The Business Transformation Effects of Information Technology

By
Bradford T. Butler

Bachelor of Science in Civil Engineering, 1998
Purdue University

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

MASTER OF ENGINEERING IN CIVIL AND ENVIRONMENTAL ENGINEERING

AT THE

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

JUNE 2001

Signature of Author _____

Bradford T. Butler
Department of Civil and Environmental Engineering
May 11, 2001

Certified By _____

George Kocur
Senior Lecturer, Civil and Environmental Engineering
Thesis Supervisor

Certified By _____

Oral Buyukozturk
Chairman, Departmental Committee on Graduate Studies

The Business Transformation Effects of Information Technology

By
Bradford T. Butler

Submitted to the Department of Civil and Environmental Engineering
on May 11, 2001 in Partial Fulfillment of the Requirements for the
Degree of Master of Engineering in Civil and Environmental Engineering

Abstract

New information technologies can greatly impact the landscape of business and even entire industries. For some, these changes are both welcome and anticipated. For others, technology seems to cause more problems than it solves. The ability to interrelate technology and business strategy is what differentiates these two groups. Strategy, not technology, should guide the direction of the business.

This thesis presents a simple set of current business frameworks for analyzing the business transformation effects of new information technologies. The analysis includes the five force method, value chain analysis, and Gary Hamel's business model. Both the five force method and the value chain analysis are from the work of Michael Porter.

Next, the thesis introduces a case drawn from the Department of Public Works (DPW) in Arlington, Massachusetts. Currently, the water department in the DPW plans to install a new wireless data collection system and a new data analysis application. The new technologies allow the DPW to collect and analyze customer's meter readings more efficiently. Through the use of the above mentioned business analysis tools, this thesis explores the possible business transformation effects caused by the implementation of the new technologies. By examining the future effects, the town can make a more educated decision regarding when and how to implement the new IT systems. Also, the analysis may help to eliminate unexpected issues before they arise both during and after the implementation.

Thesis Supervisor: George Kocur
Title: Senior Lecturer, Civil and Environmental Engineering

Acknowledgements

I would like to take this opportunity to thank those who have supported and encouraged me throughout my educational experiences here at MIT.

First and foremost, I would like to thank my family – Darrell, Esther and Chris Butler – for their continued love and support.

I would also like to thank Trisha Healey for her support during a difficult but rewarding year.

In addition, I would like to thank Gene Fribis for his encouragement to return to graduate school.

Also, I would like to thank my advisor, George Kocur, for his guidance and patience throughout the year.

Finally, I would like to thank Kent Larson from the Arlington Department of Public Works for his time and effort during our water management software project, which serves as the case study for this thesis.

Table of Contents

Abstract 3
Acknowledgements 5
Table of Contents 6-7
List of Tables 8
List of Figures 9

Chapter 1 – Introduction 10-11
1.1 Motivation 11
1.2 Thesis Organization 11

Chapter 2 – Strategy 12-43
2.1 What is Strategy 12-16
2.2 Strategic Concepts 16-33
2.2.1 Industry Analysis – 5 Force Model 16-20
2.2.2 Core Competencies 20-23
2.2.3 Competitive Advantage 23-26
2.2.4 The Value Chain 26-30
2.2.5 Exploration versus Exploitation 31-32
2.2.6 Strategic Intent 32-33
2.3 The Role of Technology 33-38
2.3.1 Technology and Competitive Advantage 34
2.3.2 Technology and the Value Chain 34-36
2.3.3 Impact of Technology on the Industry Structure 36-38
2.4 The Business Model 38-43
2.4.1 Core Strategy 39
2.4.2 Strategic Resources 40
2.4.3 Configuration 40
2.4.4 Customer Interface 41
2.4.5 Customer Benefits 41-42
2.4.6 The Value Network 42
2.4.7 Company Boundaries 42-43

Chapter 3 – Case Study of the Water Supply System in Arlington, MA 44-58
3.1 Overview 44
3.2 Current System 45
3.3 Proposed System 45-58
3.3.1 Functionality of Proposed System 47-51
3.3.2 Changes in the Flow of Information 51-54
3.3.3 Database Design for the Software Application 54-57
3.3.4 Technical Specifications for the New Technologies 58

Chapter 4 – Analysis of the Case 59-77
4.1 Industry Analysis 59-63
4.2 The Effects of the New Technologies on the Industry 64-66
4.3 The Value Chain Analysis 66-68
4.4 The Effects of the New Technologies on the Value Chain 69-70
4.5 The Business Model 71-74
4.6 The Effects of the New Technologies on the Business Model 74-77

Chapter 5 – Results, Recommendations, and Conclusion 78-85
5.1 Results 78-83
5.2 Recommendations 83-84
5.3 Conclusion 84-85

References 86
Appendix 1 – Data Dictionary 87-98
Appendix 2 – Organizational Chart 99-103

List of Tables

Table 2-1 Summary of Strategic Thinking 14
Table 2-2 The Risks of The Three Generic Strategies 26
Table 3-1 Wireless System Technologies 58
Table 3-2 Software Analysis Application Technologies 58
Table 4-1 Summary of the Industry Analysis 63
Table 4-2 Summary of the Industry Analysis Changes 65
Table 5-1 Summary of the Industry Analysis 79

List of Figures

Figure 2-1 Five Force Method 17
Figure 2-2 The Supplier Matrix 19
Figure 2-3 Core Competence 21
Figure 2-4 Three Generic Strategies 24
Figure 2-5 The Generic Value Chain 28
Figure 2-6 Sample Value Chain 30
Figure 2-7 Technologies that Affect the Value Chain 36
Figure 2-8 The Business Model 39
Figure 3-1 Flow of Information in the Current System 52
Figure 3-2 Flow of Information in the Proposed System 53
Figure 3-3 Primary Functions of the Databases Used by the DPW 54
Figure 3-4 Water Related Tables in the ICS 55
Figure 3-5 Logical Data Model 57
Figure 4-1 Five Force Method 60
Figure 4-2 The Value Chain 67
Figure 4-3 The Business Model 71
Figure 5-1 The Generic Value Chain 80
Figure 5-2 The Business Model 81

Chapter 1 – Introduction

New information technologies can greatly impact the landscape of business and even entire industries. For some, these changes are both welcome and anticipated. For others, technology is forcing firms to constantly play a game of catch up. The ability to interrelate technology and business strategy is what differentiates these two groups. Strategy, not technology, should guide the direction of the business.

This thesis presents a simple set of current business frameworks for analyzing the business transformation effects of new information technologies. The analysis includes the five force method, value chain analysis, and Gary Hamel's business model. Both the five force method and the value chain analysis come from the work of Michael Porter.

Next, the paper introduces an example case drawn from the Department of Public Works (DPW) in Arlington, Massachusetts. Currently, the water department in the DPW plans to install a new wireless data collection system and a new data analysis application. The new technologies allow the DPW to collect and analyze customer's meter readings more efficiently. Through the use of the above mentioned business analysis tools, we explore the possible business transformation effects caused by the implementation of the new technologies. By examining the future effects, the town can make a more educated decision regarding when and how to implement the new IT systems. Also, the analysis may help to eliminate unexpected issues before they arise both during and after the implementation.

1.1 Motivation

Presently, business executives do not fully understand the extent to which new technologies affect their business. On the other hand, most do recognize the power technology can have in facilitating change. Managers and executives understand that technology is much more than just a cost to be minimized. In fact, technology can be exploited as a source of competitive advantage. Yet, it is difficult to translate new technologies into a useful or measurable source of advantage. Also, aligning a firm's strategy and technology can be a daunting task. This thesis presents a simple set of frameworks for incorporating new information technologies in existing businesses.

1.2 Thesis Organization

This thesis comprises 5 chapters. Chapter 1 gives the reader a basic introduction to the topics discussed. Chapter 2 summarizes a number of current topics in business strategy. Next, chapter 3 presents the case study from the Department of Public Works of Arlington, Massachusetts. Chapter 4 then applies three business frameworks to the case study, namely the five force method, the value chain analysis, and the business model. Finally, chapter 5 recaps the results from the analyses and presents the recommendations and conclusions.

Chapter 2 – Strategy

It is impossible to discuss the effects of information technology on business without first covering business fundamentals. Strategic thinking and planning comprise the heart of business fundamentals. This chapter presents an introduction to modern strategic concepts, the role of technology in strategy, and the business model.

2.1 What is Strategy?

The leading experts of past and present offer a vast array of definitions to answer the question what is strategy. Below is a short list of notable quotes attempting to define strategy.

> "Strategy is a set of concrete plans to help the organization out perform the market." (Oster, 2)
>
> "A strategy is the pattern of objectives, purposes or goals and the major policies and plans for achieving these goals, stated is such a way as to define what business the company is in or to be in and the kind of company it is or it is to be." (Kenneth Andrews, *The Concept of Corporate Strategy*)
>
> "A strategy is an internally consistent configuration of activities that distinguishes a firm from its rivals." (Porter, preface)
>
> "Competitive strategy is the search for a favorable competitive position in an industry. Competitive strategy aims to establish a profitable and sustainable position against the forces that determine industry competition." (Porter, 1)
>
> "Strategy is the great Work of the organization. In situations of life or death, it is the Tao of survival or extinction. Its study cannot be neglected." (Tzu)
>
> "Strategy is not a rule book, a blueprint, or a set of programmed instructions. Strategy is the unifying theme that gives coherence and direction to the individual decisions of an organization ..." (Grant)

This set of definitions provides some initial thoughts about strategy. Additionally, the list proves that there is not a single explicit definition that encompasses strategic thinking. Yet, a set of common elements can be inferred. Strategy is important, it involves a significant commitment of resources, and it is not easily reversible. (Grant, 11) Also, strategy is both an art and science. It combines an economist's traditional analysis of competitors and markets with the talents of an artist to foresee opportunity with an entrepreneurial vision.

Examining the concept of strategy also provides insight on current views. The table below provides a summary of strategic thinking spanning half a century. The table presents the dominant theme, main focus, principal concepts and techniques, and organizational implications for each period spanning the 1950s to the early 1990s.

Period	1950s	1960s	1970s	Late 1970s & early 1980s	Late 1980s & early 1990s
Dominant theme	Budgetary planning and control	Corporate planning	Corporate strategy	Analysis of industry and competitors	The quest for competitive advantage
Main Focus	Financial control through operating budgets	Planning growth	Portfolio planning	Choice of industries, segments and positioning	Sources of competitive advantage within the firm. Dynamic aspects of strategy.
Principal concepts & techniques	Financial budgeting. Investment planning. Project appraisal.	Market forecasting. Diversification and analysis of synergy.	Single business unit as unit of analysis. Portfolio planning matrices. Analysis of experience curves and returns to market share.	Analysis of industry structure. Competitor analysis. PIMS analysis.	Resource analysis. Analysis of organizational competence and capability. Dynamic analysis of speed, responsiveness, and first mover advantage.
Organizational implications	Financial management as key corporate function.	Development of corporate planning departments. Rise of conglomerates. Diffusion of M-form.	Integration of financial and strategic control. Strategic planning as a dialogue between corporate HQ and the divisions.	Divestment of unattractive business units. Active asset management.	Corporate restructuring and business process reengineering. Building capabilities through MIS, HRM, strategic alliances, and new organizational forms.

Table 2-1 Summary of Strategic Thinking (Grant, 17)

Since an explicit definition is elusive, a discussion of successful strategies may prove more interesting. Successful strategies allow a firm to achieve a sustained competitive advantage in a particular market. Sustainable competitive advantages result from strategies that allow a firm to recognize opportunity and then have the clarity and flexibility to exploit it. Also, successful strategies present a clear picture of the game being played as well as the instructions for competing.

Robert Grant, in his book Contemporary Strategy Analysis, presents four critical elements of a successful strategy: simple, consistent and long-term goals; profound understanding of the competitive environment; objective appraisal of resources; and effective implementation. Similarly, Sun Tzu wrote over 2000 years ago:

> "Know the other and know yourself:
> Triumph without peril.
> Know Nature and know the Situation.
> Triumph Completely."

Simple, consistent, long-term goals allow a firm to clearly understand a target over time. A profound understanding of the environment will aid in detecting opportunity when it presents itself. Objectively evaluating a firm's resources allows managers to determine both their boundaries and potential. Finally, executives must effectively implement their vision's to achieve results.

Grant's four elements reinforce the fact that strategy is much more than just rational thinking. A successful strategy cannot be systematically handed down from the corporate office. Rather, the evolution of strategy is a process that involves holistic thinking about the organization. Henry Mintzberg describes this process as crafting strategy. Mintzberg argues that strategies should be crafted and not planned. Strategic planning stems from rational control and

a systematic analysis of competitors and markets and a company's strengths and weaknesses, which together produce an explicit, enterprise wide strategy. On the other hand, the crafting process requires traditional skill, dedication, attention to detail, and an intimacy with the environment and resources available that are developed via experience and commitment. Resulting is a novel and creative strategy that flows from the blending of formulation and implementation.

2.2 Strategic Concepts

This chapter introduces additional breadth to the understanding of strategy by covering key concepts. The concepts covered include industry analysis, core competencies, competitive advantage, the value chain, exploration versus exploitation, and strategic intent.

2.2.1 Industry Analysis – Porter's Five Forces

This first step in competitive strategy is industry analysis. The industry structure determines the relative profit level available to firms within the industry. The Five Force Method, developed by Michael Porter, allows executives to determine the attractiveness of an industry. The five forces vary significantly by industry and explain why some industries are more profitable than others are. The five forces are intensity of rivalry, presence of substitutes,

power of buyers, power of suppliers, and the threat of new entry. Figure 2-1 presents a logical view of the five forces.

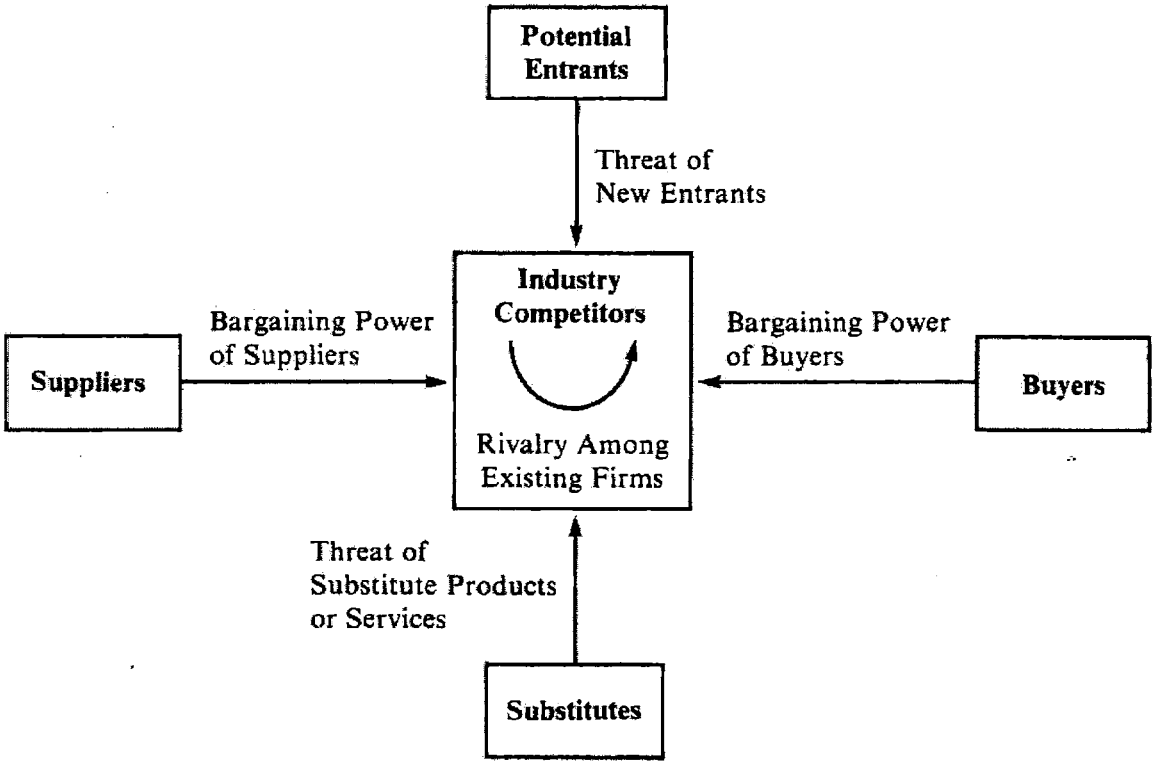


Figure 2-1 Five Force Method (Oster, 30)

The amount of rivalry and the intensity of competition greatly impact the level of profits in an industry. More intense rivalry between competitors lowers the average profit level of an industry. The level of rivalry in an industry can be measured by analyzing the amount of market response to technological innovation, the size and distribution of companies, the similarity between companies, the amount of substantial specific assets present, and the variability in the demand. (Oster, 30)

The availability of substitutes in a market limits available profits by inhibiting the ability of companies to raise prices or alter products. Substitutes are defined as products or services that can supply the same functions to the same audience. The cross elasticity of demand can quantify presence of substitutes. Cross elasticity is the ratio of the percent change in demand for one good to a one percent increase in a second good. Higher cross elasticity demands indicate a greater presence of substitutes. (Oster, 40)

The degree of buyer power in an industry can affect profits. Buyers with a high degree of power can drive prices down. On the other hand, a weak buyer force places more power in the hands of the industry. Buyers often experience more power when industry products are standardized and when the buyers have more opportunity for open transactions. In both cases the buyers can be more selective and position industry leaders against each other for bargaining purposes. Conversely, larger numbers of buyers and more fragmented buyer groups decrease the power of the buyers in an industry. (Oster, 41)

The force of suppliers similarly effects the industry as the buyer force. The force of suppliers can effect the cost of a firm's activities just as the buyer force can effect the price of the finished product. The stronger the force of suppliers, the higher the input costs of the firm. On the other hand, a low supplier force can reduce costs and increase the potential for profits. The number of suppliers, standardization of products, and buyer dependence on the supplier for quality characterize supplier power. The supplier matrix in Figure 2-2 aids in determining the strength of the supplier power (Oster, 42).

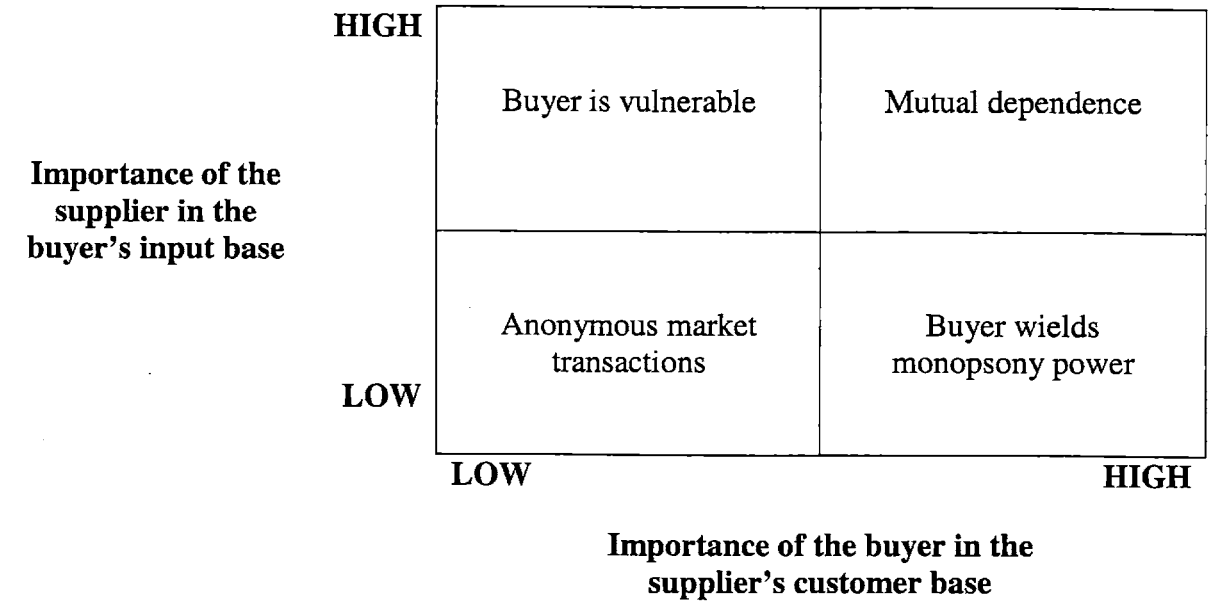


Figure 2-2 The Supplier Matrix (Oster, 43)

Large barriers to entry make an industry more attractive to the current players, but less attainable to newcomers. Significant barriers preventing new entry to an industry include patented technology, high costs to entry, steep cost curves, a bounded market, and successful branding by current participants. The only real incentive for entrance into a new industry is the opportunity for high payoffs.

Other forces exist that may impact the structure and attractiveness of an industry. Government and history both have far reaching effects on industry and should be considered when assessing the attractiveness of industry. Government may impose regulation and anti-trust laws that have dramatic impact on the force of rivalry. History may indicate the competitors that a firm will face in the future. A firm that has been active in a specific industry for a long period of time is likely to remain in the industry. Thus, executives may know who their competitors

will be tomorrow based on history. This knowledge impacts actions and aggressiveness. (Oster, 48)

Together the five forces, government, and history combine to provide an understanding of the structure of an industry. Firms must incorporate this knowledge when crafting strategy. According to Porter, "the ultimate aim of competitive strategy is to cope with and, ideally, to change those rules in a firm's favor." (Porter, 4)

2.2.2 Core Competencies

In 1981 Sun Microsystems began to produce work-stations. By 1992, Sun had grown into a place of market leadership in work-stations with sales over $3 billion. Also, during the early 1990s, advances in personal computing power diminished the demand for work-stations. However, Sun has been able to redefine the scope of its products and by the end of 1998 was a $9 billion global leader in network computing. Sun has been successful largely because they did not narrowly define themselves as workstation providers in the 80s and early 90s. Instead, Sun has always adhered to the driving principle that "The Network is the Computer". Sun's ability to exploit their core competence in networking has enabled them to achieve a source of advantage in a global market.

Prahalad and Hamel, in their article "The Core Competence of the Corporation", define core competencies as a collective learning in the organization that allows them to integrate multiple technologies and diverse production skills. Furthermore, these core competencies will

allow a firm to realize a competitive advantage in a global market by empowering individual businesses to rapidly adapt to changing market conditions.

Managers must view the organization as a diversified concept to fully understand and develop competencies. Consider the analogy of the corporation to a tree. A firm's competencies are the roots, which nourish a set of core products. Individual business units then utilize the core products as resources to produce a set of end products. The diagram below illustrates this example.

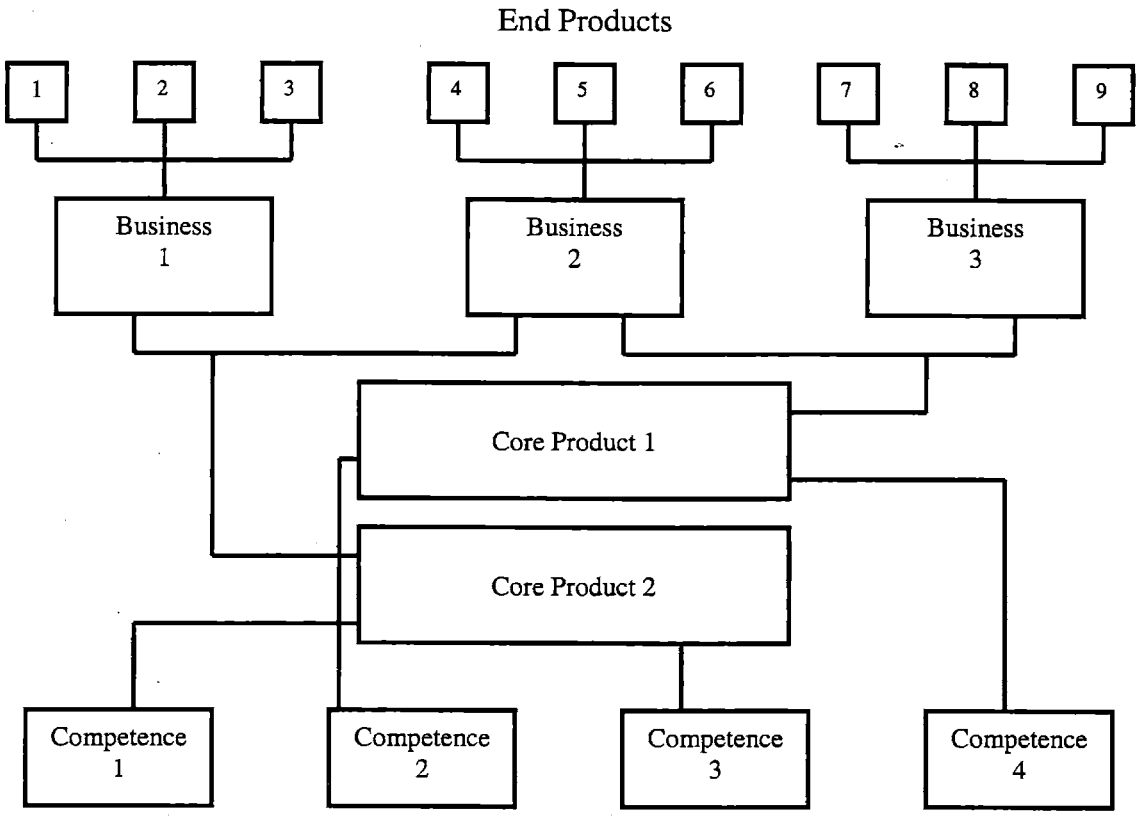


Figure 2-3 Core Competence (Prahalad, 82)

To achieve core competencies executive must develop a resolve to work across organizational boundaries with effective communication. 3M, Honda, and Cannon are examples of corporations that have developed core competencies. 3M's core competencies in substrates, coatings, and adhesives have spurred them to produce a diverse product set including "Post-it" notes, magnetic tape, photographic film, pressure-sensitive tapes, and coated abrasives. Honda's competence in engines and power trains have allowed them to become leaders in the car, motorcycle, lawn mower, and generator markets. Cannon's focus on optics, imaging and microprocessor controls has resulted in the successful production of copiers, laser printers, cameras and image scanners. Each these firms have creatively utilized their core competencies to produce a competitive line of diverse products.

A core competence must meet at least three criteria. First, it must be difficult to imitate. For example, a complex harmonization of technologies or production skills will always be hard to duplicate. Second, the competence must make a significant contribution to the value of the end products. The competence should add value to the customer. Finally, the competence should be broad enough to provide potential access to a variety of markets. The examples of 3M, Honda, and Cannon used previously demonstrate this third principle well.

On the other hand, core competencies do not include horizontal integration, vertical integration, or enormous spending on research and development. Horizontal integration between business units allows firms to cut costs by sharing resources, but sharing is not a core competence. Vertical integration forces managers to both look up and down the value chain, but core competencies make them examine skills that could be applied in non-traditional ways. Outspending others in research and development may lead a firm to technological innovation,

but utilizing these technologies to increase the value added to the customers in an array of markets might better qualify as a core competence.

2.2.3 Competitive Advantage

History proves that some firms consistently achieve a higher than average level of profits within an industry. It then follows that these firms continually perform above average in their specific industry. The idea that a firm can outperform the average profit level of an industry leads to the concept of competitive advantage. Firms who consistently outperform the industry average have developed a sustainable competitive advantage.

The concept of competitive advantage resides in the fact that a firm can provide value to its customers that exceeds the firm's cost of creating it. This value is what buyers pay for. Superior value comes from one of two sources. A firm can provide similar value at a lower price or provide unique value that offsets a premium the buyer is willing to pay. Thus, cost leadership and differentiation are the two basic types of competitive advantage.

The two basic types of competitive advantage combined with the scope of activities a firm carries out result in three generic strategies. The three generic strategies are cost leadership, differentiation, and focus. The firm's relative position within an industry should drive the choice of a generic strategy. Conversely, a firm may choose a specific generic strategy to drive a fundamental change in their position within an industry.

Cost leadership and differentiation strategies seek a competitive advantage across a broad scope of industry segments, while a focus strategy attempts to achieve a competitive advantage

in a narrow and well-defined segment within an industry. A focus strategy may attempt to gain competitive advantage by pursing either cost leadership or differentiation within the niche market. The figure below describes the interrelationships between the three generic strategies.

		COMPETITIVE ADVANTAGE	
		Lower Costs	**Differentiation**
COMPETITIVE SCOPE	**Broad Target**	1. Cost Leadership	2. Differentiation
	Narrow Target	3A. Cost Focus	3B. Differentiation Focus

Figure 2-4 Three Generic Strategies (Porter, 12)

To pursue a cost advantage a firm must decide to become the lowest cost producer in the industry. The sources of cost advantage vary by industry, but some generic sources include the pursuit of economics of scale, preferential access to suppliers or raw materials and proprietary technology. Low cost producers tend to offer simple products without unnecessary features. Instead they focus on achieving scale and harvesting lower costs from all sources. A cost leadership strategy is successful only when the firm can command prices at or near the industry average. Since the firm carefully controls costs, it can reap a higher than average level of profits by selling products with industry average prices.

A firm should seek to differentiate when buyers are willing to pay a premium for services or products that are unique along some dimension. The differentiator positions itself to meet these specialized needs more effectively than their rivals do. Again, the means of differentiation are specific to individual industries. Differentiation dimensions may include the delivery system, the marketing approach, or even the product itself. A differentiation strategy is only successful if the buyer is willing to pay a premium, which exceeds the cost incurred by the firm. Thus firms should attempt to differentiate in a way that leads to a price premium that exceeds the cost of differentiating. Also, the buyers must view the product or service sufficiently unique to justify paying a price premium. Thus, the firm must differentiate in ways different from its rivals within an industry.

A focus strategy is different from cost leadership or differentiation because it sets a narrow scope. The narrow scope usually includes a segment or small group of segments within an industry. The firm then serves the specified segment without concern for the rest of the industry. A focus strategy simply applies a cost or differentiation advantage in the narrow segment. Regardless of the choice of cost or differentiation, a focus strategy relies on the principle that the target segment requires products or services that are unique or unusual with regard to the rest of the industry. It then follows that a more broad based rival could not serve the narrow segment as effectively as a firm with a focus strategy could.

Industries are constantly evolving, so each of the three generic strategies incur a certain amount of risk. The table below contains the major risks accepted by a firm when choosing one of the three generic strategies.

Risks of Cost Leadership	Risks of Differentiation	Risks of Focus
Cost leadership is not sustained • Competitors imitate • Technology changes • Other bases for cost leadership erode	Differentiation is not sustainable • Competitors imitate • Bases for differentiation become less important to buyers	The focus strategy is imitated The target segment becomes structurally unattractive • Structure erodes Demand disappears
Proximity in differentiation is lost	Cost proximity is lost	Broadly-targeted competitors overwhelm the segment • The segment's differences from other segments narrow • The advantages of a broad line increase
Cost focusers achieve even lower cost in segments	Differentiation focusers achieve even greater differentiation in segments	New focusers sub-segment the industry

Table 2-2 The Risks of the Three Generic Strategies (Porter, 21)

2.2.4 The Value Chain

The value chain is a basic tool for dissecting and examining the individual activities a firm performs and analyzing how the activities interrelate. This tool enables us to identify sources of competitive advantage within a firm by systematically breaking a firm down into strategic activities. Within each activity sources of advantage can be explored for cost leadership, differentiation or focus strategies. The value chain analysis is specific to individual firms. Also, the analysis should be performed at the business unit level, which targets the activities within a specific industry.

Revisiting the basics of competitive advantage, we remember that value is what buyers are willing to pay for. Also, the value of the firm is the price of the products or services multiplied by the quantity the firm can sell. This can also be referred to as the total revenue. Profitability only exits if the cost incurred to create the value for customers is greater than the value the buyers are willing to pay.

The value chain helps us understand the total value of the firm by examining the value activities and margin. The value activities are the physical and technical tasks the firm carries out. Margin is defined as the difference between the total value and the cost to perform the value activities. Firms can create larger margins by maximizing the total value and minimizing the cost of the value activities. Value activities are subdivided into two categories, primary and support activities. The primary activities are those involved in the physical creation of the product or service. Support activities provide resources to both the primary activities and other support activities. Figure 2-3 presents the generic value chain.

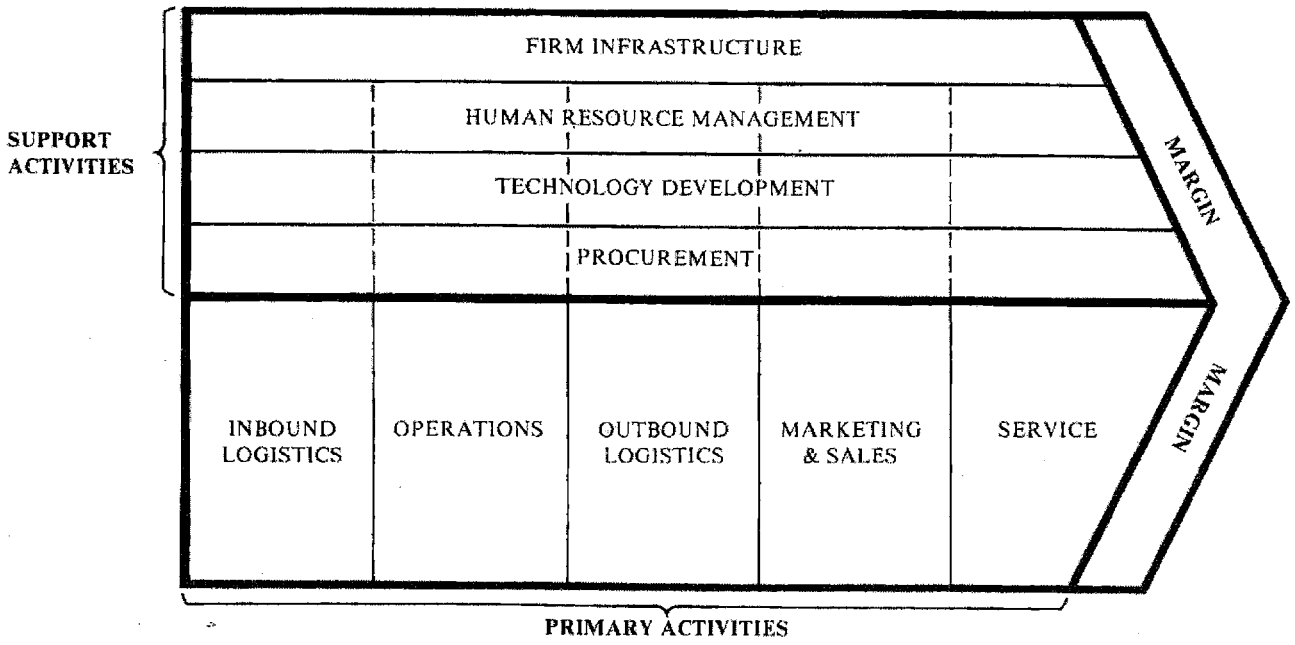


Figure 2-5 The Generic Value Chain (Porter, 37)

The value chain further subdivides both the primary and support activities. Primary activities are comprised of inbound logistics, operations, outbound logistics, marketing and sales and service. Porter gives the following definitions of each primary activity (Porter, 40).

- Inbound Logistics are activities associated with receiving, storing, and disseminating inputs to the product, such as material handling, warehousing, inventory control, vehicle scheduling, and returns to suppliers.

- Operations are activities associated with transforming inputs into the final product form, such as machining, packaging, assembly, equipment maintenance, testing, printing, and facility operations.

- Outbound Logistics are activities associated with collecting, storing, and physically distributing the product to buyers, such as finished goods warehousing, material handling, delivery vehicle operation, order processing, and scheduling.

- Marketing and Sales are activities associated with providing a means by which buyers can purchase the product and inducing them to do so, such as advertising, promotion, sales force, quoting, channel selection, channel relations, and pricing.

- Services are activities associated with providing service to enhance or maintain the value of the product, such as installation, repair, training, parts supply, and product adjustment.

Support activities include procurement, technology development, human resource management, and firm infrastructure. Procurement is a function of purchasing inputs, such as raw materials and supplies. Technology development represents a range of activities that involve an effort to improve the product or the development process. Human resource management encompasses the activities of recruiting, hiring, training, professional development, and compensation of employees. Firm infrastructure activities support the entire chain and include general management, planning, finance, accounting, legal, and government affairs.

Each activity in the value chain can be subdivided to gain a more detailed understanding of the activities. Figure 2-4 shows an example of a more detailed value chain.

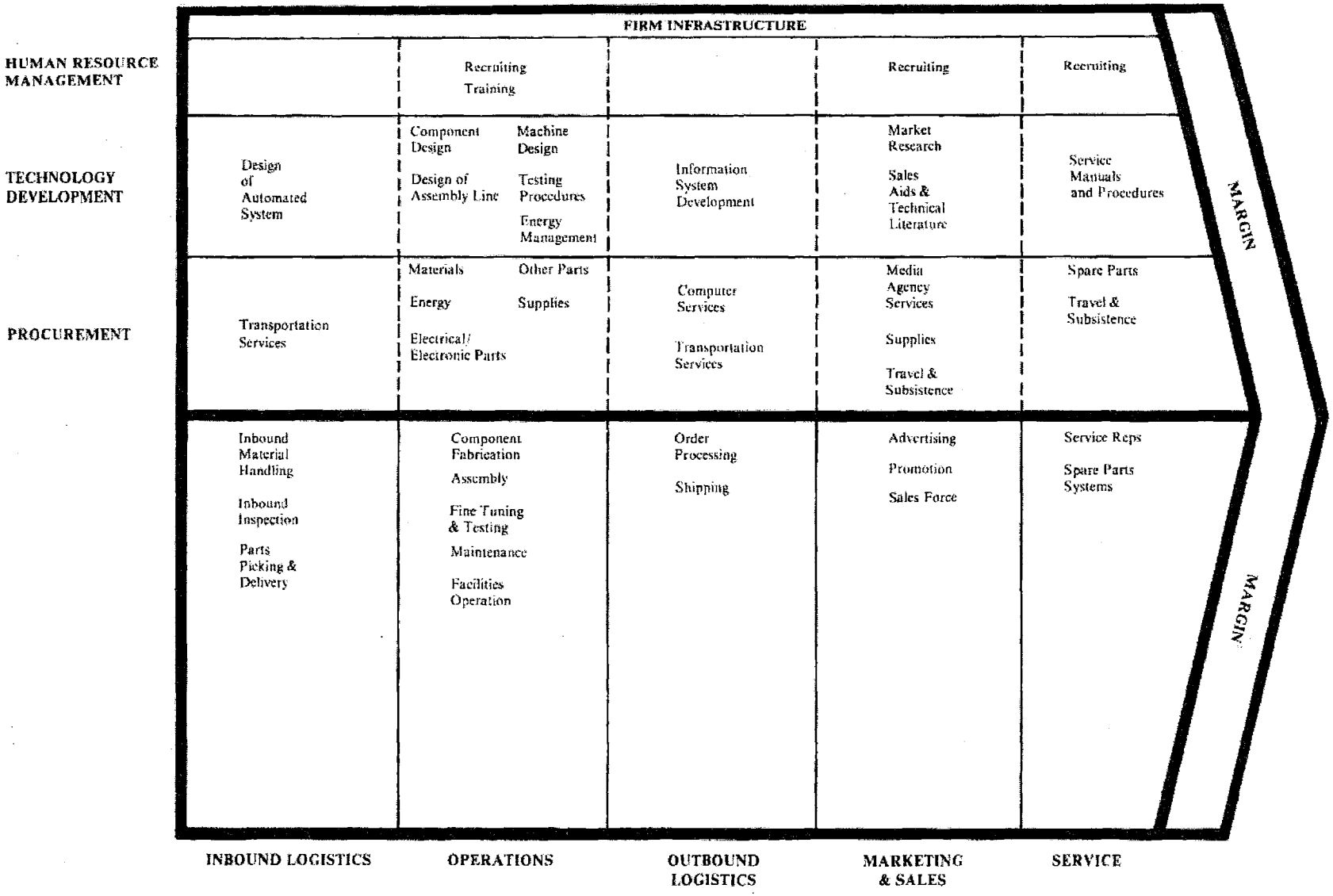


Figure 2-6 Sample Value Chain (Porter, 47)

2.2.5 Exploration versus Exploitation

Core competencies were earlier defined as a set of collective learning. Since the development and effective utilization of core competencies are large driving factors in the quest for a competitive advantage, then organizational learning becomes an important means to gaining advantage. James March discusses two main vehicles for learning in his article "Exploration and Exploitation in Organizational Learning". This section highlights the effects of both exploration and exploitation in the learning process of firms. Exploitation and exploration are both necessary components of a successful firm. Yet, both compete for scare resources within the organization. Thus, firms should make explicit decisions.

Exploration involves the experimentation of new ideas, technologies, strategies and knowledge. Often, the goal of exploration is to find new and better alternatives, to develop flexibility, and to gain new skill sets or knowledge. Firms undertake explorative processes by searching for new ideas, inventing new processes or products, and innovating or deviating from traditional standards. Exploration is associated with terms such as novel or risky, but the returns can be substantial. Also, the returns usually take a significant amount of time to be realized and the outcomes are highly variable. Firms can propagate exploration through loose discipline, relaxed control, or by fostering an energetic and stimulating environment.

Exploitation, on the other hand, relies on the elaboration of existing ideas, technologies, strategies and knowledge. Instead of reinventing, exploitation attempts to improve or refine existing ideas, technologies, strategies and knowledge. The goals of exploitation are well-defined and include improving efficiency, boosting reliability, or reducing costs. As opposed to exploration, the returns of exploitation exhibit low levels of variance and are realized over much

shorter time periods. A firm can facilitate exploitation via analysis, control, discipline, attention to detail, and commitment.

Reaching a balance between exploration and exploitation is important for an organization to gain the benefits of experimenting. Exploration without exploitation leads to a collection of undeveloped new ideas and little or no gains in core competence. Exploitation without exploration can limit creativity, stifle entrepreneurs, and reduce motivation.

It is important to realize the importance of organizational learning on competitive advantage and thus business strategy. Just as noteworthy are the methods by which people learn. Organizations will prosper if they can maintain an effective balance between exploration and exploitation in the learning process.

2.2.6 Strategic Intent

Traditional strategic thinking has been narrow sighted. Analyzing strategic fit between resources and opportunities, adopting generic strategies like low cost or differentiation and employing strategic hierarchies with goals, strategies and tactics is no longer sufficient to understand how to gain and sustain a competitive advantage in global markets. Sun-Tzu, a Chinese military strategist 3000 year ago, said "All men can see the tactics whereby I conquer, but what non can see is the strategy out of which great victory is evolved."

During the past 20 years firms with global leadership positions began with ambitions greater than their resources and capabilities. Regardless, many of these firms have been

successful. This success stems from an obsession to winning throughout the organization. Hamel and Prahalad term this obsession strategic intent.

A successful strategic intent includes a focus on the essence of winning, motivating people by effectively communicating the value of the target, leaving room for individual and team intrapreneurial contributions, a sustained enthusiasm created by adapting to evolving environments, and using intent to direct the allocation of resources (Hamel and Prahalad). Also, a strategic intent must engage all levels within the organization. To effectively capture the attention of the entire firm, managers must create a sense of urgency, develop a competitor focus at every level, provide employees with the necessary skill sets, allow time to digest one challenge before embarking on the next, and establish clear milestones and review mechanisms (Hamel and Prahalad).

Adopting a strategic intent will enhance a corporation's ability to improve current skills and provide the flexibility to identify and hone new skills. As competition increasingly changes from a local to a global scope, firms must do more than employ analytical tools. Analytical tools are not enough alone to drive and capture strategic thinking. Managers can help their firms achieve a strategic intent and thus global leadership by developing faith in their employees' ability to deliver on tough goals, motivating at all levels, and focusing attention long enough to internalize new capabilities into core competencies (Hamel and Prahalad).

2.3 The Role of Technology

Technology is a powerful factor in the business world. Changing technology can create new sources of competitive advantages and erode existing ones. Technology can alter how a firm performs activities as well as change what activities are performed. Technology can also affect the structure of an industry and thus the relative attractiveness of the industry. This section presents some of the ways technology can affect competitive advantage, the value chain, and industry structure.

2.3.1 Technology and Competitive Advantage

Technology can impact a firm's competitive advantage. New or innovative technologies may allow a firm to achieve cost savings over competitors thus helping a firm improve its position in cost leadership. Also, technology can help a firm differentiate itself from competitors. Chapter five of Porter's book Competitive Advantage lists several examples of technologies that have either improved a firm's cost leadership or aided in the quest for differentiation. (169)

2.3.2 Technology and the Value Chain

Technology can greatly impact a firm's value chain. Information technology can be especially pervasive because each value activity in the value chain creates and uses information. Technologies can help capture, process and distribute this information effectively. Also,

information technologies can help provide important linkages within the value chain. Carefully linking activities allows for increased coordination and optimization within the organization. Information technologies may not only link activities within the value chain, but may also link a firm's activities with buyers or suppliers. These linkages may influence the relative power of the firm with respect to the buyers and suppliers in the industry. Figure 2-7 links technologies with specific activities in the value chain.

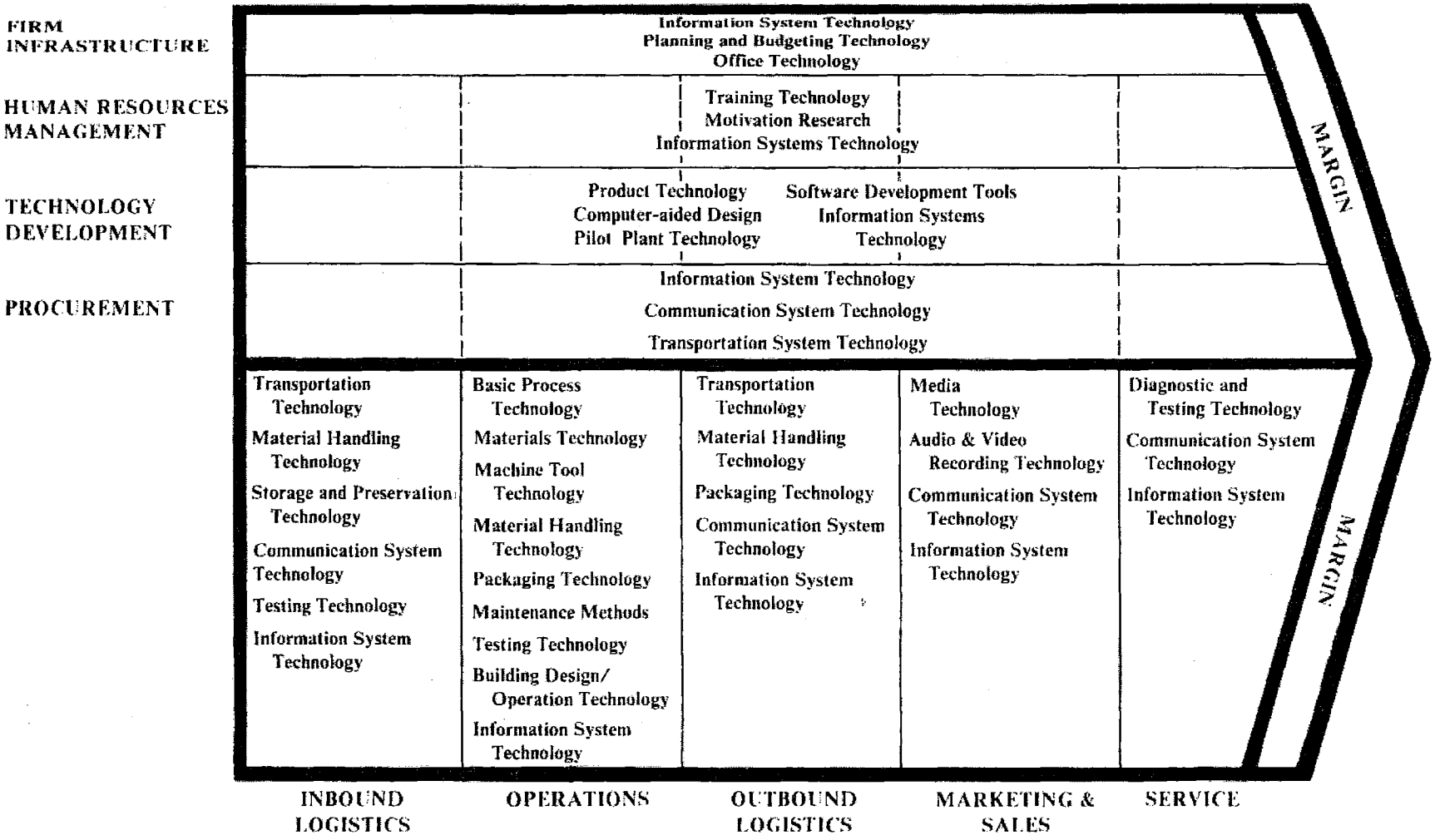


Figure 2-7: Technologies that Affect the Value Chain (Porter, 167)

2.3.3 Impact on Industry Structure

Technology not only affects individual firms but it may impact the entire industry. Industry structure will only be affected when the technology becomes widespread throughout the industry. Technology can effect each of the five forces. The resulting impact may improve or erode the attractiveness of the industry.

Technology alters both the nature and basis of rivalry within an industry by changing the cost structure or changing the exit barriers. Altering the cost structure in turn affects the pricing structure. For example, raising the fixed costs will increase rivalry. The converse is also a viable scenario. Fluctuating exit barriers help to determine how specialized an industry is. Higher exit barriers results in more specialized players thus increasing the level of rivalry. Generally, high level of rivalry lowers the attractiveness of the industry.

Technology often increases the presence of substitutes. Emerging technologies can introduce new products or change the use of exiting products. Increasing the presence of substitutes lowers the attractiveness of an industry.

Technology may shift the bargaining power of buyers by affecting differentiation and switching costs. If new technologies increase the uniqueness of the product, then buyer power will diminish. Conversely, if changing technologies lower the switching costs between possible products, the buyer power increases. Also, information technology can bring buyers together thus making the transaction more open and increasing buyer power.

Technological change affects supplier power similarly by altering differentiation and switching costs. New technologies may require more specialized raw materials thereby

increasing the supplier power. On the other hand, new technology may allow firm's to use substitute raw materials thus lowering the supplier power.

Not only do new or changing technologies affect each of the five forces, but also it may change the scope of industries. Determining the scope of an industry is a difficult task without considering technology. Innovation in technology can either widen or narrow the scope of an industry.

2.4 The Business Model

Thus far, we have covered the basic principles in business strategy as well as how technology may affect strategy. This section introduces the business model, as developed by Gary Hamel, as a framework that incorporates the earlier topics. (Hamel, 70) The business model can be broken down into four major components, core strategy, strategic resources, customer interface, and the value network. Three bridging components, the configuration of activities, customer benefits, and company boundaries link the four major components. Figure 2-8 lays out how the bridge and core components fit together.

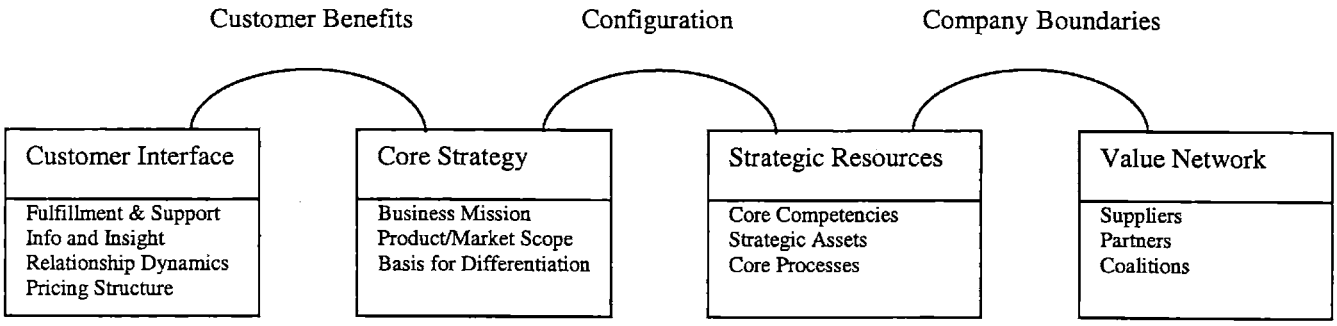


Figure 2-8 The Business Model (Hamel, 70)

2.4.1 Core Strategy

The core strategy encompasses how the firm chooses to compete. The core strategy includes the business mission, the product and market scope, and the basis for differentiation.

The business mission captures the overall goals of the strategy. In other words, the business mission describes what the business model is designed to accomplish. The mission includes the value proposition, strategic intent, goals, purpose, and performance objects. Also, the mission provides metrics to measure the progress of the firm.

The product and market scope defines where the firm competes including customers, geographical locations, and product or industry segments. In turn, the scope defines where the firm does not compete as well.

The basis for differentiation describes how we compete differently with respect to our competitors. Refer to the earlier section on competitive advantage for more information on differentiation.

2.4.2 Strategic Resources

The next component of the business model is the strategic resources. Strategic resources are the fundamental building blocks for achieving and maintaining a competitive advantage. Core competencies, strategic assets, and core processes are elements of strategic resources.

Core competencies are the unique skills and capabilities of the firm. Refer to the earlier section on core competencies for a more in depth description.

Strategic assets are the things the firm owns. Assets are things versus competencies, which are skills and knowledge. Strategic assets may include brands, patents, infrastructure, proprietary standards, customer data, and anything else valuable or rare.

The activities of the people in the firm make up the firm's core processes. Core processes include methodologies and routines that turn inputs to outputs. Core processes rely on competencies and assets to create value for the customers.

2.4.3 Configuration

Configuration is the bridge component linking a firm's core strategy to its strategic resources. The configuration defines the way the competencies, assets, and processes are linked together. The combination of resources should result in linkages that support the firm's core strategy.

2.4.4 Customer Interface

The customer interface defines how the producer reaches the consumer. The customer interface is comprised of fulfillment and support, information and insight, relationship dynamics, and pricing structure.

Fulfillment and support defines how the firm reaches the customers, the type of customer support offered, and what level of service is performed. Information and insight is the information content of the customer interface. It includes all the knowledge collected and utilized on the customers and the firm's ability to extract meaningful insights from the information. The relationship dynamics define the nature and interaction between the producer and the customer. When analyzing the relationships, take care to acknowledge the emotional and transactional characteristics. Understanding these characteristics can help a firm to create a highly differentiated business concept. The pricing structure should define what your firm charges for and how you charge for it. Firms charge customers for products or services. The firm may choose to bundle products or services or charge for them separately. Prices can be direct, indirect, flat-rate, or metered. Also, prices can be set by the firm or market-based.

2.4.5 Customer Benefits

The customer benefits are the things actually being offered to the customer. Customer benefits is the second bridge component linking the core strategy and the customer interface. Benefits should align with the customer needs, thus adding value to the customer. Benefits

translate to value for the customer. This is what the customer is willing to pay for. Firms should make conscious decisions as to what benefits are and are not being offered.

2.4.6 Value Network

The final component in the business model is the value network. Included in the value network are resources available to a firm, but outside of the direct control of the firm. Firms use the value network to complement or amplify the firm's existing resources. Suppliers, partners, and coalitions are a part of the value network.

Suppliers reside up the value chain and provide necessary inputs to the firm. Unique relationships with suppliers or privileged access to suppliers can both serve as opportunities for competitive advantage. Partners supply critical complements to a firm's final product. Partners have a horizontal relationship with the firm as opposed to the vertical relationship suppliers command. Coalitions consist of a group of competitors who work together to overcome risk and share in the rewards of changing industries. Coalitions prove especially useful in cased where investment or technology hurdles are great and in standards battles.

2.4.7 Company Boundaries

The final bridge in Hamel's business model defines the company boundaries by deciding what the firm does itself and what it contracts out to the value network. Firms must compare and contrast their core competencies, strategic assets, and core processes against the opportunities

available via suppliers, partners, and coalitions in order to make educated decisions about what activities to perform versus what activities to outsource.

Chapter 3 – Case Study of The Water Supply System in Arlington, MA

The water supply system for Arlington, MA serves as the case study for this thesis. This chapter explains both the current system and the proposed system with associated technologies.

3.1 Overview

The Department of Public Works (DPW) of Arlington, MA manages the water supply network for both residential and commercial customers in the town. The DPW purchases water from the Massachusetts Water Resources Authority (MWRA) and distributes the water to the residents and businesses in Arlington.

The DPW, part of the municipal government, then recoups the cost of the water by billing the customers twice a year. Customers are billed according to the amount of water used. The DPW currently tracks customer usage via water meters, which are installed at each point between the customers and the Arlington water supply network. The water and sewer operations in Arlington are managed as an enterprise fund within the town budget. Yet, the DPW is given substantial discretion in setting its expenditures and rates for the water and sewer services. The enterprise fund is required to show a zero profit in each fiscal year. Water and sewer expenses are not reviewed in detail by the town, as are other town budgets, nor are they cut as part of the annual budgeting process. The DPW must only ensure that revenues and costs balance.

3.2 Current System

The current Arlington system is based on manual meter readings, which are collected twice a year. An interface box is mounted on the outside of every residence and business in Arlington, so access to the inside of the building is not necessary. Employees of the DPW, physically attach a hand held data collection device to pins in the box. After returning to the office, the employees then download the readings from the collection gun to the Integrated Collection System (ICS).

The current water usage and billing data is stored in an Informix database, which is part of the ICS. The ICS also contains additional data and primarily supports the town Treasurer.

There are approximately 12,200 meters in the town. Two-family homes, apartments and business complexes usually just have one meter. Owners may sub-meter if they wish; this is outside the scope of the town's systems.

There are also 5 MWRA meter points that feed the Arlington system. The total flow from the MWRA meters is higher than the amount measured by the 12,200 Arlington meters. There is unaccounted use in the system, due to leakage, fire hydrants and other causes.

3.3 Proposed System

The proposed system includes a wireless meter reading collection system and a software application that analyzes the data. The wireless collection system will provide readings twice a day nominally and as frequently as every 10 minutes if desired. The software application

extracts the data from the wireless system and analyzes the data in order to improve the efficiency and effectiveness of the water management system.

The Arlington Department of Public Works expects to install the wireless collection system in 2001. Meters will transfer water usage data via short-range radio to a set of 5 receiver towers in the town of Arlington. The towers then transfer the data by cellular modem to a data collection server at Town Hall. The town has evaluated Hexagram as one vendor for the wireless collection system. Hexagram's STAR system will configure the meters and collect the data, but it does not analyze the data. The Hexagram system stores the data in a Paradox database.

The software application performs analysis on the data collected by the Hexagram wireless system. Three MIT graduate students, under the direction of Professor George Kocur, are building the software application. The MIT graduate students are Sebastian Bogershausen, Bradford Butler, and Mameet Khanolkar. The product will implement water management system functions, including billing data preparation, billing and rate analysis, leak detection, meter accuracy analysis, water usage analysis, water theft detection, and ad hoc analysis.

The new system offers several benefits and advantages. The key benefits of the new system are:

- More frequent billing for water usage to improve the cash flow of the town. Asking users to pay for water monthly, as they do for virtually all other services and products is more appropriate than the town carrying these costs for 6 months before collection.
- Reduced data collection expense, since the need to manually read all the meters twice a year is eliminated
- Better water system maintenance for the town through improved leak detection
- Assistance to consumers in locating possible leaks within buildings

- Ability to detect certain types of water theft, thus reducing theft. Reducing theft will pass cost savings on to customers.
- Better ability to measure water meter accuracy
- Ability to perform more detailed analysis of billing rate structures
- Ability to perform ad hoc analysis of data
- Future ability to allow customers to view their water usage online
- Ability to measure water use as frequently as every 10 minutes, to build usage profiles for selected users (possibly at their request). This would allow a customer to understand his/her water use patterns better and may suggest efficiencies. These profiles could be viewed online.
- Future ability to allow users to register with the town if they are away from home and wish to be notified if there is water usage. This would indicate a leak, pipe break or possible unauthorized entry into the house.
- Future payment of water bills online monthly, either manually or via an automatic payment/charge plan

3.3.1 Functionality of Proposed System

The proposed system will improve the efficiency and effectiveness of Arlington's water supply network. The requirements gathering process identified seven system functions including billing data preparation, billing and rate analysis, leak detection, meter accuracy analysis, water usage analysis, water theft detection, and ad hoc analysis. The MIT students completed the design for billing data preparation, individual leak detection, MWRA comparison analysis, usage patterns analysis, theft detection, and meter watch analysis. Note that the billing and rate analysis and meter accuracy analysis were not designed completely, and the leak detection was

divided into individual leak detection and MWRA comparison. Also, the ad hoc analysis evolved into a meter watch analysis.

The bill preparation functionality allows the user to review account information for suspect meters before sending billing data to the ICS. The bill prep analysis reports suspect meters with missing readings, estimated readings, abnormal increase in usage, and abnormal decrease in usage. Once the user decides all meter information is correct and accurate, he/she can aggregate the daily readings into a monthly value for each meter. The monthly meter information is then sent to the ICS for billing purposes. The following list briefly describes the calculations performed in the bill prep functionality.

- For the missing readings report, the system writes meters to the results report when the time between any two consecutive readings is greater or equal to the missing interval number of hours. Meter readings are only queried over the time period specified by the user.
- For the estimated readings report, the system writes meters to the results report for each estimated reading during the user specified time period.
- For the abnormal increase analysis, the system writes meters to the results report for each meter when the percent increase between average daily use in the current time period and the average daily use in the past time period is greater or equal to the percent increase parameter.
- For the abnormal decrease analysis, the system writes meters to the results report for each meter when the percent decrease between average daily use in the current time period and the average daily use in the past time period is greater or equal to the percent decrease parameter.

The individual leak analysis attempts to identify leaks on the customer side of the meter. The system will analyze individual meter readings to find suspect activity, which may be the results of a leak. The suspect activity includes sudden increases in use, an average increase in use

above a threshold, and constant night use. The following list briefly describes the calculations performed in the individual leak analysis.

- For the sudden increase analysis, the system writes meters to the results report when the percent increase between the use for any day during the current time period and the average daily use during the past time period is greater or equal to the percent increase parameter.
- For the threshold analysis, the system writes meters to the results report when the percent increase between the average daily use during the current time period and the average daily use during the past time period is greater or equal to the percent increase parameter.
- For the night time analysis, the system writes meters to the results report when any meter on night time monitoring during the user specified time period experiences a number of zero readings less than the zero readings tolerance parameter. The system will automatically find meters on night time monitoring by searching for meters with frequent readings during the evening hours. The user will read meters more frequently at night by configuring the Hexagram system appropriately.

The MWRA comparison analyzes the relationship between the flow of water into the Arlington network, via the MWRA meters, and the consumption of water by the Arlington meters. Arlington is subdivided into three zones; high pressure, intermediate pressure, and low pressure. Not all consumption points in the Arlington system are metered (ex. Fire hydrants). Thus, the MWRA total usage should exceed the corresponding Arlington usage per zone. The non-metered consumption is unaccounted for usage. The purpose of this analysis is to determine leaks in the Arlington water network in places between MWRA meters and Arlington meters. Periodic monitoring of the relationship between MWRA and Arlington usage may help an experienced user detect unusual behavior in the system and thus potential leaks. The following list briefly describes the calculations performed in the MWRA comparison functionality.

- The MWRA comparison analysis writes results in the Leak Detection report for MWRA comparison. The system writes results when the percent difference between the total usage of the MWRA meter(s) and the Arlington meters is greater or equal to

the given threshold parameter for each zone. The usage is calculated over the time period specified by the user.

The usage analysis allows the user to create an aggregate profile for a group of meters. The user will define the group by checking the appropriate parameter check boxes. If a box is checked, the group will include meters with the checked attribute. The aggregate profile will give the user insight on typical historical usage for groups of meters. The usage profile for the group will only span the time period specified by the user.

The water theft analysis attempts to find meters in Arlington with suspicious activity. The analysis looks for four types of suspicious behavior; continuous zero usage, negative usage, broken seals, and loss of physical connection. Meters exhibiting one of the four types of suspicious behavior will be written to the results table when the analysis is run. The user may then take appropriate action for each meter. The available actions include editing information in the database and placing meters on watch.

- For zero usage, the system will find all meters with a period of continuous zero usage equal or greater to the continuous zero use parameter. The system will only query meter data over the defined start and end date of the analysis.

- For negative use, the system will find all meters with negative use during the define start and end date. The system will not write records to the result report when meters exhibit negative use equal to or less than the tolerance parameter.

- For broken seals, the system will query the database for any occurrence of a broken seal over the defined start and end date. Each broken seal event per meter will be recorded in the results.

- For loss of physical connection, the system will query the database for each occurrence of the loss of physical connection of the wireless device. When the wireless device is disconnected from the meter, the device will send a signal to the Hexagram server indicating the action. The system will search for loss of physical connection events only during the user specified time period.

The meter watch functionality allows the user to monitor a specific meter. The user must first place a meter on watch using the Meter Watch Configuration page. Next, the user must make sure the meter watch check box is checked before the analysis is run.
After the analysis is run, the user may view a report for each meter placed on watch. The report will include a usage profile for each meter. In the Meter Watch Configuration page, the user can add meters to be watched. The user must include a reason for placing the meter on meter watch and a time period. The user may optionally include comments to further describe why the meter was placed on watch. The results report for the meter watch analysis will include a usage profile for each meter specified by the user. The profile will span the time period defined by the end date at the top of the Report Configuration page and the time period value input by the user.

3.3.2 Changes in the Flow of Information

The introduction of a new set of technologies will alter the flow of information in the water department. The flow of information in the current system is depicted in Figure 3-1. Currently, employees of the DPW manually read meters with meter gun devices. The workers then return to the office and load the information into the ICS. After the information has been verified, the ICS data is used to bill the customers.

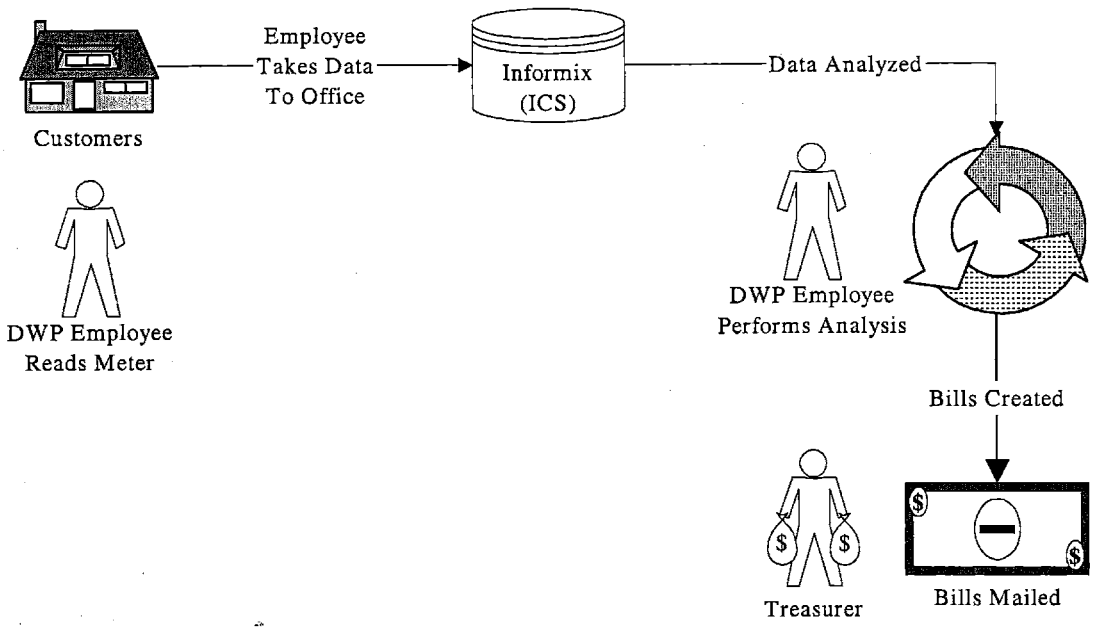


Figure 3-1 Current Flow of Information

Information in the new system will follow a different path than the current system. Wireless devices will transmit data to 5 receiver towers located in Arlington by short-range radio. The towers will then transmit the data to a Paradox database in the DPW's office via cellular modem. Next, on a scheduled basis, the water application will extract data from the Paradox database and load it into a MySQL database. The MySQL database will centrally store all data relating to the water supply network and support the analysis application. Employees of the DPW can then analyze the data, fix or adjust erroneous readings, then create usage extracts for billing. The usage records will then be transferred to the ICS for billing purposes. The DPW can choose to create billing records on any desired time frame. Monthly billing is currently considered a plausible billing period. Figure 3-2 presents a logical view of the new flow of information.

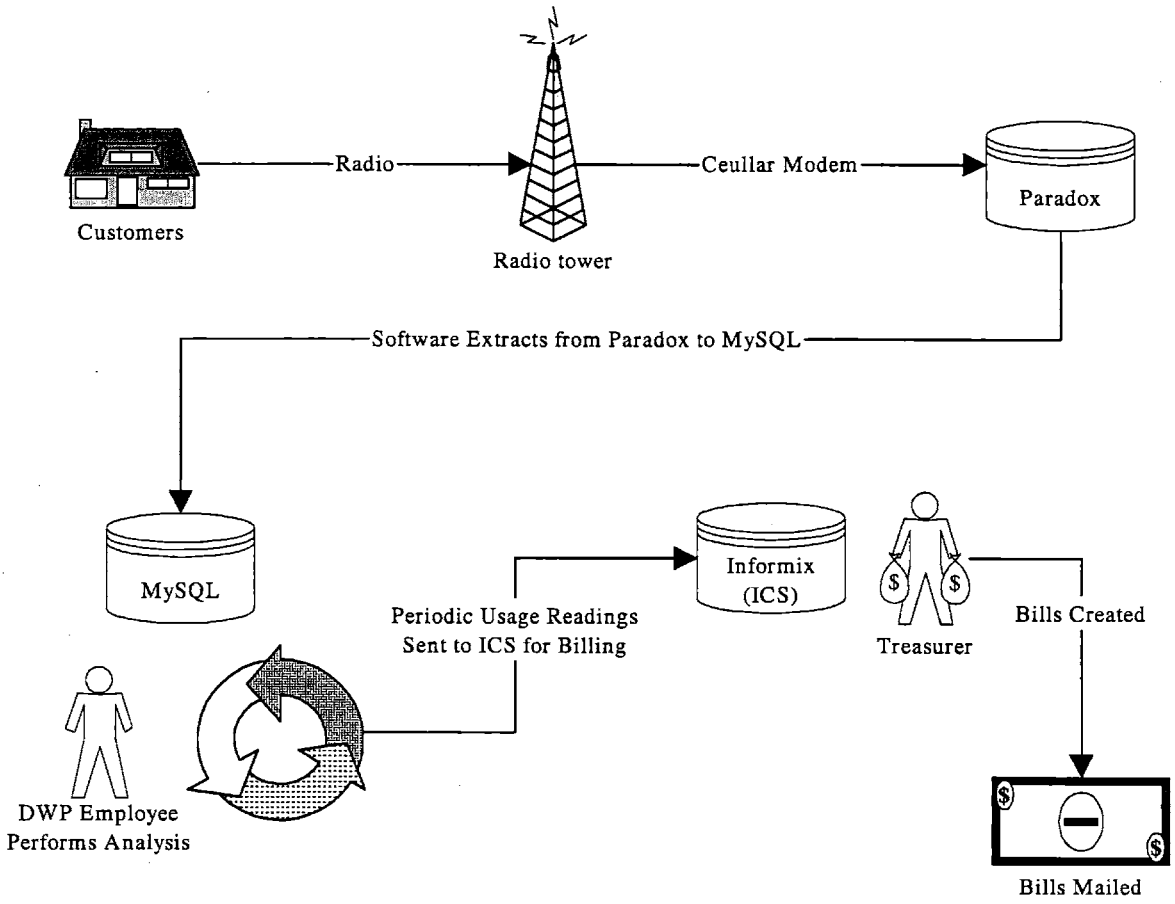
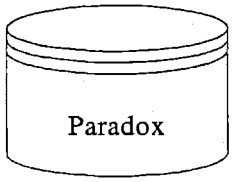
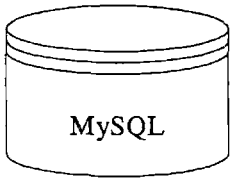
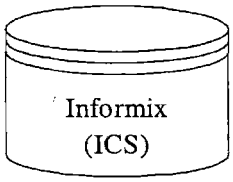


Figure 3-2 Flow of Information with the Proposed System.

The flow of information in the purposed system includes three databases: the Hexagram collection database, the MySQL database, and the ICS. The primary function of the Hexagram database is to collect and store the raw meter readings. The MySQL database exists to centrally store readings, meter information, account information, and data generated by the analysis of the analysis application. The database also includes several tables which support the operation of the analysis application. Figure 3-3 summarizes the primary functions of each database as they relate to the DWP.







Primary Functions:

- Store Raw Meter Readings

Primary Functions:

- Store Readings
- Store Account and Meter Information
- Supports the Analysis Application
- Stores the results of the analyses
- Serve as a query friendly envirnoment

Primary Functions:

- Store Periodic Readings Used for Billing Purposes
- Store Account and Meter Information

Figure 3-3 Primary Functions of the Databases Used by the DPW

3.3.3 The Database Design for the Software Application (MySQL)

The MIT students designed the MySQL database with two goals in mind. First, the database must accurately and efficiently store the data related to the town's water supply network. This includes, but is not limited to, data relating to accounts, meters, meter reads, and billing information. Secondly, the database supports the water application that analyzes the data. Tables are present to store information used in support of the application.

The current system stores data in the ICS. The tables with water related data are the "Water", "Meter", and "Mtrread" tables. The data model reflects the business rules of the water

department. Figure 3-4 represents a logical view of the tables, the attributes, and the relationship between the tables. This simple data model indicates that accounts can have one or many meters. Similarly, meters can have on or many readings. Also, a reading must relate to only one meter. A meter can belong to only one account. The Informix database (ICS) is currently not ensuring referential integrity between the tables.

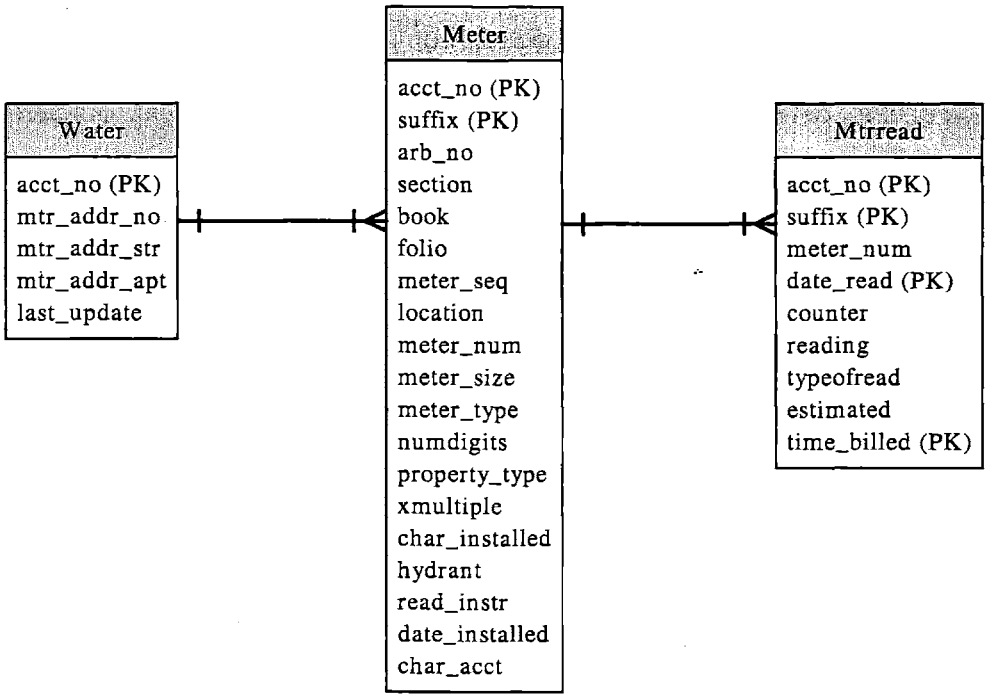


Figure 3-4 Water Related Tables in the ICS

The proposed system will use an additional database that will serve as the primary source for ad hoc queries concerning the water supply network and serve a support role for the new software application. Once the data is analyzed, the user may export a set of usage readings to the "Mtrread" table in the ICS. The ICS will then serve as the primary source of billing for the water customers.

MySQL is the chosen vendor for the database. The MySQL database is relational, but it does not ensure referential integrity or understand foreign keys. However, the database design includes lookup tables so the software application can check data validity before adding records. For instance, the database should not contain meter reads for meters not found in the Meter table. Figure 3-5 shows the data model for the water supply network information. The database contains additional tables not listed in the data model that support the software application. Refer to the data dictionary in Appendix 1 for a description of all the tables and attributes.

Again, the data model reflects the business rules of the water department. As before, we have the same relationships between accounts, meters, and readings. The data model in Figure 3-5 also contains additional business logic. The new relationships include the correlation between accounts and MWRA meters. Each account belongs to one of three zones. Each of these zones are served by one or many MWRA meters. The MWRA meters will only serve one zone. This set of rules may be subject to some dispute as connection valves do exists that connect the zones. This logic could be improved in future versions of the data model. The second new relationship links meters to meter actions. The set of meter actions is still to be determined, but could include broken seal events, vandalism, and other meter events deemed appropriate. Finally, the ICSBillRead may introduce confusion since both it and the MeterRead table contain meter readings. The MeterRead table contains the raw meter readings from the Hexagram system. On the other hand, the ICSBillRead table contains monthly readings for each meter. The ICS will use this data for billing purposes.

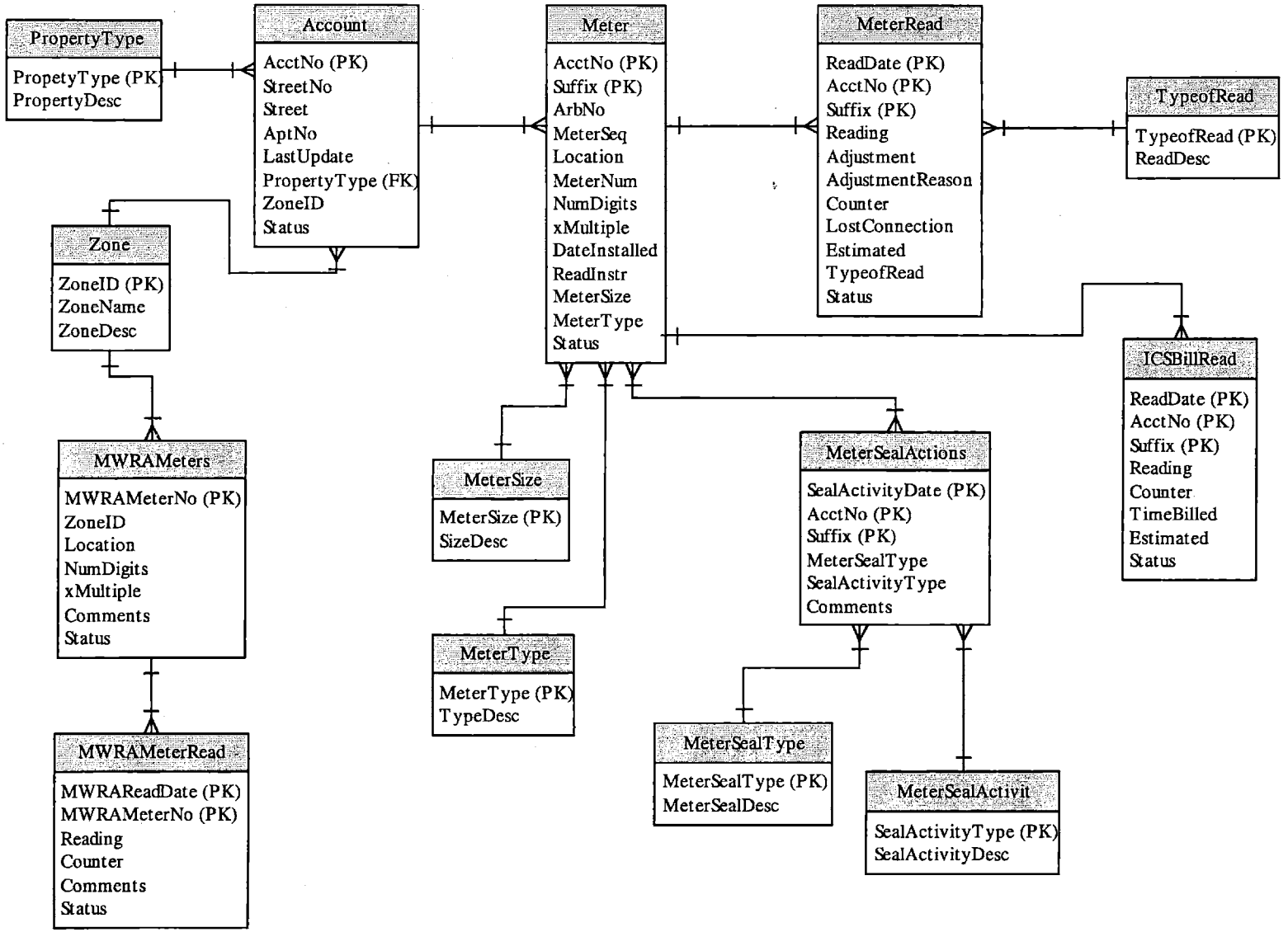


Figure 3-5 Logical Data Model

3.3.4 Technical Specifications

This section lists the technologies associated with the new water system including the wireless system and the analysis software. Table 3-1 presents the technologies used by the wireless system. The technologies involved with the MIT built software application are listed in Table 3-2.

Wireless System	
Meter to Tower Data Transmission	Radio
Tower to Database Data Transmission	Cellular Modem
Database	Paradox
Operating System (DB)	WinNT/2000

Table 3-1 Wireless System Technologies

Software Analysis Application	
Database	MySQL
Operating System	Linux
Web Server	Apache / Tomcat
Development Platform	J2EE (JDK 1.3, JSP 1.0)

Table 3-2 Software Analysis Application Technologies

Chapter 4 - Analysis of the Case

This chapter analyzes the water distribution business of the Arlington Department of Public Works (DPW). The analysis includes discussions of the industry, the value chain, and the business model. Also, included are the possible changes caused by the introduction of the new wireless collection and data analysis technologies.

4.1 Industry Analysis

The water distribution industry, in this thesis, encompasses organizations that provide potable water to both commercial and residential customers in towns in the U.S. Not included in this analysis are organizations that treat or disinfect water, or organizations that distribute water to the towns. The five force analysis includes the force of rivalry, the presence of substitutes, the buyer power, the supplier power, and the barriers to entry. Figure 4-1 displays each of the five forces.

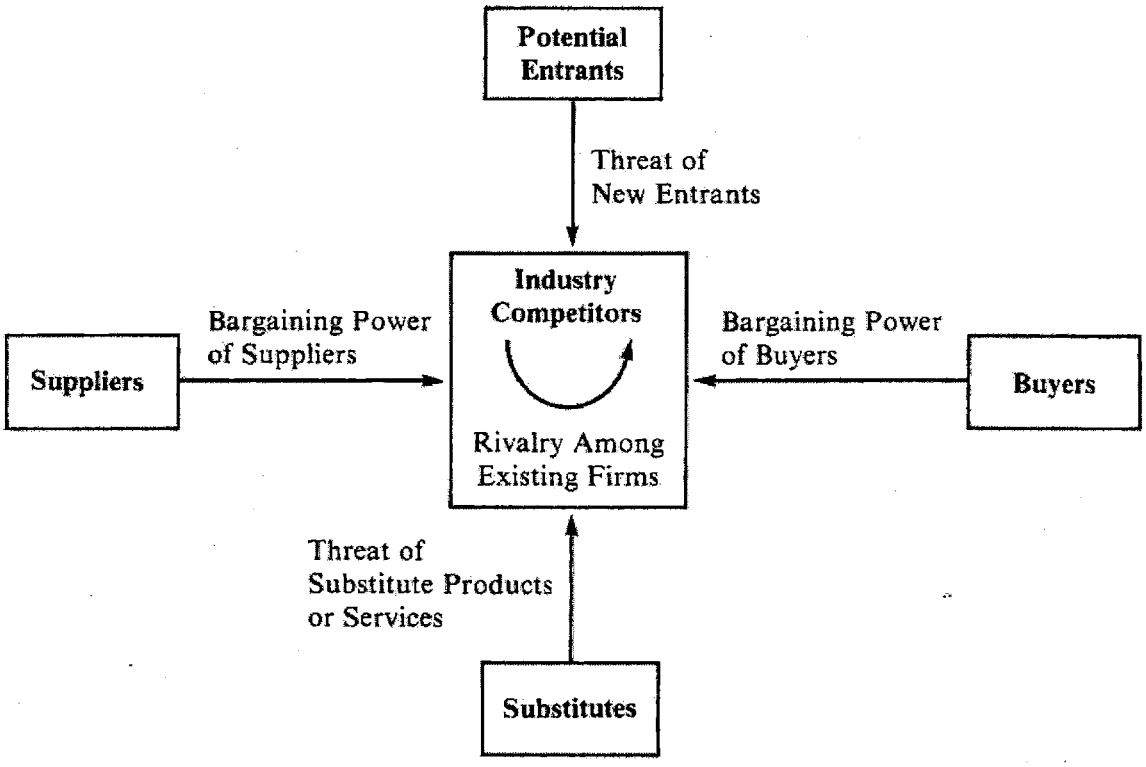


Figure 4-1 Five Force Method (Oster, 30)

The goal of this analysis differs slightly from the typical goal of the five force analysis. Normally, an industry analysis attempts to explain industry profitability. In this case, the organizations do not try to make a profit. Instead, the analysis will attempt to relate the industry structure to the costs associated with the DPW and to offer a better understanding of the industry. Even though the DPW does not attempt to reap profits, it does deal with outside forces in the same manner as profiting businesses do.

The number of competitors, the size and distribution of the competitors, the similarity between the competitors, the fixed nature of investments, and the stability of demand determine the force of rivalry. The number of organizations in the U.S. in the water distribution industry is

high. Virtually each town or region has its own organization. Yet, these firms are usually not direct competitors. Each organization has a customer base that is separate from other organizations in the industry. The size distribution of each organization varies significantly and depends directly on the size of the town. The organizations are relatively similar. Most of the organizations are municipal and therefore do not attempt to make a profit. However, there are some private water companies in the U.S. The amount of fixed investments is high. Each organization must create a physical network of pipes to connect the customers in the town to a clean water source. The net effect indicates a low force of rivalry in the industry.

The force of substitutes is determined by the availability of substitutes and switching costs. Substitutes are defined as products or services that can supply the same functions to the same audience. Substitutes in the water distribution industry include firms who deliver bottled water to residential and commercial customers. Yet, this substitute does not provide quite the same product or service. Bottle water is usually delivered only for drinking. Other substitutes include tank trucks that deliver water and those who drill their own wells. Tank trucks can provide water for purposes such as filling swimming pools. Drilling wells is an unusual form of competition but one that does exist. The service that a water distribution network provides allows the customer to utilize the connection to fresh water for multiple purposes. If the customer is residential, the water may be used throughout the home in kitchens, restroom, sinks, sprinkler systems, spas, and swimming pools. Switching costs are another measure of the force of substitutes. A customer may only switch full service providers by physically moving to another area or town. In this case the switching costs are very high. The presence of substitutes is low in the water distribution industry.

The buyer power can be determined by examining the concentration of buyers, the stability of demand, and the standardization of products. In the water distribution industry, the buyers make small and fragmented purchases. Also, the buyers have little choice of who is supplying them with water. The stability of demand varies by two factors, the number of customers in the town and well as how much each customer consumes. Town's with stable populations typically provide more stable demands. The water provided to customer's may vary in turbidity, but is usually rather standardized across the U.S. The buyer power is relatively low with the exception of industrial users. Industrial users have more options and often procure and manage their own water supplies.

The supplier power can be measured using the supplier matrix shown in Figure 2-2. The supplier matrix compares the importance of the supplier in the buyer's input base against the importance of the buyer in the supplier's customer base. The suppliers in the industry are organizations who provide clean water to the distribution networks. In the water distribution industry, the importance of the supplier in the buyer's input base is high. The organizations in the industry do not have a product, namely water, to sell to the customer without the supplier. Also, the importance of the buyer in the supplier's customer base is high. The supplier's cannot reach the customers without access to the distribution network. The result is mutual dependence between the firms in the industry and the suppliers.

The last force in the industry analysis includes the barriers to entry. Patent technologies, high entry costs, steep cost curves, bounded markets and successful branding measure barriers to entry. Patent technologies, steep cost curves, and successful branding are not significant factors in defining barriers to entry in the water distribution industry. On the other hand, high entry costs and relatively bounded markets do exists. The high entry costs stem from the large amount

of specific assets in the distribution network. Also, the market is relatively bounded by the size of the town. If the town does not grown, then the market does not have the ability to produce a significant amount of new customers. The barriers to entry are high.

This text book analysis indicates that the water distribution industry is very attractive. Rivalry is low, there are few real substitutes available, the buyer power is low, there is a mutual dependence with the suppliers, and the barriers to entry are high for potential entrants. Table 4-1 summarizes the results of the industry analysis. Again, remember that this analysis was invented to explain industry profitability. Since many of the organizations in the industry do not attempt to make profits, the results must be interpreted differently. Yet, by performing the analysis, one gains an understanding of the outside forces acting on the participants in the industry. This is still an important output as the participants in this industry are continually trying to provide a better service at a lower price.

Force	**Nature of Force**
Rivalry	Low
Substitutes	Low
Buyer Power	Low
Supplier Power	Mutual Dependence
Barriers to Entry	High

Table 4-1 Summary of Industry Analysis

4.2 The Effects of the New Technologies on the Industry

This section describes how the new wireless and data analysis technologies being implemented in Arlington's DPW might alter or affect the structure of the water distribution industry. Recall that technology only alters the structure of the industry if its use becomes widespread. The rest of this section assumes that the technology will become widespread.

The new technologies lower the force of rivalry. The technology hopes to lower the fixed operation costs and thus lessen rivalry. The technology might lower the operational costs by reducing the labor involved in manually reading the meters, detecting leaks earlier via data analysis and avoiding more costly damage and loss of water, detecting meter deterioration earlier via data analysis, and detecting theft.

The new technologies will decrease the presence of substitutes. The technologies will contribute another layer of value added services to the customer making the industry even more difficult to imitate.

The buyer power and supplier power will both be affected minimally if at all by the introduction of the wireless and information technologies. Buyers will still purchase water in the same manner, and the demand will not be affected. The relationship with the suppliers will continue to be mutually dependent.

The barriers to entry will increase slightly. As mentioned earlier the industry players have a large amount of specific assets in the physical network. This set of assets will just increase in complexity a degree as the technology improves the capabilities.

To summarize, the introduction of the wireless and data analysis application lowers the force of rivalry, decreases the presence of substitutes, and increases the barriers to entry. The supplier and buyer powers remain unchanged. Table 4-1 captures these results.

Force	Nature of Force	Effect of New Technologies
Rivalry	Low	Lowers
Substitutes	Low	Lowers
Buyer Power	Low	No Change
Supplier Power	Mutual Dependence	No Change
Barriers to Entry	High	Raises

Table 4-2 Summary of Industry Analysis Changes

The scope of the industry is an area not covered by the five force method, but one affected by the new technologies. The introduction of the wireless system and analysis application may widen the scope of the industry in two ways. First, the advent of cheaper, more efficient data collection and more powerful analysis of data improve the relationship with the customer and services provided. These benefits could easily be adapted to similar utility services for the customers in towns. If the major contribution of the participants in the water distribution industry is the safe, efficient and cost effective distribution of water to customers, then it follows that this core competence applies to other utilities such as gas and electric services. The technology being implemented in Arlington, MA may be the first step in providing a central interface between utility companies and customers. Second, the more frequent collection of data

may provide additional sources of value to both the municipal agencies and the customers. Water readings could be combined with home security systems to provide additional protection of the home or business. When the alarm is armed, it could also track the amount of water used. If a reasonable amount is being used, it could indicate a costly leak or even an unwelcome intruder. Also, the water system could be linked to home sprinkler systems and combined with weather data to conserve water or enforce water restrictions. This combination could conserve water by turning off the sprinkler system if the forecast calls for rain. Similarly, some towns could enforce lawn watering restrictions in times of water shortages. These could be enforced strictly with the new monitoring technologies.

4.3 The Value Chain Analysis

The value chain is a basic tool for dissecting and examining the individual activities a firm performs and analyzing how the activities interrelate. This tool enables us to identify sources of competitive advantage within a firm by systematically breaking a firm down into strategic activities. Recall that the value chain consists of both primary and support activities. This analysis focuses on Arlington's DPW primary activities for the water distribution business. The primary activities include inbound logistics, operations, outbound logistics, marketing and sales, and service. Recall Porter's definition of each of the primary activities. Inbound logistics are activities associated with receiving, storing, and disseminating inputs to the product, such as material handling, warehousing, inventory control, vehicle scheduling, and returns to suppliers. Operations are activities associated with transforming inputs into the final product form, such as

machining, packaging, assembly, equipment maintenance, testing, printing, and facility operations. Outbound logistics are activities associated with collecting, storing, and physically distributing the product to buyers, such as finished goods warehousing, material handling, delivery vehicle operation, order processing, and scheduling. Marketing and sales are activities associated with providing a means by which buyers can purchase the product and inducing them to do so, such as advertising, promotion, sales force, quoting, channel selection, channel relations, and pricing. Services are activities associated with providing service to enhance or maintain the value of the product, such as installation, repair, training, parts supply, and product adjustment. Refer to Chapter 2 section 2.4 for a more detailed description of the value chain. Figure 4-2 below displays a logical view of the value chain.

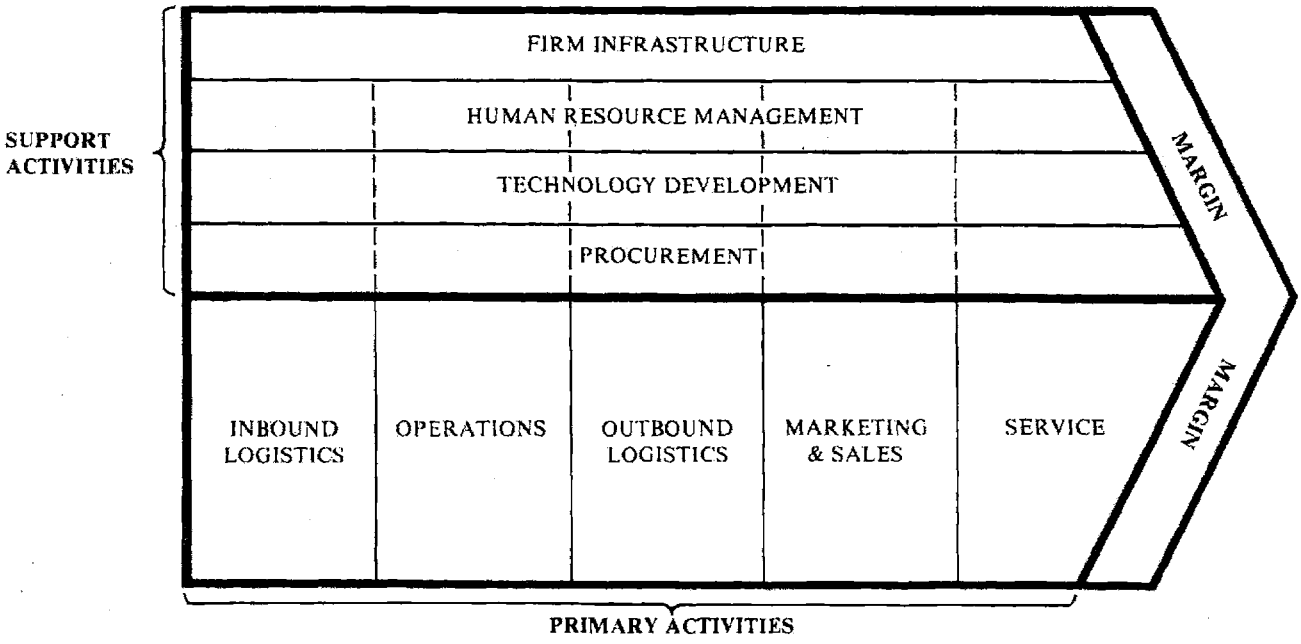


Figure 4-2 The Value Chain (Porter, 37)

The inbound logistics performed by Arlington's water business include the physical connection to the MWRA at metered input points in the distribution network. These input points serve as the connection to the supplier, which allows the input of water into the system.

The operations include the maintenance of the physical network and the operation of the system. The DPW is responsible for the safe and efficient distribution of water to their customers. The DPW services the network by replacing deterioration equipment when necessary and detecting and fixing leaks in the system.

The DPW performs outbound logistic activities by connecting the network to their customers. The DPW has installed a meter at each connection point between the customer and the distribution network. Currently, the meters are read manually twice a year. The town is also responsible for maintaining the meters.

The town performs few marketing activities, yet it does carry out some sales activities. The sales activities include channel relations and pricing. The DPW manages their relationship with the MWRA. The town then prices the water based on costs incurred. The cost incurred include purchasing water from the MWRA and the cost of operating and maintaining the physical distribution network.

The town currently provides a minimal set of service activities. The activities include maintaining the network, and maintaining the metered points between the MWRA and the customers.

4.4 The Effects of the New Technologies on the Value Chain

Information technology can greatly impact a firm's value chain. Information technology can help to capture, process, and distribute information effectively. Also, information technologies can provide important linkages between value activities that may influence the relative power of the firm with respect to buyers and suppliers. This section describes how the new wireless and data analysis technologies being implemented in Arlington's DPW might alter or affect the primary activities in the value chain.

The new technologies may have a significant impact on the inbound logistics only if data is collected from the metered connection points between the MWRA and the distribution network. By collecting this data, the DPW could monitor their interface with the MWRA more closely. This data could be used for analysis. Currently, the DPW plans to receive 15 minute interval data from the MWRA.

The new technologies will improve the town's ability to maintain and operate the physical network, thus improving operational value activities. By analyzing the frequent data provided by the wireless system, the DPW will be able to detect leaks earlier, identify meter deterioration via historical analysis, detect theft, and monitor individual meters and groups of meters.

The outbound logistic activities will change significantly with the introduction of the new technologies. First, instead of manually reading meters twice and year, the wireless system will systematically read meters twice a day with the ability to read the meters as often as every ten minutes. Changing this activity alters the town's interface with their customers. This change will have both positive and negative effects. The positive changes include the gathering of more

frequent data for less cost. The negative effects could include customer's who feel the town is invading their privacy by closely monitoring their water use. Second, the analysis application can provide a new interface with the customers. A usage profile could be made available to the customers on the web, which would allow the customers to monitor their usage. The town could take advantage of this new interface and extend the technology to allow the customers to pay their water bills online. Paying the bills online could save the town money by avoiding the cost of paper, printing, and postage.

The marketing and sales activities will be affected minimally. The new technologies may introduce a few marketing activities in the form of newspaper articles that inform the residents of the new system. The sales activities will still include channel relations and pricing. The relationship with the MWRA may deepen as the town more accurately monitors the inputs from the supplier. The pricing structure may improve as operational and maintenance costs improve. Also, by detecting theft and monitoring the unaccounted for use, customers may see a more accurate pricing structure.

Service activities will have the largest change as a result of the new technologies. The introduction of the wireless and data analysis system provides the town with a new set of value added service activities that could not be provided before. The activities include leak detection, billing analysis, theft detection, individual meter usage monitoring, group usage monitoring, and meter deterioration analysis. These new value added activities affect several of the other primary activities and provide linkages between the activities. For example, leak detection compares the flow of water into the system to the flow of water out of the system thus linking the inbound and outbound logistics. Without the frequent meter readings and the data analysis application this comparison would prove both difficult and costly.

4.5 The Business Model

Thus far, we have analyzed the water distribution industry using the five force method and described the primary activities of the DPW using the value chain. This section covers the business model, as developed by Gary Hamel, as a framework to understand the overall business concept (Hamel, 70). The business model can be broken down into four major components, core strategy, strategic resources, customer interface, and the value network. The four components are linked by three bridging components, the configuration of activities, customer benefits, and company boundaries. Figure 4-3 lays out how the bridge and core components fit together.

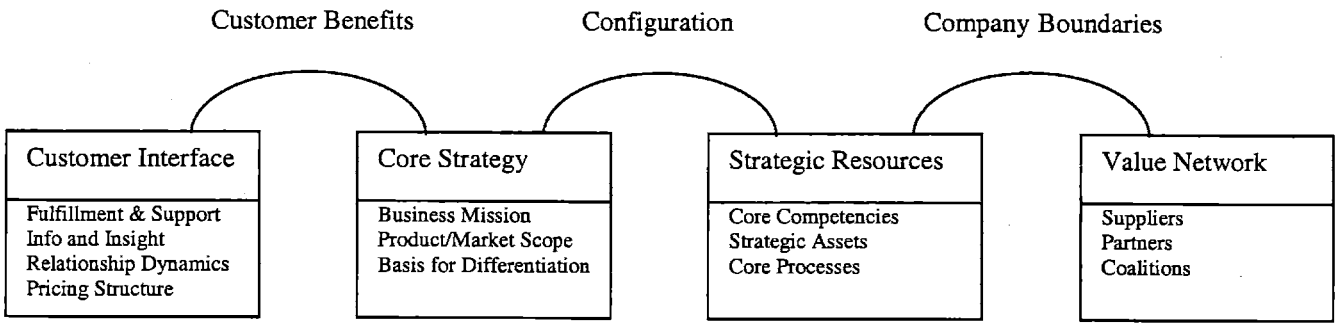


Figure 4-3 The Business Model (Hamel, 70)

The core strategy describes how the firm chooses to compete and includes the business mission, product and market scope, and the basis for differentiation. The business mission of Arlington's Department of Public Works is to provide superior service and support to the town's citizens, boards, commissions and other departments through the combined efforts of five

divisions. The five divisions are administration, engineering, properties, natural resources, and highway/water/sewer (DPW Arlington, MA). The water department's business mission is to supply both the residential and commercial customers in Arlington with clean and fresh water in a cost effective and safe manner. Their product is clean, fresh water. Their market scope includes the residential and commercial customers in the town of Arlington, MA. The water division differentiates itself by providing a complete source of water for the home or office in both a cost effective and hassle free environment. For example, if the customer choose to use a well then the customer would need to maintain the well themselves. By connecting to a water distribution network, the customer relies on the DPW to maintain their connection to a water supply.

The strategic resources are the building blocks for competitive advantage and include core competencies, strategic assets, and core processes. The DPW's core competency is their ability to safely distribute water in a cost effective and hassle free manner. To accomplish this the DPW must maintain and operate the physical distribution network, manage their relationship with the MWRA (their supplier), and offer a seamless connection to the customers. The DPW's strategic assets include the physical distribution network. The distribution network is comprised of pipes, valves, connections to both customers and their supplier, and monitoring devices or meters. The DPW have three major core processes. First, they collect monitoring information at both the inputs and outputs to the system in the form of meters and meter readings. Currently this is a manual process of readings a meter with a collection device. Second, they maintain the physical infrastructure of the distribution system. This process requires both maintenance and engineering knowledge. Third, the department processes both the monitoring information and

costs incurred to produce bills for customers. The town's treasure's office then distributes these bills by mail and collects payment.

The DPW's configuration links their core strategy to their strategic resources. The DPW is organized into five divisions. The five divisions are administration, engineering, properties, natural resources, and highway/water/sewer (DPW Arlington, MA). The highway/water/sewer division is responsible for the town infrastructure including streets and sidewalks, storm drains, water distribution system, sewer collection system, and bridges (DPW Arlington, MA). This division also provides services including snow and ice removal, street sweeping, catch basin cleaning, water and sewer customer service calls, and overseeing solid waste collection (DPW Arlington, MA). Refer to Appendix 2 for a complete organizational chart for the DPW.

The customer interface describes how the DPW reaches their customers and includes fulfillment and support, information and insight, relationship dynamics, and the pricing structure. The DPW's fulfillment and support activities center around the metered connection points between each customer and the distribution network. The DPW installs and maintains both the meters and the connections. The information and insight collected include the meter readings, which are currently collected twice a year to create bi-annual bills. The relationship dynamics cover the DPW's interactions with the customers. Currently, customers receive and return their bills by mail. Also, the department has a staff that can be reached by phone or appointment during regular business hours. The water department has a non-profit pricing structure. They must recover their operating costs through revenue on a yearly basis. Thus, the department ensures that their costs equal their revenue. The customer bills are generated based on water use. Currently the bills include both charges for sewer and water use in the town. Both are based on water use, which some customers feel is unfair. Not all water used directly affects the amount of

sewage water or waste produced. For example water used to water lawns does not get returned through the sewer system.

The customer benefits bridge the core strategy and customer interface. The customer benefits include an efficient connection to clean water. The water use is what the customers pay for twice a year.

The value network refers to the resources available to the firm, but outside of the direct control of the firm including suppliers, partners, and coalitions. The only supplier for the water department in Arlington is the MWRA. The MWRA supplies the town with a source of clean water at metered input points to the distribution network. The town relies on a fair price from the MWRA as no other suppliers have a connection to the network.

The final bridge in Hamel's business model defines the company boundaries by deciding what the firm does itself and what it contracts out to the value network. As stated earlier, the DPW uses the MWRA as a supplier of water. Alternatively, towns may choose to provider their own water sources and cleaning processes. The DPW does maintain the distribution system, collect readings, and process and collect bills.

4.6 The Effects of the New Technologies on the Business Model

This section describes how the new wireless and data analysis technologies being implemented in Arlington's DPW might alter or affect the business model. New technologies may affect each of the four major components as well as each of the three bridging components. The four major components are core strategy, strategic resources, customer interface, and the

value network. The three bridging components are the configuration of activities, customer benefits, and company boundaries.

The new technologies may affect the core strategy by impacting the business mission, product, market scope, or basis for differentiation. The new technologies in Arlington's DPW support the business mission. Actually, the new technology helps the department better accomplish their business mission by improving their interface with the customers and by allowing the department to perform a number of value added services to improve the maintenance and operation of the physical distribution network. The new technologies may widen the product offering. In addition to offering water, the department may find their ability to monitor the connection to their customers a new service. Other utilities perform similar tasks with the same set of customers. With the equipment and technology in place, the DPW may consider monitoring other products in the home or office. This new service may become a new source of revenue for the DPW. Similarly, the market scope may expand if the product offering expands. If the water department finds they can generate revenue from their monitoring services, then the market scope will widen to include the organizations paying them for their monitoring services. In addition, the market scope will continue to include the traditional residential and commercial customers in the Arlington. The DPW's basis for differentiation is improved with the addition of the new technologies. The new technologies allow them to offer another level of value added services that make the firm's product more difficult to imitate. Also, if the water department's product set does expand to include monitoring services, then a basis for differentiation in the home and office monitoring industry should be established.

The new technologies may affect the strategic resources by impacting the core competencies, strategic assets or core processes. The new set of technologies support the

department's core competencies by automating their interface with their customers and improving their ability to monitor the physical distribution network. The set of strategic assets grow slightly with the addition of the wireless monitoring and data analysis software. The core processes are reinforced by the new technologies. The wireless system allows the department to improve their collection methods. The analysis software allows the department to process the data in order to better maintain the physical network and quickly filter the data to create monthly billing profiles.

The new technologies will present only minor changes to the configuration component. The current part time job for a meter reader will be phased out as the new system is implemented. Currently, the town plans to reassign the employees with this task to other roles in the DPW.

The addition of the new technologies impacts the customer interface by altering the information and insight, and pricing structure components. The fulfillment and support component largely remains unchanged. Yet, the software could easily be extended to include a web interface for the customers. For example, the customers could log in to view their usage profile for the last month and compare this use with their typical monthly average. The area most changed is information and insight. With the new technologies, basically the same information is being collected, meter readings, but the information is collected much more often. The more frequent data points allow the software analysis application to perform a number of value added services including leak detection, meter deterioration, billing analysis, usage profiles, and theft detection. The relationship dynamics remains unchanged. Again, the software could be extended to allow a web interface with the customers. This web may be a source of information for the customers, lessening the need to place phone calls or make appointments.

The pricing structure may change because of the new technologies. The town may choose to move from a bi-annual billing cycle to a monthly billing cycle. This move would improve the cash flow for the water department. The more frequent collection of readings facilitates the migration to a more frequent billing cycle.

The new technologies will improve the customer benefits by improving the town's ability to monitor the distribution system and by providing additional value added services.

The value network will remain unchanged with the introduction of the new technologies in the water department. The town will continue to utilize the MWRA to supply water to the distribution network.

Similarly, the company boundaries will remain unchanged. The town will continue to use the MWRA as a supplier and internally maintain the distribution system, collect readings, and process and collect bills.

Chapter 5 - Results, Recommendations, and Conclusion

This chapter presents the results, recommendations, and conclusion. The results recap the industry analysis, value chain analysis, and business model framework used in Chapter 4. The recommendations include key observations for Arlington's DPW relating to the new wireless and data analysis applications. The conclusion applies the lessons learned to a broader audience.

5.1 Results

This thesis examines the business transformation effects caused by implementing a new wireless collection system and a data analysis application in Arlington's DPW. Specifically, the business transformation effects are studied using current business strategy guidelines and frameworks. The frameworks used are the five force method, the value chain analysis, and Hamel's business model concept. Each framework is studied from two vantage points. The first view attempts to describe and understand the existing business without the new technologies. The second view examines the business using each of the frameworks after the new systems are in place. By comparing the before and after states one can better understand or predict the business transformation that will take place by installing the new technologies.

The five force analysis shows that if the use of the new technologies becomes widespread the impact will be favorable on the industry. The effects of the new systems will potentially lower the force of rivalry and substitutes and raise the barriers to entry. The forces of buyer

power and supplier power will remain largely unchanged. Table 5-1 below summarizes the results of the industry analysis. Recall the five force analysis helps to explain the attractiveness and relative profit potential of the industry. The new information technologies seem to improve the structure of the industry for the current players. In turn, an improved industry structure indicates a positive direction for Arlington's DPW.

Force	Nature of Force in Existing Business	Nature of Force After New IT Systems	Effect of New Technologies
Rivalry	Low	Low	Lowers
Substitutes	Low	Low	Lowers
Buyer Power	Low	Low	No Change
Supplier Power	Mutual Dependence	Mutual Dependence	No Change
Barriers to Entry	High	High	Raises

Table 5-1 Summary of the Industry Analyses

An area affected but not covered in the five force analysis is the scope of the industry. The new technologies may significantly widen the scope of the industry in two ways. First, the ability to remotely collect readings could easily be expanded to include other utilities. Second, the frequent monitoring of the customers produces a source of value. For example, home security systems or sprinkler systems could use the data collected to expand their capabilities and improve the value of their services.

The value chain analysis breaks a firm's activities down into discrete strategic activities covering both primary and secondary categories. Figure 5-2 displays the value chain. The

analysis in this thesis focuses on the DPW's primary activities, which include inbound logistics, operations, outbound logistics, marketing and sales, and service.

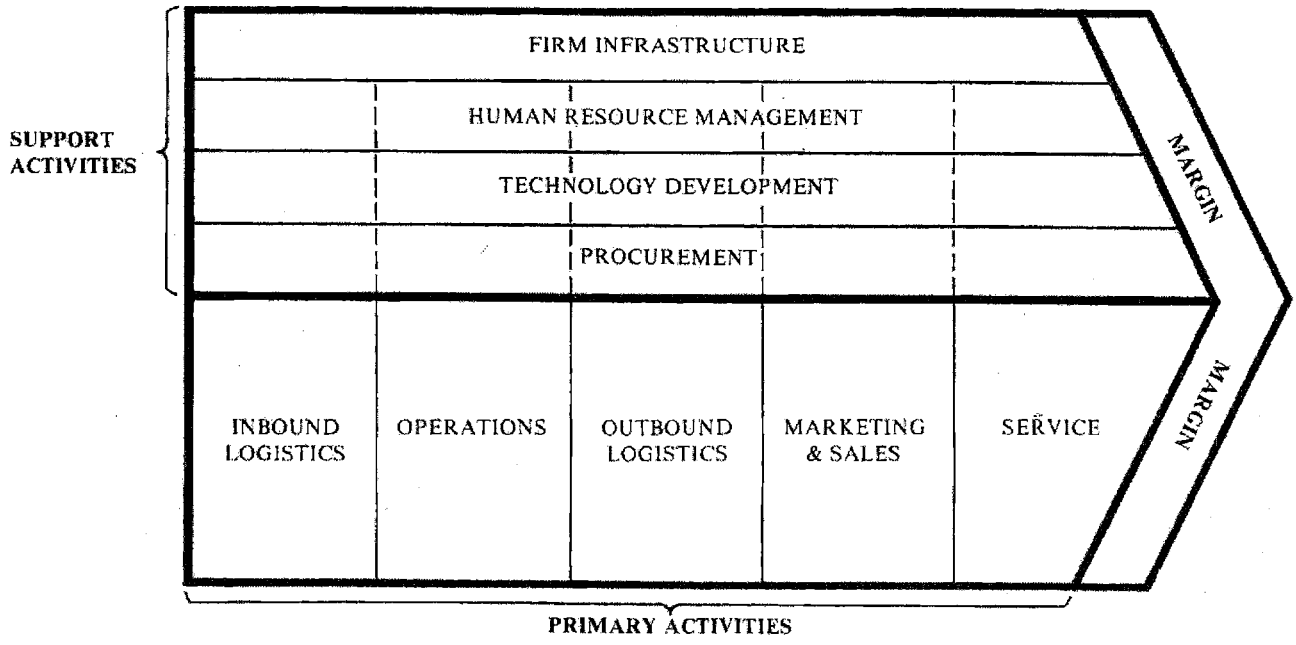


Figure 5-1 The Generic Value Chain (Porter, 37)

The new IT systems will alter the inbound logistics, operations, outbound logistics, and service activities. The current scope of the new technologies will minimally affect the marketing and sales activities. The ability to monitor and analyze the interface between the DWP and the MWRA will enrich the inbound logistics. The new system will improve the operational activities because it will allow Arlington to detect leaks, track meter deterioration, identify theft, and monitor individual meters or groups of meters. Changing the way the meters are read and the intervals between readings affects the outbound logistics. This change alters the DPW's

interface with their customers and can result in both positive and negative outcomes. The negative possibilities include customer's privacy concerns. Collecting more frequent data at a lower cost is a positive change. Finally, the new technologies will expand the service activities to include leak detection, billing analysis, theft detection, individual meter usage monitoring, group usage monitoring, and meter deterioration analysis.

Gary Hamel's business model is the third framework applied. The framework offers a simple yet complete view of the business. Hamel divides the business into four major components, which are bridged by three linking components. Figure 5-3 displays the business model.

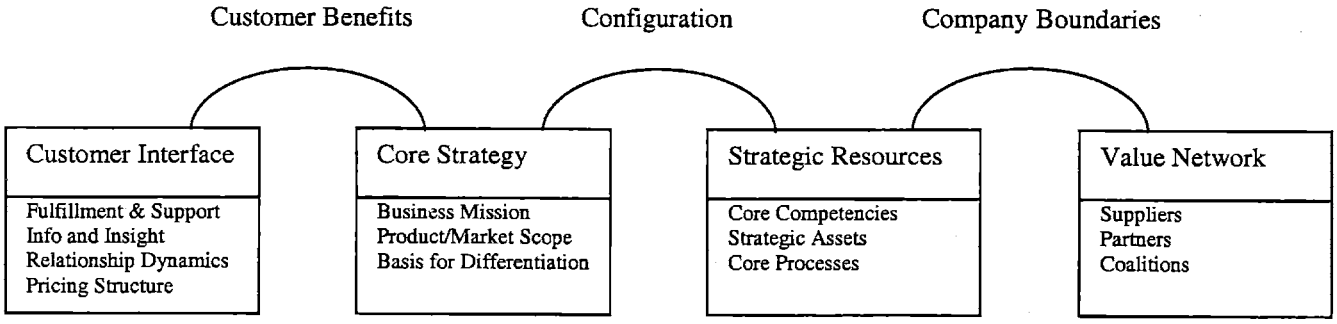


Figure 5-2 The Business Model (Hamel, 70)

The new wireless collection and data analysis systems will impact the core strategy, strategic resources, customer interface, and customer benefits. The remaining components of configuration, value network, and company boundaries will undergo little or no change. The core strategy includes the business mission, product and market scope, and basis for differentiation. The new technologies support the business mission, widen the product and

market scope, and improve the DPW's basis for differentiation. The strategic resources include the core competencies, strategic assets, and core processes. The new information systems complement the core competencies, increase the strategic assets, and improve the efficiency of the core processes. The customer interface components affected are information and insight and the pricing structure. The information and insight collected and gained for each customer increases dramatically. Also, collecting frequent data may allow the DPW to alter the pricing structure. The frequent readings will allow the town to bill their customers more often, thus increasing the town's cash flow. Finally, by improving the customer interface and adding new value added services that support the core strategy, the DPW will offer an enriched set of customer benefits.

In additional to the results of the specific analyses for the water department, we should carefully consider the town as a whole. Towns compete for customers in ways similar to other businesses. In the case of a town, the customer takes the form of a resident. Pleased residents are much more likely to remain in the town, thus continuing to pay taxes and or fees to the town. In return, the town must continue to offer a competitive array of services and products in order to show the residents that their money is well spent. This thesis examines a specific service most towns offer, a water distribution system. In the case, Arlington employs a sound competitive strategy by incorporating new information technologies that will improve the services offered by the water department. Implementing the new wireless data collection and analysis tools early in the technology adoption curve differentiates Arlington's water distribution system from other towns. This level of differentiation will make the town of Arlington more attractive to potential residents.

Another important topic not captured in the business frameworks used is the importance of controlling costs in the town. As mentioned earlier, the water department is managed as an enterprise fund that is required to show a zero profit in each fiscal year. Purchasing, installing, and integrating new information technology systems is an expensive endeavor. The town must carefully select appropriate products within this constraint framework. Currently, Arlington estimates that the wireless system will pay for itself within 18 months.

5.2 Recommendations

Arlington's DPW should consider all of the possible business transformation effects presented in this paper. Presently, the decision to implement a wireless reading collection system and a data analysis application seems to be a good choice for the town. The new technologies support the town's business model, improve several of the activities in the value chain, and may even improve the overall structure of the industry.

More importantly, the DPW should consider forming their own framework for considering new information technology systems. An effective framework should help to predict the business transformation effects across the organization. Examining the effects across department boundaries will help to ensure that the vision of the department continues to support the strategy of the town. In the case presented, Arlington's water department exploits existing information technologies to improve the services of the water distribution system while also improving the attractiveness of the town to both current and future residents. The town should consider applying this forward thinking strategy to other departments as well.

Finally, this paper examines the new technologies from a before and after view. Not included are the effects from the implementation. Often, a poor implementation strategy can stifle an effective set of technologies before benefits are ever reaped. The water department in particular may want to think about operating both the current system and new system simultaneously. Chances are the implementation of the wireless system will include an incremental roll out of the devices. This leaves a time window where some customers will have two data points during the year and others will have two readings a day. It is important that the new data analysis application is capable of incorporating both states. Also, the user must be aware of the situation so the results can be used effectively. For example, a calculated average daily use value will have much less meaning for an account will manual meter readings than an account with wireless readings twice a day.

5.3 Conclusion

Information technology is a powerful tool. The recent boom of technology stocks and the successful initial public offerings of technology based start-ups is a tribute to the power of information technology in the business world. At one point, Amazon.com, an Internet based retailer founded by selling books online, was valued higher than the entire bricks and mortar based book industry. Firms like Amazon.com were valued based on the promise of future revenues and market share. Then, late in 2000 and early 2001 we saw the technology market erode even quicker than it grew. Companies were again valued based on traditional metrics such as profits. Similarly, venture capitalists forced start-ups to rethink their high burn rates. This

lesson proves that while information technologies are powerful tools, their use in the business world is widely misunderstood. Now more than ever, companies will be forced to think carefully through Information Technology decisions.

The basis of this paper is to present a simple framework for relating new technologies to existing business strategy concepts. Managers need to develop appropriate frameworks that allow them to understand the business transformation effects of new information technologies. This task may prove difficult as the effects from new IT systems are often far reaching and cross-organizational. Overall, the framework should help clarify how the new system(s) affects the industry structure, value chain, business strategy, organizational structure, and even culture.

Information technology enables businesses to accomplish goals. IT solutions can be actively managed and help and organization achieve a sustained competitive advantage. Conversely, new technologies can drive change and alter your business in ways that erode current and future profit streams. IT can be a source of competitive advantage only if the connection between the technology and strategy is well understood.

References

Department of Public Works (DPW) , Arlington MA. "Fiscal Year 2002 Budget Statement." 2001.

Grant, R. The Concept of Strategy. Contemporary Strategy Analysis. Cambridge, MA: Blackwell, 1995: 3-28.

Hamel, Gary. Leading the Revolution. Boston, MA: Harvard Business School Press, 2000.

Hamel, G. And C. Prahalad. "Strategic Intent." Harvard Business Review May 1989: 63-76.

Malone, T. W. And J. F. Rockart. "Computers, Networks, and the Corporation." Scientific American September 1991: 128-136.

March, G. James "Exploration and Exploitation in Organizational Learning." Organizational Science Vol 2, No 1, Feb 1991.

Oster, Sharon M. Modern Competitive Analysis, 3rd ed. New York, NY: Oxford University Press, 1999.

Porter, Michael E. Competitive Advantage: Creating and Sustaining Superior Performance. New York, NY: The Free Press, 1985.

Porter, M. And V. Millar. "How Information Gives You Competitive Advantage." Harvard Business Review. July/Aug. 1985: 149-160.

Prahalad, C. K. And G, Hamel. "The Core Competence of the Corporation." Harvard Business Review May 1990.

Sun Tzu. "The Art of Strategy: A New Translation of Sun Tzu's Classic The Art of War" trans. R.L. Wing . New York, NY: Doubleday, 1988.

Appendix 1 – Data Dictionary

Table: **Account** – Stores all information relating to the customer's account				
Field	Type	Null	Default	Description
AcctNo (PRI)	varchar(20)			the account number
StreetNo	int(11)	YES		the street number
Street	varchar(50)	YES		the street name
AptNo	varchar(10)	YES		the apartment number
LastUpdate	date	YES		the last time the account was updated
PropertyType	varchar(20)	YES		the property type (references table PropertyType)
ZoneID	int(11)	YES		integer (0,1,2,3) that represents one of the three zones (refer to table Zone)
Status	enum('Act','Del')	YES	Act	indicates if the record is active or deleted, no records will be completely removed from the database

Table: **BPConfig** – Stores all information related to the configuration of the Bill Prep functionality				
Field	Type	Null	Default	Description
EndDate (PRI)	datetime		0000-00-00 00:00:00	the end date for the analysis
SysDate	datetime		0000-00-00 00:00:00	the date the analysis was run
BPMiss	enum('false, 'true')		false	flag to indicate if the BP Missing analysis should be run
BPEst	enum('false, 'true')		false	flag to indicate if the BP Estimated analysis should be run
BPInc	enum('false, 'true')		false	flag to indicate if the BP Ab Inc analysis should be run
BPDec	enum('false, 'true')		false	flag to indicate if the BP Ab Dec analysis should be run
BpMissDays	int(11)	YES	NULL	number of days before end date to look for missing reads
BpMissInterval	int(11)	YES	NULL	defines the time interval for a missing reading
BpEstDays	int(11)	YES	NULL	number of days before end date to look for estimated reads
BpIncCurrDays	int(11)	YES	NULL	the number of days used to define the current time period
BpIncPastDays	int(11)	YES	NULL	the number of days used to define the past time period
BpDecCurrDays	int(11)	YES	NULL	the number of days used to define the current time period
BpDecPastDays	int(11)	YES	NULL	the number of days used to define the past time period
BpAbDecPct	decimal(10,0)	YES	NULL	the percent decrease parameter set by the user
BpAbIncPct	decimal(10,0)	YES	NULL	the percent increase parameter set by the user

Table: **BPDecResults** – holds results for the Bill Prep Abnormal Decrease analysis				
Field	Type	Null	Default	Description
AcctNo	varchar(20)			the account number
Suffix	char(1)			a unique identifier for accounts with multiple meters
AvgPastUsage	double(19,2)	YES	NULL	the average daily usage during the past time period
AvgCurrUsage	double(19,2)	YES	NULL	the average daily usage during the current time period
PercentDec	double(21,4)	YES		the calculated percent decrease for the meter
SysDate	datetime	YES	0000-00-00 00:00:00	the date the analysis was run
EndDate	datetime	YES	0000-00-00 00:00:00	the end date for the analysis
ConfigPercent	int(11)	YES	NULL	the percent decrease parameter set by the user
CurrDays	int(11)	YES	NULL	the number of days used to define the current time period
PastDays	int(11)	YES	NULL	the number of days used to define the past time period

Table: **BPEstResults** – holds resutls for the Bill Prep Estimated Readings analysis				
Field	Type	Null	Default	Description
AcctNo	varchar(20)			the account number
Suffix	char(1)			a unique identifier for accounts with multiple meters
ReadDate	datetime		0000-00-00 00:00:00	the read date for the estimated reading

Table: **BPIncResults** - holds results for the Bill Prep Abnormal Decrease analysis				
Field	Type	Null	Default	Description
AcctNo	varchar(20)			the account number
Suffix	char(1)			a unique identifier for accounts with multiple meters
AvgPastUsage	double(19,2)	YES	NULL	the average daily use in the past time period
AvgCurrUsage	double(19,2)	YES	NULL	the average daily use in the current time period
PercentInc	double(21,4)	YES		the calculated percent decrease for the meter
SysDate	datetime	YES	0000-00-00 00:00:00	the date the analysis was run
EndDate	datetime	YES	0000-00-00 00:00:00	the end date for the analysis
ConfigPercent	int(11)	YES	NULL	the percent decrease parameter set by the user
CurrDays	int(11)	YES	NULL	the number of days used to define the current time period
PastDays	int(11)	YES	NULL	the number of days used to define the past time period

Table: **BPMissResults** – holds resutls for the Bill Prep Missing Readings analysis				
Field	Type	Null	Default	Description
AcctNo	varchar(20)			the account number
Suffix	char(1)			a unique identifier for accounts with multiple meters
Date1	datetime		0000-00-00 00:00:00	the reading at the beginning of the missing read period
Date2	datetime		0000-00-00 00:00:00	the reading at the end of the missing read period

Table: **Config** – holds all the parameters from the report configuration page, which are used to define each analysis				
Field	Type	Null	Default	Description
EndDate (PRI)	datetime		0000-00-00 00:00:00	the end date for the analysis
BoolBpMiss	enum('false','true')		false	indicates if the Bill Prep Missing reads should be run
BoolBpEst	enum('false','true')		false	indicates if the Bill Prep Estimated reads should be run
BoolBpAbInc	enum('false','true')		false	indicates if the Bill Prep Ab Inc reads should be run
BoolBpAbDec	enum('false','true')		false	indicates if the Bill Prep Ab Dec reads should be run
BpMissDays	int(11)	YES	NULL	the number of days before the end date for BP Miss
BpMissInterval	int(11)	YES	NULL	defines the number of hours between readings that indicates a missing read
BpEstDays	int(11)	YES	NULL	the number of days before the end date for BP Est
BpIncCurrDays	int(11)	YES	NULL	the number of days before the end date for the BP Ab Inc current time period
BPIncPastDays	int(11)	YES	NULL	the number of days before the end date for the BP Ab Inc past time period
BpAbIncPct	decimal(6,3)	YES	NULL	the threshold percentage for the BP Ab Inc analysis
BpDecCurrDays	int(11)	YES	NULL	the number of days before the end date for the BP Ab Dec current time period
BPDecPastDays	int(11)	YES	NULL	the number of days before the end date for the BP Ab Dec past time period
BpAbDecPct	decimal(6,3)	YES	NULL	the threshold percentage for the BP Ab Dec analysis
BoolUsgMtSz	enum('false','true')		false	indicates if the Usage Pattern should include Meter Sizes
BoolUsgAcctTyp	enum('false','true')		false	indicates if the Usage Pattern should include Account Types
BoolUsgMtSz58	enum('false','true')		false	indicates if the Usage Pattern should include the 5/8" meter size
BoolUsgMtSz1	enum('false','true')		false	indicates if the Usage Pattern should include the 1" meter size
BoolUsgMtSz112	enum('false','true')		false	indicates if the Usage Pattern should include the 1 1/2" meter size
BoolUsgMtSz2	enum('false','true')		false	indicates if the Usage Pattern should include the 2"

				meter size
BoolUsgMtSz3	enum('false','true')		false	indicates if the Usage Pattern should include the 3" meter size
BoolUsgAcctTypRes	enum('false','true')		false	indicates if the Usage Pattern should include the Residential account type
BoolUsgAcctTypCom	enum('false','true')		false	indicates if the Usage Pattern should include the Commercial account type
UsgDays	int(11)	YES	NULL	the number of days to include before the end date for the Usage Pattern analysis
BoolMtWatch	enum('false','true')		false	indicates if the Meter Watch should include be run

Table: **ICSBillRead** – stores the aggregatged Monthly readings per meter that are sent to the ICS for billing purposes				
Field	Type	Null	Default	Description
ReadDate (PRI)	datetime		0000-00-00 00:00:00	the date and time the meter was read
AcctNo (PRI)	varchar(20)			the account number
Suffix (PRI)	char(1)			a unique identifier for accounts with multiple meters
Reading	decimal(10,0)	YES	NULL	The last reading during the billing period (usually the last reading for the meter for the month)
Counter	decimal(5,0)	YES	NULL	a counter indicating how many times the meter has flipped over (ex, 99999 to 00001)
TimeBilled	datetime	YES	NULL	(created and used by the ICS system)
Estimated	enum('Y','N')	YES	NULL	flag to indicate if the reading is estimated
Status	enum('Act','Del')	YES	Act	indicates if the record is active or deleted, no records will be completely removed from the database

Table: **Meter** – stores all information relating directly to the meter				
Field	Type	Null	Default	Description
AcctNo (PRI)	varchar(20)			the account number
Suffix (PRI)	char(1)			a unique identifier for accounts with multiple meters
ArbNo	int(11)	YES	NULL	
MeterSize	double(6,0)	YES	NULL	a short hand key for the meter size
MeterType	varchar(20)	YES	NULL	a short hand key for the meter type
MeterSeq	smallint(6)	YES	NULL	
Location	varchar(20)	YES	NULL	the physical location of the meter
MeterNum	varchar(20)	YES	NULL	a number identifying the meter (not all have this number)
NumDigits	smallint(6)	YES	NULL	the number of digits the meter can read
xMultiple	double(6,0)	YES	NULL	
DateInstalled	datetime	YES	NULL	the date the meter was installed
ReadInstr	varchar(30)	YES	NULL	instructions for manually reading the meter
Status	enum('Act','Del')	YES	Act	indicates if the record is active or deleted, no records will be completely removed from the database

Table: **MeterRead** – stores the actual meter readings from the field, will contain a mix of wireless and manual raw readings				
Field	Type	Null	Default	Description
ReadDate (PRI)	datetime		0000-00-00 00:00:00	the date and time the meter was read
AcctNo (PRI)	varchar(20)			the account number
Suffix (PRI)	char(1)			a unique identifier for accounts with multiple meters
Reading	decimal(10,0)	YES	NULL	the meter reading in CCF
Estimated	enum('Y','N')	YES	N	a flag to indicate if the readings is estimated or not
TypeofRead	varchar(5)	YES	NULL	a short-hand key that represents the type of meter read
Adjustment	decimal(10,0)	YES	NULL	a value used to adjust the actual reading if it is in error, the adjustment can be positive or negative
AdjustmentReason	varchar(50)	YES	NULL	the reason the reading was adjusted
Counter	int(11)		0	a counter indicating how many times the meter has flipped over (ex, 99999 to 00001)
LostConnection	enum('Y','N')	YES	N	a flat to indicate if the wireless unit has lost physical connection with the meter
Status	enum('Act','Del')	YES	Act	indicates if the record is active or deleted, no records will be completely removed from the database

Table: **MeterSealActions** – stores a list of each meter seal action				
Field	Type	Null	Default	Description
SealActivityDate (PRI)	datetime		0000-00-00 00:00:00	the date the seal activity took place
AcctNo (PRI)	varchar(20)			the account number
Suffix (PRI)	char(1)			a unique identifier for accounts with multiple meters
MeterSealType	char(20)	YES	NULL	a short hand key for each meter seal type
SealActivityType	char(20)	YES	NULL	a short hand key for each meter seal activity
Comments	char(20)	YES	NULL	comments to explain the seal action

Table: **MeterSealActivity** – stores a complete list of each meter seal activity				
Field	Type	Null	Default	Description
SealActivityType (PRI)	char(20)			a short hand key for each meter seal activity
SealActivityDesc	char(50)	YES	NULL	the description of the meter seal activity

Table: **MeterSealType** – stores a complete list of each meter seal type				
Field	Type	Null	Default	Description
MeterSealType (PRI)	char(20)			a short hand key for each meter seal type
MeterSealDesc	char(50)	YES	NULL	the description of the meter seal type

Table: **MeterSize** – stores a complete list of each meter size				
Field	Type	Null	Default	Description
MeterSize (PRI)	decimal(6,2)			a short hand key for each meter size
SizeDesc	char(50)	YES	NULL	the description of the meter size

Table: **MeterType** – stores a complete list of each meter type				
Field	Type	Null	Default	Description
MeterType (PRI)	varchar(20)			a short hand key for each meter type
TypeDesc	varchar(50)	YES	NULL	the description of the meter type

Table: **MeterWatch** – stores a list of meters that are currently on "Watch"				
Field	Type	Null	Default	Description
AcctNo (PRI)	varchar(20)			the account number
Suffix (PRI)	char(1)			a unique identifier for accounts with multiple meters
TimePeriod	int(11)	YES	NULL	a number of days before the EndDate to query the meter for readings
Reason	varchar(50)	YES	NULL	the reason the meter was placed on watch
Comments	varchar(50)	YES	NULL	additional comments why the meter was placed on watch

Table: **MeterWatchResults** – stores the latest results from the MeterWatch functionality				
Field	Type	Null	Default	Description
DateRun (PRI)	datetime		0000-00-00 00:00:00	the date the analysis was run
AcctNo (PRI)	varchar(20)			the account number
Suffix (PRI)	char(1)			t a unique identifier for accounts with multiple meters
EndDate	datetime	YES	NULL	the end date for the analysis
AvgDayUse	decimal(6,2)	YES	NULL	the average daily use for the meter during the time period
Reason	varchar(20)	YES	NULL	the reason the meter was placed on watch
Comments	varchar(50)	YES	NULL	additional comments why the meter was placed on watch
TimePeriod	int(11)	YES	NULL	the number of days included before the end date

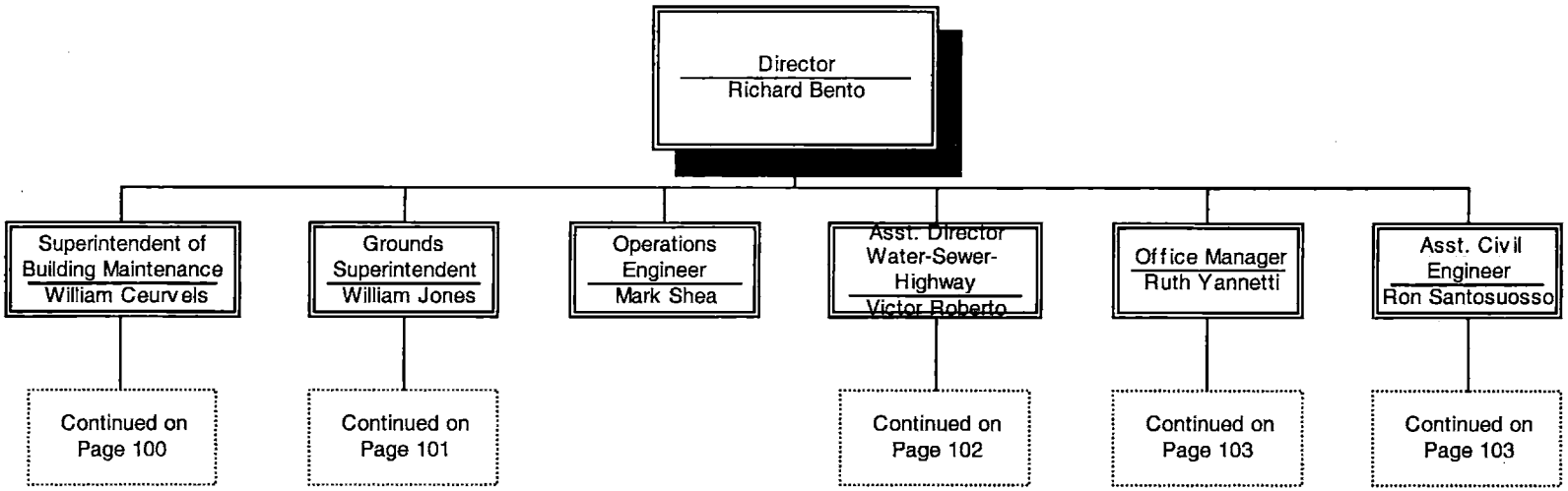
Table: **PropertyType** – stores a complete list of each property type				
Field	Type	Null	Default	Description
PropertyType (PRI)	char(10)			a short hand key for each property type
PropertyDesc	char(30)	YES	NULL	the description of the property type

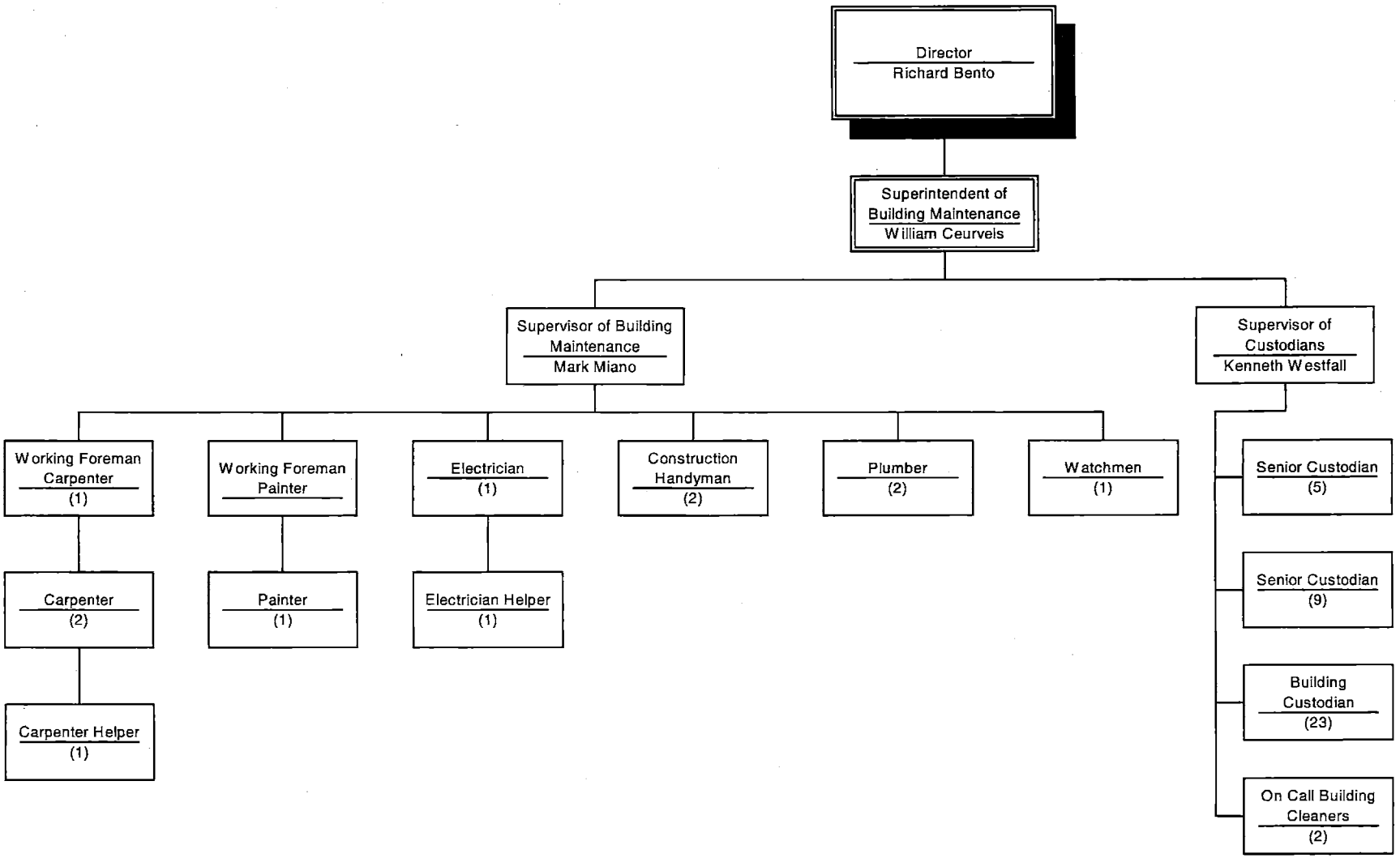
Table: **TypeofRead** – stores a complete list of each type of meter read				
Field	Type	Null	Default	Description
TypeofRead (PRI)	varchar(10)			a short-hand key that represents a type of meter read
ReadDesc	varchar(20)	YES	NULL	a description of the type of read

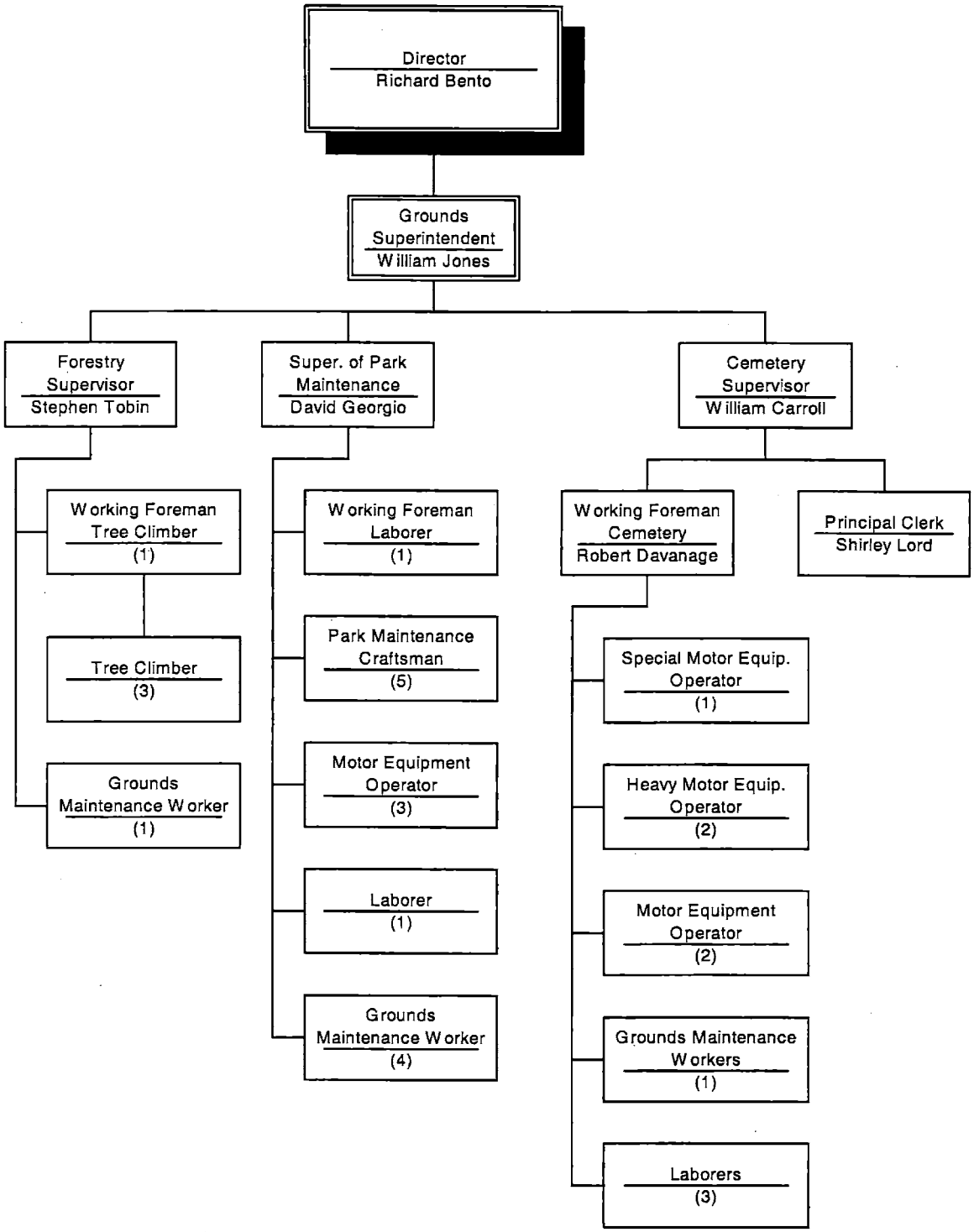
Table: **UsagePatternResults** – stores the latest results from the UsagePattern functionality				
Field	Type	Null	Default	Description
GroupID PRI)	varchar(65)			a meaningful ID that describes the attributes of the group
AvgDayUseGrp	decimal(8,2)	YES	NULL	the average daily usage of the aggregated group
MaxTotalUse	decimal(8,2)	YES	NULL	the max usage by any one meter in the group
MinTotalUse	decimal(8,2)	YES	NULL	the min usage by any one meter in the group
MaxAvgDayUse	decimal(8,2)	YES	NULL	the max average daily usage by any one meter in the group
MinAvgDayUse	decimal(8,2)	YES	NULL	the min average daily usage by any one meter in the group
DateRun	datetime	YES	NULL	the date the analysis was run
TimePeriod	int(11)	YES	NULL	the number of days included before the end date
EndDate	datetime	YES	NULL	the end date for the analysis

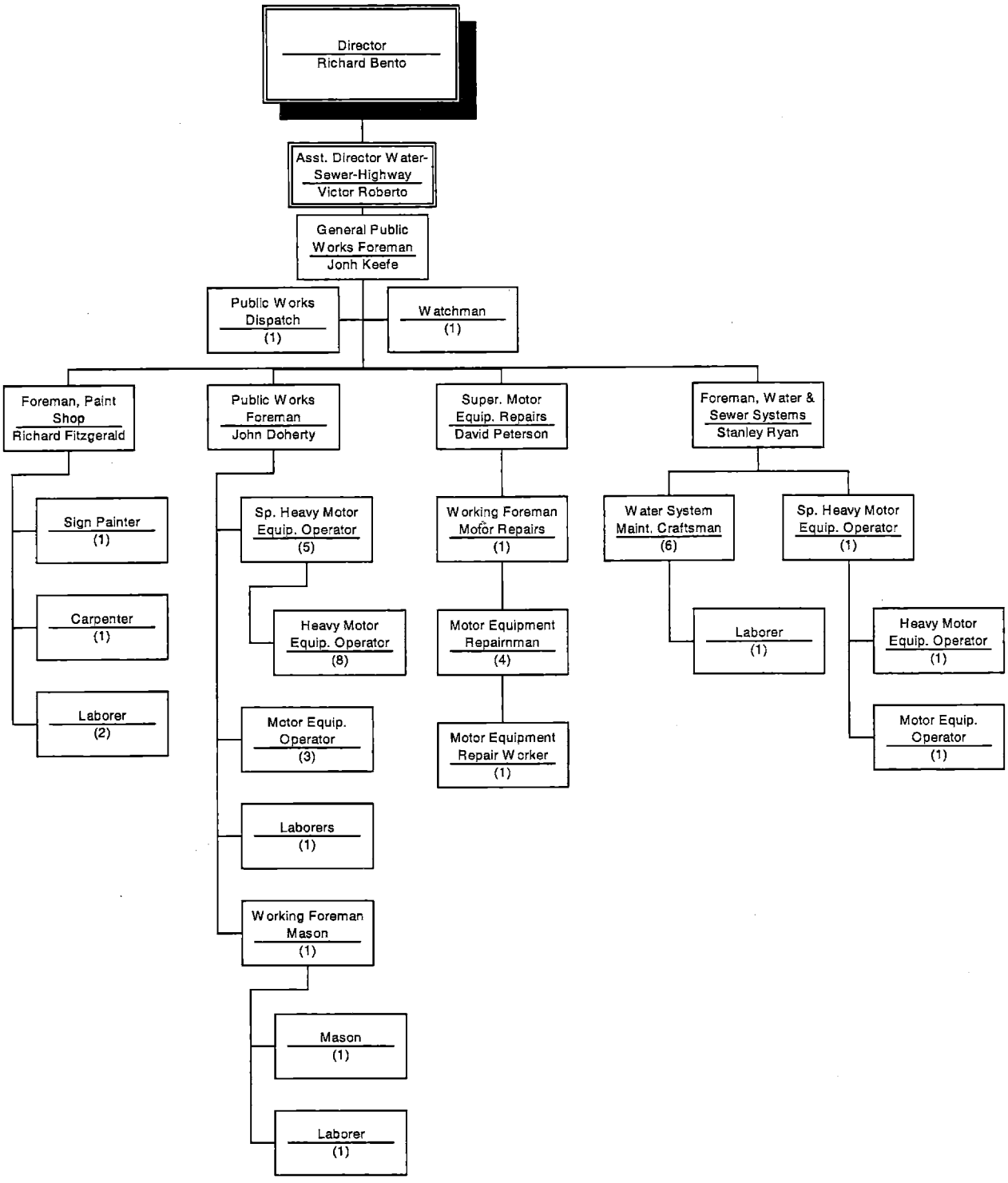
Table: **Zone** – stores a consolidated list of all the zones (High, Low, Intermediate, Not in Arlington)				
Field	Type	Null	Default	Description
ZoneID (PRI)	smallint(6)			an ID (0,1,2,3) to represent a zone
ZoneName	char(20)	YES	NULL	the name of the zone
ZoneDesc	char(50)	YES	NULL	a short description of the zone

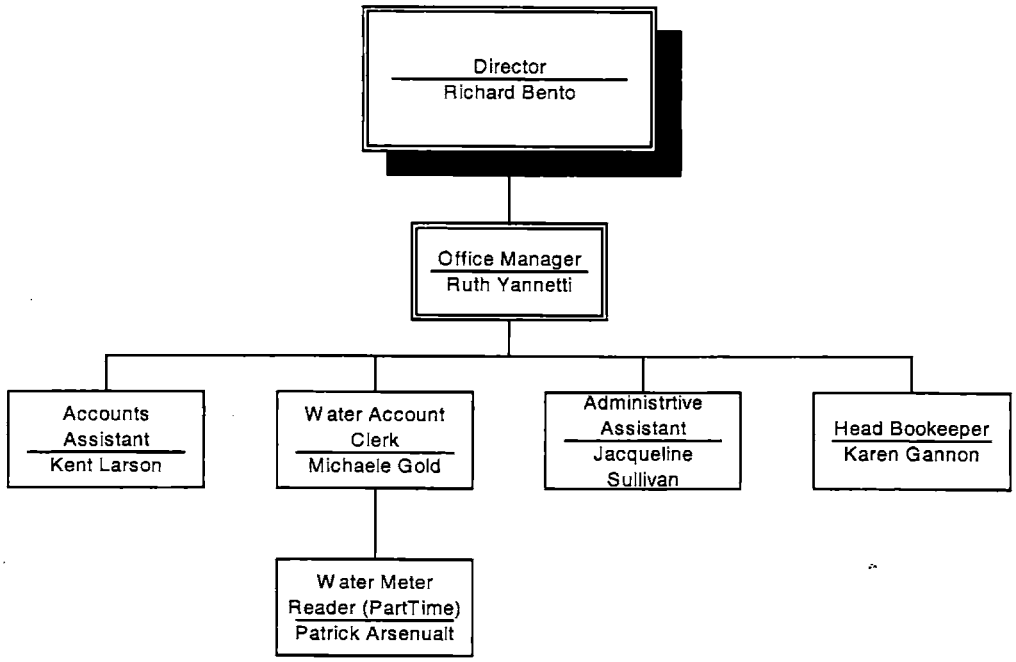
Appendix 2 – Organizational Chart (DPW)

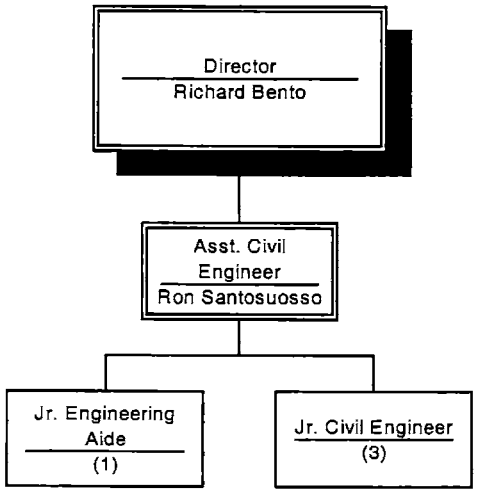



Director
Richard Bento
Superintendent of Building Maintenance
William Ceurvels
Supervisor of Building Maintenance
Mark Miano
Supervisor of Custodians
Kenneth Westfall
Working Foreman Carpenter (1)
Working Foreman Painter
Electrician (1)
Construction Handyman (2)
Plumber (2)
Watchmen (1)
Carpenter (2)
Painter (1)
Electrician Helper (1)
Carpenter Helper (1)
Senior Custodian (5)
Senior Custodian (9)
Building Custodian (23)
On Call Building Cleaners (2)


Director
Richard Bento
Grounds Superintendent
William Jones
Forestry Supervisor
Stephen Tobin
Super. of Park Maintenance
David Georgio
Cemetery Supervisor
William Carroll
Working Foreman Tree Climber
(1)
Tree Climber
(3)
Grounds Maintenance Worker
(1)
Working Foreman Laborer
(1)
Park Maintenance Craftsman
(5)
Motor Equipment Operator
(3)
Laborer
(1)
Grounds Maintenance Worker
(4)
Working Foreman Cemetery
Robert Davanage
Principal Clerk
Shirley Lord
Special Motor Equip. Operator
(1)
Heavy Motor Equip. Operator
(2)
Motor Equipment Operator
(2)
Grounds Maintenance Workers
(1)
Laborers
(3)


Director
Richard Bento
Asst. Director Water-Sewer-Highway
Victor Roberto
General Public Works Foreman
Jonh Keefe
Public Works Dispatch
(1)
Watchman
(1)
Foreman, Paint Shop
Richard Fitzgerald
Sign Painter
(1)
Carpenter
(1)
Laborer
(2)
Public Works Foreman
John Doherty
Sp. Heavy Motor Equip. Operator
(5)
Heavy Motor Equip. Operator
(8)
Motor Equip. Operator
(3)
Laborers
(1)
Working Foreman Mason
(1)
Mason
(1)
Laborer
(1)
Super. Motor Equip. Repairs
David Peterson
Working Foreman Motor Repairs
(1)
Motor Equipment Repairnman
(4)
Motor Equipment Repair Worker
(1)
Foreman, Water & Sewer Systems
Stanley Ryan
Water System Maint. Craftsman
(6)
Laborer
(1)
Sp. Heavy Motor Equip. Operator
(1)
Heavy Motor Equip. Operator
(1)
Motor Equip. Operator
(1)


Director
Richard Bento
Office Manager
Ruth Yannetti
Accounts Assistant
Kent Larson
Water Account Clerk
Michaele Gold
Administrtive Assistant
Jacqueline Sullivan
Head Bookeeper
Karen Gannon
Water Meter Reader (PartTime)
Patrick Arsenualt


Director
Richard Bento
Asst. Civil Engineer
Ron Santosuosso
Jr. Engineering Aide
(1)
Jr. Civil Engineer
(3)