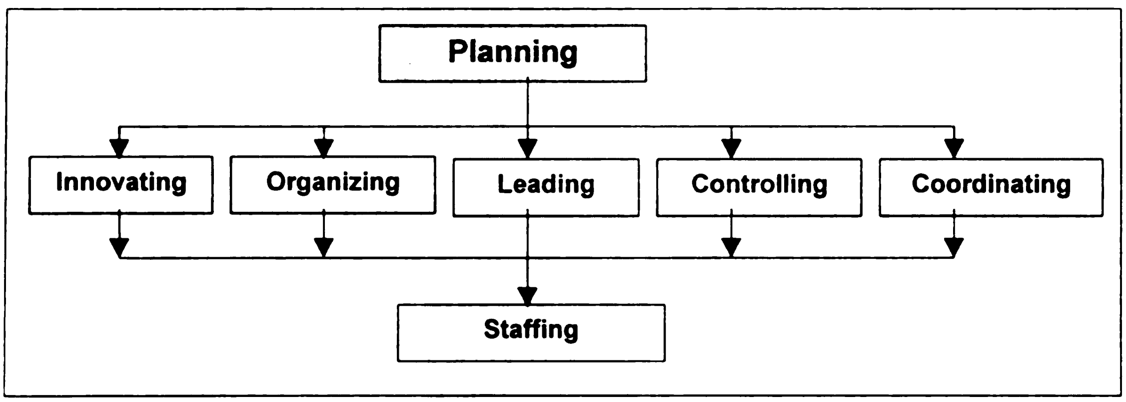


Figure 3.3.
The Hierarchy of Management Functions
(Modified from: Music 1985)

the benefits of the information revolution. Coordinating was added to highlight the importance of inter organizational coordination. Inter-organizational coordination fulfills management systems needs for integration. For example, many production homebuilding firms operate multiple sites in which many units are under construction simultaneously. Inter-organizational coordination represents the managerial function of coordinating organizational resources between the various construction sites (resource leveling). A detailed discussion of management functions is provided in the following sections.

3.4.1. Planning

Planning is the foremost management function, that is, no other management functions can be performed without first developing a plan. For example, a manager can not staff for a given construction output without first conducting a market analysis and developing a production plan to meet the identified demand.

The management function of planning is the process of establishing the goals and objectives of a firm and coordinating the entire organization, through a series of actions, to those goals. The function of planning is conducted through a series of plans; market plan, service plan, production plan, organizational plan, development schedule, and financial plan (Osgood, 1981).
Figure 3.3 illustrates planning as the foremost management function in any organization. Planning cannot be delegated, it requires top management attention, (Osgood, 1981). Plans are utilized at different levels of abstraction within the organization, therefore each manager should maintain their plans, i.e. production manager develops production plan.

3.4.2. Organizing

Organizing is the management function that groups activities, identified in plans, and disseminates them through the organization. The organizing process provides people with the means and methods for accomplishing organizational activities and assigns the corresponding responsibility and accountability. Assigning the responsibility of punch out items to the service manager is an example of organizing. Planning will allow managers insight into the current and projected capacity of their employees. Planning and organizing are directly related. For example, if an increase in new housing starts is projected beyond the current capacity of the field staff than additional staff is required (Willenbrock, 1994).

3.4.3. Leading

The managerial function of leading has a strong relationship to planning and control systems. The business plan clearly establishes a firm's goals and objectives. Managers must motivate subordinates in such a way as to achieve the objectives identified in the business plan. Additionally, managers must consistently evaluate a firm's progression toward established goals and objectives and subsequently redirect and motivate subordinates. Two main responsibilities of managers, as part of this function, are providing leadership and resolving problems (Osgood, 1981). The criteria for the leadership role is:

1. Leadership is the means by which managers assist people in achieving their own objectives while at the same time achieving those of the organization.
2. The enterprise is only one of many social systems within which people exist.

3. There is no such thing as an average person; therefore, managers must understand the complexity of human nature and manage from a situation perspective.
4. People must always be treated with dignity
5. Mangers must contend with each employee of the enterprise as a total person that is also influenced by family, neighbors, churches, etc.

(Source: Osgood, 1981)

3.4.4. Innovating

Builders must constantly adapt to their environment, market demographics and technology are two aspects that are always changing, and the impact of the Internet will surely fuel even more change. Innovating is the ability to respond to, create, or take advantage of change. Innovation can be evident at different levels of abstraction. From a production process perspective, an example of innovation is to merge traditional site-built construction practices with modular factory built components. Traditional literature does not mention this function but, in the author's opinion, considering the fast pace of technology, it has become an important management function.

3.4.5. Controlling

Controlling encompasses the functions of setting performance standards, measuring performance, analyzing variances, and correcting deviations. The managerial function of controlling is dependent on the business plan.

"The control system must, however, be designed with specifics of the organization, the individuals using the system, the cost of implementation, and the effectiveness of the system in mind." (Osgood, 1981)

The process of developing and maintaining a schedule for each job is an example of a control system. Decisions such as computerizing job schedules or just filling out pre-printed forms should be based on the organization specifics, the individuals using the system, the cost of computerization, and the effectiveness.

3.4.6. Coordinating

Coordinating is the management function that links all other management systems. One or more people may perform the activities associated with the various management functions but they must be performed and directed toward overall organizational objectives. It is the author's belief that coordination is best facilitated through inter-organizational integration. For example, suppose an organizational objective is to increase the target market of a single-family product line. Purchasing may pursue this objective by turning standard components into options, such as a bay window option or a fireplace option. The architectural department may pursue this objective by eliminating stairs and incorporating barrier free design in order to meet the needs of retirees. Facilitating inter-organizational integration is the process of coordinating the activities of the architectural and the purchasing departments.

3.4.7. Staffing

Staffing is directly related to organizational planning. Organizational planning identifies the skills necessary for different aspects of the organization. Staffing is the systems of matching the infinite variations in experience and personality to the specifics of the job. Staffing also includes the functions of recruiting, training, motivating, and reviewing, (Osgood, 1981).

3.5. Business Planning in Relationship to Managerial Proficiency

Music (1988), illustrated the relationship between managerial proficiency and construction output, noting that greater construction output can be achieved by increasing either managerial proficiency or effort (see section 3.2 for a description of Managerial Proficiency). Managerial proficiency is defined in terms of a homebuilding firm's organizational structure, management technique, management systems, and educational attitude. Business planing can lead to increased managerial proficiency through the planned exploitation and integration of market opportunities, production capabilities, organizational resources (people), and financial resources. Planning activities, and subsequently business planning can be directly linked to the management systems characteristic of managerial proficiency. Music (1988), illustrated that by increasing any of the four characteristics of managerial proficiency, the overall managerial proficiency of a firm would be increased, therefore resulting in greater construction output.

Figure 3.4 identifies the relationship of managerial proficiency and the management function of business planning. Management functions are the processes managers perform within business systems that facilitate the process of transforming inputs from the environment into products and customer satisfaction (see Figure 3.2.). Management systems, a subset of managerial proficiency, can be further decomposed into; service, office management, and business planning systems. The entity "business planning" is best described as a combination of the business system of business planning and also the management function of business planning. For example, managers utilize the business plan to establish goals and objectives of a firm. Setting goals and objectives is a management function. Managers also use the business plan as a context to constantly evaluate the goals and objectives of a firm in a constantly changing internal and external environment. Evaluation of the performance of a firm with regard to goals and objectives is a system.

Managers perform management functions within the management systems. The managerial function of planning is performed within a business's planning systems. Taken together, business systems and the management functions performed within those systems represent Business Functions. Gale, et.al, (1997), defined business functions as a group of activities which taken together support one aspect of furthering the mission of an enterprise.
Gale, et al. (1997) identified six characteristics of business functions. (1) Business functions are mutually exclusive. (2) Business functions have different skill, knowledge, and experience requirements. (3) Business functions do not

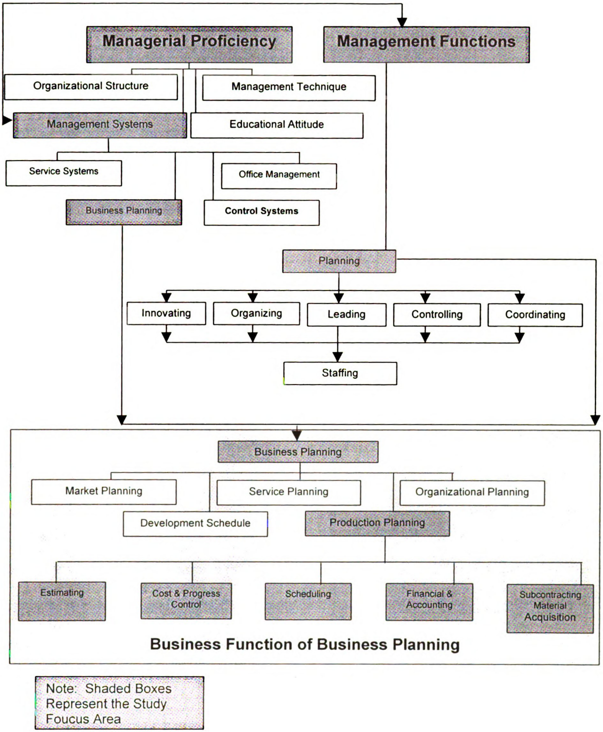


Figure 3.4.
Relationship between Management Functions and Management Systems for Production Planning

change unless the business is re-engineered. (4) Business functions are named with nouns or gerunds (ending in *ing*). (5) Two enterprises in the same line of business will tend to have commonalty in their business functions.

It is the author's opinion that the business function of business planning is similar among large production homebuilding firms. The business function of business planning can be further decomposed into market planning, service planning, organizational planning, development schedule, and production planning. Figure 3.4. graphically represents the relationship of Managerial Proficiency and Management Functions to the Business Planning Business Function.

3.6. Business Planning

The business function of business planning is essential to the success of an organization. The business plan is the document used by managers to communicate the objectives of a firm internally to the various departments and externally to partners and financial institutions. Business plans bring an entire team together, working toward common goals. Osgood (1981) explained the importance of using a plan to coordinate the activities of an organization and those involved with it.

> *"If the operational assumptions and details have been made explicit, others who interact with the business organization…will find it easier to coordinate their activities with those of the organization". (Osgood, 1981)*

The business planning process allows homebuilding firms to be prepared for anticipated problems and capitalize on future opportunities (Willenbrock, 1994). With proper business planning, homebuilding firms can be confident that decisions made today by themselves, employees, and other team members will lead to achieving established goals tomorrow. Business planning allows a homebuilding firm to be prepared for the changing economic atmosphere and still efficiently manage the barrage of daily tasks.

3.6.1. What is a Business Plan?

A business plan is the documented result of the business planning process. It is a working document that evaluates and plans every aspect of a company. The business plan presents the goals and objectives of the firm and coordinates the entire organization, through a series of actions, to those goals. Additionally, it provides a process to consistently evaluate each plan, in the context of new ideas and a changing internal and external environment. It should include a definition of the business, market plan, service plan, production plan, organizational plan, development schedule, and financial plan (Osgood, 1981) (As shown is Figure 3.5.).

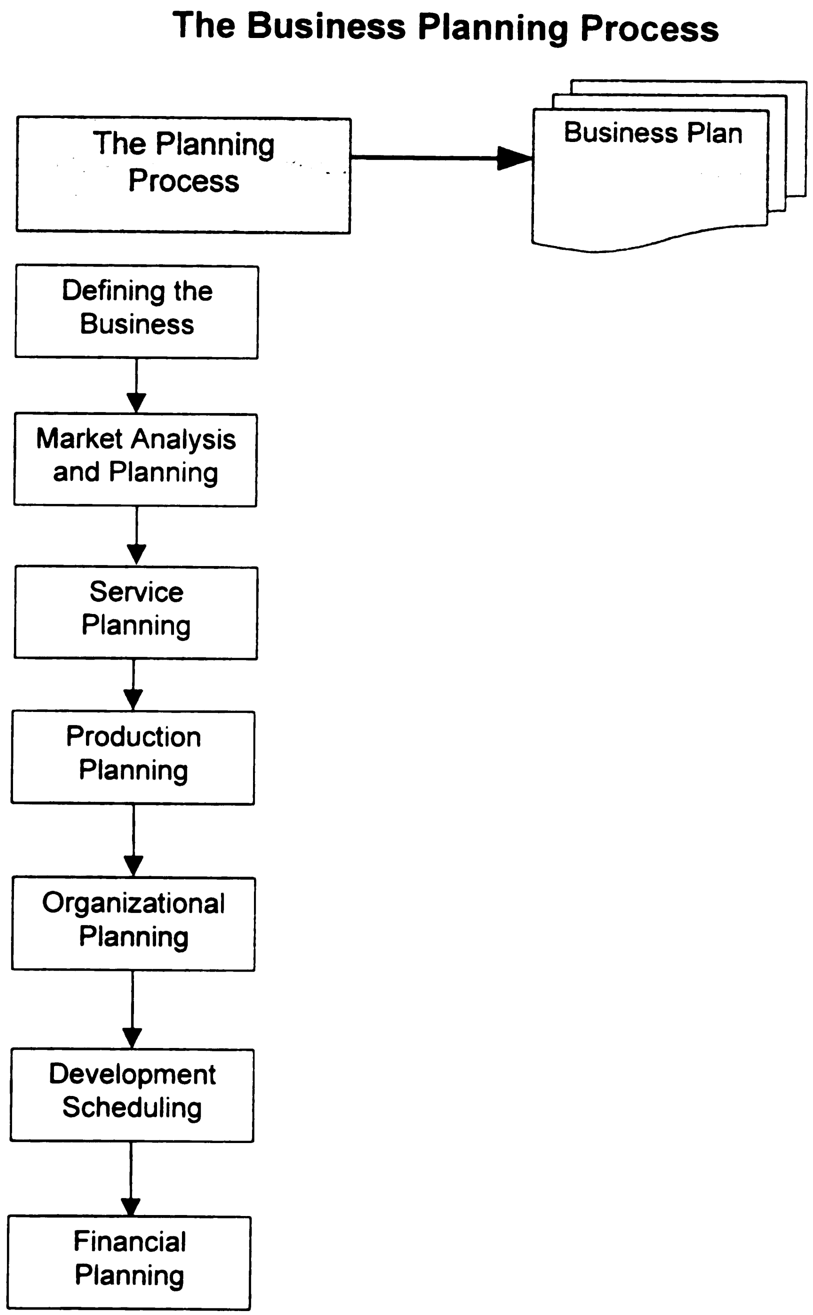


Figure 3.5.
Historical Business Planning Flow Chart
(Modified from: Osgood, 1981)

3.6.2. Definition of the Business

The definition is a detailed description of the company, products and services, the industry, opportunities, and reasons for entering the market, (Willenbrock, 1994). It should include the company mission, general information, market information, company history, products and services including warranty service, and finally advantages and disadvantages of the products and services offered, (Osgood, 1981).

3.6.3. Market Plan (Research and Analysis)

The market plan has a substantial affect on the entire organization. Without customers a company can not survive. The market plan includes how to make customers aware of the construction services offered by a firm, what message to convey to them, what specifics of the message to enforce, and how to actually secure the sale, (Abrams, 1991). The target market(s) markets are identified in the market plan.

3.6.4. Service Plan

Customer service is critical to the success of any residential building firm. The service plan should include a plan to guide customers through the total building experience from the first contact with a sales representative through the completion of the warranty period. Customer contact points are points in the construction process where the customer is involved, such as plan review and final walk-through. The service plan should include a review of these points.

3.6.5. Production Plan

Dasso (1988), defined production planning as an essential component of the business planning process. The production plan allows for the consideration of alternative strategies, which are consistent with sales and financial forecasts, as well as other areas of the organization. The production plan is the heart of any residential construction company. The production plan is the vehicle that links available internal and external resources to marketing projections and provides an organizational wide implementation platform to meet the demand.

The production plan is the central process of the business planning process. Market and service planning are inputs into the production planning process. That is so resources can be directed to meet market and customer demands. The production plan drives organizational staffing and financial planning. The level of staffing is a direct result of the production plan. Proper financial planning can not be conducted prior to production planning.

3.6.6. Organizational Plan

The organizational plan includes an organizational chart along with names and responsibilities of each individual, especially the key personnel. Also, individual experience and education should be evaluated against the skills necessary for the position.

3.6.7. Development Schedule

The development schedule integrates the entire business planing process. It should include a detailed schedule with milestones. The development schedule establishes time requirements for each business plan component in order to coordinate the business planning process, (Willenbrock, 1994). Goals and objectives, along with an evaluation of threats, should be integrated with the development schedule.

3.6.8. Financial plan

The financial plan is the quantification, evaluation, statement, and summary of the various planning activities, including the development schedule, (Osgood, 1981). Every business decision leads to an associated cost, and taken together, these numbers form the financial plan. Financial plans typically include a balance sheet, income statement, and cash flow statement

3.7. Production Planning

Production planning involves organizing and managing the process of converting raw materials into a pre-designed finished product. Production planning is defined as the function of management, which plans, directs, and controls the material supply and processing activities of an enterprise. Furthermore, planning is the process of deciding what to do in the future, directing comprises the operation of issuing orders, and control can be described as the constraining of events to follow plans. Production involves three levels of decision making; strategic, tactical, and operational (Artiba, et.al, 1997). Many production planning techniques have been developed to meet production requirements in order to satisfy desired production attributes such as agility, flexibility, and continuous productivity enhancement, (Artiba, et al., 1997). Methods such as *Material Requirement Planning* (MRP I), *Manufacturing Resources Planning* (MRP II), *Just-In- Time* (JIT), *Total Quality Management* (TQM), *Hierarchical Production Planning,* and *Trade Partnering* have been utilized by all facets of industry (Pheng et al. 1997). Fields of study related to production planning include *operations management, materials handling, finished goods and in-process inventory control,* and *maintenance management.* The evolution of production planning methods and the related fields of study have evolved from quantitative models to a systems perspective, (Artiba, et al, 1997). Artiba, et al, 1997, identified three production planning view points. Banerjee's (1997) approach to production planning is best described as the micro approach. This schema is based on the assumption that the superintendents in the field are best qualified to address the day to day production issues. Although, boundaries of behavior should be specified such as stipulating maximum cycle times per product, minimal quality standards, and cost controls. The central approach to production planning is based on the model of data flowing from the field to the planner and then decision flowing from the planner back to the field. This schema is based on the assumption that fragmented decision making, such as the micro approach, is not conducive to divisional or corporate production planning. Another philosophy of production planning and control is a combination of the previous two. With a decision support system based on a predefined hierarchical infrastructure.

3.8. Summary

Business planning is a critical management function. Its impact on management systems, through the implementation and development of business planning sub-systems, is critical to the achievement of organizational objectives. Production planning, a sub-set of business planning, is the core process of business planning. It is the vehicle that directs company resources in order to fulfill the market demands, subsequently maintaining financial objectives. As the homebuilding industry evolves to meet the constraints imposed by the environments in which these industry exists, homebuilding firms will produce a wider range of products, business systems will become as important to production efficiency as product standardization is currently. Production planning is the vehicle to achieve efficient production in an environment of increased product differentiation.

CHAPTER FOUR

STRUCTURED ANALYSIS TECHNIQUES FOR PRODUCTION PLANNING

4.1. Introduction

This chapter utilizes structured analysis techniques developed for database and information system design, to analyze and subsequently model homebuilding firm's business systems. Structured analysis is defined as an approach to the problem of analyzing and defining information systems, therefore enabling users, analysts, and designers to obtain a logical (non-physical) view of the information system and it's interfaces (McCarthy, et.al, 1997). As part of this research, structured analysis techniques are adapted for the development of a production planning methodology for homebuilding firms. Once analyzed, a logical model representing the various processes, sub-processes, and sub-sub-processes associated with production planing is developed. A logical model is a view of an organization's process inputs, outputs, and relationships.

Dasso (1988), identified four management systems used in homebuilding firms; service systems, office management systems, cost control systems, and business planning systems. The structured analysis approach to production planning, a sub-set of the business planning management system, provides managers with a view of the driving forces, associated with these systems, behind efficient production.

The definition of structured analysis has three parts. Each part is described in order to illustrate the intent of using structured analysis in this manner. The three parts of the definition of structured analysis are; (1) it will be used to analyze and define the various production planning business systems, (2) it will be used to enable users, analysis, and designers to obtain a logical (non-physical) view of production planning business systems, (3) also it will be used to enable users, analysis, and designers to obtain a logical (non-physical) view of the integration of business planning business systems. This is accomplished by modeling a typical production homebuilding firm's business as a system, then decomposing that business system, with the use of structured analysis techniques, to the level at which managers must plan, monitor, and control.

This chapter presents structured analysis and the various tools and modeling techniques associated with it. The various tools and techniques are presented in terms of how they contribute to the production planning methodology. The modeling techniques presented are accepted tools currently used today by system developers and database designers applying structured analysis techniques to information system development.

A logical view of a homebuilding firm's production planning business systems is a conceptual view or a perfect world scenario. A physical view of a homebuilding firm's production planning business systems represents an actual view, after implementation compromises have been made. Implementation compromises are a direct result of the capabilities or in-capabilities of business system resources (people, equipment, financial resources, and information resources).

In order to develop a conceptual view of a homebuilding firm's production planning business systems and subsequently identify the logical view, the structured analysis approach is utilized as a tool to achieve organizational decomposition. Organizational decomposition is a method of developing views of a homebuilding firm's operations at different levels of abstraction. This process is begun at the highest and most abstract view and is concluded when the homebuilding firm's business systems have been decomposed to the level at which managers plan, monitor, and control.

4.2. Organizational Abstraction and Business System Modeling

Various aspects of business plans are evident at three levels of abstraction. The three levels of abstraction utilized by this study are the value chain level, R-E-A Level, and task level. For example, the company mission is a representation of the highest level of abstraction, also known as the value chain level, while procedures are utilized at the lowest level of abstraction, also know as the task level. Business systems, at all levels of abstraction, form the basis for all management functions.

One of the objectives of this study is to identify the detailed information system requirements necessary for proficient production planning with the help of conceptual modeling. This is achieved by providing a methodology to decompose a homebuilding firm's business planning systems, and subsequently production planning systems, down to the level at which managers plan, monitor, and control. The methodology begins at the value chain level (the highest and most abstract view) and utilizes structured analysis techniques to decompose the production planning business systems down to the R-E-A level. It is unnecessary to track data at the task level of abstraction. Tasks can vary dramatically from organization to organization.

Each level of abstraction is described in detail in the following sections. Also the modeling techniques utilized by this study, to model each level, are described. The modeling techniques presented are value chain (Gale, et.al, 1997), R-E-A modeling (McCarthy, et.al, 1997), and data-flow-diagrams (DFD's). Data-flow-diagrams are utilized as a tool for organizational decomposition from the value chain level to the R-E-A level of abstraction

McCarthy, et.al, (1997) presented a structured approach to information system development. This methodology is designed for the conceptual modeling, physical design, and implementation of an accounting information system in a shared data environment. A portion of this methodology will be used by this study to produce a conceptual model of a generic large production homebuilding firm's information system, as related to production planning.

The methodology developed by McCarthy, et.al, (1997) presented a series of steps to organizational decomposition and business system modeling. This study adopted three steps of McCarthy's (1997) methodology for use in the proposed production planning methodology. The three steps utilized are: (1) requirement analysis, (2) view modeling and modification, (3) view analysis and integration. The remaining steps to the methodology, presented by McCarthy (1997), are not utilized by the proposed production planning methodology because the modeling techniques are company specific, therefore inferences drawn from their application will not be relevant to the production homebuilding industry as a whole.

4.2.1. Requirement Analysis

Requirement analysis can be simply defined as a procedure which attempts to determine the present and future information needs of the user community (McCarthy, et.al, 1997). The objective of the requirement analysis stage is to identify and document user requirements, then communicate the user requirements by way of feasibility documents to the next steps in the information system development methodology. Feasibility documents include the following; (1) description of the users (ex. Project managers, VP construction, sub-contractors), (2) statement of the benefits associated with the system changes ex. Improved cash flow, shorter cycle times, less material theft), (3) precise description of the objectives that the new system is to satisfy, including decision support (ex. Cycle time reporting to senior management, work-in-progress reports) (McCarthy, et.al, 1997)

4.2.2. View Modeling and Modification

The purpose of the view modeling and modification process is to generate a conceptual data model for the various value-added series of exchanges identified during the value chain and DFD modeling stages. The conceptual data model is represented with an R-E-A model. The R-E-A model represents the value added series of exchanges at the level of detail in which managers plan, monitor, and control. A value added exchange is represented by a give and take relationship. For example, a homebuilding firm gives up cash for performance of work specified on a purchase order.

Transform descriptions are also described during the view modeling and modification process. Transform descriptions illustrate data flows and describe each application's processing and access requirements. A data dictionary is produced. Constraints are identified as related to usage policies between departments or users (McCarthy, et.al, 1997). Inputs into this process are the current old information requirements, new information requirements, and user inputs.

A conceptual data model is generated using R-E-A modeling. The purpose of this modeling technique is to model the various processes identified by the DFD and identify what data, necessary for proficient production planning, must be planned monitored, and controlled by the majority of large production homebuilding firms.

Transform descriptions will be utilized to illustrate the data flows between the various departments of a typical large production homebuilding firm. They will also be used to identify the various applications, such as estimating or scheduling packages, but detail as related to specifics in processing requirements will not be investigated since only a conceptual model is being developed. For example, Dasso (1988) identified the scheduling management systems necessary for large homebuilding firms to operate at maximum managerial proficiency. One of the systems is the utilization of critical path method (CPM) scheduling system. Transform descriptions, in conjunction with the DFD's illustrate the relationship between CPM schedule and the various predecessor and successor systems, which are dependent upon it.

4.2.3. View Analysis and Integration

The views generated in the view modeling and Modification stage are integrated in the view analysis and integration stage. These views represent the various views of a production planning system for production homebuilding firms. A "global" view of a business system is a model that shows the integration of each independent business system. In order to develop a global view of the proposed system, the various local views must be integrated by following three steps. First, synonyms and homonyms must be edited out. Next, other naming inconsistencies must be eliminated. Finally the individual local views are merged into a "global" view of the enterprise (McCarthy, et.al, 1997). The global view is represented with and R-E-A model. The primary objective of this process, for the purpose of this study, is to identify the minimal data requirements and integration

necessary for proficient production planning before any implementation compromises have been made.

Implementation compromises represent the difference between the ideal system and the actual physical system implemented in an organization. The less implementation compromise, the better. For example, the view analysis and integration stage may identify that it is most efficient for the construction scheduling system to be seamlessly linked with the accounting system, allowing for automatic payment when work is completed. Data will be modeled and subsequently structured for this integration to take place. This integration may be eliminated as an implementation compromise because it currently takes too long to up-load scheduling data from field offices to the corporate mainframe.

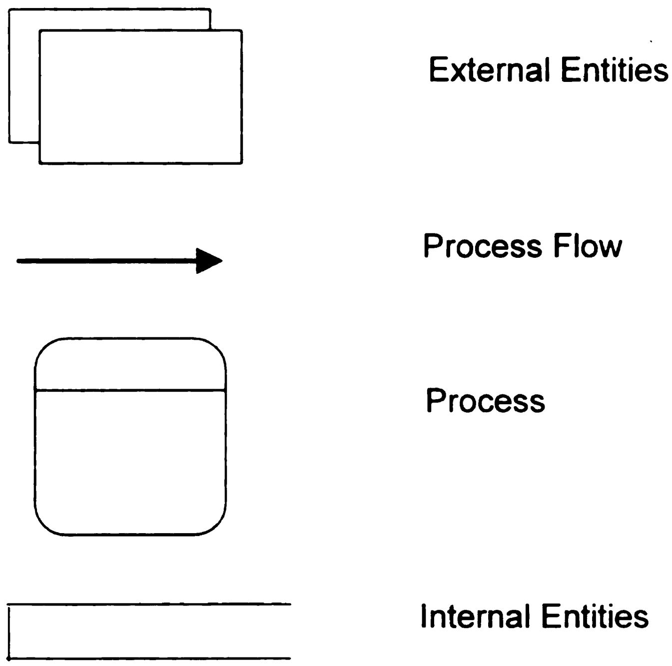
4.3. Value Chain Level of Abstraction

The porter value chain (Porter, 1985) is a tool utilized to analyze the activities a company engages in that create value. Using a value chain to model a company's business cycles allows managers to view the firm from its simplest and most abstract form. Resource inputs and outputs for specific processes are also evident with this model. The objectives of the value chain are two folds. First, Porter (1985) developed this technique for analyzing the competitive advantage, or the core competencies of an organization (Gale, et.al, 1997). Secondly, system developers adopted this technique in order to identify value-added series of exchanges. For example, evident in most business is the financing cycle. This is the process in which businesses acquire cash through financing. This is a "give and take" business cycle starting when a cash receipt from a financial institution is received by a firm, then subsequently completed when the firm makes payment to the financial institution. System developers can also use this modeling technique to identify value added series of exchanges, which will be further, decomposed with the help DFD's.

4.4. Data-Flow-Diagrams (DFD's)

DFD's are a modeling technique utilized to illustrate business processes, sub-processes, and their inter-relatedness. DFD's are a structured analysis modeling technique utilized primarily by system analysis in order to develop an understanding of the inter-relatedness of the system and it's sub-systems. The primary purpose for utilizing DFD's in this study is for organizational decomposition from the value chain level of abstraction to the R-E-A level of abstraction. Utilizing organizational decomposition to model an organization, the user first models the organization from the highest level of abstraction (value chain level). Next, each process represented on the value chain must be decomposed into more detailed processes and sub-processes. DFD's are an accepted modeling tool for performing this operation (Pheng, et.al, 1997).

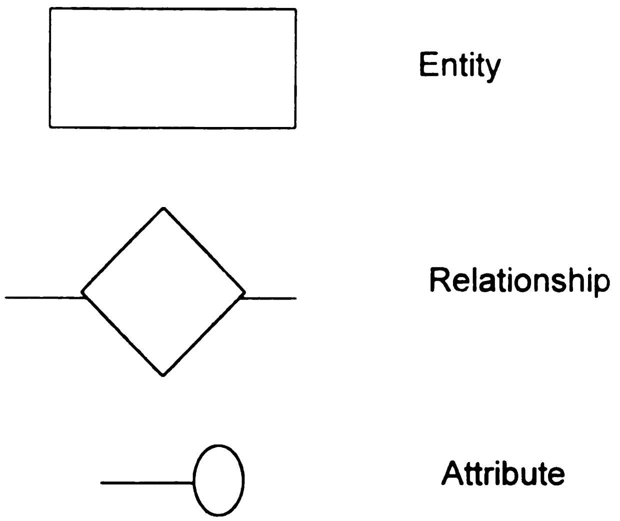
The following symbols are used in DFD modeling.



4.5. Resource – Event – Agent (R-E-A) Level of Abstraction

The R-E-A level of abstraction is a further decomposed version of the value chain, (McCarthy, et.al, 1997). This perspective allows managers or system developers to examine the sub-processes associated with each of the processes identified in the value chain. These sub-processes are often described as "give and take" exchanges. Details such as specifics in material acquisition, scope of work of sub-contractors, and departmental activities become evident. This level of abstraction encompasses organization policies and is the level at which managers must plan, monitor, and control.

R-E-A modeling is a relational database modeling technique. It has become dominant in modern database design (Rob, et.al, 1997). R-E-A models illustrate company resources, events, and agents at a given level of abstraction. DFD's illustrate company processes various levels of abstraction, by illustrating processes, sub-processes, and sub-sub-processes. R-E-A modeling technique is primarily utilized to; (1) translate different views of data among managers, users, and programmers to fit in a common framework, (2) define data processing and constraint requirements, (3) help implement a database. R-E-A models include entities, relationships, and attributes.



4.6. Task Level of Abstraction

The task level is a further decomposed version of the REA level of abstraction. Re-engineering is directed toward tasks and rarely affects higher levels of abstraction. Tasks are the daily operational activities of employees such as processing invoices or scheduling sub-contractors. Organizational procedures and rules are evident at this level. When developing a production plan, it is necessary to view the production process from both the REA level and the task level of abstraction. This allows managers to first identify what information must be planned, monitored, and controlled. Next, by modeling the task level, managers are able to identify which specific task employees must perform daily in order to maintain the desired level of control. Tasks can vary dramatically between organizations therefore the modeling conducted by this study will not be decomposed to the task level although it is a necessary component to production planning.

Tasks can be modeled with fish bone diagrams or system flow charts. Both modeling techniques represent tasks sequentially through a process. System flow charts are much more widely accepted and include greater detail, such as storage devices. Modeling tasks is an ideal methodology for not only identifying tasks but also finding the appropriate department or personnel to assign responsibility of that task to.

4.7. Summary

This chapter introduced the modeling methodologies and techniques that are used in chapter five of this study. This included a detailed discussion on the various tools associated with structured analysis. Business system modeling was discussed for the value chain level of abstraction followed by a discussion of the DFD modeling technique. The R-E-A modeling methodology was discussed for the R-E-A level of abstraction. The task level of abstraction was also presented.

CHAPTER FIVE

PRODUCTION PLANNING METHODOLOGY

5.1. Introduction

Managers of homebuilding firms must perform many managerial functions within their business system. Planning is the foremost management function. The business function of business planning is critical to any business and is certainly essential to large homebuilding firms. Proper business planning can improve some or all of the characteristics of managerial proficiency. The business planning process forces managers to examine and document all aspects of their organization. The function of business planning is not simply the process of developing a business plan document. It charges managers with the responsibility of developing and maintaining planning systems for all aspects of their organization, including but not limited to defining their business, market analysis and planning, service planning, production planning, organizational planning, development schedule, and financial planning. This chapter presents a methodology for production planning (PPM) which allows managers to examine their existing production planning system in terms of their organizations strategic plan, market demand, customer service requirements, and product characteristics. Then, it provides a platform for managers to model the appropriate production planning system.

More specifically, this methodology is focused on a combination of production planning processes identified by Banjaree (1997), as explained in Chapter 2, and expanded with structured analysis techniques, as presented in Chapter 4. It includes a diagnostic stage, characterization stage, customization stage, and concept design stage. Furthermore, the concept design stage is expanded to include requirement analysis, view modeling and modification, and view analysis and integration. View modeling and modification is conducted through the structured analysis modeling techniques; value chain modeling, DFD's modeling, and R-E-A modeling.

5.2. Outline of Production Planning Methodology (PPM)

An outline of the PPM is provided below. Each step is presented in the form of DFD's throughout the chapter, beginning with figure 5.1 the business planning process. An example, Big Builder, is utilized to illustrate each step.

I. Diagnostic Stage (4.1)

II. Characterization Stage (4.2)

  A. Product Analysis (4.2.1)

    1. Study Current Product Characteristics (4.2.1.1)

    2. Develop Desired Product Characteristics (4.2.1.2)

    3. Develop Physical Product Plan (4.2.1.3)

  B. Construction Analysis (4.2.2)

  C. Procurement Analysis (4.2.3)

D. Production Conceptual Modeling (4.2.4)

III. Customization Stage (4.3)

IV. Concept Design Stage (4.4)

A. Requirement Analysis (4.4.1)

B. View Modeling and Modification (4.4.2)

1. Develop Value Chain (4.4.2.1)

2. Develop DFD's (4.4.2.2)

3. Develop Data Model (4.4.2.3)

C. View Analysis and Integration (4.4.3)

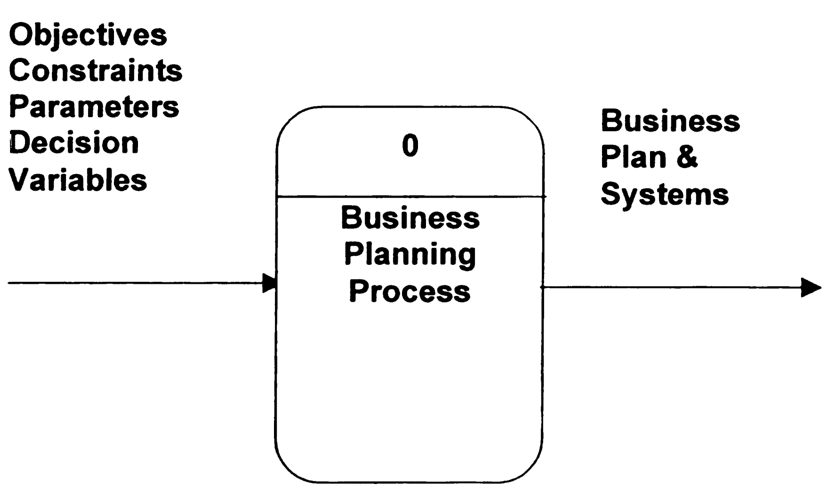


Figure 5.1.
Level 0 PPM Data Flow Diagram
Business Planning Process

5.3. Production Homebuilding Firms

Production homebuilding firms are production oriented companies. That is, they have embraced the production concept in order to produce products that are widely available and low in cost (Kotler, et.al, 1997). Production homebuilding firms strive to operate operationally excellent organizations. Operational excellency is achieved by rejecting variety and production “no-frills” products targeted toward the middle of the market where demand is huge and customers are more interested in cost than in choice (Treacy, et.al, 1995). Although, in response to resistance to urban sprawl, increased municipal control, and municipal involvement in the land development process, production homebuilding firms are offering a wider variety of products. This PPM is directed toward these homebuilding firms and their strategic plan, production building, taking into account the likeliness of increased product differentiation.

5.4. Business Planning Process

Figure 5.1 illustrates the business planning process at its highest and most abstract form. Level 0 of the PPM data flow diagram. A business is a system and a company’s business plan is a representation of that system. A business is a function of objectives of the owners, internal and external parameters, and decision variables, which result in the business system. Managers of production homebuilding firms control this system by performing a series of management functions. First managers must perform an analysis of their market(s) and plan for the specific target markets identified. Managers must recognize the demands of their clients and accommodate the needs identified from the moment clients first step foot into a model home through the completion of the warranty period. Managers must decide what they are going to build and how they are going to direct the company's resources to build it. They must build a team and constantly lead that team in such a way as to produce enthusiastic results. And all this has to occur in a complex ever-changing fragmented environment with unpredictable weather, ever-changing municipal requirements, and a cyclical economy. Then they must report the success of this system through financial statements.

Big Builder Example   Level Zero PPM:

Big Builder is a large production homebuilding firm operating in three markets in the southwestern U.S., Houston TX, Dallas TX, and Phoenix AZ. In 1998, Big Builder closed 2800 units and expects a 15% increase in 1999. Big Builder is organized into divisions, there is one division for each market area all of which construct approximately the same number of units annually. Each division operates autonomously, that is, each homebuilding division is lead by a division president who is charged with operating all facets of the business unit. The market factors driving production in each market area vary dramatically. In the case of Houston TX, Big Builder builds in many small to medium sized developments (20 – 200 units) and offers a wide range of products, from multi-family condominiums to large single-family detached homes. The Phoenix AZ division builds in only a handful of ver large planned unit developments (1200 –

10,000 units each) and offers a limited selection of single-family products. The Dallas TX market is unique as well. Big Builder offers a limited number of house plans in thee distinct market levels, entry level, move-up, and retirement Although each division offers different categories of products depending on their market area, they operate under the same mission. Big Builder's mission is "to provide the greatest value in every market area in which it operates while maintaining the highest degree of customer satisfaction, employee satisfaction, and business partner success". The operating models of each division are consistent as well. Each division strives to maintain a minimum of a three-month sales backlog. Inventory is kept at the lowest levels possible. Resource leveling is conducted at the division level, but sometimes segregated by product group (multi-family, single-family).

The above example illustrates Big Builder at the highest and most abstract form, or level 0 of the PPM. The strategic plan (production homebuilding) is evident at this level of abstraction. Also, some of the operational characteristics of Big Builder are evident at this level of abstraction.

5.5. Production Planning

Figure 5.1 illustrates the business planning process. The business planning process can be further decomposed into a number of sub-processes; definition of the business, market analysis and planning, service planning, production planning, organizational planning, development schedule, and financial planning. Figure 5.2 illustrates levels 1-7 of the PPM. As shown in Figure 5.2, production planning is the core business planning process.

Production planning is the core function of the business planning process, which means that in order to develop a production plan, the business must first be defined, market analysis and planning conducted, and a service plan developed. This also means that the organizational plan, development schedule, or financial plan can not be developed until a production plan has been produced. Brief descriptions of these processes are provided in Chapter 3. It is beyond the scope of this study to examine these processes in more detail, except when related to inputs and outputs of the production planning process. Figure 5.2 illustrates the business planning sub-processes.

As illustrated in figure 5.2, production planning is the core of the business planning processes. The production process for homebuilding firms is the value-added process of utilizing both internal and external resources such as management, cash, sub-contractor labor, and material to build homes. As noted earlier, the majority of large homebuilding firms are production oriented, therefore the production process is their core competency. It is the process in which these builders create the greatest value with the least input.

Production planning must be preformed with the needs of the market in mind. The market plan targets specific markets and identifies products, and the characteristics of those products, that will be brought to market. The production plan is the vehicle to deliver the identified products within the parameters defined by the market plan such as design and cost.

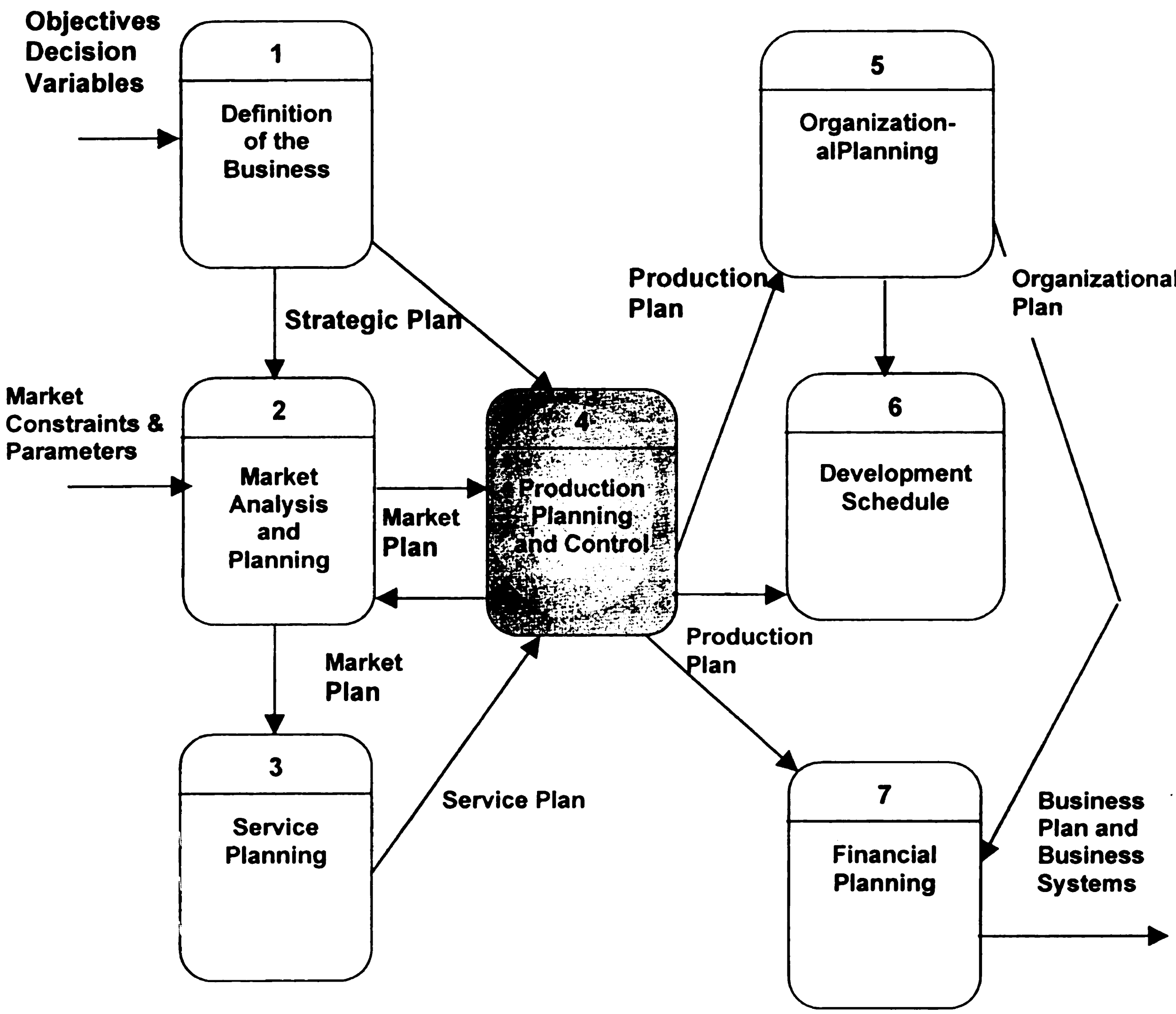


Figure 5.2
Levels 1-7
PPM Data Flow Diagram
Business Planning Sub-processes

Many large production homebuilding firms seek out development sites and markets for their standard "star" product lines. This pattern of production has been repeated time and time again by successful "Giant" builders. The underlying consistent factor of efficient production recognized by these builders is product standardization. One is certain to find a seasoned professional at any successful production homebuilding firm who will hail the success of their star "super-value-engineered" model.

In many markets there is an increasing resistance to new development. Many homebuilding firms, including large production oriented firms, have found themselves deviating from standard product lines in order to develop product based on specific community requirements for a specific development. The two direction arrows between steps 2 and 4 (figure 5.2) illustrate this phenomenon. The result is, not necessarily increased product complexity, but increased product differentiation. When increased product differentiation is interjected into a homebuilding firm's production systems, inefficiency results. This study argues that the level of detail at which managers must plan, monitor, and control production is contingent on the characteristics of the products brought to market. If a homebuilding firm continues to construct a standard product line, the production processes can be controlled at a detailed level. If a homebuilding firm must develop new product to meet specific requirements then inefficiencies result. The PPM employs a process to address this phenomenon by employing structured analysis techniques to the production planning methodology within the concept design stage. The intent is to identify the level of detail at which managers must plan, monitor, and control.

The PPM exhibits the characteristics, identified by Banjaree (1997), necessary for a production planning methodology. Banjaree's (1997) first objective, system to match the production plan with the company's market plan, is integrated into this methodology. As displayed in figure 5.2, the business planning process, the market plan (step 2) is a direct input into the production planning process (step 4). The bi-directional arrows between steps 2 and 4 represent the exchange between marketing and production necessary to determine the characteristics of products that the homebuilding firm can deliver while maintaining parameters established by market demands. Additionally, a given level of production can not be planned for without first establishing a market for each product group. This methodology expands Banjaree's (1997) requirements by suggesting that a system exist to match the long-term strategy and customer service plan with the production plan as well.

The long-term strategic plans of organizations must be considered. Figure 5.2, illustrates the relationship between the definition of the business process (step 1) and the production planning process (step 2). The long-term strategic plan is developed during the definition of the business process and is input into the production planning process.

The service plan is also illustrated as a direct input into the production planning process. Some homebuilding firms may select to develop a service plan simultaneously with the production plan. The author argues that these homebuilding firms are not differentiating between warranty and customer service. Customer service is the process of meeting the expectations of a customer at every contact point from when the customer first steps foot into a model home to the conclusion of the warranty period. Warranty is the process of repairing and maintaining a product after conveyance to a customer, for a designated period of time. Customer service must be addressed with regard to all business processes and not narrowly focused on one process such as warranty.

Banjaree (1997), also suggests that production planning methodologies include " a means for the realization of an integration path between interacting domains". A path mapping domain integration is a characteristic of the PPM. This is accomplished through the structured analysis technique view analysis and integration. This process will be described later in this chapter.

Banjaree (1997), also noted that a PPM should include a transition route mapping the difference between the existing and desired physical systems and also have a process to identify the difference between these systems. Figure 5.3, illustrates Banjaree's (1997) intent for this requirement. Both of these requirements are fulfilled by this methodology through the inclusion of the structured analysis technique, view modeling and modification. This process will also be discussed in detail later in this chapter. Figure 5.3 displays how both the desired physical production planning system and the existing physical production planning system drive the new physical production planning system. The intent of this process is premised on the assumption that you can't always throw out the old system and start entirely new. Existing systems often must be integrated with new systems.

Banjaree (1997) also argues that a PPM should include a process to construct a conceptual model of the desired system. This PPM utilizes Porter's value chain and R-E-A modeling as tools to model the desired system, taking into consideration the properties of the existing physical system and the desired physical system. Once again, the structured analysis techniques, as applied in this PPM, meet Banjaree's requirements

Finally, Banjaree (1997) noted that the PPM should include a provision for expressing the system requirements in a universal language providing means for selection of decision support tools. This author argues that the R-E-A modeling technique utilized to model the new system is a universal language which represents the new system at a level of detail consistent with what managers require for planning, monitoring, and controlling functions.

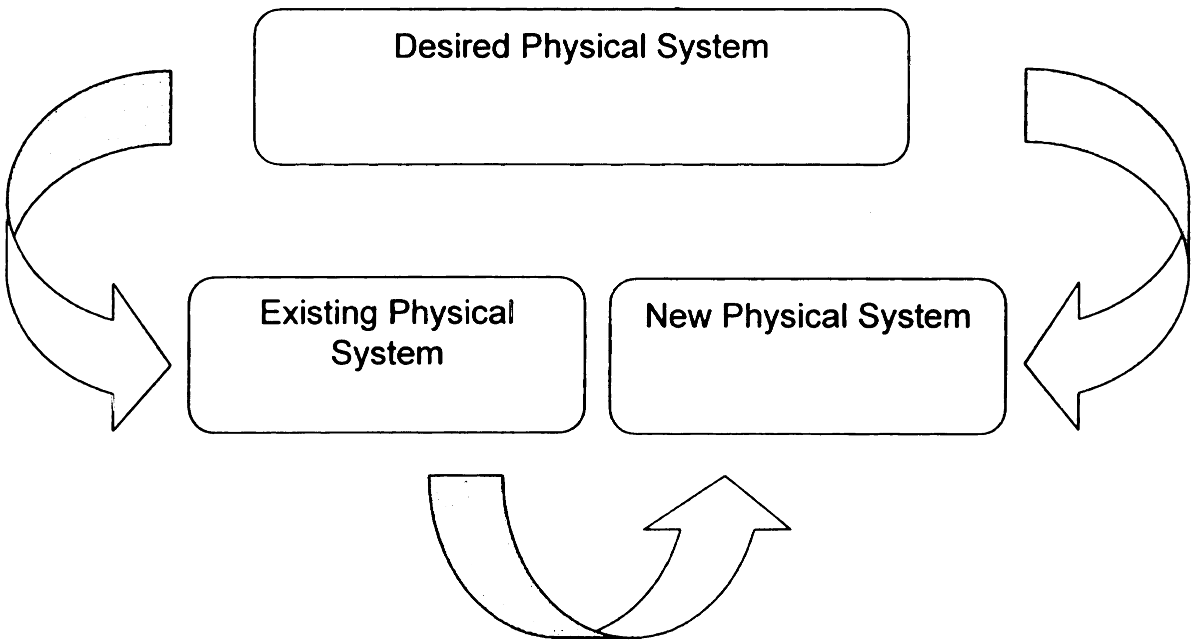


Figure 5.3
Representation of Transition Route Mapping the Difference Between the Existing and Desired Systems, Modified from Banjaree 1997

5.6. Production Planning Sub-processes

The PPM can be divided into four sub-processes, (4.1) diagnostic stage, (4.2) characterization stage, (4.3) customization stage, and (4.4) concept design stage.

Inputs into the Production Planning Process

The first step in the development of a PPM is to gather the production planning inputs. Figure 5.2, illustrates the three primary inputs into a production planning system, strategic plan, market plan, and customer service plan. The first and foremost input is that of the strategic plan. The strategic plan represents the very essence of an organization. The strategic plan identifies the products the organization will take to market and the philosophy of how organizational resources will be directed to deliver the products to the consumer. The market plan identifies the characteristics of product, which will be taken to the market, and the projected demand the production plan must meet. The service plan documents the level of warranty that service managers must plan production resources to accommodate.

The outline below identifies the various critical components of each plan, strategic plan, market plan, and service plan, as identified by Dasso (1988), for large production oriented homebuilding firms.

Inputs into the Production Planning Process

Strategic Plan

- Company Goals and Objectives are Defined

(Big Builder will provide the greatest value for housing in any market in which it operates)

- Long-term Objectives

(Increase market share by 15% of housing starts in the each market over the next 5 years)

- Short –term Objective

(Close 1100 units in each division in the next fiscal year (15% increase))

- Financial Objectives

(Increase ROI to 12%)

- Non-financial objectives

(Lower the per square foot sales price by $5.00 across all product lines)

- Primary Objective

(Build better homes at a lower square foot price)

- Critical Objectives

(Reduce hard costs)

- Specific Objectives

(Reduce hard costs to 50% of sales price)

Market Plan

- Target Marketing (Product Groups)

(Market plans may be written for a specific product group or for a specific site)

- Target Pricing

(3 bedroom 1400 s.f., 1-1/2 bath ranch for $89,900)

<u>Service Plan</u>

- Quality Objectives

(Reduce 6 month and 1 year warranty items to less than 5 per unit and reduce outstanding warranty items to <.03 per units in warranty)

Figure 5.4 illustrates the production planning sub-processes, diagnostic stage, characterization stage, customization stage, and concept design stage.

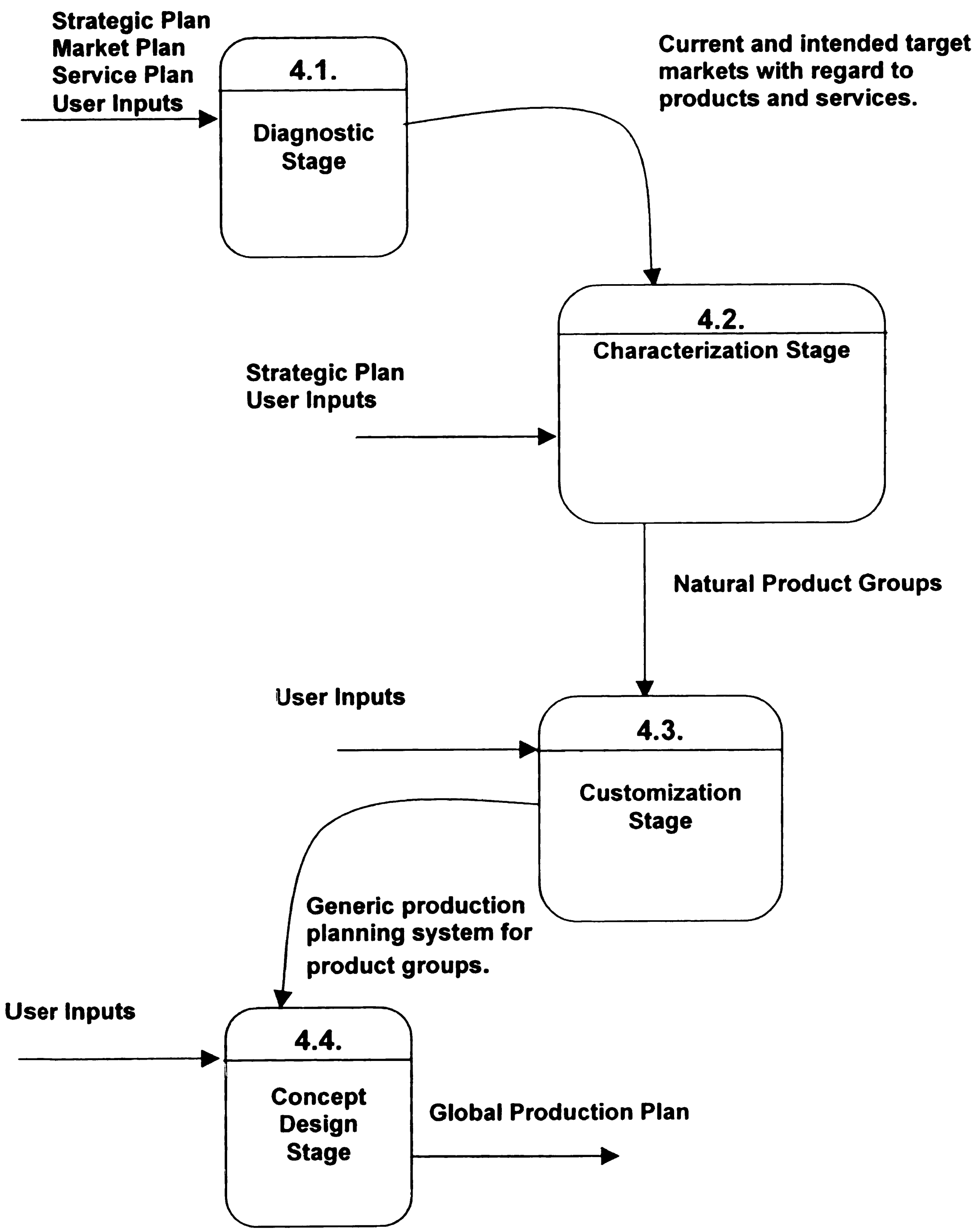


Figure 5.4
Levels 4.1-4.4
PPM Data Flow Diagram – Production Planning Sub-processes

5.6.1. Diagnostic Stage

The first step in the development of a production plan is the diagnostic stage (step 4.1). This is the process in which managers asses the current and intended customer and market segments targeted by the enterprise. Next, projected needs with regard to products and services are analyzed. Also, a detailed assessment of the competition is conducted. Following an assessment of the competition, manufacturing objectives are identified in terms of volume, delivery, critical product cost and quality, and other market or service related objectives.

The strategic plan, market plan, service plan, and user inputs, makeup the inputs into the diagnostic stage. The purpose of the diagnostic stage is to define the desired physical production planning system. This is the process of business analysis or business specification. This process includes the following:

- Review of the current and intended customer and market segments targeted by the enterprise, their present and projected needs with regard to products and services
- Assessment of competition
- Review of manufacturing task statement in terms of volume, delivery, flexibility, critical product cost, quality, and other manufacturing dimensions in terms of consistency with the adopted strategic plan, market plan, and service plan.

For Example

Big Builder's Phoenix division offers five products in large developments ranging from 1400 – 2200 s.f. Big Builder specifically targets entry level or first time single-family homebuyers. Big builder has determined that their buyers require 2 car garages, 3 to 4 bedrooms, "green construction", energy efficient design, and access to community amenities (club-house, tennis courts, swimming pools, etc.)

Big Builder assesses competition both regionally and within a given development. Keep in mind, Big Builder's Phoenix division only builds homes in very large planned unit developments, up to 12000 units.

A generalized example Big Builder's manufacturing task statement is provided below.

- *Production system must be able to deliver up to 1200 units.*
- *Sub-contracted labor will be used for all phases of construction.*
- *Current product line must be updated to accommodate "green" and "energy efficient design" while simultaneously lowering construction costs.*
- *Hard costs must be lowered by 5%A to 50% of sales price.*
- *Outstanding warranty items must be reduced to .03 items per units in warranty.*

5.6.2. Characterization Stage

The second step in the development of a production plan is the characterization stage (step 4.2). This stage is intended to identify natural product groupings based on similarities in market, product, construction processes, or geographic distribution. Each product group's production plan can then be aggregated for the firm. The characteristics of each natural product group form the basis of the production plan. Style, price point, geographic distribution, density, or some other characteristic.

The specific characteristics of any given production homebuilding firm's product groups can vary dramatically. For example, two production homebuilding firms, building the same products, have both planned 2000 closings for 1999. Builder A operates primarily in the metropolitan Chicago area while Builder B is located in seven states. Builder A manages operations form one large office while Builder B operates 7 independent divisions. The author argues that the production planning and control systems of each builder will differ substantially due to the geographic distribution of production.

The characterization stage can be further decomposed into four sub-processes, product analysis, construction analysis, procurement analysis, and production conceptual modeling. Figure 5.5 illustrates the characterization stage sub-processes.

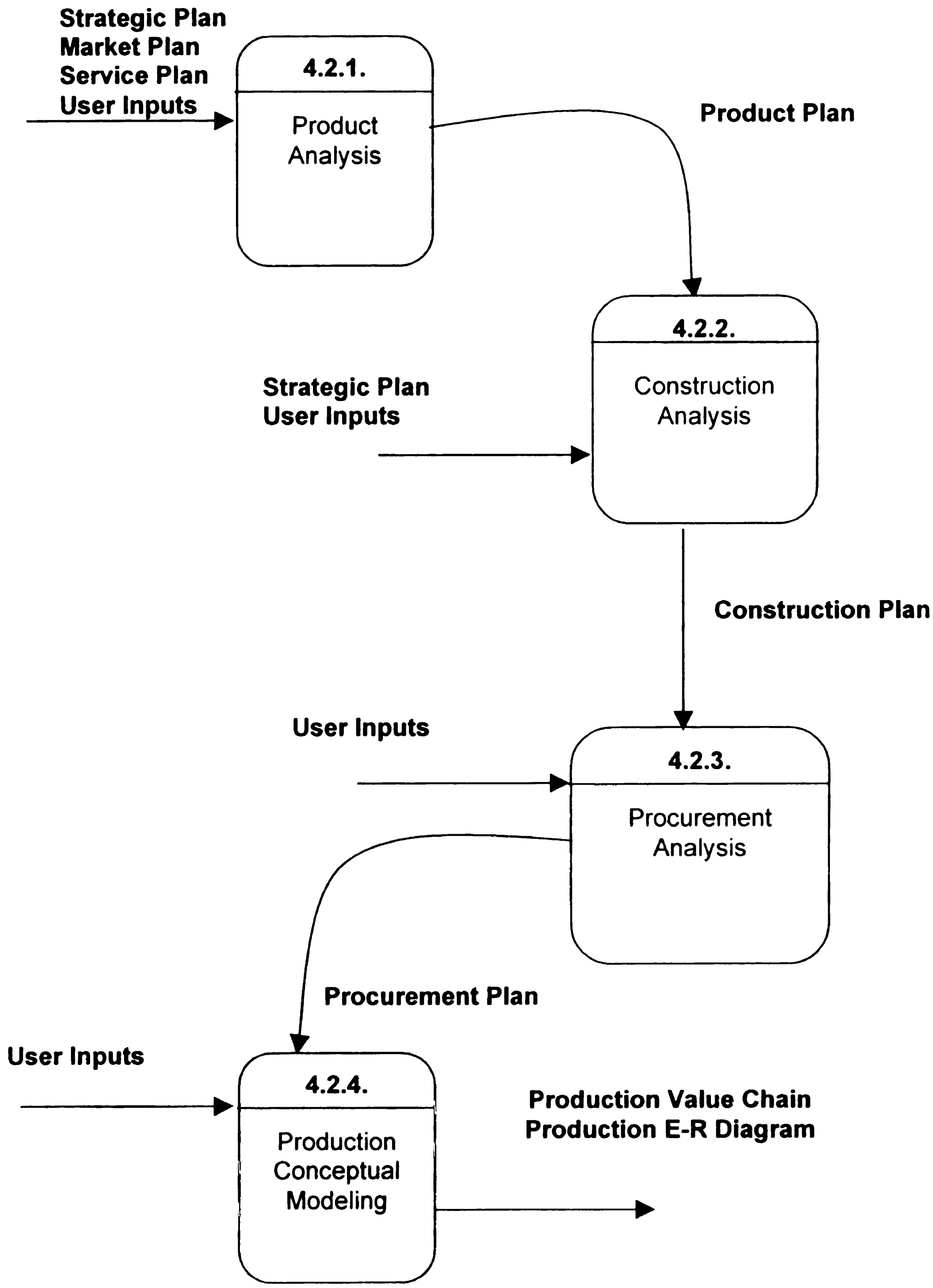


Figure 5.5
Levels 4.2.1. – 4.2.4. PPM Data Flow Diagram – Characterization Stage Sub-processes

5.6.2.1. Product Analysis

The market plan and the service plan drive the product analysis stage (step 4.2.1). Banjaree (1997), argues that the needs of the market must be evaluated with regard to the company's products. Certainly large production homebuilding firms evaluate their market with regard to standard product lines. Although, the author argues that there is an increasing amount of control being placed on land use in most states. Large homebuilding firms are finding that communities will not accept standard product lines. Movements such as traditional neighborhood development fuel this change. Product, either standard or developed for a specific project, needs to be grouped into natural product groupings. Although, product groupings must be re-evaluated regularly to accommodate for new evolving product lines. Natural product groupings form the basis for PPM system design (Banjaree, 1997).

For example:

Big Builder's market study identified a demand for approximately 2500 housing units in Big Builder's target market. Thirty percent of the demand is for town houses and seventy percent is for single family units. Since Big Builder's home building operations take place in three markets it is necessary to differentiate product, first by location and secondly by product type. Big Builder offers different product type in each market. Products may be grouped by single-family, town-house, multi-family in one market area and production and semi-custom in a second market area.

Different product groupings can have very different characteristics. For example, there is a very different relationship in the sequence of activities for a multi-family product and a single family home, especially related to total days under construction for a particular unit.

Big Builder schedules an entire row of town houses (units A-F) as one building. Once the rough frame has been constructed and the roof installed, Big Builder then differentiates between each individual unit, completing the remaining phases of construction is sequence from one unit to another. For example, the plumbers would install the underground plumbing for all six units as one activity but complete rough and finish plumbing individually, one unit at a time.

In the above example, the total cycle time from the start of construction through closing can vary by weeks between unit A and unit F. The total cycle time for the single family units should be approximately the same. Since cycle times drive cash flows, it is very important to identify these types of product characteristics.

The product analysis process can be divided into three sub-processes. First the current product and system characteristics must be examined (Level 4.2.1.1). Next the desired product characteristics must be identified (Level 4.2.1.2). Following the identification of existing and desired product characteristics for each product group the written product plan is developed. Figure 5.6 illustrates the product analysis sub-processes.

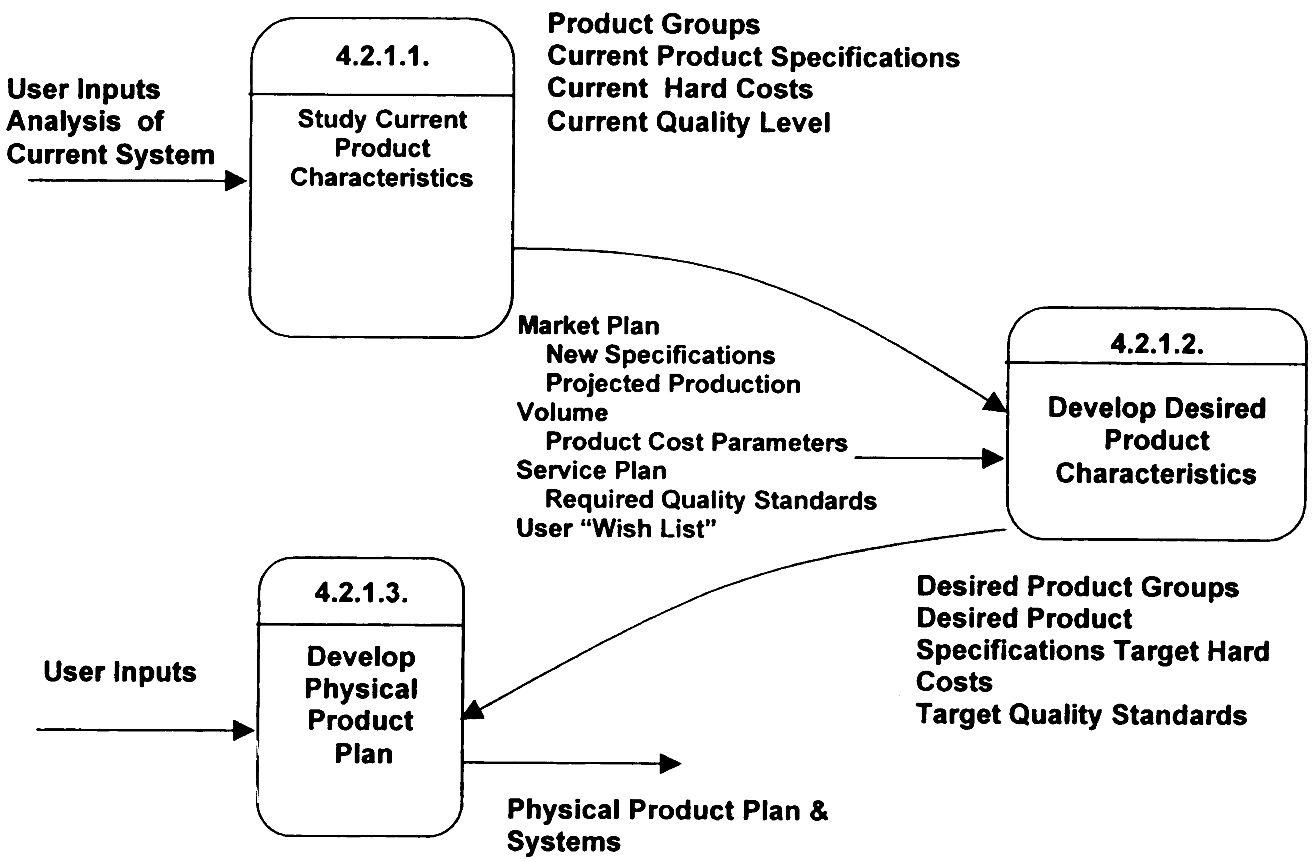


Figure 5.6
Level 4.2.1.1 – 4.2.1.3 PPM Data Flow Diagram – Product Analysis Sub-processes

The written product plan should include:

Product Plan Components

- Definition of each product group
- Product strengths and weaknesses for each group
- Product specifications for each product grouping
- Direct construction cost plan for each product group consistent with the target markets identified in the market plan.
- Indirect cost plan for each product group

Product System Components

- Product specification manual
- Quality plan for each product group including in-house inspection schedule
- Inspection forms (Frame inspection, pre walk-through inspection, etc.)
- Product action request form – for product changes

Study Current Product and System Characteristics

Current product and system characteristics should be assembled with regard to existing product groupings. This is accomplished by assembling existing product documentation and conducting a survey of purchasing and construction personnel. Items such as existing plans, specifications, and product budgets should be assembled. Also system items should be identified including any forms used.

Study Desired Product & System Characteristics.

The identification of desired product and system characteristics fulfills two objectives of the PPM. The first is a system to match the production plan with the company's market plan. This is accomplished by integrating market and service requirements with the desired new product specifications, such as higher energy efficiency or more open spaces. The second objective, fulfilled through a use survey, allows managers to identify desired product specification and system characteristics. For example, the customer service manager may request an improved sub-floor to eliminate tile warranty problems or the production manager may request some of the components of a particular product group be constructed in a factory, such as wall or deck panels.

Develop Physical Product Plan

The development of the physical product plan is the process of integrating the existing product and system characteristics with the desired product and system characteristics. First and foremost quality and cost targets should be detailed for each product grouping. Next, existing and desired product specifications should be evaluated with regard to the target cost and quality standards. Based on the identified product specifications for each product group, managers must decide what systems will be utilized to deliver these products to the market. Compromises will be made at this stage with the intention of assembling the ideal mix of product and systems in order to deliver homes within cost, quality, and efficiency targets.

Volume projected in the market plan plays a vital role at this stage. For example, it may be most cost effective to stick build the rough frame of each unit, although, when the volume requirements are considered in order to meet the projected demand, extra costs may be necessary to panelize the rough frame in order to achieve maximum product consistency under high volume.

5.6.2.2. Construction Analysis

Now that the product specifications and system characteristics have been identified in the product analysis stage, it is necessary to determine just how these units are going to be constructed. This is accomplished by dividing the construction analysis process into three sub-processes. First the current construction and system characteristics must be examined (Level 4.1.1.1). Next, the desired construction characteristics must be identified (Level 4.1.1.2). Following the identification of existing and desired construction characteristics the construction plan and systems are developed.

Warszawski (1997), identified parameters from which a construction company can analyze its construction process. Although these parameters were originally intended for use with strategic planning, it is the author's opinion that they are ideal for production system analysis. The parameters are as follows:

- What main projects does the company undertake?
- What are the preferred construction methods? Do these methods enable a company to compete successfully with others in terms of cost, productivity,

speed of construction, flexibility, and quality? In what type of projects are they particularly advantageous?

- Does the company employ its own labor – foreman and workers? What is their value in terms of age, experience, productivity, quality of work, and loyalty. It is possible and advisable to replace them by subcontracted services?
- Does the company employ subcontractors? Is the company associated with them on a permanent basis, or are they selected anew for each project? To what extent is the company involved in directing and planning of the sub-contractor's work?
- What is the quality of the company's output? Is it better or worse than that of its competitors?
- Does the company employ a quality control system in construction that allows it to specifically define the required quality of each work item and control the attainment of that quality?
- What other advantages or limitations compared with its competitors can be identified as far as construction capability is concerned.

<u>Construction Plan Components</u>

- Key management personnel
- Production organizational chart – job descriptions
- Monthly construction projections for each product group
- Number of units to be constructed for each development

- Pace of construction starts (by product group)
- Identification of construction phases for each community

Construction System Components

- Description / samples of production control reports
- System to allow for accurate cash flow projections
- System to allow for resource leveling
- Standard construction schedules for each product grouping
- Activity time requirements
- Milestones
- Target dates
- CPM
- Bar chart based on the CPM printed out and used for the field operations
- Critical path activities identified
- Total float and free float provided for non-critical activities

5.6.2.3. Procurement Analysis

Once the new product and construction characteristics have been identified, the procurement processes are examined. The procurement analysis is conducted in three steps. First the sub-contractor / trade-partner base should be identified for each product group. Next the supplier base should be identified. Finally, the builder's own forces are examined. The builder's own forces are those construction trades that are operated as a division of the builder. For example, Big Builder has a rough carpentry division that builds the rough frame for units constructed in the Dallas TX market.

Warszawski (1997), also identified parameters from which a construction company can analyze its procurement processes. Although these parameters were originally intended for use with strategic planning, it is the author's opinion that they are ideal for construction system analysis. The parameters relevant to this phase of production analysis are as follows:

- What inputs does the company purchase, and what inputs (if any) does it produce?
- What is the quality and reliability of the material suppliers?
- Does the company own or rent its construction equipment? Were the two options examined? How are the suppliers selected?

Procurement Plan Components

- Labor issues
- Subcontracting issues
- Subcontract status for each product group
- Subcontractor scope of work agreements for each product group
- Takeoff's for each product group at the appropriate level of detail. (Standard product lines should have detailed unit takeoffs, total square of siding, etc., Custom product groups should have more generalized takeoffs such as total siding bid)

Procurement System Components

- Change order policy
- Payment policy
- Callback policy
- Quotation / bid form
- Forms manual
- Employee training program
- Subcontract estimates are evaluated against a subcontract budget which is prepared from historical cost records
- Invoicing policies
- Invoice approval
- Invoice payment
- Invoice filing
- Purchase order log
- Material delivery
- Receiving ticket
- Schedule of loans and draws
- Contract control form
- Safety program

5.6.2.4. Production Conceptual Modeling

The production conceptual modeling stage is the initial modeling step of the PPM. The first step in modeling the production process is to assemble descriptions of the product data, construction data, and procurement data.

5.6.3. Customization Stage

The customization stage provides a generic production planning model for the business. The intent of the customization stage is to optimize the generic model for each product group. A conceptual production planning system for each product group will be developed in this stage, although the intent is one model for the enterprise. Therefore it is necessary to develop an aggregate model of the various conceptual production planning models developed for each product type.

5.6.4. Concept Design Stage

Now that a conceptual production planning model has been developed for the enterprise it is necessary to employ tools that will facilitate implementation for the various domains. This is accomplished by applying structured analysis techniques. The concept design stage can be broken down into three sub-processes, requirement analysis, view modeling and modification, and view analysis and integration. Figure 5.7 illustrates the concept design stage sub-processes.

5.6.4.1. Requirement Analysis

The purpose of the requirement analysis stage is three fold; (1) to develop a description of the users of the business system, (2) to develop a statement of the benefits associated with the system changes, (3) to develop a precise description of the objectives that the new system is to satisfy (McCarthy, et.al, 1997).

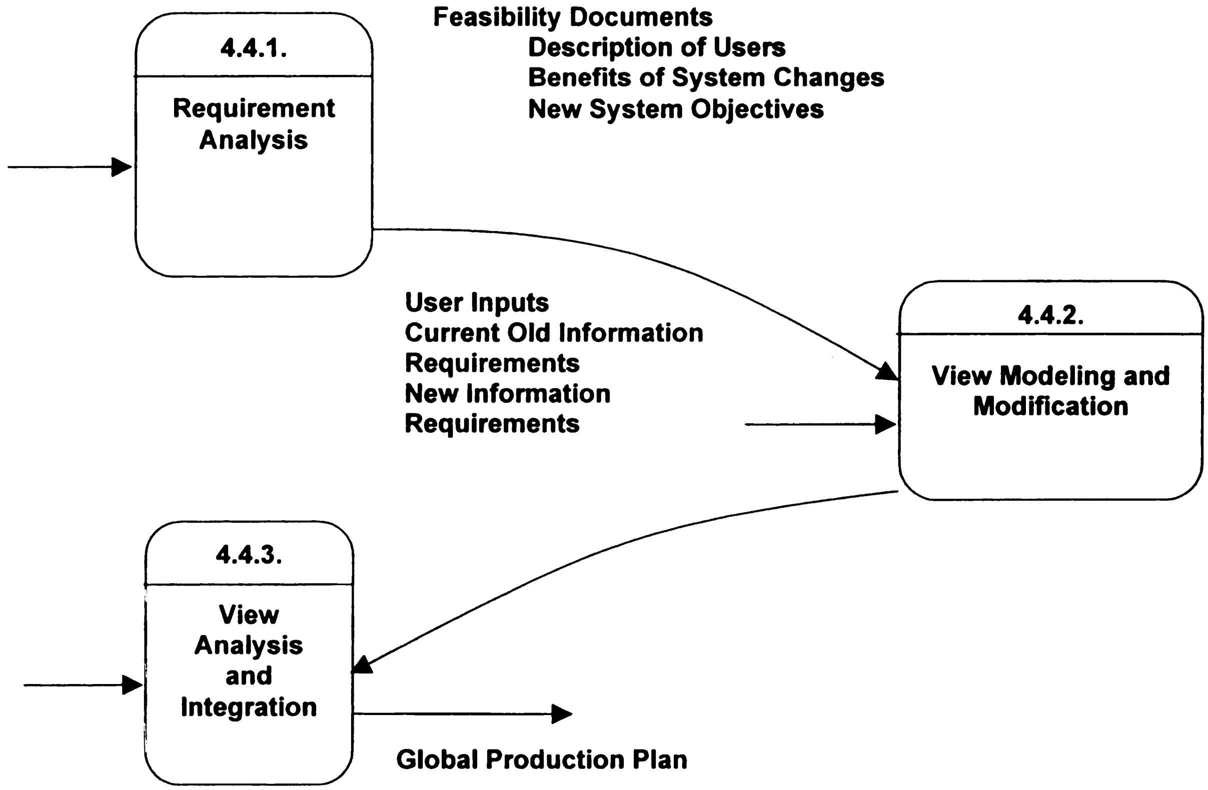


Figure 5.7.
Levels 4.4.1. – 4.4.3.
PPM Data Flow Diagram

5.6.4.2 View Modeling and Modification

The purpose of the view modeling and modification stage is to decompose the processes associated with production planning for a specific product group into a level at which managers must plan, monitor, and control that product group. This is accomplished with organizational decomposition. A value chain is utilized to model the product group in it's highest and most abstract form. DFD's are utilized to decompose the value chain processes into sub-processes and sub-sub-processes. R-E-A modeling is used to generate a conceptual data model for the various value-added series of exchanges identified during the value chain and DFD modeling stages (McCarthy, et.al, 1997). The view modeling and modification sub-processes are illustrated in figure 5.8.

5.6.4.3. Develop Data Model

Value Chain Level of Abstraction

Porter's value chain is utilized to analyze the production activities of a homebuilding firm engages in that create value. This allows managers to view production processes from the most simple and abstract form. The intent of this process is two folds, first it will be used as a technique to analyze the competitive advantage of the firm. Next the value chain will be used to identify the value added series of exchanges that occur in the production processes and what information pertaining to each process must be tracked for estimating, cost & progress control, scheduling, financial & accounting, and sub contracting & material acquisition.

The first step is to identify what production processes a firm engages in. A typical production homebuilding firm engages in the processes modeled in Figure 5.9. Other processes, more organizational specific, must be modeled at this stage as well. The author argues that all production homebuilding firms engage

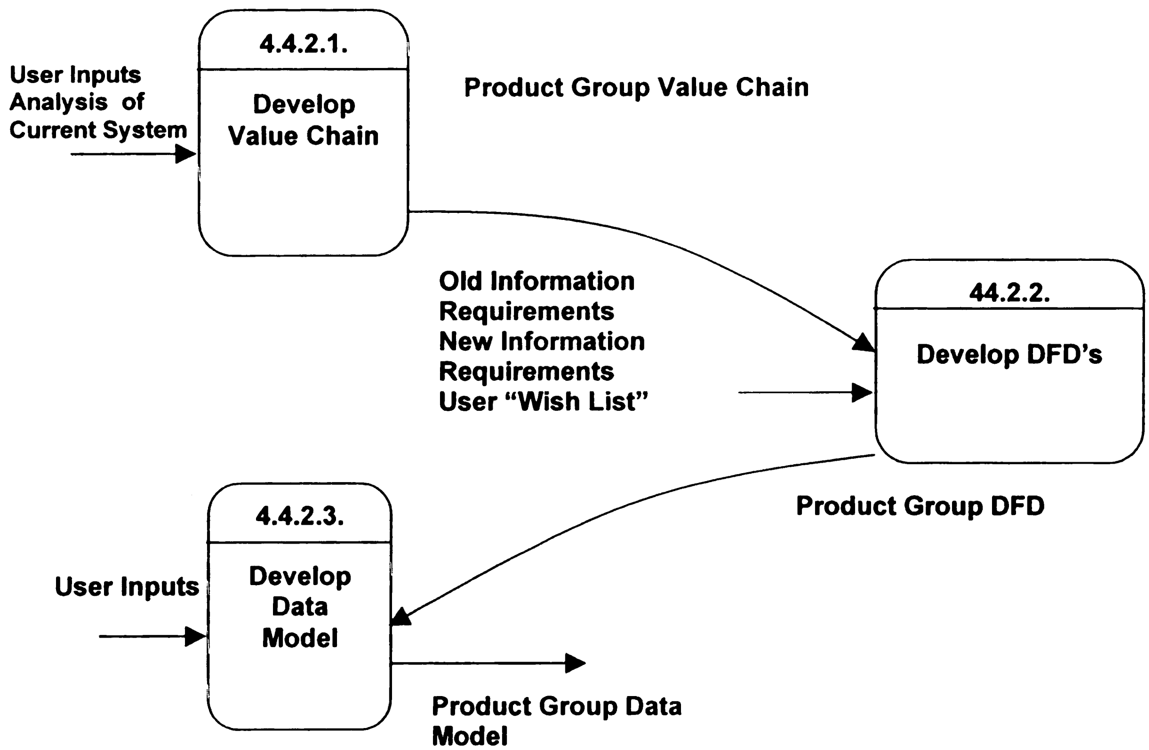


Figure 5.8.
Level 4.4.2.1 – 4.4.2.3
PPM Data Flow Diagram

in the following production related value added series of exchanges.

- Employee service acquisition and consumption
- Sub-contracting
- Material acquisition and consumption
- Fixed asses acquisition and consumption
- Land acquisition and consumption

Each process can be further decomposed into a number of sub-processes which managers must plan, monitor, and control. The planning and controlling functions of each of the above processes may be conducted at any point during a specific unit's life cycle. Consider materials as an example.

- Historic material pricing is utilized at the **Estimating Stage**
- Purchase orders used for **Cost Control** contain material pricing
- Delivery dates for a particular material are used for **Progress Control**
- Material lead times are inputs into the production **Schedule**
- Payments to suppliers and delivery dates are inputs into **Financial and Accounting** systems
- Material specifications are inputs into the **Material Acquisition** process

Data Flow Diagrams – Decomposition R-E-A

Data flow diagrams are a modeling technique utilized to decompose the value chain level of abstraction down to the R-E-A level of abstraction. DFD's are a modeling technique used to model processes, sub-processes, and sub-sub-processes including process inputs, outputs, and their interconnectivity.

Resource-Event-Agent Level of Abstraction

Entity relationship modeling is a modeling technique used to model series of exchanges at a level at which managers must plan, monitor, and control. The modeling technique, as described by (Geerts, et.al, 1997) represents a further decomposed version of the value chain. The intent of this section is to identify standard entities and relationships typical of the majority of production homebuilding firms.

Entity relationship modeling is used to illustrate the relationships between common entities associated with each of the typical production processes. Entities represent occurrences or existences that are tracked in a database as a table, such as customer, bank account, or financial transaction. Each entity has a relationship with one or more entities, for example every unit constructed has a relationship with vendors. Each entity also has one or more attributes. Attributes represent columns in a table, such as customer name, customer number, etc. An entity can have one or more occurrences to exist. These occurrences represent rows in a table, such as customer number one, customer number two, etc. There are different types of entity relationships, one-to-one, one-to-many, and many-to-many.

It is impossible to develop a generic data model for all production builders, although certain entities and relationships are standard. No cardinalities, relationship types, or attributes are standard and therefore are not included in the model. Figure 5.10 illustrates the standard entities and relationships typical of most production builders.

McCarthy, et.al, (1997), presented a structured approach to the design of accounting transaction systems. This approach integrated both structured analysis and database design techniques to form a new methodology. The product analysis stage of the PPM is closely related to the requirement analysis processes described by the authors. Requirement analysis is defined as a procedure which attempts to determine the present and future information needs of the user community. The scope of which includes all levels of decision making – strategic planning, management control, and operational control – and its output consists of data and processes specifications that are used in subsequent stages of database design, McCarthy et.al, (1997). The PPM proposed by this study has taken this process one step further, arguing that the characteristics of product groups drive the information needs.

For the purpose of production planning processes, the PPM presents the use of R-E-A modeling to fulfill the information analysis and definition process defined by McCarthy, et.al, (1997). This process fulfills Banjaree's objectives 4 & 5 by providing (4) process to construct a conceptual model of the desired system planning system and (5) provision for expressing the system requirements in a universal language providing means for selection of decision support tools. The R-E-A framework clearly identifies the information requirements.

The system development process presented by McCarthy, et.al, (1997), includes the physical system design. The physical system design is beyond the scope of this research but is an essential component. The R-E-A framework developed in the conceptual modeling process identifies the information requirements. Requirements may or may not be fulfilled in the physical design of the system due to implementation compromises that must be made. Implementation compromises are typically a result of the capabilities of existing system and technology (McCarthy, et.al, 1997).

5.6.4.4. View Analysis and Integration

In the view modeling and modification stage a data model was generated for the production planning and controlling processes associated with each product group. The purpose of the view analysis and integration process is to assimilate each of the production planning systems for each product group into a complete system for the company. In order to develop a global view, each local view must be integrated following the steps outlined in section 4.2.3.

5.7. Production Plan Development

The production plan is a document that identifies the specific goals and objectives for each product group related to the characteristics of the products, construction practices, and the sub-contractor and supplier base. The production plan must be continually refined and updated taking into account the dynamic market characteristics evident in any market. The production plan fulfills purposes beyond the establishment of objectives, it is intended to identify what information must be controlled as well.

Production plan development is the process of implementing each process, sub-process, and sub-sub-process associated with step 4. This is best accomplished through the sue of a cross-functional project team with expertise related to estimating, scheduling, cost & progress control, sub-contracting, and financing. Additionally, consultants may be required to perform the data modeling and/or information system implementation.

5.8. Summary

The PPM integrates database design and structured analysis techniques with the production planning process. This is accomplished through a series of processes, sub-processes and sub-sub processes, each described in detail in this section. Examples are provided throughout the chapter to further illustrate processes. Additionally, a series of check lists are provided for different aspects of the PPM.

Typically the system development process is driven by user requirements. This methodology presents the production planning process, including the role of information systems, in a method driven by both user requirements and the characteristics of product groups. The emphasis on product groups further substantiates and reinforces the applicability of the PPM in an environment of increased product differentiation.

A PPM that takes into account the likeliness of increased product differentiation provides managers with a system to match their production planning business system with the characteristics of their products. The ability to identify the appropriate level of detail necessary for proficient planning and control of production, based on product characteristics, allows managers to have the highest quality of information required for decision support.

CHAPTER SIX

INDUSTRY ELEVATION

6.1. Introduction

Two production homebuilding firms were examined with regard to the production planning systems in use. The production planning systems and production planning related information systems, utilized by both builders, were examined through interviews and the researchers experience working with the existing systems currently used by each builder. The intent of this evaluation was to identify the information systems, as related to production planning, utilized by both homebuilding firms, in the context of the PPM.

6.2 Description of Builder A

Builder A is a medium to large production builder dominant in one metropolitan statistical area. Builder A constructed approximately 600 units in 1998, a combination of single family and multi-family homes. Builder A's products can be categorized into four distinct groups, standard town house product line, standard site built single-family product line (homes constructed entirely on site), custom multi-family product line, and site ready single-family product line (homes constructed in a factory). In 1988 Builder A was operating three site built single-family developments, two site ready single-family developments, three town house projects, and two custom multi-family projects. Builder A utilized the same production planning systems for each product group although the characteristics of each product group vary dramatically.

6.3 Description of Builder B

Builder B is a medium sized production / semi-custom builder dominant in a specific market area, a city, and township. Builder B constructed approximately 100 town house and single-family homes in 1998. Builder B has a standard single-family product line but often accommodates customers' requests for slight customizations. Builder B also designs community specific multi-family and town house projects.

6.4 Interview Questions

Senior management of both builders were interviewed with regards to their production planning activities, production control systems, and the role of information systems in production planning. In addition to interviews, the author has worked in various roles, with both homebuilding firms, associated with production planning including information system design, development, and implementation. Specifically, the author coordinated the implementation of a purchase order accounting system for builder B and a revised production scheduling system for Builder A.

Both interviews were conducted in a qualitative and informal format. That is, the subjects were encouraged to diverge from their topic, give specific examples, tell war stories, etc. This format was essential in order for the investigator to identify potential areas or circumstances not previously considered. The following interview questions were used as a guide but not necessarily directly adhered to. In addition to the interviews the author made numerous observations of each company's production planning systems.

Interview Questionnaire

1. Define the strategic plan of your organization including the mission and core values.

2. What impact does the strategic plan have on the daily performance of your business systems?

3. Define the business planning functions performed in your organization, 1 year planning, 5 year planning?

4. Do you perform market analysis and planning with regard to your standard products?

5. In what ways have municipal requirements driven your market planning and subsequently your product development and production processes?

6. What land use trends do you foresee will impact your production processes?

7. Define production planning.

8. What construction-specific production control systems are currently in place in your company?

9. What purchasing / procurement production control systems are currently in place in your company?

10. What product specific production control systems are currently in place in your company?

11. Define the project life cycle for a particular unit from the initial sales agreement through the completion of the warranty period.

12. At what point(s) during the project lifecycle is your information system utilized (i.e. sales, financing, construction, warranty, etc.)?

13. In what ways does your production system and information system vary with each product group?

14. What level of integration exists among the IS functions of each department?

6.5 Observations and Inferences Drawn

The concept of production planning was not addressed specifically by either Builder A or Builder B. However, specific production planning related "parts and pieces" were utilized by both homebuilders, either informally or formally. Both homebuilders responded positively to the concept of formally implementing a product group specific production planning system within their organization.

The characteristics of product groups can easily be identified at the highest level of abstraction, the company mission. The strategic plan of an organization encompasses the very essence of a strategic plan. If a builder embraces the production concept through product standardization then a decision related to increased product differentiation must be evaluated with regard to existing management systems designed for standardized product.

6.5.1 Impact of Strategic Planning

The diversity of products resulting from the strategic plans of Builders A & B places high demands on the production systems of each builder. Builder A has a formal strategic plan and does not deviate from the objectives set forth. Builder A has four distinct product groups, and each product group is specifically targeted to be "low cost for the particular market area". Builder A targets low cost housing in all markets in which it operates, typically first time homebuyers, empty nesters, and single parents. The product types required to meet market demands vary dramatically from municipality to municipality; therefore, Builder A has responded with four specific product groups designed to meet the needs of each specific target market.

Builder B has a more loosely structure mission / strategic plan. Builder B's plan is more focused on reputation and customer service and is designed to meet the needs of the general market whether first time home buyers, move up buyers, or high end customs.

6.5.2 Business Planning Activities Used by Subject Builders

Builder A and B addressed the concept of business planning formally but only specifically in terms of strategic planning, market planning, organizational planning, and financial performance. Neither builder planned business performance as a whole. For example, both builders projected the number of units to be started and closed monthly for one year detailed by each product. Builder A projected in more detail by identifying specific development objectives. The actual number and type of units constructed by both builders varied dramatically from the one-year plans set forth.

6.5.3 Municipal Demands

Builder A is a large production builder and evaluates markets with regard to the company strategic plan and products. Recently Builder A has had to make multiple custom changes to it's standard product line to meet the specific demands of a local market, taking it as far as developing entirely new product for a specific development. Land must be acquired and development approved before revenue can be generated. Therefore Builder A has to accommodate the requirements of municipalities in order to guarantee a supply of developable and buildable land for the future.

Builder B continues to offer slightly customized standard products but has encountered increased resistance in the local city and township in which it has enjoyed consistent absorption rates for years. Therefore Builder B has begun to reach out to other markets with its products dramatically increasing the geographical distribution of production activities.

6.5.4 Construction-Specific Production Planning System

The control of construction systems with both subject builders lies with the project managers. Builder A has implemented an extensive detailed production scheduling system across some sites, although this system has slightly evolved at each site, similar to Darwin's evolutionary theory of species, and therefore is used for different purposes by each project manager. No other formal construction control systems are in place. Builder B allows project managers to develop and control their own production systems mostly by hand. Neither Builder A nor Builder B differentiates between product groups when implementing any form of construction control. Neither builder had considered product characteristics as the driving force behind construction control.

6.5.5 Purchasing / Procurement Production Control Systems

The evolution of the purchasing control systems for each builder was reflective of new information technology available and growth. Builder B tracked costs on a unit basis therefore generating specific itemized purchase orders. The semi-custom nature of Builder B's products resulted in multiple variances that had to be balanced on an itemized basis. The characteristics of Builder B's semi-custom products prevent Builder B from achieving efficiencies with this cost control system. Also, the information system implemented by Builder B was specifically designed to track costs in this fashion. In this case, the specifics of the software package chosen drove the level of detail at which managers plan, monitor, and control. It is the author's opinion that Builder A's procurement and cost control system is a fairly good match given the diversity of products constructed by the builder. Although certain essential information was lacking, such as a system to utilize historic cost information, detailed unit costing for production products, and standardization.

6.6 Analysis of PPM Evaluation

Both homebuilders recognize the need for comprehensive production planning. In fact, both homebuilders have dealt with the impact of increased product differentiation on their production systems. The availability of a production planning methodology that illustrates the sequential processes required for proficient production system development would have been invaluable to each builder's management team.

For example, Builder B embraced a task specific software package that provided estimating, scheduling, cost control, and accounting functions. Builder B then re-engineered the company from bottom up, starting with the capabilities of the software package. This led to a system that did not fit the builder's strategic plan, semi-custom / production building. Hence, after two years of commitment, the software is now only used for accounting functions.

6.7 Summary

The level of detail at which managers plan, monitor, and control for Builder A and Builder B are inversely proportional to the level of detail required for the characteristics of the majority of products produced by each builder. For example, Builder B maintains unit pricing line items on a purchase order for siding (number of square, lnft of corners, etc.). Builder B maintains a standard budget for each product but allows customizations. Therefore the estimator must revise each line item on the standard budget to reflect customizations before a purchase order is generated. If slight variances occur they must be accounted for on a line by line basis as well. Builder A creates a new budget for each product on a community by community basis. Different cost structures are maintained for the same product between communities. Although this is a standard product, no detailed unit costing is utilized. Specifically, the quantity of rough lumber material varies from community to community for the same house. Detailed unit costing would allow Builder A to account for the difference in rough lumber material quantities between communities.

CHAPTER SEVEN

SUMMARY AND CONCLUSIONS

7.1 Introduction

This chapter restates the objectives of this research and discusses each objective in terms of how the objective was fulfilled. Following the objective discussion, future areas of research are presented.. Conclusions are provided in the last section.

7.2 Objectives

This research had three primary objectives:

- Develop a production-planning methodology (PPM) for large homebuilding firms. This methodology should be applicable to the majority of residential construction companies producing greater than 5 million dollars of construction output annually.
- Identify the detailed information system requirements necessary for proficient production planning.
- Evaluate the research findings of the proposed production planning methodology. Evaluation will be conducted through the application of the proposed methodology on an example production homebuilding firm. Additionally, two production homebuilding firms will be examined to further evaluate the research findings.

7.3 Develop a Production-Planning Methodology

The development of a comprehensive production-planning methodology (PPM) for large homebuilding firms was certainly the most complex objective established. This objective was primarily accomplished through the integration of a methodology for production plan development, as suggested by Banjaree (1997) and structured analysis techniques as defined by McCarthy e.al, (1997). By integrating the above noted work the author was able to fulfill the following objectives, identified by Banjaree (1997), necessary for any comprehensive production plan.

- A system to match the production plan with the company's market plan.
- A path mapping domain integration.
- A transition route mapping the difference between the existing and desired systems.
- A process to identify the difference between the existing and desired physical systems.
- A process to construct a conceptual model of the desired system.
- A provision for expressing system requirements in a universal language providing means for selection of decision support tools.

The challenge of this methodology was to find a way to convey the various processes, sub-processes, and sub-sub-processes that must be performed in order to develop a production plan for large homebuilding firms. A series of

Data-Flow Diagrams (DFD), provided in Chapter 5, was developed to illustrate the various steps, the inputs and outputs of each step, and their interconnectivity. In addition to the DFD's, a summary outline of the methodology was provided in Chapter 5.

7.4 Identify the Information System Requirements Necessary for Proficient Production Planning

Early in the research, the author discovered that the information system requirements necessary for proficient production planning are organizational specific. That is, like snowflakes, no two production planning information systems are alike. In response to this realization, the author provided sub-processes and sub-sub-processes associated with production planning that would identify the level of detail at which managers must plan, monitor, and control. This was accomplished through the integration of structured analysis techniques with the proposed methodology. However, data alone does not illustrate the information system requirements. To answer this question, the author utilized Dasso's (1988) detailed classification of managerial proficiency (Appendix B) to identify what information is required.

7.5 Applicability and Essentiality of the Industry Evaluation

An industry analysis was conducted to further evaluate the work. It was found that, due to the complexity of the subject matter and the vast differences between the two homebuilding firms examined, a structured approach to achieving this objective was impossible. Therefore, the author relied, to some degree, on his comprehensive work experience in areas directly related to production planning as either an employee or consultant with each subject builder. Additionally, the comprehensive foundation of the work developed in Chapters 2, 3, 4, and 5 contribute to the validity of the methodology.

7.6 Areas of Future Research

Very little research has been conducted related to business planning in residential construction. The author feels that there is a substantial need for research related to the most critical components of business planning for large homebuilding firms, such as scheduling and cost control systems. Additionally, this methodology did not emphasize one particular type of production planning such as just-in-time, or material resource planning. Application and analysis of various production planning types should be conducted to identify what characteristics are critical for production homebuilding.

7.7 Conclusion

In conclusion, this methodology provides a detailed sequential process for production planning system development for large homebuilding firms. The author feels that a seed for future production planning research, for the production homebuilding industry, has been provided with the production planning methodology. This was accomplished largely in part by the inclusion of standard procedures and modeling techniques. Such a methodology, if implemented, will support the growth and survival of large homebuilding firms, lead to increased trade partnering, and facilitate business system integration.

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APPENDIX A

DETAILED CLASSIFICATION OF PLANNING AND CONTROL SYSTEMS FOR HOME BUILDING FIRMS

(Source: Dasso, 1988)

Part 1 Detailed Definition of the Managerial Proficiency Levels for Business Planning

Level I: Business Planning

1. No definition of the business is provided
2. Market Planning
   - 2.1. No market analysis
   - 2.2. No inventory of company strengths and weaknesses
   - 2.3. Goals and objectives are not defined
3. Five-year plans and long-term planning are not performed
4. One-year plans are not developed

Level II: Business Planning

1. No written definition of the business is provided
2. Market Planning
   - 2.1. Market analysis
     - 2.1.1. Field inspections
     - 2.1.2. Real estate brokers
     - 2.1.3. No formal analysis of the competition
   - 2.2. Company strengths and weaknesses are not inventoried
   - 2.3. Company goals and objectives are defined, but not in writing
   - 2.4. Strategies to achieve objectives are not outlined.
3. Five-year plans are not developed and long-term planning is not performed
4. One-year plans
   - 4.1. Sales plan
   - 4.2. Production plan
     - 4.2.1. Lot improvement cost plan
     - 4.2.2. Direct construction cost plan
     - 4.2.3. Indirect cost plan
     - 4.2.4. Cost estimate plan
   - 4.3. Cost of sales plan
   - 4.4. Gross profit plan
   - 4.5. Administrative plans
     - 4.5.1. Operating expense plan
   - 4.6. Profit plan
   - 4.7. Cash flow statement
5. One-year plans are revised annually

Level III: Business Planning

1. Written definition of the business exists
2. Market planning
   - 2.1. Market analysis
     - 2.1.1. Analysis of the competition
       - 2.1.1.1. Building permits
       - 2.1.1.2. Courthouse records

2.1.1.3. Field inspections
2.1.1.4. Comparable development form is used
2.1.2. Analysis of economic trends
2.1.3. Analysis of market conditions
2.1.3.1. Building costs
2.1.3.2. Financing
2.1.3.3. Vacancies
2.1.4. Analysis of demand factors
2.1.4.1. Employment
2.1.4.2. Income
2.1.4.3. Population
2.1.5. Analysis of supply factors
2.1.5.1. Construction activity
2.1.5.2. Housing inventory
2.1.6. Market plan
2.1.6.1. Target marketing
2.1.6.2. Pricing
2.1.6.3. Advertising
2.2. Inventory of strengths and weaknesses
2.2.1. The builder firm
2.2.2. The builder
2.2.3. The builder's staff
2.2.4. Subcontractors
2.3. Company goals and objectives are defined
2.3.1. Long-term objectives
2.3.2. Short-term objectives
2.4. Strategies are developed to achieve organizational objectives
3. Long-term planning
3.1. Production planning
3.2. Organizational planning
3.3. Development schedule
3.4. Financial planning
4. Five-year plan
Company is not proficient in the development of the five-year plan. All forms of planning within the organization are not well integrated. Production, organizational, and financial plans do not interrelate well with one another. The five-year plans revised and updated once a year.
5. One-year plan
5.1. Sales plan
5.2. Production plan
5.2.1. Lot improvement cost plan
5.2.2. Direct construction cost plan
5.2.3. Indirect cost plan
5.2.4. Cost estimate summary
5.3. Cost of sales plan
5.4. Gross profit plan

5.5. Administrative plan
5.5.1. Operating expense plan
5.5.1.1. Finance expense plan
5.5.1.2. Marketing expense plan
5.5.1.3. G&A plan
5.6. Profit plan
5.7. Cash flow statement
6. One-year plans are revised and updated quarterly

Level IV: Business Planning

1. Written definition of the business exists
2. Market planning
2.1. Market analysis
2.1.1. Analysis of the competition
2.1.1.1. Comparable development form is used
2.1.1.2. Unit mix comparable development form is used
2.1.1.3. Price adjustment form is used
2.1.2. Analysis of economic trends
2.1.3. Analysis of market conditions
2.1.3.1. Building costs
2.1.3.2. Financing
2.1.3.3. Mortgage default
2.1.3.4. Development trends
2.1.3.5. Vacancies
2.1.4. Analysis of demand factors
2.1.4.1. Employment
2.1.4.2. Income
2.1.4.3. Population
2.1.4.4. Households
2.1.4.5. Market absorption
2.1.5. Analysis of supply factors
2.1.5.1. Construction activity
2.1.5.2. Housing inventory
2.1.6. Market plan
2.1.6.1. Target marketing
2.1.6.2. Pricing
2.1.6.3. Advertising
2.2. Inventory of strengths and weaknesses
2.2.1. The builder firm
2.2.2. The builder
2.2.3. The builder's staff
2.2.4. Subcontractors
2.3. Company goals and objectives are defined
2.3.1. Long-term objectives
2.3.2. Short-term objectives
2.3.3. Financial objectives

2.3.4. Non-financial objectives
2.3.5. Primary objectives
2.3.6. Critical objectives
2.3.7. Specific objectives

2.4. Company objectives are evaluated in terms of company resources, money, time, skill, and personnel

2.5. Strategies are developed to achieve objectives
2.5.1. Strategy outline
2.5.2. Weighing of strategies according to merits
2.5.3. Strategy evaluation
2.5.3.1. Company resources
2.5.3.2. External forces

3. Long-term planning
3.1. Production planning
3.1.1. Labor issues
3.1.2. Subcontracting
3.1.3. Equipment purchase decisions
3.2. Organizational planning
3.2.1. Organizational chart
3.2.2. Key management personnel
3.2.3. Board of Directors
3.3. Development schedule
3.3.1. Activity time requirements
3.3.2. Milestones
3.3.3. Target dates
3.4. Financial planning
3.4.1. Company cash flow requirements
3.4.2. Sources of funds
3.4.3. Break-even analysis
3.4.4. Profit-and-loss forecasts

4. Five-year plan
The company, at this stage, understands the implications of long-term planning. Successful long-term or five-year plans are developed, based on the proper interrelationships with all other organizational plans.

4.1. Production plan
4.2. Organizational plan
4.3. Time plan
4.4. Financial plan

5. The five-year plan is revised and updated annually

6. One-year plan
6.1. Sales plan
6.2. Production plan
6.2.1. Lot improvement cost plan
6.2.2. Direct construction cost plan
6.2.3. Indirect cost plan
6.2.4. Cost estimate summary

6.3. Cost of sales plan
6.4. Gross profit plan
6.5. Administrative plan
    6.5.1. Operating expense plan
        6.5.1.1. Finance expense plan
        6.5.1.2. Marketing expense plan
        6.5.1.3. G&A plan
6.6. Profit plan
6.7. Cash flow statement
7. One-year plans are revised and updated monthly

Part 2 Detailed Definition of the Managerial Proficiency Levels for Office Management

Level I: Office Management

1. No organizational chart
2. No job descriptions
3. No procedures manual
4. Informal operating policies
    4.1. Invoice approval
    4.2. Payroll
    4.3. Bank reconciliation
    4.4. Sales contract
5. No personnel policies
6. Informal purchasing policies
    6.1. No purchase order system
7. Office staffing
    7.1. No employee training
    7.2. No office supervision
8. Record keeping
    8.1. No design of forms
    8.2. Poor filing techniques
    8.3. No record retention list
9. All systems are executed manually

Level II: Office Management

1. Office organization
    1.1. No formal organizational chart
    1.2. Job descriptions are not well defined
2. No procedures manual
3. No formal operating policies
    3.1. Informal invoice approval
    3.2. Informal payroll processing
    3.3. Informal bank reconciliation
    3.4. No formal sale contracts

4. No formal personnel policies
5. No formal purchasing policies
    5.1. Purchase order system
    5.2. Informal subcontracts
6. Office staffing
    6.1. Poor office training, because of procedures manual has not be developed
    6.2. Informal office supervision
7. Record keeping
    7.1. Form design has been accomplished
    7.2. Filing system
        7.2.1. Job unit file
        7.2.2. Subject files
    7.3. No record retention list
8. Office automation
    8.1. Word processor
    8.2. All other systems are manual

Level III: Office Management

1. Office organization
    1.1. An organizational chart exists
    1.2. The chart outlines general responsibility and authority
    1.3. Job descriptions exist
2. Formal development of a procedures manual
    2.1. Company history
    2.2. Company goals and objectives
    2.3. Company strategies
    2.4. Company policies
        2.4.1. Operating policies
            2.4.1.1. Invoice processing
                2.4.1.1.1. Invoice approval
                2.4.1.1.2. Invoice payment
                2.4.1.1.3. Invoice filing
            2.4.1.2. Payroll Processing
                2.4.1.2.1. Time cards
                2.4.1.2.2. Payroll checks
                2.4.1.2.3. Withholding
            2.4.1.3. Bank account reconciliation
                2.4.1.3.1. Deposit and check review
            2.4.1.4. Sales Contracts
                2.4.1.4.1. Sales closing procedures
                2.4.1.4.2. Contract control form
            2.4.1.5. Customer Service
                2.4.1.5.1. Callback policy
                2.4.1.5.2. Inspections
            2.4.1.6. Receipts

2.4.1.6.1. Cash receipt journal
2.4.1.6.2. Loan draws
2.4.1.6.3. Sales contracts
2.4.1.6.4. Options, upgrades
2.4.1.6.5. Change orders
2.4.2. Personnel policies
2.4.2.1. No separate personnel policy manual
2.4.2.2. Formal personnel policy
2.4.2.2.1. Overtime
2.4.2.2.2. Benefits
2.4.3. Purchasing policies
2.4.3.1. No separate purchasing manual
2.4.3.2. Purchase order system
2.4.3.2.1. Purchase order log
2.4.3.3. Subcontracts
2.4.3.3.1. Subcontract status sheet
2.4.3.3.2. Change order policy
2.4.3.3.3. Payment policy

3. Record Keeping
3.1. A forms manual does not exist
3.2. Form control
3.3. Form checklist
3.4. Filing
3.4.1. Subject files
3.4.2. Subject list
3.4.3. Job unit file
3.4.4. Record retention list

4. Office staffing
4.1. Interview of applicants
4.2. Employee training
4.3. Formal office supervision

5. Office automation
5.1. Word processor
5.2. Payroll
5.3. Data recording

Level IV: Office Management

1. Office organization
1.1. An organizational chart exists
1.2. The chart outlines general and specific responsibility as well as authority
1.3. Job descriptions exists

2. Formal development of a procedures manual
2.1. Company history
2.2. Company philosophy
2.3. Company goals and objectives
2.4. Company strategies

- 2.5. Company policies
  - 2.5.1. Operating policies
    - 2.5.1.1. Separate operating policy manual
    - 2.5.1.2. Invoice processing
      - 2.5.1.2.1. Invoice approval
      - 2.5.1.2.2. Invoice payment
      - 2.5.1.2.3. Invoice filing
    - 2.5.1.3. Payroll processing
      - 2.5.1.3.1. Time cards
      - 2.5.1.3.2. Payroll checks
      - 2.5.1.3.3. Withholding
    - 2.5.1.4. Receipts
      - 2.5.1.4.1. Cash receipt journal
      - 2.5.1.4.2. Loan draws
      - 2.5.1.4.3. Option, upgrades
      - 2.5.1.4.4. Change orders
      - 2.5.1.4.5. Sale contracts
      - 2.5.1.4.6. Closing balances
    - 2.5.1.5. Bank reconciliation
      - 2.5.1.5.1. Deposit and check review
    - 2.5.1.6. Sale contract
      - 2.5.1.6.1. Sales closing procedures
      - 2.5.1.6.2. Contract control form
      - 2.5.1.6.3. Sales contract manual
    - 2.5.1.7. Customer service
      - 2.5.1.7.1. Callback policy
      - 2.5.1.7.2. Inspections
  - 2.5.2. Personnel policies
    - 2.5.2.1. Separate personnel policy manual
      - 2.5.2.1.1. Overtime
      - 2.5.2.1.2. Safety
      - 2.5.2.1.3. Benefits
      - 2.5.2.1.4. Special services
  - 2.5.3. Purchasing policies
    - 2.5.3.1. Separate purchasing policy manual
    - 2.5.3.2. Purchase order system
      - 2.5.3.2.1. Purchase order log
      - 2.5.3.2.2. Delivery of material
      - 2.5.3.2.3. Receiving ticket
    - 2.5.3.3. Subcontracts
      - 2.5.3.3.1. Subcontract status sheet
      - 2.5.3.3.2. Change order policy
      - 2.5.3.3.3. Payment policy
      - 2.5.3.3.4. Callback policy
      - 2.5.3.3.5. Quotation/bid form
      - 2.5.3.3.6. Subcontract agreement

3. Record keeping
    3.1. A forms manual exists
        3.1.1. Form control
        3.1.2. Form design checklist
    3.2. Filing
        3.2.1. Subject files
        3.2.2. Subject heading list
        3.2.3. Job unit file
        3.2.4. Extra copy file
        3.2.5. Record retention checklist
4. Office staffing
    4.1. Interview of applicants
    4.2. Employee training
    4.3. Office supervision
    4.4. Employee relations
5. Office automation
5.1. All company systems are automated, including: payroll, data collection, recording, word processing, estimating, accounting, cost control, and purchasing.

Part 3 Detailed Definition of the Managerial Proficiency Levels for Estimating

Level I: Estimating

1. Unit costs estimates, square foot, linear ft., etc.
2. Historical unit cost records.
3. Material pricing based on vendor quotations.
4. Equipment costs are considered as overhead
5. Subcontractor

Level II: Estimating

1. Estimates are prepared from historical records, based on work item productivity data.
2. Quantity take-off is not checked
3. Material pricing is based on vendor quotations, under a purchase order system.
4. Labor costs are determined from productivity data.
5. Equipment costs are allocated.
6. Subcontractor's estimates are not properly evaluated.
7. Job and company overhead are allocated on a % basis.
8. Finance costs are not included in the estimates.

Level III: Estimating

1. Estimates are prepared from historical records which are based on a work item definition.
2. Quantity take-offs are checked against possible error or omissions.
3. Material prices are determined from vendor quotations, purchase order system is used.
4. Labor costs are determined from historical work item records, based on productivity.
5. Subcontract estimates are evaluated against a subcontract budget which is prepared from historical cost records.
6. Job overhead costs are itemized per project.
7. Finance costs aer included in the estimates.
8. Company overhead is allocated on a percentage basis.

Level IV: Estimating

1. Estimates are prepared from historical records which are based on the construction activity definition.
2. Quantity take-offs are checked.
3. Material prices are determined from vendor quotations and prices are locked in by a purchase order system.
4. Labor costs and equipment costs are determined from historical data which is modified to reflect the particular characteristics of the project.
5. Subcontract estimates are evaluated against a subcontract budget which is prepared from historical cost records.
6. Job overhead costs are itemized per project.
7. Finance costs are included in the estimate
8. Company overhead costs are allocated on a percentage basis, which is periodically revised.

Part 4 Detailed Definition of the Managerial Proficiency Levels for Scheduling

Level I: Scheduling

1. List of activities or operations
2. Dates for completion of these activities are indicated.
3. No updating is possible with this type of system.
4. Actual progress is not shown on the schedule.
5. Critical activities are not identified.
6. Interrelationships and dependencies among activities are not provided.
7. The effect of changes in one activity on all other activities cannot be determined.

8. Schedule is not integrated with the chart of accounts.
9. Procurement of material is not integrated with the schedule.

Level II: Scheduling

1. Bar Chart Schedule
2. Manual system
3. Progress on activities is assumed to be linear with time, there is no physical percentage of completion indicated on the bar chart.
4. Critical activities are not apparent from the schedule.
5. Interrelationships and dependencies among activities are not provided.
6. The effect of changes in one activity on all other activities cannot be readily determined; therefore, it is limited as a control device.
7. Provides a good visual representation of the construction activities.
8. It is easy to understand and therefore, it is commonly accepted by field personnel.
9. Activities many be integrated with the chart of accounts.

Level III: Scheduling

1. CPM / Critical Path Method schedule
2. A bar chart is developed from CPM, for field operations
3. Critical activities are indicated.
4. Floats on non-critical activities are provided.
5. Procurement of material is integrated with the schedule.
6. Early and late schedules are evaluated based on time vs. cost relationships.
7. Resource leveling of manpower, material, equipment, and money is possible.
8. Manual updating can be cumbersome.
9. Project monitoring and progress reporting can be effectively done.
10. The effects of changes in one activity on all other activities can be determined.

Level IV: Scheduling

1. CPM schedule
2. A bar chart based on the CPM schedule is printed out and used for the field operations.
3. Critical activities are indicated.
4. Procurement of material is integrated in the schedule.
5. Floats on non-critical activities are indicated.
6. Early and late schedules are evaluated based on time vs. cost relationships.
7. Activities are coded based on the chart of accounts.
8. Integration of cost (budget) and time (schedule) is achieved by distributing costs over the activities.
9. System allows for accurate cash flow projections.
10. The effect of one activity on all other activities can be determined.

11. Resource leveling of manpower, material equipment, and money is possible.
12. Project can be easily monitored and provides for adequate progress reporting.

Part 5 Detailed Definition of the Managerial Proficiency Levels for Cost Control

Level I: Cost Control

1. No cost control system

Level II: Cost Control

1. Manual cost control system based on productivity
2. Work item definition
3. Daily time card
4. Labor cost report, weekly
5. Purchase order system
6. Material status report, weekly
7. Job progress form, monthly
8. Job control sheet, monthly
9. Work item file form, to update historical data.
10. Cost control is not integrated with overall accounting system.

Level III: Cost Control

1. Conventional cost control system
2. Work item definition
3. Labor costs
    - 3.1. Time card
    - 3.2. Man-hour distribution report
    - 3.3. Man-hour unit cost report
    - 3.4. Man-hour status report
    - 3.5. Progress report
    - 3.6. Productivity report
4. Equipment costs
    - 4.1. Production costs
        - 4.1.1. Daily equipment time card
        - 4.1.2. Equipment summary sheet
        - 4.1.3. Equipment time distribution sheet
        - 4.1.4. Equipment unit cost
        - 4.1.5. Equipment use schedule
    - 4.2. Usage costs
        - 4.2.1. Equipment ownership card
        - 4.2.2. Equipment cost report
        - 4.2.3. Equipment depreciation report
        - 4.2.4. Equipment rental record

5. Material costs
    5.1. Purchasing
        5.1.1. Bill of materials
        5.1.2. Purchase order
        5.1.3. Purchase order log
    5.2. Using materials
        5.2.1. Invoice approval form
        5.2.2. Material status report
6. Subcontract costs
    6.1. Progress payment report
7. Management reports
    7.1. Project cost report
    7.2. Project summary cost report
    7.3. Overhead distribution report
    7.4. Project cash flow
8. Management reports are performed monthly

Level IV: Cost Control

1. Network – based cost control, integration of cost and schedule.
2. Construction activity definition
3. Labor costs
    3.1. Time card
    3.2. Manhour distribution report
    3.3. Manhour unit cost report
    3.4. Manhour status report
    3.5. Progress report
    3.6. Productivity report
4. Equipment Costs
    4.1. Production costs
        4.1.1. Daily equipment time card
        4.1.2. Equipment summary sheet
        4.1.3. Equipment time distribution sheet
        4.1.4. Equipment unit cost
        4.1.5. Equipment use schedule
    4.2. Usage costs
        4.2.1. Equipment ownership card
        4.2.2. Equipment cost report
        4.2.3. Equipment depreciation report
        4.2.4. Equipment rental record
5. Material costs
    5.1. Purchasing
        5.1.1. Bill of materials
        5.1.2. Purchase order
        5.1.3. Purchase order log
    5.2. Using material
        5.2.1. Invoice approval form

    5.2.2. Material status report
6. Subcontract costs
    6.1. Progress payment report
7. Management reports
    7.1. Project cost report
    7.2. Project summary cost report
    7.3. Overhead distribution report
    7.4. Project cash flow
    7.5. Activity bar chart
    7.6. Schedule status report
    7.7. Cost curve
    7.8. Production curve
    7.9. Cash requirements curve
    7.10 Cash income curve

Part 6 Detailed Definition of the Managerial Proficiency Levels for Financial and Accounting Systems

Level I: Financial and Accounting

1. This system is designed to fulfill the requirements given by the Internal Revenue Service (IRS) for the purpose of taxation.
2. The system uses the cash basis for accounting: that is, income recognized after actual payments are received.
3. Manual accounting system. Transactions are manually journalized into a general journal and posted in the general ledger. At the end of the accounting period a trial balance is prepared.
4. Financial statements:
    4.1. Balance sheet
    4.2. Income statement
    4.3. Statement of changes in financial position.
5. Annual accounting cycle.

Level II: Financial and Accounting

1. This system uses the accrual basis for accounting; that is , transactions are recognized at the time an obligation for payment is incurred.
2. The system is project or job oriented, costs and revenues are broked down on a project-by-project basis.
3. Job cost system: One Write System
    3.1. Uses pegboard
    3.2. Record of invoices and work in progress
        3.2.1. Accounts payable
        3.2.2. Work in progress
        3.2.3. Vendor accounts payable subledger
    3.2.4. Job cost subledger
4. Manual system: Transactions are manual journalized and posted.
5. Financial statements:

5.1. Balance sheet
5.2. Income statement
5.3. Cash flow statement
5.4. Statement of changes in financial position

6. Annual accounting cycle.

Level III: Financial and Accounting

1. This system uses the accrual basis for accounting.
2. The system is project or job oriented.
3. Subsidiary ledgers are used to break down into detailed accounts the accounts found in the general ledger or chart of accounts.
4. The job cost system is not kept in balance with the general ledger system,. It is in effect a single entry system. The job cost system receives information from payroll and accounts payable.
5. Computerized accounting system.
6. Financial statements
   - 6.1. Balance sheet
   - 6.2. Income statement
   - 6.3. Cash flow statement
   - 6.4. Projected cash flow, on a monthly basis
   - 6.5. Statement of changes in financial position
7. Financial Analysis
   - 7.1. Ratio analysis
     - 7.1.1. Liquidity
     - 7.1.2. Leverage
     - 7.1.3. Profitability
8. Monthly accounting cycle.

Level IV: Financial and Accounting

1. This system uses the accrual basis for accounting.
2. The system is projected or job oriented.
3. Subsidiary ledgers are used to break down general ledger accounts or the chart of accounts.
4. The job cost system is linked and kept in balance with the general ledger.
5. Computerized accounting system
6. Financial Statements
   - 6.1. Balance sheet
   - 6.2. Income statement
   - 6.3. Statement of changes in financial position
   - 6.4. Cash flow statement
   - 6.5. Projected cash flow, on a monthly basis
7. Financial and profitability analysis:
   - 7.1. Ratio analysis
     - 7.1.1. Liquidity
     - 7.1.2. Leverage
   - 7.2. Profitability analysis

7.2.1. Company profitability evaluation
7.2.2. Project profitability evaluation

Part 7 Detailed Definition of the Managerial Proficiency Levels for Subcontracting

Level I: Subcontracting

1. Location of subcontractors
   1.1. Local HBA
   1.2. Suppliers
2. Selection of subcontractors
   2.1. Selection is based solely on price
3. No formal invitation to bid
4. Negotiation with subcontractors
   4.1. Price negotiation

4.2. No builder estimates are available as reference to be used in the proper evaluation of subcontractor's estimates

5. Communication with subcontractors
   5.1. Oral communication
   5.2. No subcontract agreement
   5.3. Company policies and procedures are not furnished to subcontractors.
6. Controlling subcontractors
   6.1. Poor supervision
      6.1.1. No quality checks
      6.1.2. Inspection is left to local inspectors
      6.1.3. No formal change order procedures
   6.2. Coordination
      6.2.1. No meetings
      6.2.2. No formal scheduling of subcontractors
         6.2.2.1. Phone calls
         6.2.2.2. No follow up calls

Level II: Subcontracting

1. Location of subcontractors
   1.1. Local HBA
   1.2. Suppliers
   1.3. Inspectors
2. Selection of subcontractors
   2.1. Fair prices
   2.2. Material waste consciousness
   2.3. Cost consciousness
3. No formal invitation to bid
4. Negotiation with subcontractors

4.1. Price negotiation
4.2. Subcontractor's estimates are evaluated based on builder's own estimate based upon internal historical records.

5. Communication with subcontractors
   5.1. No written subcontract agreement
   5.2. Plans and specifications are provided
   5.3. Company policies and procedures are verbally provided
      5.3.1. Compliance with schedule
      5.3.2. Payment policy
      5.3.3. Acceptance of work
6. Controlling subcontractors
   6.1. Supervision
      6.1.1. Quality checks are performed
      6.1.2. Acceptance of work
      6.1.3. No formal change order system
   6.2. Coordination
      6.2.1. Informal scheduling of subcontractors
         6.2.1.1. Phone call
         6.2.1.2. No follow up calls

Level III: Subcontracting

1. Location of subcontractors
   1.1. Local HBA
   1.2. Suppliers
   1.3. Banks, S&L
   1.4. Credit bureau
   1.5. Inspectors
   1.6. Subcontractors list form
2. Selection of subcontractors
   2.1. Financial stability
   2.2. Quality of workmanship
   2.3. Cost consciousness
   2.4. Ability to maintain schedule
   2.5. Dependability
   2.6. Material waste consciousness
   2.7. Adequate insurance
   2.8. Fair prices
3. Formal invitation to bid
   3.1. Subcontract packaging
   3.2. Instructions to subcontractor's sheet form
4. Negotiating with subcontractors
   4.1. Fair cost estimates
   4.2. Evaluation of subcontractor's estimates
   4.3. Price negotiations
   4.4. Builder performance record
5. Communication with subcontractors

- 5.1. Written subcontract agreement
- 5.2. Plans and specifications
- 5.3. Company policies and procedures
  - 5.3.1. Acceptance of material on the job
  - 5.3.2. Compliance with schedule
  - 5.3.3. Acceptance of work
  - 5.3.4. Payment policy
    - 5.3.4.1. Application of payment form
  - 5.3.5. Liability and insurance
  - 5.3.6. Lien protection / Affidavit of release of liens
- 5.4. Change order system
  - 5.4.1. Field order form
  - 5.4.2. Change order form
  - 5.4.3. Change order authorization
- 5.5. Penalties
- 5.6. General conditions

6. Controlling Subcontractors
   - 6.1. Supervision
     - 6.1.1. Quality checks
     - 6.1.2. Inspection of work
     - 6.1.3. Acceptance f work
   - 6.2. Coordination
     - 6.2.1. Scheduling of subcontractors
       - 6.2.1.1. Written notification
       - 6.2.1.2. Follow up calls
     - 6.2.2. Construction weekly meetings

Level IV: Subcontracting

1. Location of subcontractors
   - 1.1. Local HBA
   - 1.2. Suppliers
   - 1.3. Banks, S&L
   - 1.4. Credit bureau
   - 1.5. Subcontractor list form
2. Selection of subcontractors
   - 2.1. Financial stability
   - 2.2. Quality of workmanship
   - 2.3. Cost consciousness
   - 2.4. Ability to maintain schedule
   - 2.5. Dependability
   - 2.6. Cooperation
   - 2.7. Adequate work force
   - 2.8. Prompt service on repair work
   - 2.9. Ability to conduct business in a professional manner
   - 2.10. Material waste consciousness
   - 2.11. Adequate insurance coverage

- 2.12. Fair prices
- 2.13. Subcontractor's evaluation form
- 2.14. Subcontractor's statement of qualifications

3. Formal invitation to bid
   - 3.1. Subcontract packaging
     - 3.1.1. Scope of the work
     - 3.1.2. Material take-off
     - 3.1.3. Site inspections
     - 3.1.4. Bid proposal
   - 3.2. Status of bid documents form
   - 3.3. Instruction to subcontractors sheet form
4. Negotiating with subcontractors
   - 4.1. Fair cost estimates
   - 4.2. Evaluation of subcontractor's estimates
   - 4.3. Price negotiation
   - 4.4. Builder performance record
   - 4.5. Value engineering
5. Communication with subcontractors
   - 5.1. Written subcontract agreement
   - 5.2. Plans and specifications
   - 5.3. Company policy and procedures
     - 5.3.1. Acceptance of material on the job
     - 5.3.2. Compliance with schedule
     - 5.3.3. Callback warranty provision
       - 5.3.3.1. Callback form
     - 5.3.4. Acceptable and unacceptable construction methods
     - 5.3.5. Use of equipment, material, and temporary facilities.
     - 5.3.6. Payment policies
       - 5.3.6.1. Application of payment form
     - 5.3.7. Liability and insurance coverage
     - 5.3.8. Lien protection requirement / Affidavit of liens
     - 5.3.9. Safety and accident procedure
   - 5.4. Change order system
     - 5.4.1. Field order form
     - 5.4.2. Change order form
     - 5.4.3. Change order authorization
   - 5.5. Penalties
   - 5.6. General conditions
6. Controlling subcontractors
   - 6.1. Supervision
     - 6.1.1. Quality checks
     - 6.1.2. Inspection of work
     - 6.1.3. Acceptance of work
   - 6.2. Coordination
     - 6.2.1. Scheduling of subcontractors
       - 6.2.1.1. Written notifications

6.2.1.2. Follow up calls

6.2.2. Construction meetings

6.2.2.1. Pre-construction meeting

6.2.2.2. Progress meetings

(Source: Dasso, 1988)