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A STRATEGIC MANAGEMENT AND INNOVATION APPROACH TO ONSHORE GAS TRANSMISSION PIPELINE CONSTRUCTION

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ABSTRACT

This research investigates whether a traditional manufacturing planning and control strategy would make Onshore Gas Transmission Pipeline Construction more competitive and if so, design the strategy. An in-depth case study of Gas Transmission Pipeline Construction was carried out, along with an extensive literature review. The current pipeline construction process was analyzed from a strategic management perspective. From this perspective, it was found that the traditional 'make and sell' attitude of manufacturers has now almost entirely given way to a customer orientated 'sense and respond' service philosophy. This is compounded by the needs for waste avoidance, cost efficiency and service to the customer. This research investigates the strategic opportunities for establishing advantages over competitors by designing unique service oriented supply chain strategies. Rather than relying on functional hierarchy and command and control governance where a chain of commitments are poorly connected and difficult to reconfigure, the pipeline construction participants are challenged to develop more flexible process designs around a state of the art service based architecture. *Complexity reduction* has traditionally been used to deal with intricate construction supply chains. However, the architecture developed and demonstrated in this thesis will allow participants in pipeline construction to develop strategic opportunities around ideas of *complexity absorption.* The architecture is built on the premise that complexity *absorption* creates an organization that is strategically superior because it becomes a complex adaptive system that is unique to that organization. A case study is presented based on a major onshore gas transmission pipeline construction organization that illustrates an application consisting of Pipeline Construction Portal and Service Oriented Architecture. This model is internet-based and has three main constituents of Web Services, Portal and Client Services.

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CHAPTER ONE
INTRODUCTION

1.1 Overview

This research is concerned with the improvement of the operations management system of architectural, engineering, and construction (referred to in this thesis as AEC) industries through a study of the operations management system in the context of large scale construction. In particular onshore gas transmission pipeline construction will be used as a major case study. Pipeline construction managers have traditionally relied on their own tacit knowledge and experience to manage the construction process. They draw on theories from project management to assist in the planning and control of the construction project, as described in the project management book of knowledge *(PMBOK, 2002)*. That is, the construction industry today is organized into projects and current production theory and practice are heavily influenced by the concepts and techniques of project management. According to the PMBOK(2002) "*a project is a temporary endeavour undertaken to produce a unique product or service*." Making of multiple copies of a product does not occur through projects described by this methodology. Any historical or strategic information relating to projects is usually stored only in the mind of the human project manager (Neto, 2002). This focus on product uniqueness and the project form of organization has dominated thinking about production in AEC industries, so far as to discourage learning from non-project industries such as product and service manufacturing (Koskela, 1992).

Some AEC industries today, concerned with costly construction delays and suboptimal use of resources in an increasingly competitive global market, are turning to production and operations management theories and practices to determine whether a better management of operations could be achieved with a cross-fertilization of ideas and practices between traditional construction methods and production and operations management approaches. This had led to a lot of research activity by the Lean Construction Institute at Berkley, California, where the focus has been on the construction process itself, with the introduction of lean production principles into the construction process. See for example, Koskela (2000); Ballard (2000), and others, and the study of construction as an integrated lean supply chain. There is also a strong demand emerging in many AEC industries today for a more coherent strategy-based theory of construction (see for example, work undertaken by the International Lean Construction Institute at Berkeley, California) and systems to support this theory.

A strategy-based approach has also been proposed by the onshore gas transmission pipeline construction industry partners. They questioned whether a traditional manufacturing strategy and planning and control system would be a more preferred method of managing gas pipeline construction. This was the motivation for the current research project.

This research studies gas transmission pipeline construction from a strategic operations management perspective and proposes some enhancements to the existing process.

The present chapter outlines the research background and the fundamental questions that lead to the research objectives of this thesis in Section 1.2. Section 1.3 presents the research objectives. Section 1.4 presents the research design including the research questions. Justification for the research is given in 1.5. The scope and limitations of the research are discussed in Section 1.6. Thesis organization is presented in 1.7. A summary of the chapter is given in Section 1.8.

1.2 Background

The design and construction of AEC facilities (architectural, engineering, construction) poses difficult management problems to which the existing models and techniques of management, based on the project management view of production planning and control have proven inadequate. As many authors have noted, construction is a complex and non-linear process (eg. Sterman, 1992). Construction is carried out under intense budget and schedule pressure. For example, it costs AU$80k/ day to lay an onshore gas pipeline. Approx 6km of pipeline/day are laid

(GCI Kenny WA, personal communication.). In a pipeline spanning thousands of kilometers, there are many budget and time issues to be resolved. Production management concepts based on the PMI (2002) project management control model have not proven capable of solving these problems. The PMI (2002) model is based on the assumption that the work to be done can be divided into parts and managed as if those parts were independent from one another. This is fundamentally a contracting mentality, which facilitates the management of contracts rather than the management of production or work flow. Production management in project management is the 'local' responsibility of those (subcontractor organizations) to whom the various parts are assigned or contracted. If everyone meets their contractual obligations, the project performs successfully. Unfortunately, this approach is the opposite of robust. When something goes wrong, as it very often does, the entire structure is prone to collapse. Koskela (2000) confirms the poor performance of construction regarding waste, as shown in Table 1.1 below.

Table 1.1 Compilation of data on Construction Waste (Koskela, 2000)

Waste	Cost	Country
Quality costs (non conformance)	12% of total project costs	USA
External quality cost (during facility use)	4% of total project costs	Sweden
Lack of constructability	6-10% of total project cost	USA
Poor materials management	10-12% of labour costs	USA
Excess consumption of materials on site	10% on average	Sweden
Working time used for non-value adding activities on site	App. 2/3 of total time	USA
Lack of safety	6% of total project costs	USA

More recently it has been recognized by researchers in construction that by considering the construction process as a total integrated supply chain, operational waste can be eliminated. This is in line with other areas of manufacturing research (see for example papers in Towill (2000) and Womack (2000)).

Treating the construction process in a holistic manner is an important step in operations management thinking, as traditionally project and operations managers have dealt with the intricacies of construction by a complexity reduction approach, as indicated above. However, as many researchers have noted (Porter,1995; Gaither and

Frazier, 2004), operational effectiveness alone is not sufficient to gain an unfair competitive advantage. In order to gain and sustain competitive advantage a strategic management approach must be adopted. From a strategic management perspective two approaches, or schools of thought have emerged: the enterprise-centric approach, which states that strategic advantage lies in clearly identifying and strengthening core competencies and capabilities within the firm; and the *coopetition* approach, where the approach to strategy focusses less on identifying capabilities within the firm and more on identifying opportunities to achieve competitive leverage by mobilizing resources outside the firm. Using different labels—value nets and business ecosystems—Hagel III and Brown (2005) draw attention to the strategic advantages that managers can create by shaping and leveraging broader networks of resources beyond their individual enterprise.

Organizations, such as AEC organizations must consider both approaches, as most construction organizations are made up of a network of subcontractor organizations. In considering a strategic management approach to pipeline delivery, AEC industries must develop an operations strategy that harnesses the complementary capabilities from all of the subcontractor organizations. Simply harnessing the capabilities of the value or supply network is not sufficient. As Hamel (2000) notes, to gain and sustain competitive advantage in the 21st century, executives must look to innovatory business concepts and models. That is, they must look beyond the product and service level to the underlying processes and how these processes accelerate capability building across the value network. Accelerated capability building is considered to be the most powerful source of competitive advantage in a global economy characterized by intensifying competition (Hagel III and Brown, 2005). The challenge is to convert the capability building into performance improvement as quickly as possible.

This research studies the onshore gas pipeline construction process from a strategic management and innovation perspective. It can be shown that the strategic positioning of the pipeline construction organization is out of alignment with pipeline construction operations. An e-operations strategy is proposed, which will enable the acceleration and continuous building of the construction network's dynamic capabilities. The contribution of this research is that it presents a detailed and dynamic strategic architecture for construction managers to create a learning organization, by leveraging the tacit knowledge of all members of the construction value network. This strategy, unlike many manufacturing and operations strategies focuses on leveraging and building the intangible assets of the construction network. This will create value for the shareholders as well as the customers.

Research Objectives

1. Study and analyze onshore gas transmission pipeline construction planning and control from a value network perspective
2. Describe the execution capabilities and strategic positioning of the existing pipeline construction planning and control system
3. Identify areas of misalignment that exist in the current manufacturing planning and control value stream
4. Recommend improved and aligned framework

1.3 Research Design

Prior to selecting a research strategy, it is necessary to determine the research topic, question, and purpose. The *topic* of this research is engineering management; more specifically, designing a manufacturing planning and control strategy and system to improve the design and construction processes of architectural/ engineering/ construction projects – in particular, onshore gas transmission pipeline construction. The *questions* driving this research are presented below.

Research Question 1. What is the current planning and control strategy and system for Gas Transmission Pipeline Construction and what are the limitations?

Research Question 2. How do the processes and sub-processes in Gas Transmission Pipeline Construction differ from a manufacturing system?

Research Question 3. Are the manufacturing planning and control strategy and system applicable to pipeline construction?

Research Question 4. In view of the most recent developments in manufacturing philosophy, does this have potential for improving the efficiency of pipeline construction?

Research Question 5. Specifically, can a model be developed to apply manufacturing strategy and systems to gas transmission pipeline construction?

The *purpose* of this research is to evaluate and improve the effectiveness of the management of this process, so that a more effective utilization of resources, including IT, may be achieved.

1.4 Justification

As mentioned above, a lot of research activity is currently underway to improve the construction process, particularly in the building trade. This research at present focuses largely on improvements in operational effectiveness of the construction process. See for example, Ballard (2000); Koskela (2000). However, the argument presented here is, based on a literature review of many other areas of research in operations management, and the author's own case studies, that to make onshore gas transmission pipeline construction more efficient, planning and control has to be managed as an integrated business process across all organizations involved in pipeline construction and this process has to be strategically aligned. That is, to deal with complexity, it is preferable to manage the entire value chain/supply chain and align it, rather than managing individual and fragmented member organizations of the supply chain. The integrated model proposed by this research will also leverage and build the intangible resources of the supply network. This will enable a learning organization for pipeline construction. This research aims to be a first step in identifying a more appropriate planning and control model and subsequent architecture for AEC decision support.

1.6 Research Scope

The scope of this research is limited by three major factors: business type, industry type, and geographical location.

Business Type. This research is limited to the study of planning and control in onshore gas transmission pipeline construction. Many other construction services exist, however, due to time constraints and the complexity associated with each additional service, the research focus is on the onshore gas transmission pipeline construction.

Industry Type. The framework emphasizes only one industry in the AEC sector, namely the large scale engineering and construction industry. Therefore a lot more research is required to compare and contrast the findings from other AEC industries, even building and construction, roadwork and bridge construction.

Geographical Location. A lot of travel was undertaken in this case study, ranging from the Illawarra district in NSW, the ACT, and the far north of WA. However, there are many more geographical locations of pipeline construction in Australia and the surrounding oceans which were not covered.

1.7 Thesis Organization

The outline of the thesis is presented below.

Chapter 1 - Introduction

The present chapter places the research in its context and introduces the background that led to the choice of research questions and their corresponding objectives. It included the need for understanding and consolidating the core ideas underlying current production management planning and control theories and an indication of the strategic alignment and adaptation that is needed for all systems in today's global economy. The chapter also discusses the reasons for choosing gas transmission pipeline construction as the main source of data. The chapter also presents the working hypothesis, the research scope and an outline of the research method.

Chapter 2 – Theoretical Issues in Operations Strategies

This chapter presents a brief overview of planning and control issues relevant to the current research. It argues that although construction management follows a project management approach to planning and control, the present production management approach to planning and control has shortcomings as well. It argues that the main reason all planning and control approaches fail is because they only focus on operational effectiveness within one organization. It is argued that operational effectiveness and/or operational strategies in isolation are inadequate in coping with the chaos and complexity of current global organizations and their planning and control processes. It concludes by stating that a planning and control system must take the value network approach, and manage across enterprises, and that these value streams must be competitive and require management as a whole.

Chapter 3 – Research Method

Chapter 3 presents the research methodologies. It explains the reasons for choosing "case study" as the research strategy and describes, in some detail, the content of the research design; including the data collection techniques, the protocol for data collection, the unit of analysis and the criteria for selecting the relevant companies. Finally, it presents an overview of the case studies themselves and the criteria used to interpret the research findings.

Chapter 4 - Case Study Analysis and Proposed Architecture

Chapter Four continues on from the initial findings and recommendations made in Chapter Two. It describes the proposed Strategy Architecture in detail

Chapter 5 – Summary and Conclusion

This chapter simply concludes with a presentation of the major findings related to the research questions, emphasising and highlighting the most important contributions of the study succinctly. The last section of this chapter lists a number of suggestions for future research that the researcher believes are necessary for continuing the advancement of knowledge in this field.

1.8 Summary

Chapter One has laid the foundation for this research by outlining the relevant background information, the research objectives, research design, justification and need for further research in this area, and the scope and limitations of this research. Chapter Two now presents a detailed overview of the current literature associated with one of the themes of this research, namely manufacturing planning and control.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction and Overview

As stated previously, the aim of this research is to determine whether a contemporary manufacturing planning and control strategy would make gas transmission pipeline construction more sustainably competitive, and if so, design the strategy. The literature review begins in Section 2.2 with a list of the findings on the state of manufacturing strategy in the 21st century, what organizations need to do to sustain competitive advantage, and how this impacts on the design of an appropriate strategy. Section 2.3 then presents a comparison of the issues raised in 2.2 with reference to the case study. Section 2.4 then makes some recommendations for a feasible strategy for gas transmission pipeline construction. A summary of the chapter is presented in Section 2.5.

2.2 Findings

2.2.1. 21st Century Manufacturing is a Buyer's Market

Manufacturing business has changed. It is now widely recognized that the balance of power is with the buyer (Nelson and Kirby, 2000). What used to be a sellers' market in the 20th Century has now changed to a buyers' market, as depicted in Figure 2.1 below (Nelson and Kirby, 2000):

Please see print copy for figure

Figure 2.1 The 21st Century Buyer's Market (Nelson in Gartner, 2000)

This has created an entirely new manufacturing environment. The 'Make and Sell' (or push) manufacturing management philosophy, is shifting to what Haeckel (2004) refers to as a 'Sense and Respond' (or pull) manufacturing philosophy, with the focus on the customer and providing customer value. Sense and respond is a managerial framework developed by Haeckel (2004) for organizations facing increasingly unpredictable, rapid and often discontinuous change. Most organizations today are in a state of transition from a Make and Sell (Make-to-Stock production) to a To-Order, Sense and Respond environment. Traditional Make and Sell manufacturing organizations relied on a strategic plan of action, a functional hierarchy structure, and command and control governance. Operations relied on a chain of commitments linked in advance by process designs, that were poorly connected, and hard to reconfigure or change the flow (Haeckel, 2004). To-Order manufacturing organizations rely on a strategic design for action, are made up of dynamic modular capabilities, and rely on governance through context and coordination. Operations are linked dynamically in a (subcontractor) network structure, which makes them easy to adapt and change the flow of processes (Haeckel, 2004). The features of these organizations are presented in Figure 2.2 below.

Please see print copy for figure

Figure 2.2 Managerial Frameworks for Manufacturing Organizations (Haeckel, 2004)

This transition greatly impacts on the role of the manufacturing strategy – also referred to as operations strategy, and by extension, the operations management system. Previously many authors have referred to this as the manufacturing planning and control system – an instance of the operations strategy. Evidence for this transition is present in the literature. Potter et al (1999), in a study of over 800 manufacturing organizations in the UK, noted only 10% effectiveness in existing manufacturing planning and control systems. This was expressed in terms of assistance to management in maintaining competitive advantage and gaining competitive advantage in the global marketplace. They noted a critical factor was that the current systems no longer aligned with the manufacturing business model. Scheu and Wacker (2001) arrived at similar conclusions from their study of Japanese manufacturing.

2.2.2. Sustainable Competitive Advantage in Today's Organizations is Achieved by Business Concept Innovation

Competitive advantage is defined as: '*A market position established either by providing comparable buyer value more efficiently than competitors, or by performing activities at comparable cost but in unique ways that create more buyer value through differentiation'.*
www.itcdonline.com/introduction/glossary2_abcd.html*(2006)*

Competitive advantage refers to something a firm can do more cheaply (a cost advantage) or uniquely (differentiation) that will provide higher margins. Competitive advantage grows fundamentally out of value a firm is able to create for its buyers that exceeds the firm's cost of creating it. Competitive advantage stems from the many discrete activities a firm performs in designing, producing, marketing, delivering, and supporting its product.www.e-competitors.com/Glossary/terms_c.htm(2006)

The pursuit of competitive advantage (the competitiveness model) is at the heart of strategic management theory (Fahy, 2000). Aharoni (1993) argues that, whatever its different definitions, strategy entails an attempt by a firm to achieve and sustain competitive advantage over other firms. Fahy (2000) says that advantage is a relative concept that is only meaningful when compared to another entity or set of entities. A competitive advantage, then, is an advantage one firm has over a competitor or group of competitors in a given market, strategic group or industry (Fahy, 2000).

Any given firm may have many advantages over another firm, such as a more adaptive workplace culture, a superior production system, a lower level of wages or more productive workforce and salaries, or an ability to deliver superior customer service, but the important advantages are those in which customers place a higher level of *value* (Coyne, 1986). Positions of advantage are generally regarded as being either *differentiation* or lower delivered *cost* (Porter, 1985) or both (Gilbert and Strebel, 1989). *Cost advantage* is gained when an organization outperforms its rivals on cost alone and is therefore not necessarily a strategic advantage – doing things cheaper for the customer. *Differentiation advantage* means deliberately choosing a way of doing activities to deliver a unique mix of value that the customer values and is willing to pay for because they cannot obtain the same value elsewhere. More than one firm in a given market can have a competitive advantage. For example, firm A can have an advantage over firm B but firm B can also have an advantage over firm C (Kay, 1993).

The goal of organizations is to sustain their competitive advantage.

In marketing and strategic management*, sustainable competitive advantage* is defined as:

…an advantage that one firm has relative to competing firms. It usually originates in a core competency. To be really effective, the advantage must be difficult to mimic, unique, sustainable, superior to the competition, and applicable to multiple situations.

http://en.wikipedia.org/wiki/Sustainable_competitive_advantage (2006)

Traditionally, manufacturing organizations competed on cost. Today they compete on cost and differentiation.

As Hamel (2000) notes: '*Business concept innovation is the foundation for value creation in the 21st century economy – an innovatory business concept is not only the product as such but the product delivery or bundling, including the novel experience for the customer (*Hamel, 2000).

2.2.3. To Compete, Organizations Must Recognize Customer Experience and Service Along With Facilitating Goods

In recent years, there has been a recognition that the service, or how the goods are delivered to the customer and how the customer is treated - the experience for the customer, provide many manufacturing organizations with a competitive edge (see, for example, Metters et al (2003). Metters et al (2003) point out that manufacturers are only able to have limited competitive advantages in terms of the goods provided. This is because recent activities in manufacturing, for example, work, study type activities, and the application of technology, have driven the cost of producing goods down and increased the range of goods available to the extent that price and range are less important as order winning criteria. Speed of delivery through distribution channels and the quality of the service and support systems, for example, are now emerging as order winning criteria and thus, sustainable strategic advantages. Martin and Horne (1992) concluded from their interviews with senior executives from 241 US-based multinational firms that there is a widespread attempt by organizations to move from previously product-dominated views towards a service orientation.

A second reason for the increasing concern for service activities is a recognition of the economic importance of the service economy (Haynes and DuVall, 1992; Metters et al, 2003). Service activities in most western economies now account for about 70 per cent of GDP and employment, comprise the fastest growing sector and are a major supporter of many countries′ balance of payments (Johnston, 1994).

In other words, sustainable competitive advantage results from innovation involving a holistic service-based operation. Innovation results from the creation of new knowledge, and new knowledge is created in the process of organizational learning (Meso and Smith, 2000). Therefore it is important for an operations strategy to ensure that it leverages the intangible assets of the organization. If organizations only exploit the tangible assets of the firm, they risk losing or diluting their sustainable competitive advantage (Meso and Smith, 2000). Consideration of intangibles and their exploitation in strategy development is continued below in the discussion of the resource based view.

2.2.4. Sustainable Competitive Advantage is Linked To Intangible Assets

At the beginning of the 1990s the source of value creation in the industrialized economies shifted from tangible to intangible assets. In 1982 the value of tangible assets, reported on the balance sheet of Standard & Poor 500 companies in the U.S. on average made up 62% of the market value of these companies in the U.S. (Daum,2001). In 1998 only 15% of the market value of S&P 500 companies was represented through the value of their tangible assets, 85% was the portion of the market value assigned to intangible assets (Daum, 2001). According to Daum (2001), if companies fail to leverage intangible assets, value will be destroyed at a speed never experienced before.

Intangible assets are knowledge and relationship based assets, for example, the value of the relationship to the people or organizations a company sells to (customer value), the value of the relationship to organizations or individuals through which a company sells or is doing business with in general (business partner network value), the R&D pipeline of new leading edge products that will increase a company's market share and will generate new revenue and free cash flow in the future (R&D pipeline or innovation capital), a highly skilled and talented work force that is committed to the company (human capital), leading edge business processes, organization structures and a corporate culture that help to convert individual knowledge and skills of employees into relationship value and innovation capital which the company owns when employees go home (structural capital) (Daum, 2001).

Management Challenges

According to Daum (2001), in order to exploit the full potential of existing intangible assets and to enable an organization to constantly build new intangible assets, management has to do two things – *create structural capital*, that is, adapt organization structures and business processes in order to enable the organization to make its people more productive and to better leverage supplier relationships to build sustainable customer value and customer capital; and *improve the management system* – that is, develop more appropriate steering tools and techniques.

Daum (2001) argues that management can no longer rely on financial information alone to run a business, as was the case in industries such as project manufacturing industries. As mentioned in Chapter One, operations management concepts based on the Project Management Institute's (2002) project management control model are not adequate for running knowledge based businesses. In fact, it has been noted that these control models have not proven adequate for running traditional companies either, where the focus was on tangible assets (see also Ballard, 2000). This is because the PMI model is based on the assumption that the work to be done can be divided into parts and managed as if those parts were independent from one another. This is fundamentally the 'contracting mentality', that facilitates the management of contracts rather than the management of production operations. Production management in project management is the 'local' responsibility of those to whom the various parts are assigned or contracted. If everyone meets their contractual obligations, the project performs successfully. Unfortunately, this approach is the opposite of robust. When something goes wrong, as it very often does, the entire structure is prone to collapse. Construction and pipe-laying industries are typified by this problem. Hence the main motivation for this research.

In terms of value, Daum (2001) notes that in organizations today where there is an emphasis on innovation and organizational learning, approximately 85% of the market value of companies is not reported in financial statements, as these are dealing with intangible assets. Therefore, financial accounting is no longer adequate as a basis for the management system. To create sustainable competitive advantage by utilizing intangible assets, it is important to have strategies that provide a strategic recipe for combining different intangible assets, for example, combining R&D efforts with marketing expertise to ensure that the right products and services are developed (Daum, 2001). With today's dominance of intangible assets, strategy has become increasingly important. A strategic management system helps organizations focus different activities in one direction. Also intangible assets have only a relative value. The value is changeable, dependent on market perception and changes in customer preferences, technology changes, and so on. The value of intangible assets is very much dependent on external influences. Therefore the management system has to take into account the fact that such external changes trigger internal changes of company strategies and also trigger related change management activities. Companies have to manage strategy as a continuous dynamic process, so that strategy can be adaptive to changing business conditions and resource allocations are also dynamic.

2.2.5. The Right Operations Strategy is Crucial for Value Creation

A key component of the strategic management system for management of intangibles is the operations strategy and the operations management system, which is responsible for value creation by managing the intangible assets.

Operations Management is defined in this thesis as *the management of the internal and external systems, resources, and technologies that create and deliver the firm's primary products and/or services* (Lowson and Burgess, 2004).

The term *Operations Strategy*, and not *Manufacturing Strategy*, is used also to denote the difference in scope and is defined as " *a long range game plan for the production of a company's products/services and provides a guideline or roadmap for what the* *operations function must do if business strategies are to be achieved*" (Gaither and Frazier, 2002).

Another, more detailed definition is given by Lowson (2002):

"The total pattern of decisions about and strategic management of the operational activities, core competencies and processes, technologies and resources used in any supply system to create and deliver product/service combinations and the value demanded by a customer/consumer. The strategic role involves the blending of these various elements and precepts into one or more unique, organization-specific, strategic architectures".

An Operations Management System is an instance of an Operations Strategy

An Operations Management System is a Value Creation System.

2.2.6. The Role of the Operations Strategy Has Changed

In the 20th century manufacturing organizations, the role of the manufacturing strategy was that of follower within the organizational strategies, as evidenced by a sample definition from Hill (1987):

The manufacturing strategy represents a coordinated approach, which strives to achieve consistency between functional capabilities and policies for success in the marketplace (Hill, 1987).

In this role, manufacturing strategy is there to align manufacturing with marketing. It is an externally focussed role – along with the corporate strategy, it looks to the market to determine its competitive priorities (Gagnon, 1999).

Today, in the dynamic customer focussed sense and response to the environment, the manufacturing strategy – now referred to as the operations strategy – has become a leader of strategy – a competitive weapon, as evidenced by a recent definition:

The operations strategy is concerned with setting broad policies and plans for using the resources of a firm to best support its long term competitive strategy (Chase, Jacobs, and Aquilino, 2005)

Some researchers argue that the operations strategy is the competitive strategy, directly supporting the business strategy (see for example, Meredith and Shafer, 2000). The operations strategy has become the implementer of competitive advantage and indeed can become the sustainable strategic advantage in itself. For example, companies such as Dell Computer basically offer very undifferentiated almost commodity products but create strategic advantage through a unique relationship with their suppliers in a very innovative supply chain.

2.2.7. The Scope of the Operations Strategy is the Value Chain or Network

Taylor (1999) and Lowson (2003) identify three 'levels' of operations strategy, the industry level, the firm level, and the value chain level.

Industry Level. In the 1970s and 1980s, the dominant view of strategy centred around Porter's Five Forces Model. Porter (1985) argued that sustainable superior returns were driven by industry factors: the threat of suppliers, buyers, substitutes and new entrants into an industry. This was known as the Market-Based View or MBV. A successful firm was one that picked a winning industry and established market share, dominating competition and constructing barriers to entry for other players, often with the help of privileged assets such as a favourable regulatory endowment. An example might be Telstra, the formerly government owned (now partially privatized) Australian telecommunications carrier Telecom but who are now struggling to maintain their profitability in an increasingly deregulated market where obscure legacy customer service obligations actually threaten to create a strategic disadvantage for them.

Firm Level. In the 1990s, the Resource Based View gained credibility at the expense of Porter's Five Forces, led by academics such as Teece, Pisano, Shuen, Rumelt, and Hamel and Prahalad. This view argued that sustainable superior returns were achieved by investing in a firm's dynamic capabilities ie firm capabilities which are not easily replicable, tradeable, or substitutable. A successful firm was one that developed bundles of capabilities that its competitors struggled to imitate, buy or find an alternative for. An example might be WalMart, the giant of the US retail business.

Value Chain or Value Network Level. "Coopetition" This view has emerged over the past several years, as the next step in strategic thinking beyond the firm level. It argues that sustainable superior returns are not just driven by a firm's capabilities, but also by the value chain or network in which it operates. In other words, one of the firm's capabilities is the way it manages firm boundaries and its *inter*firm resources such as alliances and joint ventures. The term "coopetition" refers to firms collaborating together to grow rent along their value chain, then competing with each other to divide up the spoils (Taylor, 1999). Coopetition combines the meanings of "compete" and "cooperate" into a single concept. It represents a condition in which two business entities may compete or cooperate on business opportunities during the course of their relationship. (Rasmussen, 2006).

2.2.8. The Operations Strategy Must Leverage the Organization's Core Competencies and Capabilities to Create Value

With the shift to the provision of services and the provision of the customer experience for manufacturers (along with a high quality product and speed of delivery), it is understandable that successful manufacturing companies are looking towards their human resources to develop competitive advantage in their operations, the providers of the product and service, as well as the processes and technology. Evidence for this can be seen by the shift away from the market-based view (MBV) of operations strategy to the resource based view (RBV) of operations strategy.

The Resource Based View

The RBV perspective focuses on the internal organization of firms, and so complements the traditional MBV, which has an emphasis of strategy on industry structure and strategic positioning within that structure as the determinants of competitive advantage.

RBV argues that only by focussing on the internal resources and capabilities can a company compete in a unique and inimitable and non-substitutable way. Before going on to discuss issues in RBV, some definitions are presented below.

Resources

A resource is a basic element that a firm controls in order to best organise its processes. A person, machine, raw material, knowledge, brand image, and a patent can all be viewed as examples (Lowson, 2003).

A distinction is made between *tangible and intangible resources (Godfrey and Hill, 1995).* According to Taylor (1999), successful production comes from the management of 'soft assets' that is, knowledge assets or intangible resources. Taylor (1999) argues (for the agricultural industry) that the greater the degree of a firm's resources that are intangible, the greater the sustainability of superior firm performance. This research supports Taylor's views that firms today need to focus on leveraging the intangible resources of the organization in order to achieve sustainable competitive advantage. The following section presents a brief discussion of intangible resources.

Intangible Resources

The phrases 'intangible assets', 'intellectual or human capital', 'knowledge assets' or 'intangible resources' is defined as:

That body of instructions, recipes, methods of doing things – the things that accountants classify as intangible assets if they recognize them at all. They tell us how to take something that isn't very valuable and rearrange it into a new configuration that is more valuable (Romer, 1998).

Knowledge that exists in an organization that can be used to create differential advantage (McDonald, 1999).

Intangible resources which are especially important to the manufacturing industry include:

- The intellectual property rights of patents, trademarks, copyright and registered designs;
- Trade secrets

- Contracts and licenses
- Databases
- Proprietary research and development
- Brand reputation
- Corporate reputation
- Management techniques
- Personal and organizational networks and relationships
- Know-how of employees, professional advisers, suppliers and distributors
- Organizational culture - the ability to react to innovate, and react swiftly to change
- Growth options - the ability to formulate strategies which deliver sustainable superior returns

Kay (1993) identifies three of the most important intangible resources as being: the firm's ability to innovate; its reputation; and its network of relationships – both internal and external.

When resources are combined they can lead to the formation of *competencies and capabilities* (Prahalad and Hamel, 1990).

Competencies

Competencies refer to the fundamental knowledge owned by the firm (knowledge, know-how, experience, innovation, and unique information). To be distinctive they are not confined to functional domains but cut across the firm and its organizational boundaries. Competitive advantage can come from a focus upon key competencies (those things in which the firm specialises or which it does well).(Lowson, 2003).

Capabilities

Capabilities reflect an organization's ability to use its competencies.

Capabilities refer to the dynamic routines acquired by the firm; the managerial capacity to improve continuously the effectiveness of the organization. Capabilities represent the firm's collective tacit knowledge of how to initiate or respond to change *that is built into an organization's processes, procedures and systems, and is embedded in models of behaviour, informal networks and personal relationships (Lowson, 2003).*

The resource-based view draws attention to combinations of internal resources, competencies, and capabilities that are generated and cannot be purchased externally (Lowson, 2003). According to Lowson (2003), sustainable competitive advantage can be built over time based upon unique combinations of resources and competencies. Resources form the basis of unique value creating activities (Eisenhardt and Martin, 2000). The activities and processes utilising these components are difficult for competitors to replicate. Like other researchers today, Lowson (2003) argues that products and technologies offer only a short-term strategic advantage, as they have a relatively limited life span and are easy to copy or improve upon, so it is the service provided and the customer experience, which are directly linked to the provider organization's intangible assets, which lead to innovation through enhanced business concepts.

Not all capabilities are strategic. At a strategic level, the importance of these core competencies and resources must be supported in three ways (Lowson, 2003):

1. *The value they provide to the customer must be continually augmented*. In other words, determining the activities that the customer values most and working to improve the competencies related to them.
2. *Analysis of internal competencies and resources to convert them into goods and services with a market value*. Organizations must capitalize on creativity and innovation to transpose the internal expertise into value for customers that can then be sold. This creative conversion of resources and competencies will lead to the development of new and modified goods.
3. *Development of new activities and competencies that can be used to enter new markets*. The organization must use existing capabilities for diversification into new and unrelated markets.

Lowson's (2003) definitions presented above highlight the importance of the fact that resources, capabilities and competencies are *dynamic and constantly changing* (Teece *et al.*, 1997).

Dynamic Capabilities

*Dynamic capabilities are the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments (*Teece, Pisano, and Shuen, 1997).

Dynamic capabilities are the firm's processes that use resources – specifically the processes to integrate, reconfigure, gain and release resources – to match and even create market change. Dynamic capabilities thus are the organizational and strategic routines by which firms achieve new resource configurations as markets emerge, collide, split, evolve, and die (Eisenhardt and Martin, 2000).

According to Eisenhardt and Martin (2000), although dynamic capabilities are idiosyncratic in their details and path dependent in their emergence, they have significant commonalities across firms from the same industry – popularly termed 'best practice', and are therefore not as unique as some RBV researchers imply. This would suggest that dynamic capabilities per se are not likely to be sources of sustained competitive advantage (Eisenhardt and Martin, 2000). According to Eisenhardt and Martin (2000), the value of dynamic capabilities for competitive advantage lies in their ability to alter the resource base: create, integrate, recombine, and release resources. Eisenhardt and Martin's (2000) reconceptualization of dynamic capabilities is presented in Table 2.1 below.

Table 2.1 Eisenhardt and Martin's (2000:1111) Reconceptualised Dynamic Capabilities

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The above discussion also highlights the need for a dynamic and adaptable operations strategy formation process. This dynamic view was not discussed in early RBV research, but is becoming increasingly important with the emphasis on the organizational intangibles, such as knowledge and learning. One of the criticisms of the RBV was the fact that it is static and does not support a dynamic changing environment (Truss, 2000). This research argues that this has nothing to do with the RBV as such, which is the content of the operations strategy. What determines whether a strategy is dynamic or static depends on the prevailing school of thought (Mintzberg, 1998(a)). This is discussed in the next section.

2.2.9. The Operations Strategy Is *NOT* a Plan

Sustainable competitive advantage is achieved through business concept innovation. Therefore, the operations strategy must support the innovation of business concepts, for example in this research, the innovation of business processes or project processes. Business processes are becoming increasingly complex. The reasons for this complexity, according to Behrens(2003) are as follows:

The time products remain in the market is decreasing, while demand for longevity and durability of products is increasing; customer demands for increasingly complex deliverables and mass customization remain unabated; trends for more globally dispersed manufacturing and design operations create opportunities, but at the same time create business challenges; company and product value depends not only on innovation and improved efficiency, which also includes new methodologies, technologies, and business alliances; product development now must also include planning for after sales service and end of life retirement; as processes and products become more complex, risk also increases.

Traditionally the operations strategy (and other organizational strategies, such as the business strategy, the project strategy) has always attempted to manage complexity by reduction. The favoured approach to strategy formation/execution was by top down planning and control and governance structures. However, to achieve and sustain competitive advantage complexity must be harnessed and managed, not reduced. This approach requires a different type of operations strategy.

But what is strategy? Once upon a time everybody knew the answer to that question. Mintzberg (1998 (b)) suggests that the concept and formation of strategy depend on the prevailing school of thought and proposes ten schools of strategy formation, as shown in Table 2.2 below.

Table 2.2 Mintzberg’s (1998) Ten Schools of Strategy

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The design school, for example, sees strategy formation as a process of conception; the planning school sees it as a formal process based on structured techniques, while the learning school sees strategy building as an emergent process of continuous change based on trial and error (Shenhar, 2004).

Johnson, Scholes, and Whittington (v7. 2004) offer a simpler analogy involving ‘lens’ of design, experience, and ideas. They show that strategies evolve as a combination of them but with varying emphasis on each depending on the firms and business environments involved.

In production and operations management the prevailing school of thought was until recently, the Planning School (Mintzberg, 1998) or Design Lens (Johnson et al) and thus becomes a matter of efficiently planned manufacturing processes but limited in terms of more imaginative or ‘fuzzy’ customer responsive aspects of strategy development that tend to be based on ideas. Lane and Maxfield (1996) say that strategy is there to achieve control. The best way to achieve control, and how much control is achievable, depends on “the foresight horizon”. If the foresight horizon is clear, it may be possible to anticipate the possible consequences of any course of action, including responses of all other relevant agents, and to chart out a best course that takes into account all possible contingencies – the operations strategy as classical plan and control approach. In this classical model the strategy is seen as optimizing commitment. The strategy specified *a precommitment* to a particular course of action. Choosing a strategy meant *optimizing among a set of specified alternatives* on the basis of an evaluation of their relative value and the probability of their possible consequences (Lane and Maxfield, 1996).

Strategy formation as traditional planning and control is linear and involves two main processes - strategy formulation as a plan and strategy implementation. An example of a classical planning and control strategy is given by Markowicz (2000).

Example of an Operations Strategy as Plan and Control

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Figure 2.3. A static operations strategy – the centralized plan approach (Markowicz, 2000)

According to Markowicz (2000), in the static operations strategy approach where the plan or schedule is developed and operators are tasked with executing the plan (the centralized plan approach), there is scarce expensive intelligence, narrow data bandwidth, and sequential operations. The issues for this type of strategy are that it is not sufficiently dynamic, all contingencies cannot be taken into account, and there is no local point of view. He uses an example from container yard operations to illustrate this, as depicted in Figure 2.4 below:

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Figure 2.4 Container Yard Operations Under a Static Operations Strategy (Markowicz, 2000).

The formation of strategy is closely linked to prevailing management philosophy and management techniques of the organization. In production and operations management in the project manufacturing industries, such as the AEC industries, the prevailing management philosophy has been scientific management following Taylor (McCarthy, 1999).

Traditional scientific management theory assumes that:

· Rigid procedures are needed to regulate change
· Hierarchical organizational structures are means of establishing order
· Increased control results in increased order
· Organizations must be rigid, static hierarchies
· Employees are interchangeable "parts" in the organizational "machine"
· Problems are solved primarily through reductionist task breakdown and allocation
· Projects and risks are adequately predictable to be managed through complex up-front planning

Traditional engineering product and process lifecycle methodologies stressed predictability (one has to plan every last detail of a bridge or building before it is built), and linear development cycles – requirements led to analysis which led to design which in turn led to development. Along with predictability, they inherited a deterministic, reductionist approach that relied on task breakdown, and was predicated on stability – stable requirements, analysis and stable design. This rigidity was also marked by a tendency towards slavish process "compliance" as a means of control. This leads very much to a 'push' approach that is not at all conducive to modern customer response strategies.

Regardless of the particular methodology, the traditional engineering manager is often seen as a Tayloristic "taskmaster" who develops and controls the master plan that documents (often in excruciating detail) the tasks, dependencies, and resources required to deliver the end product. The manager then monitors the status of tasks and adjusts the plan as necessary. Underpinning this mechanistic approach is the assumption that equates people to interchangeable, controllable commodities. As the literature will attest, traditional command-and-control management is largely derived from the principles of Frederick Taylor's "scientific management." Taylor's scientific management approach was based in turn on the seventeenth century science of Newton that saw the world as a vast and magnificently ordered "clockwork universe" governed by the classical laws of nature (McCarthy, 1999). In Taylor's world, it was the manager who had the specialized problem solving knowledge. The traditional process of reducing tasks into ever-smaller components for assignment and tracking often causes degeneration into "fractal" tasks, tasks at ever repeated smaller scales. The traditional tool for guidance – a plan with fractal tasks – often has tasks at too small a level to be really meaningful. Traditional managers have long prevented openness and freedom of information because of a fear that it will result in chaos. Because of this fear, traditional managers have controlled information and meted it out on a "need to know" basis. On traditionally managed construction and software development projects, teams often feel like they don't know what is going on – only the project manager has the "master plan" and only the project manager interacts with the project sponsor. In traditional management, everything is seen through the prism of control: scope control,: change control, risk control and most importantly – people control. Elaborate methodologies, tools and practices have been evolved to "manage" an "out-of-control" world. However, tools fail when neat linear task breakdowns cannot easily accommodate complex non linear processes, and neat schedules require frequent updating to reflect the reality of changing dates and circumstances. This is particularly the case in construction management where subcontractors are used. Traditional managers, have come to believe that more control would give more order. Unfortunately, this conventional view doesn't really help in the uncertain real world of subcontractor manufacturing because life is characterized by probabilities, not certainties.

As case studies and experience have shown, in the management of projects such as software development and building and construction, unforeseen events can lay the best of plans to naught in an instant. The project plan must be continuously adapted by the project manager. In addition, skilled professionals do not take well to micromanagement. Tools and techniques reach their limitations quickly when used inappropriately. Research and case studies reveal that imposing command-and-control management on teams is not effective management. In the subcontractor industry for example, there are situations where committed skilled subcontractors are often worth as much or more to their employers than their managers because their meaningful integration into supply chains is crucial if objectives are to be reached.

Organizational Responses to Complexity and The Complex Adaptive Systems Philosophy

Ashmos et al (2000) point out that organizations have two possible responses to managing complexity, *complexity reduction* and *complexity absorption*.

Complexity Reduction. Organizational approaches to complexity by reduction are mechanistic and reductionist. In the reductionist approach organizations simplify their internal makeup as a way of achieving order in what seems like a disorderly world. The pursuit of equilibrium has been seen as the role of good management and in the reductionist approach managers are rewarded who achieve stability and balance (Ashmos et al, 2000). According to Ashmos et al (2000), these organizations become simpler over time because management develops a preoccupation with a narrow singular focus, which reinforces a push for simplicity based on job specialization, job descriptions and a singular focus and mission. Predictable stability becomes the norm and change is considered to be a radical departure from the norm. Boisot and Child (1999) say that organizations that attempt to reduce complexity emphasize codification (specifying categories to which data are assigned) and abstraction (limiting the number of categories that need to be considered in the first place). Therefore, managerial responses to complexity based on codification and abstraction would include minimizing the number of goals and strategic activities to be considered, formalizing and centralizing structural/decision making patterns, and minimizing the number of interactions and connections necessary for decision making.

Complexity Absorption. A complexity absorption response to environmental complexity involves holding multiple and conflicting portrayals of the variety in the environment. Managerial responses to complexity from the absorption perspective include the development of multiple and sometimes conflicting goals, the importance of a variety of strategic activities, more informal and decentralized structural/decision making patterns, and a wide variety of interactions and connections for decision making (Ashmos et al, 2000).

Organizations absorb complexity when they create processes or *ad hoc* structures that facilitate information exchange and allow the generation of multiple interpretations of information. Other complexity absorption responses include internal structures that encourage information exchange across internal organizational boundaries (Ashmos et al., 1996) as well as sense making and interpretation (Thomas and McDaniel, 1990). Multiple interpretations seem to be a sign of a turbulent environment, and processing multiple interpretations requires ongoing efforts at sense making, even if these efforts often seem disorderly and laden with conflict (Weick, 1995). Therefore, complexity absorption is characterized by varied information exchange mechanisms, the emergence (or possibility) of multiple interpretations because of the presence of varied and conflicting goals, and the structural flexibility that can support making sense of interactions.

Organizations that deal with complexity by complexity absorption pursue managerial strategies that reinforce the nature of the organization as a complex adaptive system (Ashmos et al, 2000).

A complex adaptive system (CAS) is one in which decentralized, independent individuals (agents) interact in self organizing ways, guided by a set of simple, generative rules, to create innovative, emergent results (Highsmith, 2004)

A CAS can be distinguished from a pure multi-agent system (MAS) by focussing on the properties of agents themselves as well as the system. In a CAS, the features like self-similarity, emergence, and self-organization are applied to the system.

In a MAS, agents do not evolve. In CASs, the agents as well as the system are adaptive: the system is self-similar. A CAS is a complex, self-similar collectivity of interacting adaptive agents. Other important properties of a CAS are adaptation (or homeostasis), communication, cooperation, specialization, spatial and temporal organization, and reproduction. They can be found on all levels: cells specialize, adapt and reproduce themselves just like larger organisms. Communication and cooperation take place on all levels, from the agent to the system level. Other definitions of CAS are:

A CAS behaves/evolves according to three key principles: order is emergent as opposed to predetermined (eg Neural Networks), the system's history is irreversible, and the system's future is often unpredictable. The basic building blocks of the CAS are agents. Agents scan their environment and develop schema representing interpretive and action rules. These schema are subject to change and evolution. (source: K. Dooley, AZ State University)

Macroscopic collections of simple (and typically nonlinearly) interacting units that are endowed with the ability to evolve and adapt to a changing environment. (source: Complexity in Social Science glossary a research training project of the European Commission). Figure 2.5 shows a graphical representation of a CAS based on the above definitions *(http://en.wikipedia.org/wiki/Complex_adaptive_system)(2006)*

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Figure 2.5 Complex Adaptive System

CAS Principles Relevant to the Operations Strategy

An example of a dynamic operations strategy based on CAS principles is given by Markowicz (2000) in his study of harbour crane operations. The general approach is shown in Figure 2.6 below. Rather than a top-down plan and control approach, in the dynamic CAS approach the plan acts as a compass, operators act as local intelligent controllers.

Please see print copy for image

Figure 2.6 A Dynamic Operations Strategy Approach based on CAS (Markewicz, 2000).

This enables late binding and decentralized intelligence. Local intelligent controllers have the ability to gather local information, external contextual information, and can reason and control locally. The benefits of the dynamic approach are that more information is processed, both global and local. The information is better. There is more intelligence due to more thinking cycles and opportunities for reasoning by human input. The system is more 'democratic' due to natural collaboration and learning. It is policy based and incentive driven. An example of a control tower from the static (now) and dynamic operations strategy (future) perspective is shown in Figure 2.7 below.

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Figure 2.7. Static vs Dynamic Operations Strategy Example (Markewicz, 2000).

As the previous discussion demonstrates, a dynamic operations strategy approach based on CAS would present a radical change of philosophy for many production and operations managers. This research argues that managers must adopt this philosophy as a means to support a dynamic capabilities approach to operations. To enable a dynamic operations strategy based on CAS, the Internet must be utilized. However, before concluding this section, it is important to note that the Internet alone cannot achieve sustainable competitive advantage.

The Role of the Internet in Creating Sustainable Competitive Advantage

According to Porter (2001), sustainable competitive advantage can be achieved in two ways. One way is by operational effectiveness – doing the same things your competitors do but doing them better. Operational effectiveness can have many forms including better technologies, superior inputs, better trained people, a more effective management structure, to name a few. The other way to sustainable competitive advantage is by strategic positioning – doing things differently to competitors in a way that delivers a unique type of value to customers. For example, this can mean offering a different set of features, a different array of services, or a different logistical arrangement, for example.

There is a widespread agreement that the Internet has greatly improved operational effectiveness across the value chain (Porter, 2001). The Internet has enabled ease of access and the speeding up of real time information. Because it is an open platform with common standards, companies can often tap into the benefits without very much additional expense (Porter, 2001), as opposed to previous generations of information technology. However, as Porter (2001) points out, simply improving operational effectiveness is not providing a competitive advantage. Once a company establishes a best practice, other companies will quickly imitate this. Best practice competition leads to competitive convergence (Porter, 2001), with many companies doing the same thing in the same way, and customers end up making decisions based on price, which undermines industry profitability. The Internet actually makes it more difficult to sustain operational effectiveness than ever before. For previous generations of IT, application development was a long and arduous, hugely expensive process, which made it harder to gain an IT advantage, but also made it more difficult for competitors to imitate systems. The openness of the Internet, combined with advances in software architectures, development tools, and modularity, makes it much easier for companies to design and implement applications. As fixed costs for developing systems decline, as is the case with Internet-based applications, it makes processes easier to imitate. Today nearly every company is developing similar types of Internet applications, often drawing on the same generic packages offered by third party developers, such as IBM. The resulting improvements in operational effectiveness will be shared across many companies who will converge, offering the same services. In many cases, companies have no choice if they wish to stay competitive, they have to deploy Internet technology (Porter, 2001).

Strategic positioning, according to Porter (2001), is the only way to stay competitive. The only way to generate higher levels of economic value is to compete in a distinctive way. Porter (2001) says that companies today define competition involving the Internet almost entirely in terms of operational effectiveness. They seek speed and agility hoping to stay one step ahead of competitors. However, without a strategic direction, speed and agility lead nowhere, because no unique competitive advantage is gained or improvements are generic and cannot be sustained. Porter (2001) states that the Internet provides a better technological platform than any previous generations of IT when it comes to reinforcing a distinctive strategy, tailoring activities and enhancing fit. In the past IT worked against strategy, as many software packages were hard to customize, and companies were forced to purchase off the shelf software and change their organizational processes and strategies to suit the software. It was also difficult to connect discrete applications to one another. ERP systems linked activities but companies were forced to adapt their processes to the way ERP did things. So as a result IT was a force for standardizing processes and speeding competitive convergence. Internet architecture, along with general improvements in software architectures and development tools and techniques, has become a much more powerful tool for strategy, because it is much easier to customize Internet applications to suit the company's strategic position. The Internet allows a common IT platform across the entire value chain and it is possible to build systems tailored to the individual organization's requirements. As Porter (2001) points out, in order to sustain competitive advantage organizations must tailor their value chains – that is, organizations must specify the activities required to produce their product and/or service that enables the company to offer unique value. The value chain must be highly integrated. This allows the company activities to fit together as a self-reinforcing system, making it more difficult for competitors to imitate – because competitors wishing to imitate a strategy will have to replicate the entire supply and demand chain, rather than individual parts. Therefore to gain these advantages, companies must stop adopting generic off-the-shelf packaged applications and tailor the deployment of Internet technology to their particular strategies. This will result in a more sustainable competitive advantage.

Many have argued that the Internet makes strategy obsolete. However, the opposite is true. Because the Internet tends to weaken industry profitability without providing proprietary operational advantages, it is more important than ever for companies to compete through strategy. According to Porter (2001), the winners will be those companies that view the Internet as a complement to, not a cannibal of, traditional ways of competing. In other words, the Internet must be seen as a means of differentiation that cannot be easily copied. Firms cannot achieve any degree of competitive advantage by utilizing similar technology for similar competitive goals. Porter's (1986) original hypothesis that competitive advantage emanates from linkages in the value chain, rather than elements in the chain itself seems to have been deemphasized. The Internet could be seen as a (communication) linkage. If all competitors standardize this linkage no sustainable competitive advantage can be achieved.

2.2.10. The Operations Strategy is not the Project Strategy

Architectural, engineering, and construction (AEC), including software construction industries are known as build-to-order industries (BTO) or BTO production, because it is only on confirmation of the customer order that the operations strategy and operations management system are designed and implemented. This is particularly the case in gas transmission pipeline construction and software construction. In many cases the concept of uniqueness is carried through to the operations strategy design and implementation for each product/customer group. At the extreme end of dynamic network organizations, consisting of subcontractor organizations, every customer request restructures the organization. On confirmation of an order, roles and accountabilities are formed. That is, there exists a capability network of potential subcontractor organizations which potentially may collaborate to produce a product or service. Before an order is activated, the network is connected, but not 'interoperable' (Haeckel, 2003). When an order is activated, the capability network becomes interoperable and coherent by a system design of 'accountable roles' (Haeckel, 2003).

The above discussion indicates that for project manufacturing industries of the type dealt with in this research, the operations strategy could be the project strategy. It should be noted that in most project management circles project management is seen as 'execution only' and not dealing with 'front end decisions' where value can be created (Morris, 2005). It is understood that in a software project strategy, lifecycle issues directly related to the execution of the project are dealt with. 'Front end' issues, such as procurement, financing, and sourcing are often not included in the project strategy(Morris, 2005). Like operations strategy, project strategy must be viewed as the competitive strategy and must be dynamic and formed with each new project and include decisions on capacity, procurement and sourcing, tendering, and other 'front end' matters as well as the execution.

This research argues, however, that there should be a separate but compatible operations and project strategy for BTO project manufacturing, and that the operations strategy can provide the backbone for the project strategy. Based on the above discussion, the following recommendations can be made.

Recommendation 1: A Dynamic Integrated e-Operations Strategy Based on CAS Principles

Project manufacturing organizations, such as the AEC industry will create and sustain competitive advantage if they adopt, as one of their operations strategies, regardless of a particular project, an e-operations strategy based on CAS principles.

An e-operations strategy is defined as e*lectronically mediated data/information exchanges, and the information communication technology systems that support them, to facilitate the operation, enhancement, re-engineering and integration of the range of business processes, both within an organization and externally (up- and down-stream)(Lowson, 2003)*

The e-operations strategy must be an integrated strategy-business-IT model. The strategy being proposed in this research focuses on dynamic capabilities of the organization, that is, the organizational and individual knowledge required to sustain innovation of business concepts by creating a learning environment. This will ensure that capabilities remain strategic.

The dynamic e-operations strategy based on CAS principles will:

- Recognize the importance of teamwork and collaboration. Recognizing individual subcontractors and other stakeholders as intelligent skilled professional agents and placing value on their autonomy will form the basis for all other practices in operations (autonomous intelligent agents).
- The project manager will establish the intent of the project and this will serve as a guide on which subcontractors can base their own initiatives, actions, and decisions. The vision can be reinforced at every opportunity by examining decisions on the project to see if they align with the organizational goals (establish vision and goals, rather than detailed top down plans).
- Simple rules and practices will support complex team behaviour (local strategic rules support complex overlaying behaviour).
- Open information will allow subcontractor teams to adapt and react (sense and respond) to changing conditions in the environment. All stakeholders (security clearance allowing) must have timely access to all information, including design information
- To impose order, some control must be imposed. However, plans will be at a high enough level to allow innovation, creativity and rapid response to dynamic environments. Subcontractor teams will have a level of autonomy to quickly adapt solutions to changing situations on their own. Rigid command-and-control structures must be dismantled in favour of a more adaptive, organic model (emergent order is bottom up).
- Operating on the edge of chaos will require continuous learning and adaptation to changing environmental conditions.(non-linear dynamic systems continuously adapt when they reach a state of dynamic equilibrium called the edge of chaos)

The dynamic e-operations strategy based on CAS principles creates the following strategic capabilities:

- Sustaining innovation by enabling teams and individuals to be creative.

Tayloristic practices and lack of timely and quality information of today's construction environment stifle creativity. Therefore an e-operations strategy based on CAS principles will speed up routine tasks and cut down on non-value adding activities such as searching for specifications and other documents, allowing more time for creative activities;

- Improving re-use of knowledge assets and people;
- Improving the productivity of all available resources;
- Improving the quality and testability of the product,
- Ensuring specification and regulatory conformance;
- Enabling valued collaboration amongst all stakeholders (Behrens, 2003).

2.3 The Case Study

An extensive case study of gas transmission pipeline and other construction and sand mining industries (see Appendix A for detail) reveals that most organizations today are in a state of transition from a top down command and control structure to a structure that supports sense and respond. While their organization structures reflect a complexity absorption approach, their operations remain traditional, with a top down planning and control strategy based on a command and control governance structure. There is an argument for adopting a more dynamic approach to operations.

2.3.1 The Complexity of Gas Transmission Pipeline Construction

All construction projects, which includes pipeline construction projects, belong to the class of complex dynamic systems (Sterman, 1992). Sterman (1992) lists the following traits of construction projects:

Construction projects are extremely complex, consisting of multiple interdependent components.

That is, the cause and effect of such systems are not closely related in time and space. This fact was also pointed out by Vrijhof (2002) in case studies of the building industry undertaken in Finland. For example, changing location of a fitting in a pipeline engineering drawing may cause subsequent changes in other subsystems such as welding, or even trenching etc, necessitating rework far beyond the original change. In the case of pipeline construction these changes may then cause subcontractors to reschedule and go to another site , delaying the whole process. Such juggling of resources to handle the rework may then lead to delays on other projects which find themselves dependent on completion of the deferred tasks. According to Sterman (1992) it is important for the causal impact of change to be traced throughout the entire system.

Construction projects are highly dynamic.

Processes such as hiring, firing, and training unfold over time. There are multiple delays in carrying out programs, discovering and correcting errors, and responding to changes in scope and/or specification of the construction project. This means that the short run response to a perturbation may differ from the long run response. An example of this would be the hiring of additional subcontractors, which may add to the capability of the organization in the long term, but in the short term experienced people might have to divert time from their work to train the recruits, reducing productivity.

Construction projects involve multiple interacting feedback processes.

Feedback refers to the self- reinforcing or self - correcting side effects of decisions. For example, when a project falls behind schedule, one possible managerial response is to increase the use of overtime. The extra hours help bring the project back on schedule, reducing the need for overtime in the future. This feedback process is self-correcting. However, if overtime runs for an extended period workers get tired and burned out leading to lower productivity, a higher rate of errors, increased employee turnover, thus further delaying the project and leading to pressure for still more overtime. This is a self- reinforcing feedback process. According to Sterman (1992), tightly coupled construction projects contain large numbers of important feedback relationships and these feedback relationships or processes need to be monitored. For example, a change in customer specifications and subsequent issue of an engineering change order may require the hiring and training of additional engineers, which in turn diverts skilled engineers from design work to training. Trainees may generate more errors, increasing work. Engineering changes render other previously completed work obsolete. Purchase orders already issued may have to be revised; some subcontracted components in process must be reworked. This leads to additional design and construction work being done without firm knowledge or related components and subsystems interacting, leading to more rework. Additional hiring can lead to congestion in the shop and at the construction site lowering productivity, increasing errors, and possibly leading to safety incidents. As effects accumulate, other areas of the construction supply chain may be affected. Quality and timeliness suffer and customer relations can deteriorate (Sterman, 1992).

In this fashion the impact of the original change ripples through the entire organization, not to mention the supply chain, slowing productivity, raising costs at every stage in the project.

If changes are large enough, the ripple effects create schedule compression and increase the degree of concurrency in design and between design and construction, resulting in excessive overtime, fatigue, increased errors, reduced quality, and strains on the project team, such that a seemingly innocuous design change can exceed by many times the direct cost of the change order itself (Sterman, 1992).

Construction projects involve nonlinear relationships.

Nonlinearity means causes and effects do not have simple, proportional relationships. As shown in the previous example, the relationship between worktimes and productivity.

Construction projects involve both hard and soft data.

A large scale construction project, such as pipeline construction, is not merely an engineering project – consisting of drawings, steel, pipes, and wiring. As several authors have pointed out (Sterman1992; Vrijhof et al 2000), construction projects are human enterprises and cannot be understood solely in terms of relationships between technical components. As Vrijhoef et al (2000) notes, construction supply chains are 'networks of commitments'. Gas Transmission Pipeline Construction projects, like other areas of construction, are highly complex and dynamic. Some of the characteristics of pipeline projects that make them dynamic are discussed below.

2.3.2 Characteristics of Pipeline Construction Projects

- Work is dispersed among many temporary locations – gas pipelines range over thousands of kilometres in Australia. Workers move from one location to another along the pipeline. The work area itself is very large - 22 kilometres.
- Long service life of a typical project – gas transmission pipeline projects can take several years to complete and then can last for many decades with maintenance
- There is a small amount of standardization; each pipeline project has distinctive features
- There are a large number of tasks requiring a high degree of manual skills necessary to complete a typical pipeline construction product. Although automation is used, it is in isolated instances, such as welding automation, or Internet-based hydrostatic testing
- The work environment is rugged, harsh, often hazardous and unpredictable
- There is a high turnover of workers and a lack of skilled workers, for example pipeline welders need a special qualification to work on pipelines, as opposed to say, boilermaking.
- Authority is divided between sponsor, designers, local government, sometimes state and federal government bodies, contractors, and subcontractors, and consultants
- Production is on-site and localized orders (ie 22 kilometre spreads) are extremely diverse
- Project manager has overview of entire project

- There is a distribution of power amongst rival firms – buyer and seller concentration
- High degree of vertical and horizontal integration
- Converging supply chain directing all materials to the construction site where the object is assembled from incoming materials. The `construction 'factory' is process-focused, with the entire site dedicated to the production of one product
- It is a temporary supply chain producing one-off construction projects through repeated reconfiguration of project organizations
- Build-to-order (Engineer-to-order) supply chain, with every project creating a new product or prototype. There is little repetition, again with minor exceptions. The process can be very similar, however, for projects of a particular kind. This will be discussed further below in the BTO section.

Considering the complexity of construction projects, it can be seen that many organizations are 'out of alignment'; they appear to be in a state of evolving towards absorbing complexity but at the same time managerial responses appear to be reductionist. Take for example, gas transmission pipeline construction. They have restructured to absorb complexity and become more organic. The subcontractor network organization is organized so that every customer request for a new pipeline can restructure the organization. The subcontractor network, which is also the supplier or value web, is formed for each order, and roles and accountabilities are also formed new for each pipeline (see Figure 2.8 below). That is, there exists a capability network, an APIA network of organizations, which potentially may collaborate in gas transmission pipeline construction. Before an order is activated, the APIA network is connected, but not 'interoperable' (Haeckel, 2004). When an order is activated for a pipeline, the capability network becomes interoperable and coherent by a system design of 'accountable roles' (Haeckel, 2004).

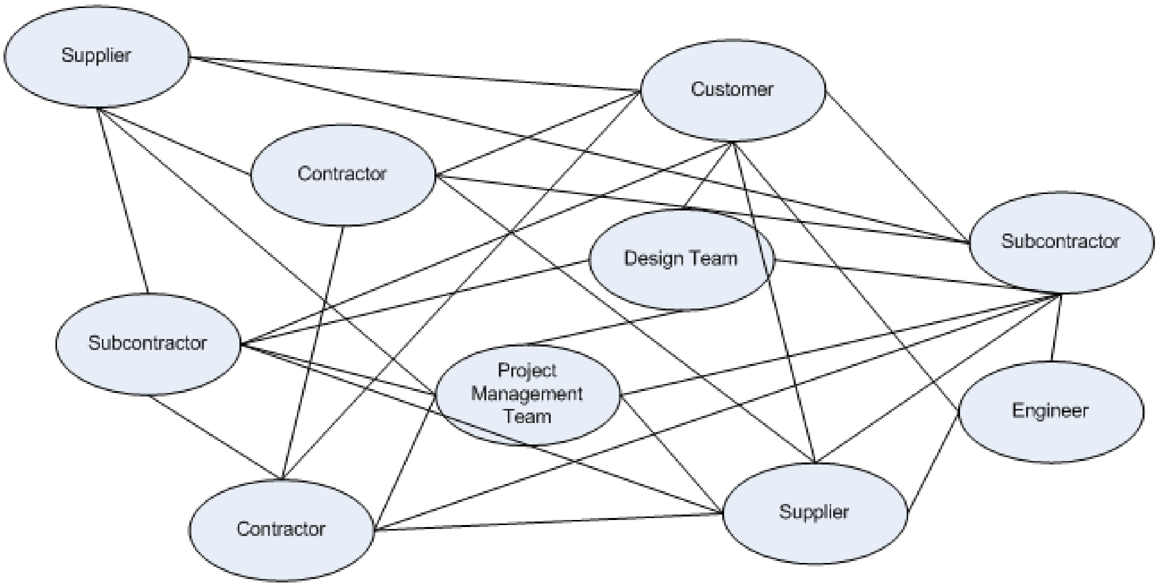


Figure 2.8 A Gas Transmission Pipeline Capability Network – Connected, but not Interoperable.

This is out of alignment with operations, as illustrated below.

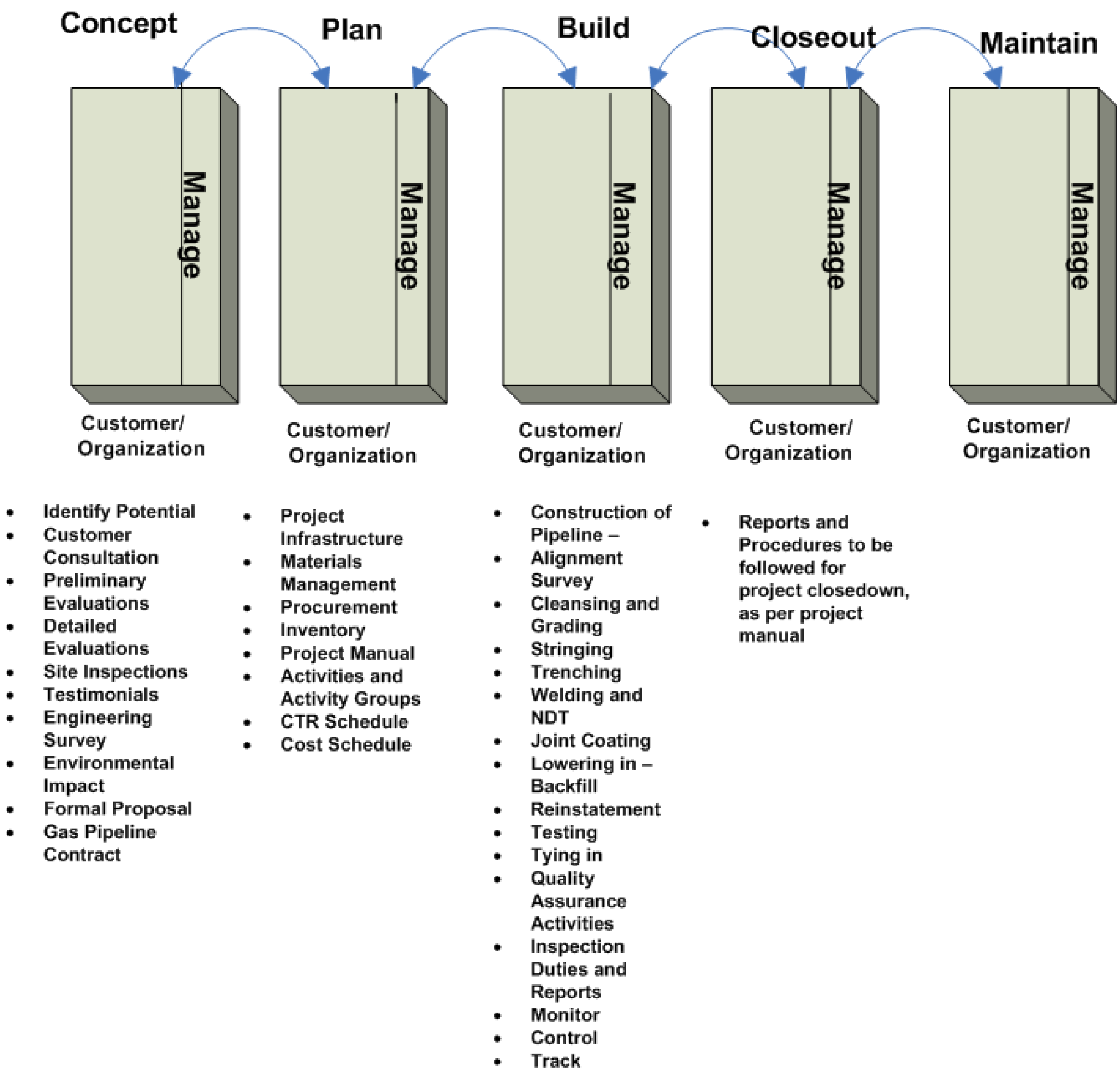


Figure 2.9. Operations strategy in current pipeline construction is top down planning and control strategy.

The issue here is that pipeline construction management has adopted a reductionist approach to managing complexity by adopting an operations strategy that is based on reductionist thinking. The traditional reductionist style of management through planning and control leads to many gaps and waste in the process. Some observations are presented below.

2.3.3. Current Shortcomings in Gas Transmission Pipeline Construction Management

- By trying to reduce and simplify complexity a lot of waste is being produced in pipeline construction through fragmentation – there appears to be a divide and conquer approach.
- Pipeline construction process is reduced by fragmentation into many small components which are independent of each other. Subcontractors work as independent organizations, no overall coordination of subcontractors and subcontractors are not an integrated part of the process
- Therefore the current Pipeline Supply Chain is over-the-wall and sequential as well as fragmented
- Causes waste at process interfaces, disciplines, and organizations of each handover – leads to more complexity not less
- Fragmentation of management roles – none of the managers on Production site or at site office have complete picture of the pipeline construction supply chain; fragmentation of participants leads to misconceptions and misunderstandings
- Fragmentation of design and data, leading to omissions and errors;
- Fragmentation of information, information not up-to-date, not available, incomplete;
- Occurrence of late and costly design changes can lead to unnecessary liability claims; lack of true lifecycle analysis of project, leading to inability to maintain competitive edge etc
- Planning is fragmented, causing complexity, rather than alleviating
- Control is a top down deterministic push control, focussing only on budget and contract control
- Planning is based on hierarchical organization structure –static not dynamic, it is a deterministic approach with no allowance for dynamic adaptive planning
- IT is also fragmented with islands of automation and hence information (for example, specialized software –NDT; GIS displays; welding data)
- Management tools: Desktop MS Project used
- Manual Integration of Information
- Tools support only a small part of project planning and scheduling by means of GANTT or PERT, CPM
- Fragmentation causes waste of overproduction

- Waste of waiting – for materials or components, design changes, subcontractors
- Transportation and/or disposal are wasteful – use of surplus inventory
- Information and communication – hard copy, not timely, incomplete
- IT – duplication of data and effort

This has considerably reduced the value of the gas transmission pipeline construction process, as seen in figures 2.10 and 2.11 below:

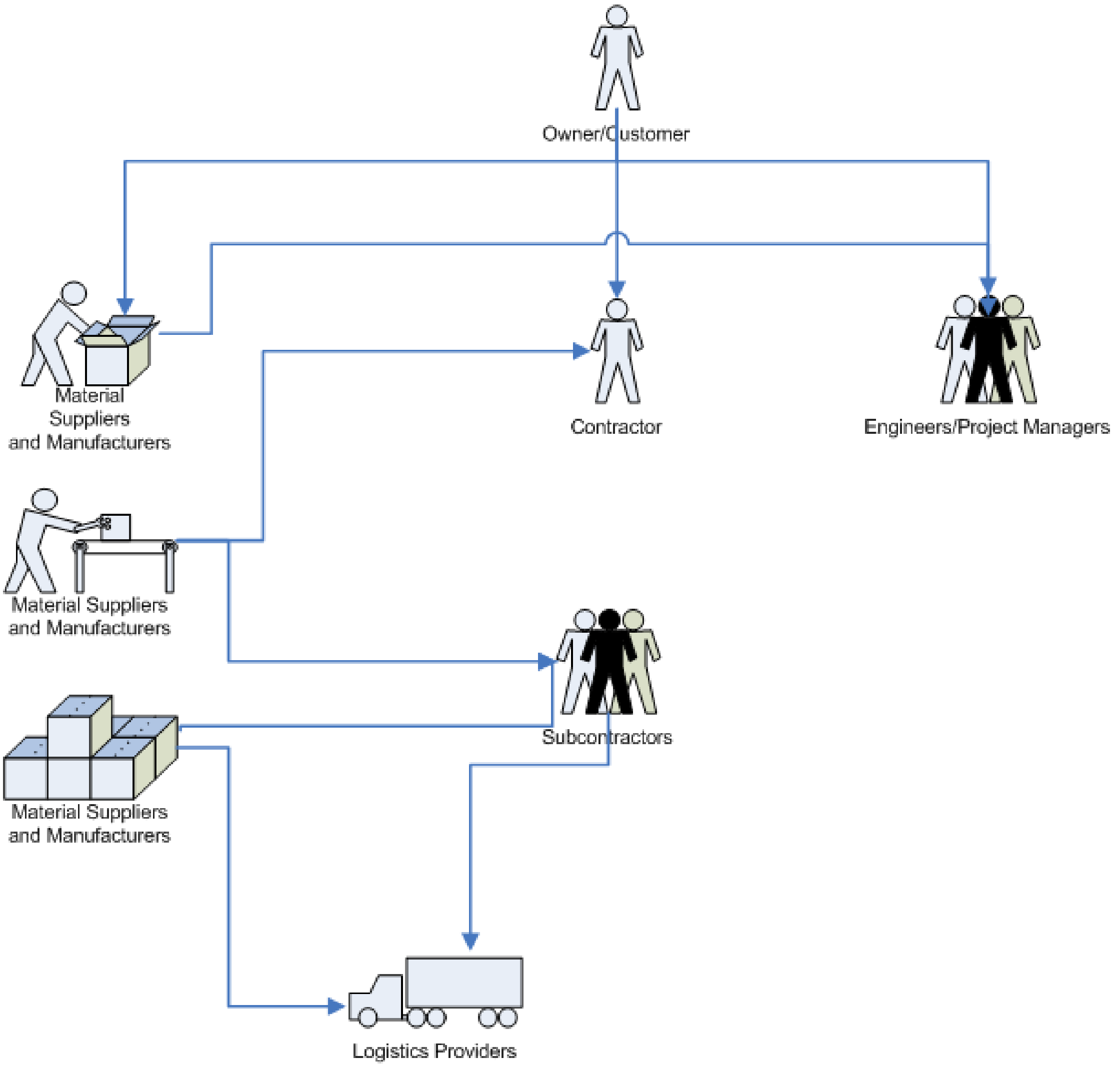


Figure 2.10 Pipeline Construction Value Chain

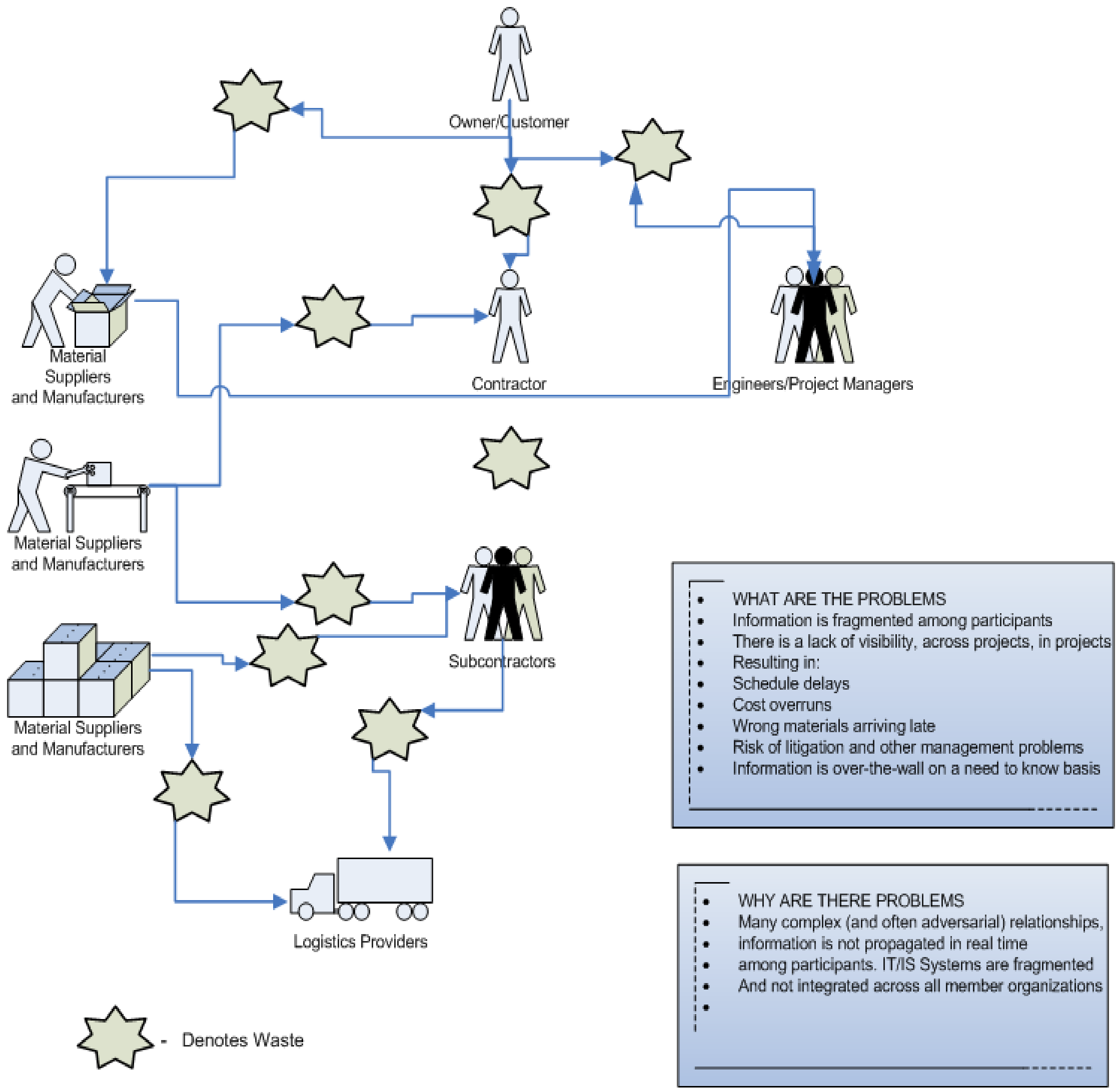


Figure 2.11 Shortcoming and Waste in Current Pipeline Construction Value Chain

Recommendation 2 Integrate the Operations Strategy and IT with the Business Activities and Integrate all Activities (subject to security considerations):

It has been stated that construction projects are swamps of complexity, as illustrated in Figure 2.12

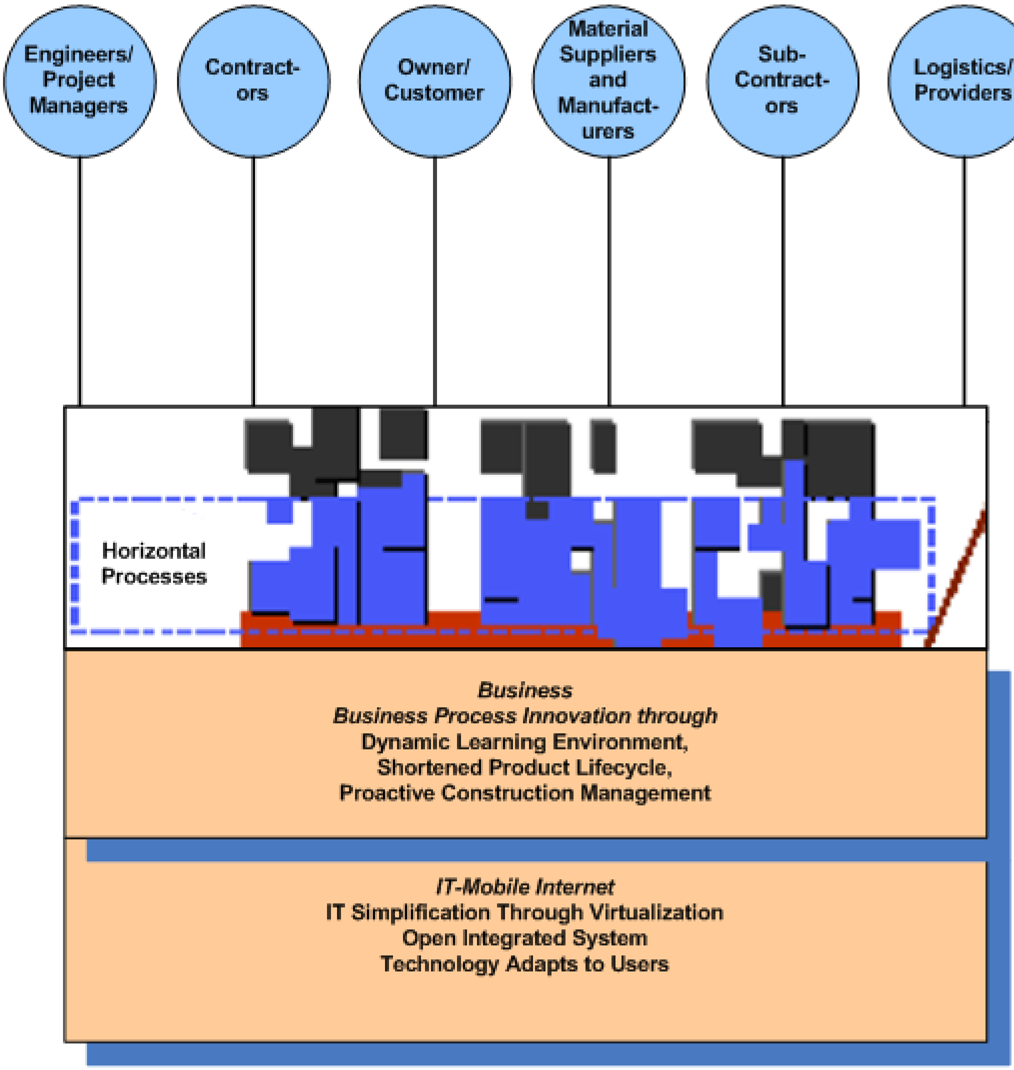
below.

Figure 2.12 The Construction Swamp of Complexity.

IT is about managing complexity, yet the construction industry has tended to be a lagging adopter of IT (Hapgood, 2004). As Hapgood (2004) notes, instead of a consensus as to what has inhibited the spread of IT within the construction industry, there's speculation. Hapgood (2004) suggests that contractors have a project-centred view of business and that they may be reluctant to add continuing overhead expenses like IT staff. Another issue would be fear of litigation, which could also lead to reluctance in adopting new technologies. Finally, the construction industry tends to be highly outsourced. Clients hire contractors who hire subcontractors who hire other subcontractors, and this may inhibit the kind of information-sharing that IT would facilitate. Hapgood (2004) notes that there is a " dark, lingering suspicion" in construction that "making information readily available and transparent could be troublesome."

Whatever the reason, in the past few years this resistance has begun to crumble. IT is starting to permeate the construction industry, helping it to manage issues such as centralization, facilitating collaboration among subcontractors, and streamlining scheduling and materials handling. And as construction projects grow in complexity—with larger jobs, more government regulation, and more sophisticated materials and building techniques—the role of IT in managing that complexity inevitably will grow along with it. However, without an integrated strategy, business, IT approach, IT is notorious for adding to complexity, rather than absorbing it (Andriole, 2004).

The Internet enables all activities to be potentially integrated. This will establish the backbone for a collaborative learning environment. If the culture of collaboration can be established, strategic capabilities necessary for innovation can be achieved. More details of this will be presented in Chapter Four. Figure 2.13 shows the integrated strategy, business, IT model being proposed for gas transmission pipeline construction.



Dynamic Integrated e-Operations Strategy for Gas Transmission Pipeline Construction

Figure 2.13 A Dynamic e-Operations Strategy for Gas Transmission Pipeline Construction

2.4 Summary

This chapter has presented the findings of the literature review relevant to the research questions posed in Chapter One. As argued above, an operations strategy is important for pipeline construction, however, it must not be a traditional planning and control strategy, as this will stifle innovation of business concepts, which is required for organizations to stay competitive. A dynamic operations strategy based on the Internet is proposed as one strategy which will foster an organizational learning environment through collaboration of all stakeholders as a team. The arms length competitive culture of APIA members must be overcome. Before continuing with a more detailed discussion of the e-operations strategy for pipeline construction, Chapter Three presents a more detailed discussion of the methodological issues relevant to the current research.

CHAPTER THREE
METHODOLOGY

3.1 Overview

Chapter Two presented a discussion of the issues in 21st century planning and control systems relevant to pipeline construction industries. This chapter now presents the research method and the data collection techniques adopted. Initially, an overview of the research design is presented in Section 3.2, followed by a discussion of the philosophical approach adopted in Section 3.3. Section 3.4 presents a discussion and justification of the research strategy, followed by the research questions in Section 3.5. The reasons for choosing the case study approach are presented along with a review of its critical aspects. The chapter proceeds with a description of the protocol adopted in the data collection and a general description of the (one in-depth and two minor) case studies developed in this research in Section 3.6. Finally it presents the analytical strategy adopted and the criteria for interpreting the findings is presented in Section 3.7. The chapter concludes with a summary in Section 3.8.

3.2 Overall Research Design

The present research uses ‘case study’ as the main research strategy in investigating the planning and control process in onshore gas transmission pipeline construction. Yin (1994) defines “case study” as an empirical investigation into contemporary phenomenon operating in a real-life context. It is particularly valuable when there is not a clear delimitation between the phenomenon and the context itself. Therefore, this research strategy is the most suitable because it incorporates all the normal uncertain conditions faced by practitioners (Robson, 1993; Yin, 1994). This initial section gives a general view of the research design that shapes the contents of this chapter. It describes the logic used for getting from the initial research questions to the conclusions.

a. Firstly, it was necessary to establish an overall theory in order to set up a ‘benchmark’ for onshore gas transmission pipeline construction planning and control.

A theoretical framework was initiated at the outset of the empirical work. The literature review supporting this theoretical framework covered initially operations management in general, with a particular focus on construction and manufacturing management from an intra-organizational perspective. The theoretical framework evolved (alongside the data collection as the observations of practice drove the researcher to bring it closer to the kind of problems encountered in construction practice today) into covering planning and control issues from an inter-organizational perspective, supply chain management and value stream analysis, and finally into studying the literature on the alignment of execution capabilities, including the planning and control requirements of the supply chains with the strategic positioning of the chains.

b. Industry conferences on Supply Chain Management strategies and execution were attended to gain a better understanding of the processes and issues discussed in the literature.

c. A pilot case study of onshore gas transmission pipeline construction was undertaken, which was regarded as the 'explanation building phase'. With this approach the researcher looks for evidence that matches the theory, in order to build an explanation of the facts (Yin, 1994). The pilot case study was undertaken with Duke Energy International at Kembla Grange, NSW. A general description of the onshore gas transmission pipeline construction process was created, along with a study of present tools and technologies used in construction and the type of resources and information required by the contractors as well as a study of the contractor organizations and their roles in the construction process.

d. After initial data was collected in the pilot study, the research questions could be refined. An in-depth case study of onshore gas transmission pipeline construction was then carried out. The particular emphasis was on the planning and control of the construction process from an integrated supply chain perspective. From this case study, waste in the planning and control process could be identified. Further literature reviews and conference visits suggested that operational effectiveness by elimination of waste was not sufficient. The process had to be strategically aligned both within the organization, with strategic and tactical goals, as well as across organizations in the supply chain. For this purpose the case study then examined the overall strategic alignment of the construction process.

e. Following the major case study, which was undertaken with industry partners of the CRC-WS, members of the APIA (Australian Pipeline Industry Association), as well as contractor organizations involved in on-and off-shore pipeline construction in both Eastern and Western Australia, a detailed description of the gas transmission pipeline construction planning and control process was produced (see Appendix A). It is believed to be the only comprehensive description of the pipeline construction management process available. The report was distributed and feedback obtained to ensure its reliability. Some minor case studies were then undertaken. These minor case studies were at a Western Australian mining company, TiWest Joint Venture:Chandala Dry Mill and Synthetic Rutile Plant, the Cooljarloo Sand Mining Site. The purpose of these minor studies with another AEC industry was to ascertain whether their focus was solely on operational effectiveness, how effective these operations were, and whether operations were strategically aligned.

e. Evidence gathered from the theoretical framework and the case studies taken together can become part of what can be classified as a ‘learning repository’ or knowledge base (following Senge, 1990,1995,1998). This repository, available at the University of Wollongong, can be utilized to create pipeline construction learning organizations. The initial case studies undertaken for this research have so far used a ‘push learning strategy’, for organizations involved in pipeline construction, where the researcher presents reports and seminars to the relevant organizations using their own perceptions of the situation. It is hoped that sub contractor organizations involved in the gas transmission pipeline construction process will contribute to knowledge acquisition in construction and also utilize the information collected in this research in a pull learning mode, in order to improve the construction process and themselves become ‘learning organizations’(Senge,1990, 1995,1998).

3.3 Philosophical Background

Two distinct philosophical approaches for developing research have been the subject of a long-standing debate in management science: the positivist and the interpretive (or phenomenological) approach. The **positivist approach**, often designated as quantitative research, believes that the subject under analysis should be measured through objective methods rather than being inferred subjectively through sensation, reflection or intuition. Among the major implications of this approach is the need for independence of the observer from the subject being observed, and the need to formulate a hypothesis for subsequent verification. Positivism searches for causal explanations and fundamental laws, and generally reduces the whole into the simplest possible elements in order to facilitate analysis (Easterby-Smith et al., 1991; Remenyi et al, 1998).

On the other hand, the **interpretive approach (**referred to by Easterby-Smith et al as the **interpretative approach**), also known as the phenomenological, hermeneutic, or qualitative approach, understands reality as holistic, and socially constructed, rather than objectively determined. The interpretive approach arose largely in reaction to the application of positivism to the social sciences, in the last half of the twentieth century. According to this philosophy, the researcher should not gather facts or simply measure how often certain patterns occur, but rather appreciate the different constructions and meanings people place upon their own experiences and the reasons for these differences. The interpretive approach tries to understand and explain a phenomenon, rather than search for external causes or fundamental laws (Easterby-Smith et al., 1991; Remenyi et al, 1998). Table 3.3 summarises the main features of both philosophies:

	Positivist Paradigm	**Interpretative Paradigm**
Basic beliefs:	The world is external and objective Observer is independent	The world is socially constructed and subjective Observer is part of what is observed Science is driven by human interests
Researcher should:	Focus on facts Look for causality and fundamental laws Reduce phenomena to simplest elements Formulate hypotheses and then test them	Focus on meanings Try to understand what is happening Look at the totality of each situation Develop ideas through induction from data
Preferred methods include:	Operationalising concepts so that they can be measured Taking large samples	Using multiple methods to establish different views of phenomena Small samples investigated in depth or over time

Source: Easterby-Smith et al. (1991)

Table 3.1 Key Features of the Positivist vs Interpretive Paradigms

As Remenyi et al (1998) argues, these approaches are both important, and not mutually exclusive, but should be considered complementary to one another.

3.3.1 Engineering Management as a Field of Study

Roozenberg and Eckels(1995) regard Engineering Management as belonging to the general field of technology, rather than science. Science pursues knowledge acquisition, while “technology-the design, making, and using of artefacts-is a systematized form of action.” Both can be pursued methodically. For both, certain rules have been developed, the observation of which is supposed to “…contribute to efficient performance of the activity involved.” Both processes involve reasoning. Which conditions should these two different reasoning processes meet, so they can claim reliability, meaning that the conclusions to which they lead are correct or true? The criterion for reliability of scientific reasoning is the truth of the resulting statements. The criterion for reliability of technological reasoning is the effectiveness of the action process, based on that reasoning. We may pose a ‘scientific question’ about a technological claim: ‘Is it true that the proposed action will be effective?’ That is the type of question posed in this thesis. ‘Is it true that implementing a specific set of strategies and techniques collectively called “the planning and control system of production control” improves the reliability and efficiency of the pipeline construction process?’

Given this ‘scientific’ question about a technological matter, the issue now is what methodological rules are appropriate, what kind of data is needed to answer the question, and what kind of inferences can we expect to make from such data. These issues are discussed in the following section.

3.4 Research Strategies

According to Robson(1993:40), the three traditional research strategies are *survey, experiment*, and *case study*. These are discussed below with respect to the current research.

Surveys

Many engineering management theses pose claims about some aspect of engineering management action, use surveys to collect data regarding same, then apply statistical analyses to test the adequacy of their claim. This methodology works from a sample of a population to claims about the population itself by statistical generalization. ‘If 79% of a 151 member sample report that they include safety records in their pre-qualification of welding sub-contractors, what generalization can I make regarding all members of the population that pre-qualifies welding sub-contractors?’ Rules of statistical generalization exist for answering such questions. However, statistical generalization from sample to population is an appropriate methodology in the field of engineering management only if one is interested in testing claims about current behaviour. If the objective is to introduce new policies and behaviours with the intent of improving engineering management practice, a different type of methodology is needed. In the current world of pipeline construction management practice, there may not be any practitioners following the new strategies and techniques proposed in this research, so there is no sample to take. The question is not ‘How many people employ, say, a Lean Production system in gas transmission pipeline construction and with what effect?’. The relevant research question has the form ‘Will the desired consequences result from taking the proposed action?’ ie ‘Will a manufacturing planning and control strategy and system enhance pipeline construction management?’ Therefore, a type of experiment rather than a survey is needed.

Experiments

In the previous section it was argued that a survey strategy is inappropriate for the question posed by this research. The research strategies that could possibly lend themselves to investigation of this research question include *true experiments, quasi-experiments,* and *case studies*. *True experiments* require establishing a control group that differs in no relevant way from the experimental group. A true experiment was not appropriate because of the difficulty of establishing a control group and lack of control over extraneous variables. At a later stage, it would seem to be possible to use a pre-test, post-test, single group design, measuring for example waste and flow of the same group before and after implementation of a Lean Production Control system.

This approach however has several difficulties because flow reliability and waste are not an explicit, measured objective of traditional production control systems, so pre-test quantitative data is not available, and our ability to generalize from the experimental results is limited by the possibility that those who try a Lean Production planning and control method in pipeline construction are somehow different from those who do not so choose. The second difficulty could be managed by conditioning and qualifying the inferences drawn from the experiment. The first difficulty, the lack of quantitative data on flow reliability for the pre-test, could be handled by substituting subjective data, in the form of interview results. However, this is clearly an inferior solution, and so a more effective research strategy must be found. *Quasi-experiments* are "…experiments without random assignment to treatment and comparison groups." (Campbell and Stanley, 1966, cited in Robson, 1993, p. 98) They sacrifice some of the rigour of true experiments, but are nonetheless appropriate for a large range of inquiry, where true experiments are impossible or inappropriate. The key issue regarding quasi-experiments is what inferences can be drawn. It is proposed that inferences be justified in terms of study design, the context in which the study occurs, and the pattern of results obtained (Cook and Campbell, 1979). While this strategy responds to the difficulty of generalizability posed above, it still leaves us without pre-test quantitative data on flow reliability and waste in design, and consequently, is not by itself an adequate strategy for pursuing this research.

Case Study

Case study is "…a strategy for doing research through empirical investigation of a contemporary phenomenon within its real life context using multiple sources of evidence" (Robson, p. 52). Case studies are an appropriate research strategy when there is little known about the topic of interest, in this case, for example, how pipeline construction is managed; and a change in theory or practice (for example, introducing lean production control in pipeline construction) is proposed (Robson, p.169). Multiple case studies allow the researcher to pursue a progressive strategy, from exploration of a question to more focused examination of trials. Given the exploratory nature of the research question being posed, a multiple case study strategy at this early stage seems inappropriate.

Traditionally, case study has been viewed by some as a less desirable form of empirical research strategy, due to the possibility of bias on the part of the observer. Without careful protocols it is easy to see how different interpretations can fit the empirical evidence collected in a case study. Quite often this bias is reflected in the use of equivocal evidence or, in other words, evidence that could have a contrary interpretation by another person (Yin, 1994; Remenyi et al, 1998; Platt et al, 1996).

However, as Remenyi et al. (1998) and Yin (1994) argue, bias can similarly affect the conduct of any research strategy. Furthermore, Yin (1994) asserts that the perspective of reality from the viewpoint of someone "inside" a case study is invaluable in producing an accurate portrayal of a real phenomenon. Therefore, the practical validity of a case study resides in the fact that it operates within a "real world" context that gives findings a higher sense of openness to public scrutiny. Nevertheless, the case study research strategy is still seen as "soft" research by many researchers and generally considered as time-consuming, too expensive and likely to generate excessive documentation. These arguments do not consider the fact that a case study has more flexibility in relation to other research strategies when studying "real world" events. In experimental designs, for instance, any failure to carry out the pre-specified research design has serious implications and, often, is fatal in terms of interpretations. In the same way, a survey calls for considerable and detailed preplanning before one starts data collection which, in turn, may face unexpected impediments when applied in "real world" conditions (Robson, 1993; Remenyi et al., 1998). In the context of this research, perhaps the most critical aspect of a case study approach is the fact that it provides a limited basis for the traditional "scientific generalisation" (Yin, 1994; Remenyi et al., 1998). Nevertheless, like all experimental observations, case studies results can be generalised to theoretical propositions (analytical generalisation) but not to populations or universes (statistical generalisation). Therefore, the aim of case studies cannot be to infer global findings from a sample to a population, but rather to understand and articulate patterns and linkages of theoretical importance (Remenyi et al., 1998). Additionally, it is important to emphasise that case studies deal with unique situations and, because of that, it is not possible to elaborate detailed and direct comparisons of data. However, results and conclusions are comparable in a general sense. Comparison of case studies can also lead to the formulation of theoretical conjectures or, in some circumstances, the confirmation of working hypotheses or to suggest empirical generalisations (Remenyi et al., 1998). Such comparisons may also more accurately suggest new areas of investigation for quantitative research (Platt et al, 1996).A very important advantage of the case material lies in the richness of its detailed understanding of reality. This means it can work as an effective mnemonic device. Indeed, good case study material can be compelling in the way the narrative feels real to the reader and, thus, gives aesthetic appeal that attracts "human interest". The real-life story contained in a case study seems to be a more humanistic mode of presentation than other traditional research strategies. In particular, the peculiar rhetorical style of case study material is useful when exposing research findings to audiences without scientific background. This rhetorical strength also makes it important that such material be used carefully in ways which support, rather than override, the logical grounds for the conclusions reached (Platt et al, 1996).

3.5 Research Questions Revisited

As stated in Chapter One, when selecting a research strategy, it is necessary to determine the research *topic, question, and purpose*. The *topic* of this research is engineering management; more specifically, designing a manufacturing planning and control strategy and system to improve the design and construction processes of architectural/ engineering/ construction projects – in particular, onshore gas transmission pipeline construction. The objectives and *questions* driving this research are presented below.

3.5.1 Research Objectives

5. Study and analyze onshore gas transmission pipeline construction planning and control from a value network perspective
6. Describe the execution capabilities and strategic positioning of the existing pipeline construction planning and control system
7. Identify areas of misalignment that exist in the current manufacturing planning and control value stream

8. Recommend improved and aligned framework

3.5.2 Research Questions

Research Question 1. What is the current planning and control strategy and system for Gas Transmission Pipeline Construction and what are the limitations?
Research Question 2. How do the processes and sub-processes in Gas Transmission Pipeline Construction differ from a manufacturing system?
Research Question 3. Are the manufacturing planning and control strategy and system applicable to pipeline construction?
Research Question 4. In view of the most recent developments in manufacturing philosophy, does this have potential for improving the efficiency of pipeline construction?
Research Question 5. Specifically, can a model be developed to apply manufacturing strategy and systems to gas transmission pipeline construction?

To fulfil these objectives, and answer the research questions a literature review, and a major in-depth case study of onshore gas transmission pipeline construction were selected, followed by some minor case studies of planning and control in another AEC industry, the sand mining industry.

Traditional *purposes* of research are *exploratory, descriptive, and explanatory* (Babbie, 2001). *Exploratory* research is generally conducted to develop an understanding of some phenomenon. *Descriptive* research is undertaken to describe the precise measurement and reporting of the characteristics of some population or phenomenon under study. *Explanatory* research is conducted to discover and report some relationships among different aspects of a phenomenon under study. The purpose of this research is then descriptive, exploratory and explanatory as the aim is to study and analyze the existing integrated process of planning and control of gas pipeline construction. It could be argued that an additional purpose is to *evaluate* the existing process. Evaluation does not fit neatly within the above-mentioned traditional purposes of enquiry, as specified by Babbie(2001). Technological research draws on the traditional goals of exploration, description, and explanation, but also has the overriding goal of improving practice. Therefore the purpose of this research is also to determine the extent to which the current planning and control method of pipeline construction is effective.

3.6 Research Methods

3.6.1 Data Collection Methods

Executing a research strategy requires methods for data collection and analysis. The research methods available for case study, the research strategy adopted in this thesis are direct observation, documentary analysis, and interviews.

3.6.1.1 Observations

The assessment of business processes such as planning and control processes is complex, and requires an extensive knowledge of exactly how an organization conducts business. Observations allow the researcher to elicit data from people in their natural work environment. Due to the complexity of this research, observations were the first method used to gain data and develop a broad understanding of the organisations involved in the case study, and enabled the researcher to gain a high level view of the business process, and the interaction between suppliers and clients in that process. After gaining an understanding of each subcontractor organization the time required for interviews is relatively shorter and minimizes disturbances to all participants.

3.6.1.2 Document Analysis

Document analysis involves analysis of documentation to solve a problem or answer a question (Cavana et al, Delahaye, and Sekaran, 2001). Within this research, document analysis was used to provide an in-depth insight into the process of pipeline construction, as well as the many documents required for monitoring and control of the construction process, such as the contracts, project planning documents, and many more. These documents were provided by Australian sub-contractor organizations involved in the gas transmission pipeline construction process and other academics.

3.6.1.3 Semi-Structured Interviews

Semi structured interviews are the third and final method used, and allow in depth results to be gained. Semi-structured interviews are useful as they can help clarify questions or help uncover new questions. This helps obtain richer and more complex data than simply just by using questionnaires (Cavana et al, 2001). Semi-structured interviews involve using a pre-planned approach to the interviews like structured interviews, but the interview is commenced as an unstructured interview (Cavana et al, 2001). This provides the interviewee the chance to introduce new topics as required, and when the interviewee's information is drying up, a new planned question can be asked. The interviews were conducted with various employees along each supply chain, gathering facts and perceptions relevant to the objectives of this research. They were used in conjunction with the observational studies to verify and gain a better understanding of the preceding results and to clarify any issues that arise from the previous methods. Interviews were conducted in person and by telephone. Qualitative data were obtained from these interviews.

3.6.2 Data Analysis and Evaluation

McNeill (1989) suggests three key concepts for data analysis and evaluation: reliability, validity, and representativeness. *Reliability* concerns the extent to which research can be repeated by others with the same results. "*Validity* refers to the problem of whether the data collected is a true picture of what is being studied." *Representativeness* concerns whether the objects of study are typical of others, and consequently, the extent to which we can generalize.

Reliability

The case studies undertaken should be considered reliable. Although the problem being studied is very complex, the sources used have all been treated carefully to reflect the meanings and intentions of each author. The majority of sources written are widely used in pipeline construction. The interviews were conducted with very reliable and well respected members of the sub-contractor organizations. However, it is widely known in pipeline construction that there are no overall standards for terminology and definitions, including documents, and data. A future research project would have to establish standards for terminology and definitions as well as data.

Validity

The study was performed in a way that it was reliant on the sources used for the study. The sources were the ones found in the time period of the research masters thesis and may not cover all aspects of the problem at hand. Also the terminology may change over time. The validity of the study should be considered as moderate.

Representativeness

It is believed that the study itself is highly representative of not only onshore gas transmission pipeline construction in Australia, but also in the entire Asia-Pacific region. This is evidenced by the fact that many of the sub-contractor organizations work in this region due to the thousands of kilometers of pipeline being constructed and the geographical location of these pipes eg the Eastern Gas Pipeline from New Guinea to Bass Strait.

3.7 Analytical Strategy

3.7.1 Unit of Analysis

The definition of what is the “unit of analysis” is of paramount importance to any analytical strategy. Dubin (1978) stresses that only when these units are put together, with their correspondent interactions, do they enable the generation of “laws” as the term law is usually employed in science. Different types of units can be considered, from individuals, to organisations, small groups, roles, events, etc. The definition of the analytical boundary determines the limits of data collection and analysis. This boundary, in turn, can be defined by the propositions set up in the theoretical framework (Yin, 1994), or simply by what will or will not be studied (Miles, 1994).

Dubin (1978) suggests that "units of analysis" may be represented either by attributes or variables. An *attribute* is a property of an element of practice (material, method, equipment, human management practice) distinguished by the quality of being present. In this research, a *variable* is a property of a practice that may be present to a certain degree. According to this definition the present research interprets the "unit of analysis" as the integrated supply chain or value stream and as such is intra- as well as inter-organizational and is definitely a variable.

3.8 Summary

Chapter Three has presented a justification and description of the methodology chosen to support and solve the research objectives and questions. The methodology chapter highlighted the proposed research design and described the purpose of the research as descriptive, exploratory, explanatory, and evaluative. It outlined the data collection techniques utilized, and described the unit of analysis as the pipeline construction supply chain or value stream. The data collected was qualitative and its reliability and validity were also discussed with reference to the qualitative approach. Chapter Four will now present the results of the case study.

CHAPTER FOUR
A SERVICE ORIENTED PORTAL ARCHITECTURE FOR GAS TRANSMISSION PIPELINE DELIVERY

4.1 Introduction

Chapter Two explored the research question which was will a manufacturing strategy and planning and control system make gas transmission pipeline construction more effective and if so, design the strategy and system. The chapter arrived at several conclusions and recommendations. These were:

- The manufacturing industry has moved from a make and sell product-focussed environment to a sense and respond to-order service-focussed environment;
- Industries compete today on services, with or without facilitating goods. Production alone is not a competitive priority;
- Pipeline construction needs to be managed as a service delivery system;
- Service delivery as a to-order or on demand environment requires an integrated approach to the entire value chain (web) from the initial customer order to the delivery of the service (including the product) and back (if necessary);
- Gas transmission pipeline construction (like all to-order industries) is a non-linear, complex adaptive system and should be managed holistically;
- This does not mean that the traditional manufacturing strategy and top down deterministic business model and approach to manufacturing planning and control is appropriate. Control is federated, and as a complex adaptive system, control must be emergent and local as well as top down;
- What has to be controlled and what is emergent needs to be determined by the (sub-) contractor organizations. At present only project control is managed, which is largely conformance to budget and push;
- A new dynamic non-linear business model is required for gas transmission pipeline construction;

- This dynamic model has a tight integration of business processes, people and workplace, information technology and operations strategy, as illustrated in Chapter Two, Figure 2.13;
- To enable the dynamic and flexible approach, it is proposed that gas transmission pipeline construction be managed as a portfolio of business services. Further research is required so that members of the APIA can decide which services they manage best;
- It was also suggested that by developing gas transmission pipeline construction as a portfolio of services, the workplace culture, governance structure and employee attitudes must change to one of collaboration, rather than competition;
- An e-operations strategy is proposed, which utilizes the internet as an enabler. This will enable the APIA to leverage the intangible assets of the organization into strategic capabilities;
- The IT/Internet must not be treated in an add-on manner, but requires simultaneous development of the operations strategy, business methods, and the underlying technology;
- For this reason a standards-based technology and business architecture both within and across processes is proposed;
- In developing the IT/Internet component, the organizations must look beyond simply providing automated functions to replace human steps, in particular in the areas of decision making and judgement, the IT must become an integrated part of all business processes. That is, each business service must be designed for the tight integration of strategy, process, IT, and people and provide operational intelligence for gas pipeline construction. That is, the IT solution is strategy-driven.

This chapter starts out with a more detailed discussion of the shortcomings or ‘pain points’ observed in pipeline construction (as identified in Chapter Two), and the strategic capabilities that are enabled by the integration of Internet technology into the workplace and business processes in Section 4.2. It then goes on to briefly discuss the relevant Internet technologies appropriate for gas transmission pipeline construction for today and the future in Section 4.3. Finally it suggests an approach to developing a business service and portal architecture for pipeline construction and maintenance in Section 4.4. The Chapter concludes with a summary in Section 4.5.

4.2 Problems With Existing Gas Transmission Pipeline Construction

4.2.1 Pain Points

An analysis of pipeline construction operations revealed the following operational shortcomings or 'pain points' for operations managers and project managers:

Information Access, Knowledge Management and Organizational Learning
Collaboration and Communication
Workforce and Relationship Management
Project and Portfolio Management
Materials and Inventory Management
Supply Chain Management/Logistics Management
Design
Financials
Maintenance and Service Management
Equipment handling and Tracking

These pain points also impact on strategic and tactical initiatives. They are discussed in more detail below.

4.2.1.1 Information Access, Knowledge Management and Organizational Learning

Lack of timely, in depth, and relevant information to pipeline partners could be one of the causes of collaboration and control problems in pipeline construction. Information is fragmented and only hard copy information or scanned information is available and sometimes by word-of-mouth only. Knowledge management and knowledge are fragmented and out of date, and knowledge is shared only on a limited basis.

Knowledge is also restricted to single projects and phases. Knowledge gained by one design team for one project is not always recorded or passed on to designers from other projects. Experience gained on one project is not transferable to other projects, unless the same project manager is employed. There is at present no facility for a lessons learned (project history) database to be accessed by subcontractor organizations. This leads to a limited shared learning about methods as well as achievable outcomes between organizations. Learning is shared mostly at conferences and seminars and occurs sporadically. There is also no allowance for multilingual or multicultural aspects of information exchange. Information when available on the Internet is not selective by role or viewing device, resulting in too much or not enough information being communicated. Information is presented for a general APIA audience and not personalized by role or viewing device, such as pocket PCs. There is no one point of access for all information from the various systems involved in pipeline construction.

4.2.1.2 Collaboration and Communication

As noted in Information Access, management teams and subcontractor organizations do not have the basic tools to collaborate with peers, regional management, and corporate offices. At present information and communication is hard copy. Providing the right information to the right people at the right time and providing ready means of communication to solve issues saves time. It also creates a work environment that is open, and supports the breaking down of silos of culture, subcontractor organizations, information, and automation. For example, data entry is duplicated or manual entry is required because related systems are not well integrated. There is no efficient means of viewing and communicating what needs to be done among say off- and on-site personnel. There is also no efficient way of sharing information and collaborating with head office or site office in real time.

4.2.1.3 Workforce and Relationship Management

The pipeline workforce could be said to be made up of the needs of management and the needs of the individuals. These are not distinguishable in the present system. This should be addressed, as it is commonly understood in today's competitive climate that employees are the most important asset of an organization. At present, decisions are made sequentially by specialists and thrown over the wall. There is no involvement of downstream players (subcontractors) in upstream decisions. There is also a lack of appropriate vocational training and lack of adequate information and communication. There is a limited awareness and understanding of IT/Internet and its potential benefits to the project. This can lead to distrust. Also the lack of inclusion of all participants in pipeline construction decisions leads to an arms length and often adversarial culture among the subcontractor organizations. This could lead to high turnover rates and unavailability of qualified personnel. Presently training is not provided on the job and is regarded as secondary because time away from work is costly. Current performance management systems are either paper based or standalone desktop PCs. This also has to do with information access. At present there is no facility where participants can view or update information from the field in a real time manner. From a human resource perspective there is no real time access to employees credentials and qualifications, suggestions, grievances, time sheets and so on.

4.2.1.4 Design

The present approach to product and process design is fragmented. The product design is outside of the project lifecycle and if drawings need to be accessed or changed during the construction process, this requires a long wait. There is no focus on concurrency of design, process, and supply chain. Not all product lifecycle stages are considered in design – all product lifecycle stages should be considered in design, otherwise errors can occur. There is no link between the supply chain design and the product design. If concurrency were considered, sourcing would be design-build. As it is, decisions about sourcing contracts are made separately from the product (and process) design. There is no one point of access to relevant partners such as design team and client team. Clients cannot collaborate in the design process. Because design is not integrated there is no access to supplier or manufacturer online, no access to compliance regulations and other standards, and no access to other databases such as project databases from other projects, while designing and planning for the new project. Advantages of collaboration in the design stages cut down on errors at a later stage. Project designers can also collaborate in online modelling.

4.2.1.5 Materials and Inventory Management

Once again, time-intensive manual processes related to inventory and materials handling with a focus on surplus is time consuming. Because there are only manual processes or desktop systems used, there is a lack of visibility of stock flow, a lack of integration with maintenance and equipment service management, and equipment tracking. Participants build up large inventories to protect their own interests. There is a lot of surplus at the end of the project, which the project manager must sell or take to a new site. As mentioned elsewhere (Anderson, 2004), the BTO pipeline requires a spontaneous supply chain with spontaneous inventory management, but there is a lack of focus on automatic restocking, for example, by using autonomic logistics (discussed below). There is no automatic integration with other systems, such as General Ledger, Accounts Payable, Purchase Order, Job Costing, and Equipment Control.

4.2.1.6 Supply Chain Management

Supply chains are treated as separate organizations linked together through the market. They are fragmented, with limited communication between disciplines within a phase and between phases. In some cases strategic alliance relationships between the primary supplier (contractor or consultant) and sub-suppliers based on pre-established relationships and experiences exist. The intent is to continue a working relationship. Electronic sourcing and procurement is not realized to its full potential. For example, the downloading and printing of tendering documents for estimating purposes; electronic funds transfer is state of the art but is not being utilized by gas transmission pipeline construction. This can also lead to information and communication problems, as noted above.

4.2.1.7 Project and Portfolio Management

The monitoring and control of all information relating to the project in an up to date manner is not possible using manual procedures, or limited desktop PC facilities. There is no central one point of access integrated way of enquiring and reporting on project progress. For example, there needs to be a way of enquiring on contract status from different viewpoints, such as customer, project manager, contractors, or combinations of the above. There is no means to view contract value, billings to date, cost to date, variance, forecasted costs to complete, percentage completion and projected profit. This is because there is no integration with financial management systems.

A top level overview is not available in real time, such as the facility of selecting a specific job, opening a job status inquiry window that reveals the next level of detail. There is no means of viewing by cost class, cost code, contract item or master cost code in an integrated and real time manner. In this view, it would also be possible to view original budget, any change orders that may have been issued, the projected budget, costs to date, forecasted costs to complete and the projected variance by cost code. There is no means of doing a drilldown showing each individual transaction and drilling down further and further into the project, so that project managers can easily see if an employee's time or a material invoice was charged to a project by mistake. There is no means of viewing change orders to control say revisions in estimates, track changes and control accounts for extra work. Controlling changes in real time can affect the prime contract and any number of subcontracts and is important at this stage. There is also no means of viewing all open change orders. There is no means to automatically increment budget, contract, and subcontracts. There is no electronic means of managing documents of multiple document types like CAD files, spreadsheets, word or any other electronic document in a central server. There is no means of having access to documents from a single source of all documents for all members of the team, sharing information as required.

The above discussion of the pain points (shortcomings) identified across the pipeline project requires strategic capabilities supported by a mobile internet platform. Following is a summary of the current factors limiting strategic advantage and the strategic capabilities enabled by integration of Internet technology.

4.3 Sustainable Competitive Advantage Enabled by the Internet

As noted in Chapter Two, the Internet enables sustainable competitive advantage through the innovation of business processes and concepts. This innovation comes about by leveraging the organization's dynamic capabilities (intangible assets).

4.3.1 Information Access, Knowledge Management, Organizational Learning

Factors Limiting Strategic Advantage	**Strategic Capabilities Enabled By Internet Technology**
At present managers must divide their time between the 'back room' for meetings and the site. Electronic information from the site is delivered once a day to PCs in the back room or uploaded to a data warehouse	Create mobility for management teams by providing access to all relevant information from a multifunction wireless PDA device Enable real time field data capture using wireless and pocket PC
Too much information is communicated if on the web, and is hard to find when needed. Unable to highlight critical communication Information is built for a general APIA audience Best practice information is either not available or hard to share due to fragmentation	Target the information directly to the people who need it. Push critical (required) information to each user (group), and let users pull important information from relevant forums (optional). Provide the ability to search a list of pipeline policies and standards for quick reference

4.3.2 Scheduling

Factors Limiting Strategic Advantage	**Strategic Capabilities Enabled By Internet Technology**
Creating the schedule involves a great deal of manual intervention and collection of information.	Have the scheduling system develop the core schedule on appropriate drivers from diverse departments and subcontractors, allocate hours and compare to budget. Provide tools for evaluation of schedule effectiveness.
Quick concise picture of staffing levels within and between subcontractor organizations is not readily available to allow for flexible adjustments.	Notification immediately of scheduling problems. Integration of all relevant systems.
Need the ability to prioritize jobs and allocate resources dynamically	View a comprehensive schedule and job assignment, with highlights of major issues, and assessment of the days critical activities. View crew time sheets and daily job logs across (sub-) contractor organizations.

4.3.3. Workforce

Factors Limiting Strategic Advantage	**Strategic Capabilities Enabled By Internet Technology**
High turnover rates, unavailability of qualified personnel Predominantly on the job training, inconsistent learning Training viewed as secondary because	Capture and view suggestions, issues, and grievances. Provide learning to employees electronically as needed, based on role. Include short briefings on products, regulatory or corporate policies, job

time away from work is costly	instruction (issues and lesson learned and other learning information).
Lack of and consistent tracking of required learning and training completion	Be able to view a summary of all employees' training or learning history, professional and industrial certifications, job descriptions and classifications, compared to requirements or planned.
Current performance management systems either paper based or desktop PC based. Immediate feedback and counselling is poor.	Be able to log an employee performance issue with ready reference to appropriate policies and guidelines.

4.3.4 Project and Portfolio Management

Factors Limiting Strategic Advantage	**Strategic Capabilities Enabled By Internet Technology**
Communications and job delegations are not always coordinated in corporate or site office.	View and access from one source all jobs and projects assigned.
Need ability to prioritize jobs and allocate employees dynamically. Need ability to adjust plans dynamically.	Assign jobs to employees with ability to remove, reassign, and update jobs on the work list. Incorporate emerging needs into job plan; adjust staffing to accommodate for unforeseen events. Scanning with a handheld device, automatically generate new urgent job to check for a label, or ID, for the item in question. View a status of all projects that are currently underway.

	Do contract status enquiry. Control estimate revisions, track change orders, control force accounts and extra work View all approved change orders for jobs and subcontractor and automatically increment budget , contract and subcontract View contract value, billings to date, costs and projected profits in real time
Time sheets and other project documents are not in uniform format across projects and project managers. Poor feedback channels to the corporate office regarding project and portfolio information	Associate an industry-specific format for all information Provide an integrated document manager for all gas transmission pipeline project documents

4.3.5 Collaboration and Communication

Factors Limiting Strategic Advantage	**Strategic Capabilities Enabled By Internet Technology**
Data entry is duplicated, or manual intervention is required, because related systems are not well integrated.	Information capture and routing of pipeline project information to and from management by electronic workflow.
Need more efficient means of viewing and communicating what must be done among the off- and on-site personnel.	View a list of jobs and meetings for the upcoming week. View and maintain a pipeline-level event calendar for all to see.
Need ability to communicate more	Provide e-mail and instant messaging for

efficiently with regional management and the corporate office on time-sensitive matters and sharing best practices.	pipeline management teams. Provide access to online team rooms and bulletin boards for sharing best practices.

4.3.6 Inventory and Maintenance Management

Factors Limiting Strategic Advantage	**Strategic Capabilities Enabled by Internet Technology**
Time-intensive manual processes related to managing inventory with focus on surplus.	Track materials in real time Track inventory quantities on hand, on order, and on reserve at any number of locations, for any number of subcontractors Automatically update the value of inventory - based on current average cost - each time a purchase or adjustment is made. Posts transactions in any unit of measure, and automatically converts them to a standard unit of measure for each item. Distribute inventory transaction costs to General Ledger account, to a job and cost code, or to a piece of equipment or component. Make enquiries on items by entering either a Primary Material Code, a Location Code, or an Item Code or

	description. Provide just in time e-procurement capability with automatic restocking utilizing RFID technology Access product information by scanning a UPC code with a scanning device or PDA to assist customers.
Inability to manage stock outs.	Generate an automated alert and restocking job when site stock needs replenishing.
Lack of visibility of stock supply flow.	Modify an order for inventory before it is shipped, receive notification when it is shipped from supplier.
Poor feedback channels	Communicate to the head or site office, and cancel an incoming inventory shipment if necessary.
Time-consuming and difficult to locate stock to satisfy requirements.	Provide inventory search for selected items in nearby pipeline projects.
Lack of integration of maintenance and equipment service management	Provide an equipment module that keeps track of all company owned equipment, and costs associated with each piece of equipment and allocate costs to jobs or subcontractors. Provide reports on costs per hour of owning and operating equipment, age of machines, and all purchased and rental equipment

Lack of integrated repair and maintenance program for on site equipment	Provides a method of analyzing major vehicle and component repair requirements, and a means of budgeting for future expenditures.

4.3.7 Key Performance Indicators and Alerts

Factors Limiting Strategic Advantage	**Strategic Capabilities enabled by technology**
Information is disparate across multiple sources and PCs, so is time-consuming to put together. Islands of information exist. Information is often, fragmented, incomplete, not up to date, or information is too detailed.	Have a consolidated view of key performance indicators by role that are normally stored in different systems. For example, Corporate-, Customer-, Employee-, Project Manager-, Vendor-, or Contractor- Centres.
Information is not timely, thus not actionable. Local data collection on site is not integrated in real time.	Ability to register for notification when selected pipeline events (conditions, measurement points, and so on) occur, and receive notification of those events interactively with a PDA. Ability to monitor specific key events and provide analytics that sense out of range conditions to create actions to a manager for response, for example, statistical and real time process control.

Several solution alternatives were considered for gas transmission pipeline construction. What is required is an open and robust technology framework that enables a to-order construction environment. The proposed solution enables an on demand construction environment. Its purpose is to bring the business (systems, information, and knowledge) to the people who need it and in a form that is usable within the context of the work, or business process, they are performing. In so doing, it creates a cumulative benefit for all members.

4.4 Key Features of the To-Order Pipeline Construction Environment

The following section describes the main features and highlights recommended for the to - order (sense and respond) gas transmission pipeline construction environment. The focus in this chapter is on a description of the conceptual architectures of the system. It is understood that once these architectures (business, IT) are in place then integration of current back-end legacy systems can be facilitated. Several case studies and prototypes have been developed and tested, as indicated in Appendices A, B, and C. The final recommendation documented in this chapter is for a gas pipeline portal and service oriented architecture, which will integrate planning, design, delivery, and maintenance.

4.4.1 Role-based Partner Portal

A role based partner portal is provided which allows one point of access to all systems. Where all employees access knowledge and systems needed for their work. This model highlights the pipeline management team roles, but other roles can participate in and use the portal as required. The portal provides secure access to all of the components in the system. The actual component functions presented will vary based on the defined role of the individual seeking access. The portal determines and adjusts the format of content to suit the characteristics of the user interface (device) being used during the session. To allow for location of critical information or knowledge, the portal supports a search function across all pipeline enterprise content. The portal also manages and coordinates the delivery of alerts that are generated by other systems. The portal enables companies to streamline their workflow by capturing payroll, equipment usage, material costs, and hired equipment data at the source, and update their corporate systems without the re-keying of data. This data is then transferred to the company server using wireless Internet access. Data entry is done only once – digitally – which eliminates double entries and mistakes. Individual and group access will be provided for all roles, such as owner/customer, contractor, subcontractor, supplier, engineer and project manager, and so on. A key feature of the portal will be the identity management component. This is discussed briefly in the next section.

Identity Management

Identity management addresses the concerns of system access by providing credentials to authorized users. It is unlikely that a large business like APIA if integrated would buy all their applications, middleware, hardware, and other IT assets from a single vendor. Even if the infrastructure were purchased from a single vendor, it is also unlikely that a single security model with a single security policy is implemented across all vendors' technologies. A typical enterprise is built over time, incrementally, with products from multiple vendors introducing multiple security models. As the number of disparate security models grows, the cost of managing security policies, credentials, and access control lists grows as well. And, the user experience can become more complicated as users must remember additional credentials for each system they access. The identity management service will reduce the overhead costs to both the system administrator and end user by providing a single point of control for credential management, and providing users a seamless experience when being authenticated (who you are) and authorized (what can you see) to use those systems.

4.4.1.1 Business Needs

Efficiently and effectively managing user authentication and authorization require a single point of control for administration, authorization, and authentication requests. On the administrative side, security tools can provide the system administrator with a suite of tools that enable management of credentials from a single point of control.

A seamless, integrated experience is also necessary, or users would need to provide the credentials again and again as they move from one system to another. The construction portal provides a single point of access to back-end applications and content in a personalized and customized manner. The portal works in conjunction with the security manager, access Manager, to provide the credential mapping and single sign-on functions required to help the portal provide a seamless, integrated experience.

4.4.1.2 Enabling Technology

Identity management must consider easy to use technology, such as pupil recognition or voice recognition, and in some cases even thumb print recognition, along with more traditional identity management. Portal and service oriented architecture is utilized.

4.4.2 Mobile Wireless Network/ Web Service Oriented Architecture

The portal must be supported by a network infrastructure with adequate bandwidth to deliver content between pipelines and other enterprise locations. Pipelines require handheld devices that must be supported by wireless (internet) infrastructures. The proposal for pipeline construction is that business processes will be converted to business services in the form of web services in a service oriented architecture framework. The advantage of the SOA framework is that it is open and based on international standards. This will be discussed in more detail below. This enables access to all pipeline related processes and data at a single point.

4.4.3 Workforce and Relationship Management

People management encompasses human resource management and workforce management. Human resource management addresses the issues around attracting, hiring, and retaining employees, and managing their benefits and compensation.

As noted above, there is a high turnover of subcontractors within the industry. Recruiting, hiring, and training new employees is expensive for management and takes away from their time spent helping to meet customer requirements. Paper-driven business processes, or those business processes involving an intermediary such as a subcontractor/manager, are typically error-prone and time consuming in terms of labour involved and time to execute the workflow. Self-service is the key with individuals being able to update personal information

The system will deliver workforce management capabilities to enable seamless integration of components to plan staff schedules, capture accurate hours worked in accordance with work rules, and pay the staff. It must provide human resource management functions consisting of integrated and paperless processes to support selection, hiring, and measurement of employee performance. It must also provide access to employee OH&S information to save HR staff time on site and at Corporate HR. Digitizing employee data and measures will provide Corporate HR greater visibility into the pipeline sites, letting them become more of a strategic partner to proactively help address management and employee issues. The portal must deliver short-duration, available anytime/anywhere training, and knowledge enhancement materials through the portal. Completion of any module should automatically record the employee's compliance with the training requirement. Performance measurement should allow entry of comments to an employee file anytime/anyplace, and provide the ability to complete a formal assessment process electronically with appropriate routing of information.

4.4.3.1 Business Needs

Properly managing the workforce within the company is critical to the success of the company. Workforce management includes managing the time and attendance of the subcontractors. Schedules need to be generated and revised based upon availability of subcontractors. To do this, management needs to have access to appropriate project performance reports that will let them make the right decisions around scheduling. These reports will also permit management to plan, forecast, and budget appropriately to ensure that the correct subcontractors are available to enable the work to progress.

To provide direct electronic access, reducing personnel overhead, cutting material costs, and delivering accurate results. The employee may review and update their personal information, pay details, etc or simply answer questions regarding their benefits in a timely manner, without waiting for a manager or other intermediary to help.

Employees can also view their own personal pay information and undertake individualized workplace training.

4.4.3.2 Enabling technology

Most of the above jobs are currently done on paper. Doing it electronically can greatly improve workforce management and reduce costs. Several applications are available that permit workforce management within a pipeline construction. Integrating the applications into the online workplace will let the company more effectively schedule and plan for future needs.

Web Portal and Web Service technology is available to help develop individual applications. This will be discussed further below.

4.4.4 Job Management, Communication, and Collaboration

Job management lets the operations or project manager be sure that the right jobs are assigned to the right individual or individual workstation at the right time. Managers must be able to monitor the status of jobs, and respond appropriately if scheduled jobs do not meet the desired schedule. Pipelines are expected to plan and prioritize jobs that are both internally and externally generated. Externally generated jobs require significant coordination of communication and materials between the head office and the rest of the company. Some job management functions include:

- assigns jobs to relevant subcontractor or workstation
- Employees view the assigned jobs and update the jobs management system with the latest status
- Reassigns a job to another subcontractor/workstation.

The system must deliver the critical function of allowing pipeline sites and head office to communicate, and share important information in digital form from a central repository. Information can be specifically targeted to pipeline sites and individuals and must include a feedback process. Head office can also benefit from job management as they gain greater visibility into the pipeline construction, and can use job management to better manage and monitor their interactions.

4.4.4.1 Business Needs

A pipeline construction manager can log on to the pipeline construction site and view the jobs assigned to individuals (workstations). Jobs assigned by the head office are visible without having to access a different system. The manager can view the status of jobs, assign jobs, and close jobs.

Pipeline construction employees can use the integrated online workplace to determine what jobs have been assigned to them and update the status appropriately. This modified status can be seen immediately by the pipeline construction manager and those at the head office. This is possible by integrating a job management system into the portal.

Single sign-on between the portal and job management system needs to be implemented, and user identity across the different systems needs to be properly managed. Integrating the different technologies this way lets users access job-related activities that are pertinent to their role using any device at any location, and lets them get a clear perspective of the jobs across the entire corporation.

4.4.4.2 Enabling Technology

Web Portal in conjunction with a web services framework will enable individual or corporate job management.

4.4.5 Role-Based Business Process Integration

As mentioned above, the pipeline construction process is complex and consists of a variety of complex business processes, starting with the order submission, design, build, procurement, sourcing, HR management, to name but a few. The successful management of processes depends on the availability of in-depth up to date information, being provided by these various subsystems. Information can be in ‘hard’ real time, coming from the operational level - individual workstations on site, such as automated welding, hydrostatic testing and so on, individual subcontractor information such as time sheets etc. It can also be at the tactical level, and can be information provided by the site office and project management team

Then from a strategic perspective other aspects of information are provided by the various systems to the head office for strategic use.

The system must deliver the connection using the portal to all critical enterprise systems required to support pipeline construction activities. Examples are access to materials and supplies management and inventory management, or material planning systems in conjunction with stocking configurations, financial management systems, HR systems, site data collection and monitoring systems. The key issue here is that the portal must map the business process flow between these applications when necessary and map an interface to the manager based on the way work is performed.

4.4.5.1 Business Needs

Granularity and timeliness of information are crucial to managing the integrated process. Providing the right information for the right device (eg PC or PDA) to the right person at the right time in an integrated manner is necessary. The information may be displayed in structured, text, multimedia (such as photos and videos) or GIS/GPS maps.

4.4.5.2 Enabling technology

In addition to the web portal and web service technology, autonomic logistic devices are available to enable automated tracking and restocking of inventories, in this case the pipeline pieces, as well as valves and other smaller items.

Autonomic logistics is a broad term used to describe technologies that predict failure in operating systems, monitor stockage levels in consumables, automatically report impending failures and order replacements without human intervention. These technologies could have payoffs in construction logistics, possibly leading to the day when supplies automatically will flow to the pipeline before they run out. Autonomic logistics are already used in the military and today, a jet plane monitor can indicate that an engine part has failed, and a message can then be automatically relayed to people on the ground. Subsequently, maintenance personnel are then able to replace the unit when the plane lands. The message from the jet can also trigger a procurement action — the ordering of any spare parts that need to be replaced in the inventory. Thus, the engine sensors "sensed" a failure and the system "responded" to that sensing (Haeckel, 1999). There are a number of manufacturers who currently provide this brand of autonomic action, including Caterpillar and Honeywell. Honeywell has an interesting proposal regarding autonomic logistics in that it has coined a "one-off" production response for its customers. In other words, they are currently proposing that should a part fail and need replacing, then they will send the part — not out of their inventory stocks — but rather it will come right off the production line and be sent to the consumer within 72 hours of notification. Such a process is necessary, if a spontaneous supply chain for BTO construction is to be realized.

Autonomic logistics can come in other forms such as *telematics or remote diagnostics*. Telematics deals with transmitting data from vehicles, as well as electronic and mechanical components back to centralized servers for the purpose of logistics, command and control, and anticipating vehicle fleet maintenance requirements. For example, IBM has a telematics device that displays how a user can take an electronic or mechanical device such as a motor or engine, connect it to a diagnostics data output device, then to a laptop PC and monitor performance, as well as the on-board diagnostics and prognostics data of that motor. Such a device is used by Ford Motor Service in Wollongong.

The Ford telematics device is an example of how we can use real-time data to track vehicle location via a geo-positional system and monitor engine performance as well as lifecycle maintenance milestones of that motor, such as routine preventive maintenance, hours operated, miles driven, fuel and oil consumed, engine and oil temperature, oil pressure, tire pressure, emissions, and MTBF (mean time between failure). This technology can then be used by logisticians, planners, motor vehicle operators and maintenance personnel to monitor diagnostics and prognostics anywhere in the world, via a local "ruggedized" PC/laptop or PDA terminal.

Moreover, it could also share that data with other organizations (e.g., suppliers) through various communications means, including wireless, via local LAN or satellite uplink. In this scenario, telematics data can even be used in a "disconnected" environment where no wireless coverage exists, and then synchronized when wireless coverage is once again regained, for example in remote offshore or onshore pipeline construction.

To address communications shortfalls experienced by some customers, a communications suite called Secure Wireless Infrastructure System — previously called *First Responder* — that is compact, light-weight, encrypted, scalable, ruggedized and loaded with bandwidth has been developed. In partnership with companies such as Cryptek, Inmarsat, Intelsat, Cisco Systems and others, IBM's communications solution includes satellite and voice-over-Internet-protocol phones, as well as wireless and wired LANs allowing for secure voice and data communications anywhere in the world

Remote diagnostics encompasses using available information technology, sophisticated algorithms and the Internet in order to monitor high-value equipment and machinery around the clock from virtually anywhere. Hospitals currently use this service provided by General Electric in order to keep their CAT scans and MRI machines up and running 24 hours a day, seven days a week. Operators can contact a "hotline" in order for a technician to walk them through fixing the critical machine.

Remote diagnostics can also be utilized to enhance maintenance of remote pipelines, which are at present being monitored by outdated SCADA systems.

Both telematics and remote diagnostics fall under the autonomic logistics header and are examples of currently available (Internet) technology that both "senses" and "responds" to technological failures.

The autonomic logistics devices mentioned previously are a step towards obtaining a sense-and-respond operations environment. However, they don't take full advantage of institutional knowledge that is available. Haeckel (1999) defines the current problem facing many businesses and governments today:

"*Connecting* determines what the firm can institutionally sense. In the 1970s, networks sprang up in multiple places for multiple purposes. As a result, many companies today are criss-crossed by dozens of independent networks that are incompatible technically and thus actually inhibit, rather than promote, information sharing. Separate networks reinforce the tribal mentality that exists in functional hierarchies, with the result that in many organizations the left hand rarely knows what the right is doing. This 'lobotomization' of the corporate intellect remains perhaps the single largest impediment to realizing the potential of technology to help manage large companies" (Haeckel, 1999).

It will be up to individual gas transmission pipeline contractor organizations to decide how and what form of autonomic logistics should be utilized.

4.4.6 Role-based Key Performance Indicators, Alerts, Analytics

Role based KPIs, alerts, analytics and business activity monitoring represent the exception reporting, business sense and respond tools. The portal must deliver both KPI and trend analysis from the data warehouse of historical transactions, and balance the information in a way that lets pipeline construction management teams readily spot a deviation from expectations and drill down for details of cause. Also, event-monitoring software must be resident in the infrastructure to apply rules to selected data being monitored, and report exceptions in the form of alerts to a user device. Examples would include stock out conditions, late shipments, and cases where a subcontractor was scheduled but is not signed in, or results of hydrostatic testing on site.

4.4.6.1 Business Needs

As mentioned previously, the present traditional approach to managing pipeline construction is a project management approach. This requires the project manager to manage budget and contract issues. At present as mentioned above this process is still extremely inefficient.

Near real-time information would enable the manager to see correlations between pipeline construction revenue with linkages to labour costs. The manager may adjust employee working hours, call in extra people, or cancel shifts using prescriptive, formulaic methods to more effectively manage profit figures in a repeatable, controllable fashion. A reliable and integrated business intelligence system would cut down considerably on the time taken to perform these ta

4.4.6.2 Enabling Technology

Data warehouses and other data stores available as off-the-shelf products provide the foundation for collecting, aggregating, and analyzing information that is delivered to company management. The data originates from multiple sources: the pipeline construction scheduling application for labour data, the individual workstation applications data, and the supply chain applications, for example. The database acts as the central collection point for all this disparate information and puts the data in a form that enables efficient reporting.

Once the data is collected, it must be summarized into useful, meaningful data that is readily understood. Any number of proprietary systems applications such as SQL's Business Objects, Crystal Decisions, can be purchased to provide concise reports in numbers or pictures. These applications also include report creation and publishing features to enable the near real-time reporting necessary to manage business profit objectives. The portal and web service architecture will enable seamless integration of this technology.

4.4.7 Collaboration

4.4.7.1 Business Needs

Collaboration, as a form of communication, lets subcontractors rapidly interact one-on-one or as virtual teams. Because of the organizational structure of the gas pipeline network, multiple forms of electronic communication are needed to interactively manage the construction process. Forms of collaboration include instant messaging, online team rooms, and e-mail.

Different types of collaboration can be used, for example, instant messaging, email, electronic meetings and virtual team rooms.

4.4.7.2 Enabling technology

There are multiple technologies available to enable various forms of collaboration among employees. Instant messaging, virtual team rooms, and e-meeting capabilities are essential for construction on line. On the back end, subscription channels are linked to delivery channels to effectively manage what content should be delivered and how it should be delivered. For example, a news story about the company may not warrant an instant message to a pervasive device because wireless bandwidth is expensive. Rather, it could be delivered to the subscriber's e-mail inbox. A high priority problem, however, would likely require an alert to be delivered as quickly as possibly to the end user. This would be done utilizing existing Internet technology such as location aware telecommunication services

4.4.8 Knowledge Management and Organizational Learning

4.4.8.1 Business Needs

Providing pipeline members access to the right information at the right time is critical. This is often not possible because contractors have problems locating the information they need in the mountains of data that need to be searched. Even if the information is located, the contractor may not know what to do with it if they are unable to locate the expertise required to answer their questions.

A knowledge management system is required that organizes areas of expertise with people that have the relevant information.

4.4.8.2 Enabling technology

Construction online lets users log on and quickly locate the information required to work effectively. This is because the underlying component tracks all the information that users need from multiple sources such as e-mail, file servers, databases and collaboration platforms, without users having to publish anything explicitly to a knowledge repository. Online availability is also provided so users can chat to the appropriate individual if there are any questions about the information that is retrieved.

4.4.9 Summary

This concludes a discussion of the business needs for an on demand e-business environment for gas transmission pipeline construction, and the strategic capabilities that will be enhanced or developed with an open and standardized web architecture. The next section will discuss the internet technology related to the proposed project. The discussion will be restricted to those Internet technology components that will be utilized in stage 1, namely the portal and service oriented architecture.

4.5 Internet Technologies Relevant to Stage I of the Pipeline Construction On Line Project

4.5.1 Service Oriented Architectures

This research is proposing that gas transmission pipeline construction provide all capabilities – design, plan, deliver, maintain – as an ecology of e-business services. By ecology is meant that gas transmission pipeline construction become a service provider to other organizations, but also a service broker and a service requestor. It is proposed that operations management in gas transmission pipeline construction be implemented as an ecology of e-business services, providing services for all partners working on pipeline construction who are members of the APIA (Australian Pipeline Industry Association), and enabling collaboration with global partners as well. What is presently manual will become Internet based as a service, not simply as a transaction. The services will be implemented as web services. The following section describes some of the key issues in web services from an e-business perspective. Technical details are not included.

"The term *architecture* is widely understood and used for what it is--a top-down description of the structure of the system." (Rechtin, 1991).

"The *software architecture* of a program or computing system is the structure or structures of the system, which comprise software components, the externally visible properties of those components, and the relationships among them."

(Bass, Clements, and Kazman,1997)

Service-oriented architecture presents an approach for building distributed systems that delivers application functionality as services to either end-user applications or other services. It is comprised of elements that can be categorized into *functional* and *quality of service*, as illustrated below (Ganci et al, 2001):

Please see print copy for image

Figure 4.1 Elements of a Service Oriented Architecture (Ganci et al, 2001).

Functional aspects include:

- *Transport* is the mechanism used to move service requests from the service consumer to the service provider, and service responses from the service provider to the service consumer.
- *Service Communication Protocol* is an agreed mechanism that the service provider and the service consumer use to communicate what is being requested and what is being returned.
- *Service Description* is an agreed schema for describing what the service is, how it should be invoked, and what data is required to invoke the service successfully.
- *Service* describes an actual service that is made available for use.
- *Business Process* is a collection of services, invoked in a particular sequence with a particular set of rules, to meet a business requirement. Note that a business process could be considered a service in its own right, which leads to

the idea that business processes may be composed of services of different granularities.

The *Service Registry* is a repository of service and data descriptions which may be used by service providers to publish their services, and service consumers to discover or find available services. The service registry may provide other functions to services that require a centralized repository.

Quality of service aspects include:

- *Policy* is a set of conditions or rules under which a service provider makes the service available to consumers. There are aspects of policy which are functional, and aspects which relate to quality of service; therefore we have the policy function in both functional and quality of service areas.
- *Security* is the set of rules that might be applied to the identification, authorization, and access control of service consumers invoking services.
- *Transaction* is the set of attributes that might be applied to a group of services to deliver a consistent result. For example, if a group of three services are to be used to complete a business function, all must complete or none must complete.
- *Management* is the set of attributes that might be applied to managing the services provided or consumed.

4.5.2 The Evolution of IT Architectures

According to Ganci et al (2001), IT architectures have evolved from monolithic mainframes to the Service Oriented Architectures of today’s environment.

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Figure 4.2 Evolution of IT Architectures (Ganci et al, 2001)

In order to alleviate the problems of heterogeneity, interoperability and ever changing requirements, a service-oriented architecture should provide a platform for building application services with the following characteristics:

- Loosely coupled
- Location transparent
- Protocol independent

Based on such a service-oriented architecture, a service consumer does not even have to care about a particular service it is communicating with because the underlying infrastructure, or service "bus", will make an appropriate choice on behalf of the consumer. The infrastructure hides as many technicalities as possible from a requestor. Particularly technical specificities from different implementation technologies such as J2EE or .NET should not affect the SOA users.

4.5.3 Service Oriented Terminology

Ganci et al (2001) provide the following service-oriented terminology:

Services: Logical entities, the contracts defined by one or more published interfaces.

Service provider: The software entity that implements a service specification.

Service consumer (or requestor): The software entity that calls a service provider. Traditionally, this is termed a "client". A service consumer can be an end-user application or another service.

Service locator: A specific kind of service provider that acts as a registry and allows for the lookup of service provider interfaces and service locations.

Service broker: A specific kind of service provider that can pass on service requests to one or more additional service providers.

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Figure 4.3 Service Oriented Terminology (Ganci et al, 2001)

This research is interested in the business services architecture, and in particular the services for gas transmission pipeline construction.

Another important aspect of service based development is the interface-based design

4.5.4 Interface-based design

In both component and service development, the design of the interfaces is done such that a software entity implements and exposes a key part of its definition. Therefore, the notion and concept of “interface” is key to successful design in both component-based and service-oriented systems. The following are some key interface-related definitions:

Interface: Defines a set of public method signatures, logically grouped but providing no implementation. An interface defines a contract between the requestor and provider of a service. Any implementation of an interface must provide all methods (Ganci et al, 2001).

Published interface: An interface that is uniquely identifiable and made available through a registry for clients to dynamically discover.

Public interface: An interface that is available for clients to use but is not published, thus requiring static knowledge on the part of the client.

Dual interface: Frequently interfaces are developed as pairs such that one interface depends on another; for example, a client must implement an interface to call a requestor because the client interface provides some callback mechanism.

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Figure 4.4 A CRM Service and its Interfaces (Ganci et al, 2001)

Figure 4.4 above shows the UML definition of a customer relationship management (CRM) service, represented as a UML component, that implements the interfaces AccountManagement, ContactManagement, and SystemsManagement. Only the first two of these are published interfaces, although the latter is a public interface. Note that the SystemsManagement Applications or Services interface and ManagementService interface form a dual interface. The CRM service can implement any number of such interfaces, and it is this ability of a service (or component) to behave in multiple ways depending on the client that allows for great flexibility in the implementation of behaviour. It is even possible to provide different or additional services to specific classes of clients. In some run-time environments such a capability is also used to support different versions of the same interface on a single component or service.

4.5.5. Layered Application Architectures

Another important aspect of the architectural approach is the notion of the layered application architecture. This is illustrated in figure 4.5 below.

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Figure 4.5 Layered Application Architecture(Ganci et al, 2001).

As mentioned above, this research is concerned only with the service layer, and in that layer the business services.

4.5.6 SOA Collaborations

The collaboration of the software services is illustrated in the following diagram (Ganci et al, 2001):

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Figure 4.6 Collaboration of Software Services

Figure 4.6 shows the collaborations in a service-oriented architecture. The collaborations follow the “find, bind and invoke” paradigm where a service consumer performs dynamic service location by querying the service registry for a service that matches its criteria. If the service exists, the registry provides the consumer with the interface contract and the endpoint address for the service.

The roles in a service-oriented architecture are (Ganci et al, 2001):
Service consumer: The service consumer is an application, a software module or another service that requires a service. It initiates the enquiry of the service in the registry, binds to the service over a transport, and executes the service function. The service consumer executes the service according to the interface contract.
Service provider: The service provider is a network-addressable entity that accepts and executes requests from consumers. It publishes its services and interface contract to the service registry so that the service consumer can discover and access the service.
Service registry: A service registry is the enabler for service discovery. It contains a repository of available services and allows for the lookup of service provider interfaces to interested service consumers.

Each entity in the service-oriented architecture can play one (or more) of the three roles of service provider, consumer and registry.
The operations in a service-oriented architecture are:
Publish: To be accessible, a service description must be published so that it can be discovered and invoked by a service consumer.
Find: A service requestor locates a service by querying the service registry for a service that meets its criteria.
Bind and invoke: After retrieving the service description, the service consumer proceeds to invoke the service according to the information in the service description.
The artifacts in a service-oriented architecture are:
Service: A service that is made available for use through a published interface that allows it to be invoked by the service consumer.
Service description: A service description specifies the way a service consumer will interact with the service provider. It specifies the format of the request and response from the service. This description may specify a set of preconditions, post conditions and/or quality of service (QoS) levels. In addition to dynamic service discovery and definition of a service interface contract, a service-oriented architecture has the following characteristics:

- Services are self-contained and modular.
- Services support interoperability.
- Services are loosely coupled.
- Services are location-transparent.
- Services are composite modules, comprised of components.

These characteristics are also central to fulfilling the requirements for an e-business on demand operational environment

4.5.7 Services in the context of SOA

In service-oriented architecture, services map to the business functions that are identified during business process analysis. The services may be fine- or coarse-grained depending upon the business processes. Each service has a well-defined interface that allows it to be published, discovered and invoked. An enterprise can choose to publish its services externally to business partners or internally within the organisation. A service can also be composed from other services.

4.5.8 Services vs. Components

A service is a coarse-grained processing unit that consumes and produces sets of objects passed-by-value. It is not the same as an object in programming language terms. Instead, it is perhaps closer to the concept of a business transaction such as a CICS® or IMS™ transaction than to a remote CORBA object.

A service consists of a collection of components that work in concert to deliver the business function that the service represents. Thus, in comparison, components are finer-grained than services. In addition, while a service maps to a business function, a component typically maps to business entities and the business rules that operate on them. As an example, let us look at the Purchase Order component model for the WS-I Supply Chain Management sample, shown in Figure 4.7

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Figure 4.7 Purchase Order component model (Ganci et al, 2001)

In a component-based design, components are created to closely match business entities (such as Customer, Purchase Order, Order Item) and encapsulate the behaviour that matches the entities' expected behaviour. For example, the Purchase Order component provides functions to obtain information about the list of products ordered and the total amount of the order; the Item component provides functions to obtain information about the quantity and price of the product ordered. The implementation of each component is encapsulated behind the interface. So, a user of the Purchase Order component does not know the schema of the Purchase Order table and the algorithm for calculating tax, rebates and/or discounts on the total amount of the order. In a service-oriented design, services are not designed based on business entities. Instead, each service is a holistic unit that manages operations across a set of business entities. For example, a customer service will respond to any request from any other system or service that needs to access customer information. The customer service can process a request to update customer information; add, update, delete investment portfolios; and enquire about the customer's order history. The customer service owns all the data related to the customers it is managing and is capable of making other service inquiries on behalf of the calling party in order to provide a unified customer service view. This means a service is a *manager* object that creates and manages its set of Components.

4.5.9 Web Services Architecture

A Web service is an interface that describes a collection of operations that are network accessible through standardized XML messaging. A Web service is described using a standard, formal XML notion, called its service description. It covers all the details necessary to interact with the service, including message formats (that detail the operations), transport protocols and location. The interface hides the implementation details of the service, allowing it to be used independently of the hardware or software platform on which it is implemented and also independently of the programming language in which it is written. This allows and encourages Web Services-based applications to be loosely coupled, component-oriented, cross-technology implementations. Web Services fulfil a specific task or a set of tasks. They can be used alone or with other Web Services to carry out a complex aggregation or a business transaction. A web service may be a single document or executable component, such as a tax calculation, or it may be a full business subsystem, such as a customer relationship management system (Kreger, 2001).

The to-order pipeline delivery environment is based on the concept of a Service Oriented Architecture (SOA). A Service Oriented Architecture views every application or resource as a service implementing a specific, identifiable set of (business) functions. Services communicate with each other by exchanging structured information—messages or documents (sometimes called business objects). Their capabilities are defined by interfaces declaring messages they can produce or consume, policy annotations declaring quality of service required or provided, and choreography annotations declaring behavioural constraints that must be respected in service interactions. The actual implementation is hidden from the requester of a service, thus Service Oriented Architectures are a convenient way to achieve application integration by allowing new and existing applications to be quickly combined into new contexts. Existing applications are “adapted” to service declarations. The interaction of services can be direct, or can be mediated through an intelligent infrastructure, which we will call an Enterprise Service Bus (ESB)(Kreger, 2001).

A web services architecture (WSA) is a service oriented architecture that has implemented its services as Web Services, as is the case with the proposed research. The collaboration of Web Services is illustrated below.

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Figure 4.8 Web Services Collaboration Architecture (Ganci et al, 2001)

The advantage of the web service oriented architecture is that it is based on global internet standards and protocols for all business application. This makes the application truly integrated across organizations. Web Services utilize the WS – I standard services. There is no application service for pipeline construction, although there is a standard for supply chain management illustrated below in Figure 4.9:

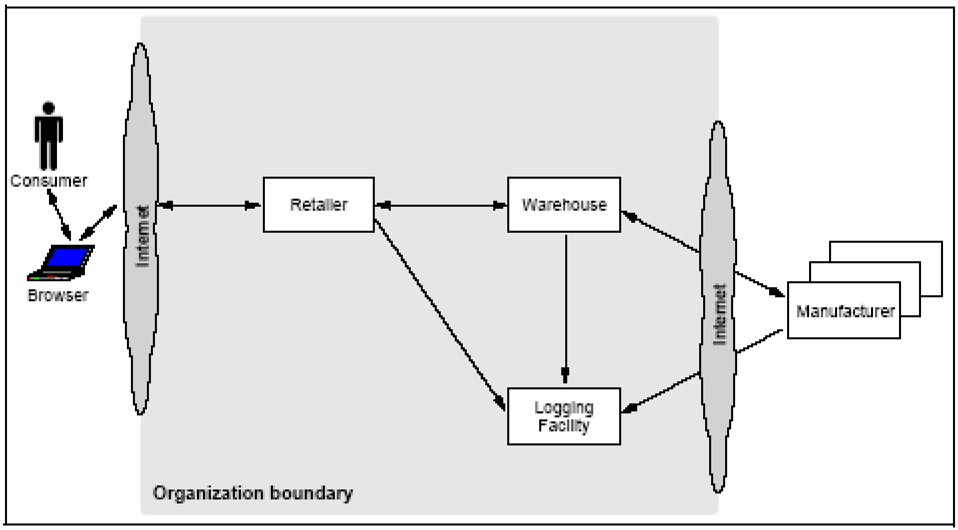

Figure 4.9 The WS-I Technical Architecture for Supply Chain Management

4.6 Portals and Portlets (Chandran et al, 2003)

Portals are commonly used to provide people with access to information and applications in a condensed form. Typically, portals display personalized information from various sources in a single page, thus allowing the user to efficiently access this information instead of visiting various Web sites one after the other (Chandran et al , 2003). Depending on customizable user settings, various portlets usually rectangular areas that display information are included in the page. As Web Services become the predominant method for making information and applications programmatically available on the Internet, portals and portal development tools need to allow for integration of Web Services as data sources. Figure 4.10 illustrates some common data flows between portals, portlet services and Web services.

There are initially two integration points for Web Services and portlets: portlets that use Web Services as a backend and portlets that are described, wrapped and published as Web Services. An example of the first, which will be the predominant scenario, is a news portlet that allows the user to configure the news categories to track and then gets the news for these categories live from a Web service whenever it is displayed. In this case, the portlet code runs locally on the portal and uses the Web service to access information. The rendering of the content is done by the portlet itself.

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Figure 10. Portals and portlets

Figure 4.10 Portals and Portlets (Chandran et al, 2003)

An example of the second use of Web Services by portals is enabling sharing of portlets with other portals. In this scenario, a remote server that is another portal publishes portlets as remote portlet Web Services in a Web Services directory. The portal can thus find the remote portlet services in the directory and bind to them. As a result, the remote portlets become available for the portal users without requiring local installation of the portlet code on the portal itself. Other opportunities for integration of Web Services and portal technologies will emerge as these technologies mature.

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Figure 4.11 Portal Aspects (Chandran et al, 2003: pp 20)

Figure 4.12 shows standardized layers of portals. This technology builds on the already standardized 7 layer network model for telecommunications.

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Figure 4.12 Portal Layers (Chandran et al, 2003)

As illustrated above, the standardized layers of the portal model provide an excellent means for designing the to-order construction environment. By utilizing international standards, it is possible eventually to form a pipeline IT grid, in which all member organizations will have standardized work practices and data formats.

Figure 4.13, also from Chandran et al (2003) shows the different types of portals possible. This research deals with the operations portal, although as mentioned previously, it will be of strategic and tactical importance as well as operational.

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Figure 4.13 Portal Types and Services (Chandran et al, 2003 : pp 23)

The next section goes on to discuss aspects of web services relevant to e-business and the current prototype.

4.7 Business Processes, Workflows and Web Services (Kreger, 2001)

Web Services are composable, which is an important characteristic of Web Services identified previously. Workflow, as a primary mechanism to compose Web Services in a nontrivial fashion, is critical for the rapid creation of new, higher-function Web Services. Workflow provides choreography for interactions between component Web Services. *Business processes* are graphs or webs of activities that carry out some meaningful business operation. Examples are purchasing an airline ticket, managing inventory in a warehouse, and ordering furniture for a home or office. Long-running transactions, such as tracking an order to fulfilment or supporting collaborative planning, forecasting and replenishment (CPFR) are also business processes. Business processes vary in level of granularity, and the details of a business process will vary from enterprise to enterprise.

Workflows are business processes that are run in an IT environment using a tool. Workflow tools allow businesses to define each of their business processes as a series of activities carried out by individuals or applications, and vary the sequence through the activity series depending on the output data from each individual activity.

Web services and workflows can interact together to create non-trivial e-business services. Some examples of these are described briefly below.

Example 1 A Simple Workflow and Web Service

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Figure 4.14 An example of a Simple Web Service Workflow (Kreger, 2001)

Figure 4.14 above shows a simple web service and workflow usage. In this example, the web service is a seller service. In this example, the buyer service, which might be a simple client, is ordering goods from the seller service. An example of this would be an online book order. The seller service interface is defined using the WSDL (web service definition language) and the order is invoked by the buyer using an internet protocol SOAP (service oriented architecture protocol) and the WSDL. These are Internet wide standards common to all applications, regardless of platform used (such as IBM, Microsoft, SAP, ERP, or whatever). Therefore by implementing e-business services as web services, an application or enterprise integration technology is automatically provided. The next example shows a slightly more complex workflow and web service interaction.

Example 2. A More Complex Workflow/Web Service Combination

In Figure 4.15 the client or buyer service places an order. In this case, the seller service makes use of a credit validation service to ensure that the buyer can pay for the goods before shipping to the buyer. In this case the credit validation service is a third party web service available to e-business services in general.

Please see print copy for image

Figure 12. More complex workflow

Figure 4.15 An Example of a More Complex Workflow (Kreger, 2001)

Example 3 Composed Workflows and Web Services

The next example, illustrated in Figure 4.16 below shows the seller web service implemented as a complete workflow that is encapsulated as a complete web service. The seller service consists of a credit validation activity, an inventory management activity, and a customer accounting activity. The seller service presents a single interface (described above) to the buyer service using a single WSDL (Web Service Definition language) definition, thereby hiding the details of the lower level workflow that it encapsulates. In the above example, the enterprise that provides the workflow for the seller service does not expose the details of this service to public applications and services that seek to use the seller service. That is to say that the seller service participates in public workflow, whereas the actual workflow that makes up the seller service is a private workflow, visible to only selected members of the organization proving the seller service.

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Figure 4.16 An Example of a Composed Workflow (Kreger, 2001)

Example 4. Another Workflow/Web Service Composition

In this example, illustrated below in Figure 4.17., the inventory management service itself is shown to consist of a workflow including several steps. Note also that in this example, the credit validation service that is actually part of the workflow for the seller service goes out on the public Internet and utilizes a public credit service, which it might find and bind using information retrieved from a web service registry such as UDDI. In the example below, the customer accounting service is an encapsulated Enterprise Java Bean (EJB), which in turn is part of the customer application.

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Figure 4.17 Further Example of a Web Service/Workflow Composition (Kreger, 2001)

The above examples illustrate the flexibility of web services. It is possible to design and build all business applications utilizing web services and standards. Example 4 shows that underneath all of the web services are coded applications. The advantage of web services is that legacy systems may be used without change as long as the existing design is retained.

What the web services illustrate also is that as it is definitely the B2B environment where a lot of collaboration is required by members of the ecosystem, in order to ensure efficient operations.

4.8 Gas Transmission Pipeline Service Delivery as a Service Oriented Architecture and Web Portal

The above discussion described the advantages of a web services and portal architecture for gas transmission pipeline construction. For example, if we take the present pipeline model as illustrated in Figure 4.18 below, most of the services in this model are manual or at least isolated transactions.

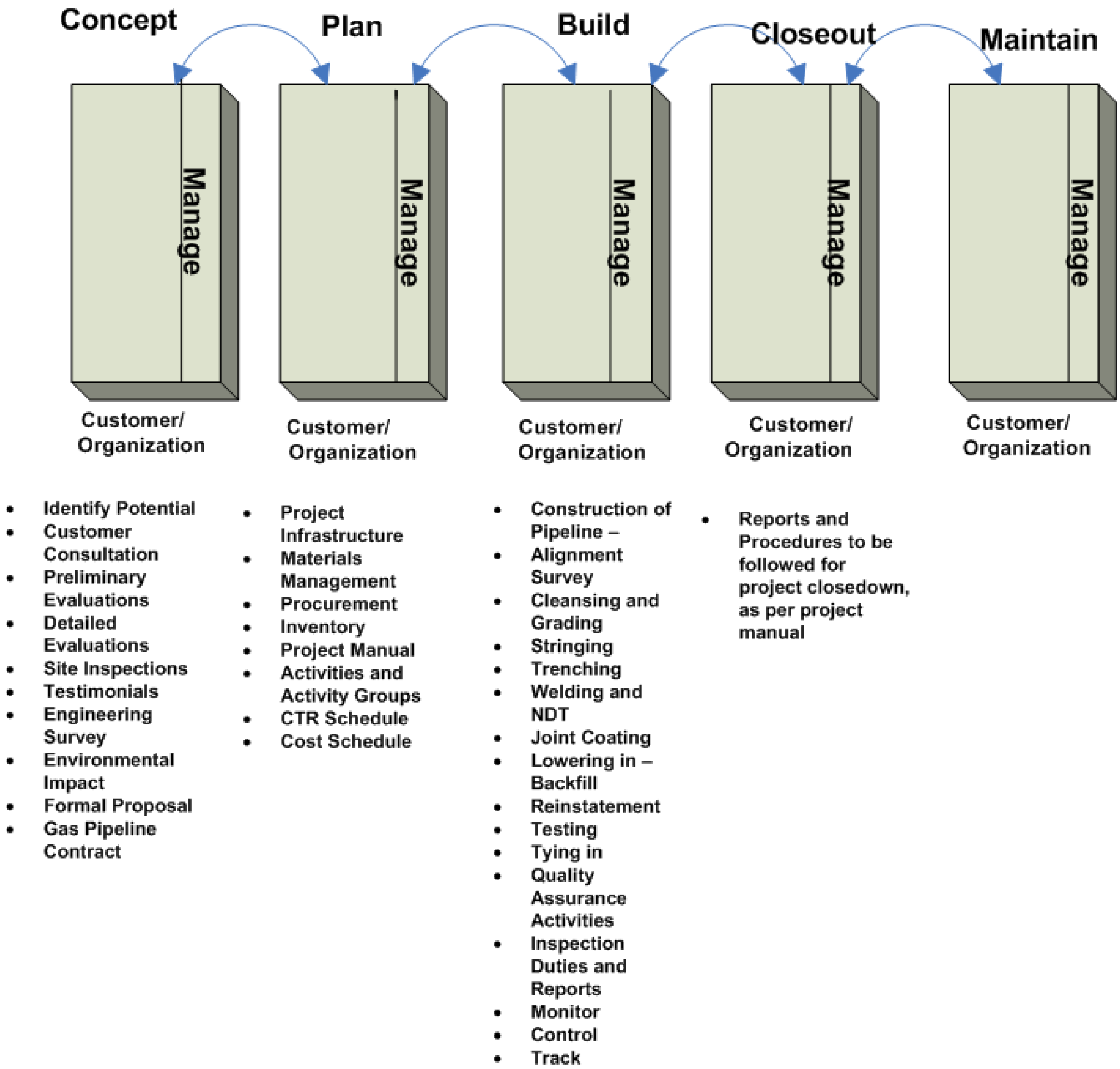

Figure 4.18 As Is Gas Transmission Pipeline Construction Business Architecture

Instead of a linear over the wall approach as depicted above, the integrated architecture would be in the form of a business ecosystem, as depicted below:

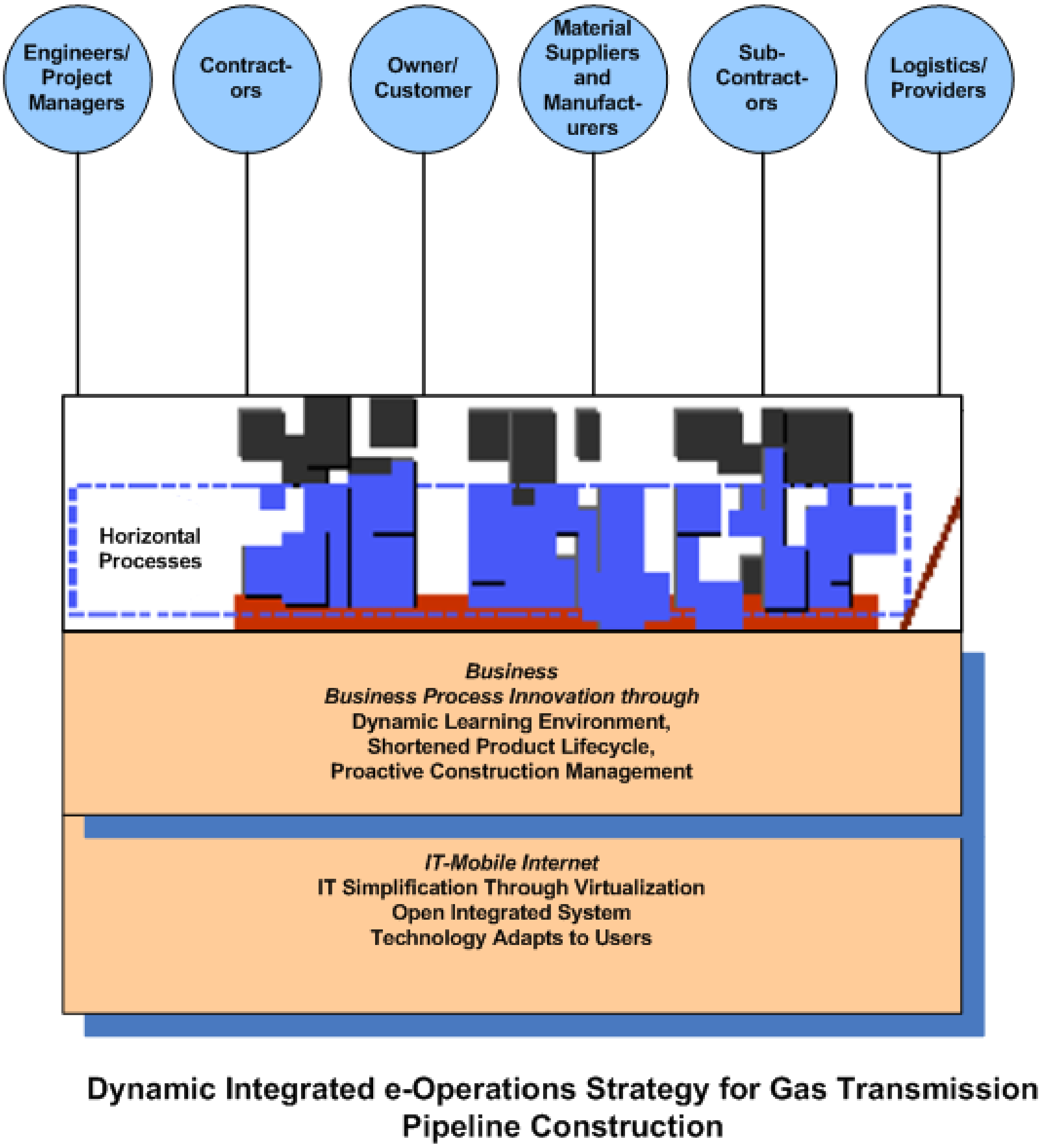

Figure 4.19 Pipeline Construction as an Integrated Process

As mentioned above, the business processes will be offered in the form of e-business services (with or without facilitating goods). Referring to the above 4.18 transactions, these could be offered as e-business services, such as:

Planning Services
Inspection Services
Survey Services
Evaluation Services
Contract Writing Services

Materials and Inventory Management Services

Procurement Services

Tendering Services

Bidding Services

Welding Services

Design Services

Hydrostatic Testing Services

Financial and Accounting Services

And so on

Each of these services would have an operational strategy, an IT component, as well as a physical product component. Further research is required to identify a core set of e-business services for pipeline construction. Where required a composite web service and workflow could be utilized as illustrated below in Figure 4.20 as shown in part of a design example:

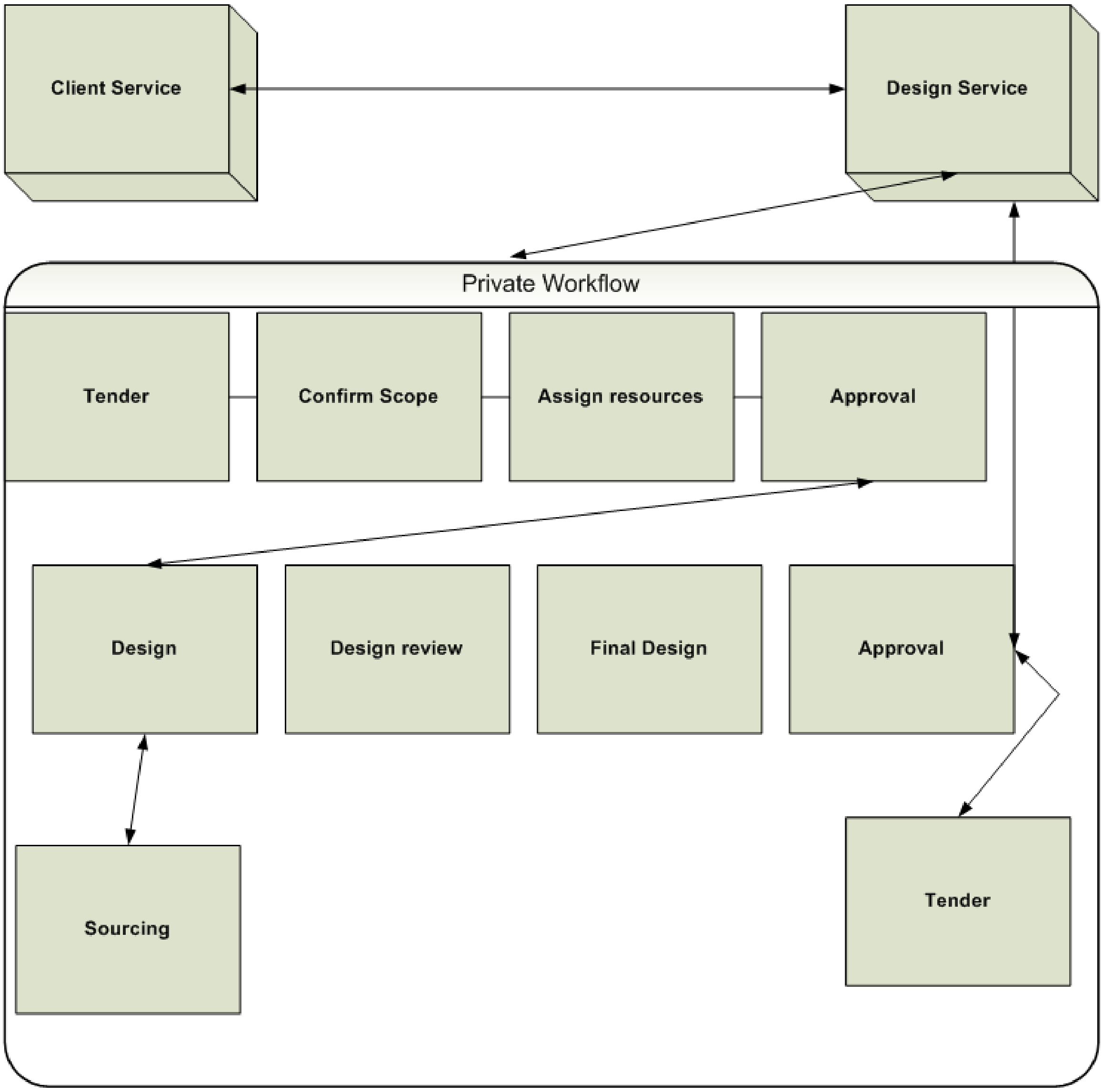

Figure 4.20 A Suggested Design Web Service For Pipeline Construction With Private Workflow

Finally, Figure 4.21 below gives an overview of the portal and service oriented architecture proposed.

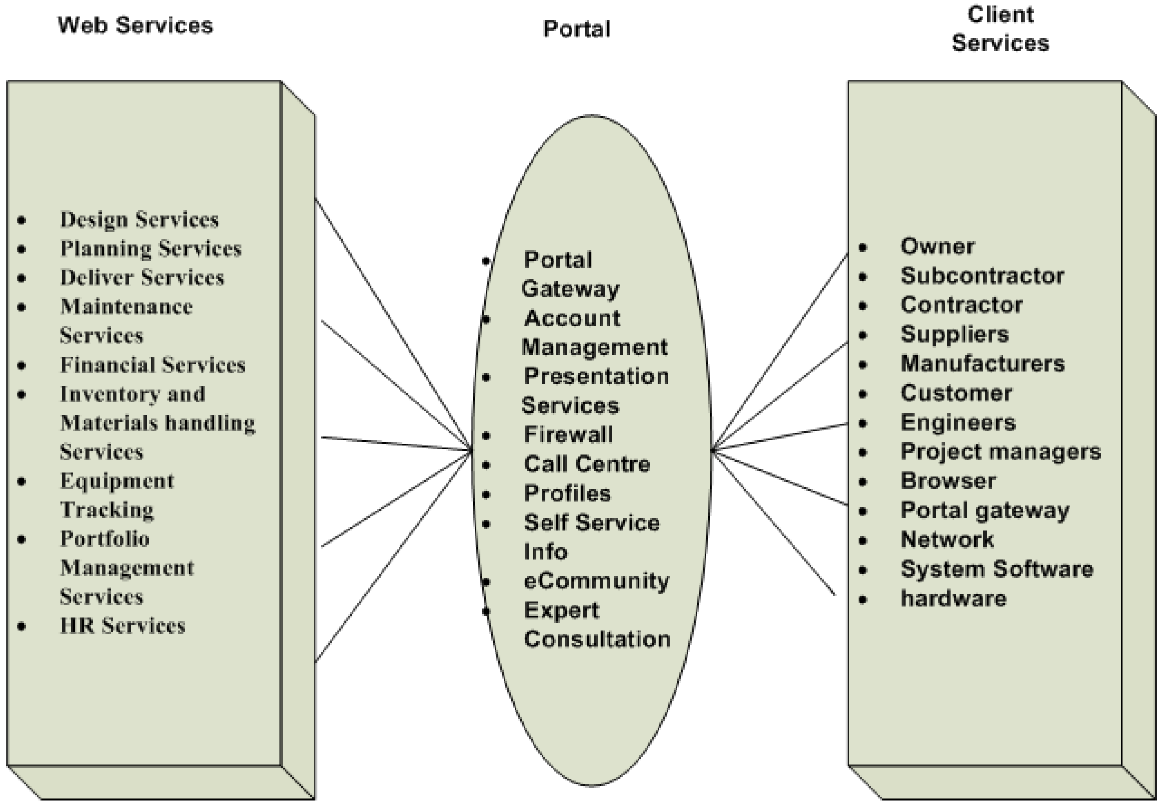

Figure 4.21 Proposed Pipeline Construction Portal and SOA

4.9 Summary

This chapter has presented a discussion of a proposed Internet based IT architecture for gas transmission pipeline design, delivery, and maintenance. It is suggested that this type of architecture would be suited to all AEC industries. The final chapter, Chapter Five discusses some future research and conclusions.

CHAPTER FIVE
CONCLUSIONS AND FUTURE WORK

5.1 Introduction

The chapter reviews the research undertaken in this thesis and presents the findings alongside the research questions in Section 5.2. Section 5.3 presents suggestions for future work.

5.2 Research Questions Revisited

5.2.1 Research Question 1. *What is the current planning and control strategy and system for Gas Transmission Pipeline Construction and what are the limitations?*

The current planning and control strategy and system for onshore gas transmission pipeline construction is a top down planning and control strategy based on project management techniques, which is a complexity reduction approach based on command and control hierarchy and governance. The limitations of this approach are that it does not support sustainable competitive advantage for the organization as it does not provide for innovative business concepts. Innovative business concepts come from building and leveraging the intangible resources of the (network) organization. The operations strategy must provide a means of leveraging intangible assets to create a learning organization. Only then can we achieve innovative business processes, which will lead to sustainable competitive advantage. At present the planning and control strategy is based on Tayloristic or mechanistic management techniques, top down control, and fragmentation and management of fragments. The strategy should be approached from a complexity absorption perspective, where elements of the construction process are allowed to emerge, as well as be controlled in a top down manner. To achieve a learning organization and build the dynamic capabilities a more dynamic operations strategy and operations management system are required.

5.2.2 Research Question 2. *How do the processes and sub-processes in Gas Transmission Pipeline Construction differ from a manufacturing system?*

The current accepted design of the manufacturing system for AEC industries is the project form, which utilizes project management theory, as described in the project management body of knowledge (PMBOK, 2002). That is, the construction industry today is organized into projects and current production theory and practice are heavily influenced by the concepts and techniques of project management. According to the PMBOK (2002) *"a project is a temporary endeavour undertaken to produce a unique product or service"*. Project operations are of large scale and finite duration; they are non-repetitive, consisting of multiple and often simultaneous tasks that are highly interdependent (Meredith and Shafer, 2002). The primary characteristics of the tasks are their limited duration and, if the output is a physical product, such as a gas pipeline or a ship, their immobility during processing. Generally, staff, materials, and equipment are brought to the output of the transformation system and located in a nearby staging area until needed. Projects are also noted for their limited lives. Resources are brought together for the duration of the project where some are consumed while others, such as equipment and personnel are deployed to other uses at the conclusion of the project. Typically the output is unique (a ship, a building, a gas pipeline).

5.2.3 Research Question 3. *Are the manufacturing planning and control strategy and system applicable to pipeline construction?*

An appropriate manufacturing strategy and planning and control system are applicable to pipeline construction. However, the strategy and system would have to be designed to suit a project manufacturing organization. Case studies and research indicate that many manufacturing industries in Australia and elsewhere are reorganizing themselves as project-centric, that is, they have adopted a project-based business process, as opposed to the traditional functional organizational model. This view is supported by other researchers nationally (for example, a recent Warren Centre survey has revealed that on average 35% to 40% of all business across industry is project-based, rising to nearly 100% in some organizations), and internationally, see Deloitte (2001). Manufacturing organizations used to be functional structures but are moving towards flexible project structures. The move is from fixed product teams to more agile and often virtual teams that collaborate for a specific project, which may be a product or service development. The project based approach cuts across all organizational and functional boundaries and includes managerial as well as technological factors. Organizations realize that there is a growing need to utilize resources that are driven by planning and scheduling processes, such as machines, materials, people, tools, optimally. The need to optimize, often in response to customer demand and changing market conditions, is what lies behind the agile philosophy of today's organizations and the reason organizations are moving towards a dynamic project based business process.

By adopting an agile project-based business process, processes are dynamic and reconfigurable to suit the requirements of the customer order. In other words, most manufacturing environments today are Build-To-Order (BTO). What is needed is the appropriate operations strategy and tactical IT system to support this process.

Many industries have traditionally been project-based. In these organizations the project is an institutionalized form. These are organizations that have large products often which are produced over a number of years and possibly distributed over hundreds of kilometres. These are aerospace firms, pipeline construction and building firms, minerals mining, road and rail firms, and IT firms. These companies have used the project type of organization for so long that it has become an institutionalized and permanent part of their organization structure, however, traditional project management approach and software systems that support it are not adequate for construction industry projects, especially today, with increased use of subcontractors, and the widespread distribution of these organizations. This is because the project management approach traditionally utilized by these companies is not integrated with production and is itself over-the-wall. That is, in the project lifecycle-from project initialization, planning, implementation, and closeout-are all undertaken by different subcontractor organizations and they themselves make use of subcontractors. There is a lot of information produced in a construction process and this information is being passed 'over the wall' to the next phase of the project. Furthermore it is in the form of a hard copy manual, and not accessible to all parties concerned. During the implementation phase of the project there is a lot of interaction with materials and supply chain, as well as production itself and the traditional project management information of cost, resources, and time. This aspect of integration is not supported. That is, current IT support is fragmented, causing islands of information and automation.

Many issues are listed in the literature for success or failure of a project, but central to the success of any project is the planning and control dimension. The planning and control tools and methodology are the tangibles of project management. Without a sustainable planning and control strategy and system for pipeline construction, companies will not remain competitive.

A planning and control strategy and system for today's pipeline construction must be agile and take into account the intangible as well the tangible of the assets of the organization. This change in mindset must focus on the 'soft' issues. This cannot be achieved without a culture of trust and collaboration by all partner organizations in the value network.

5.2.4 Research Question 4. *In view of the most recent developments in manufacturing philosophy, does this have potential for improving the efficiency of pipeline construction?*

This thesis has argued that recent developments in manufacturing philosophy will provide a benefit for the pipeline construction industry. This research has proposed that the industry adopt as one of its operations strategies, an Internet based operations strategy. This thesis has also shown details of how to implement this strategy. As mentioned previously, this strategy will provide a means of building dynamic capabilities in the organization to create a learning organization. By doing this, processes will become more innovative, leading to sustainable competitive advantage.

5.2.5 Research Question 5. *Specifically, can a model be developed to apply manufacturing strategy and systems to gas transmission pipeline construction?*

A model that is being proposed for gas transmission pipeline construction is a needs capapbilities model. This model is dynamic and based on the notion of manufacturing as a sense and respond business, rather than a make and sell business. The operations strategy and architecture map easily to this model, which is depicted below in Figure 5.1.

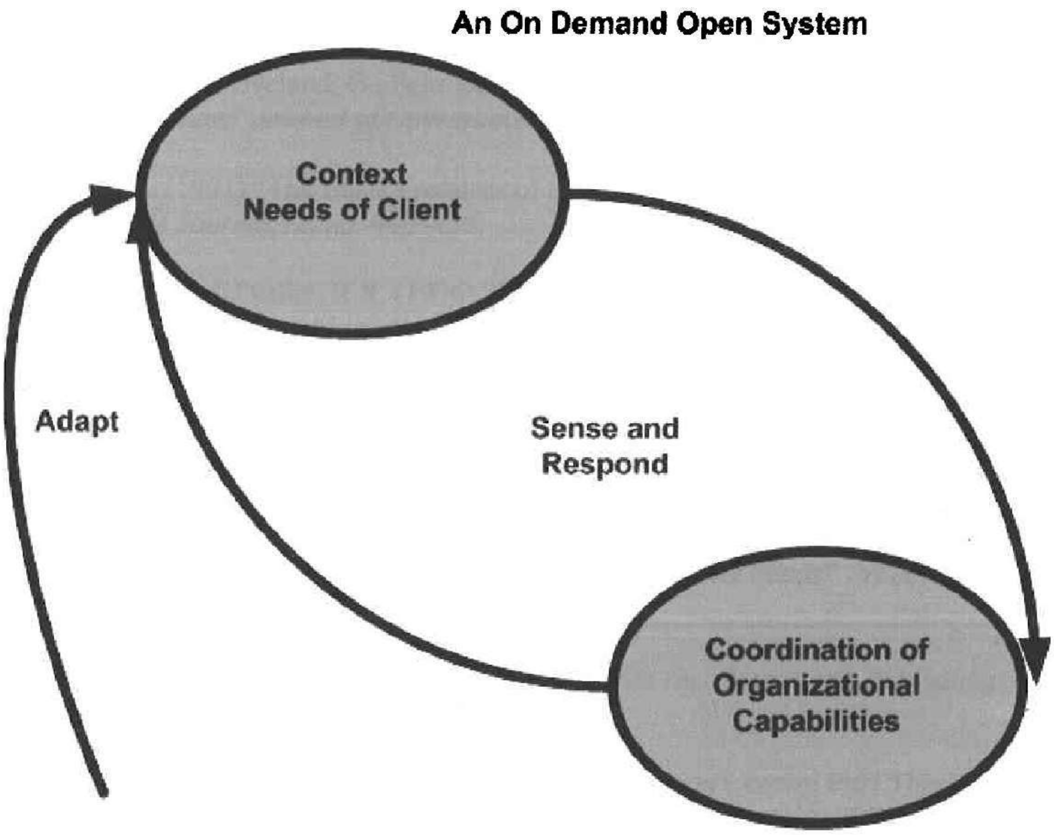

Figure 5.1 A Needs/Capabilities Model for a Complexity Absorption Approach to Pipeline Construction Project Operations

5.3 Future Directions

This research has presented a strategic operations architecture for Gas Transmission Pipeline Construction. The architecture is dynamic and represents a holistic approach. It allows participants in pipeline construction to develop strategic opportunities around ideas of complexity absorption, rather than the current strategy of complexity reduction. Future work to be carried out would entail a detailed analysis of gas transmission pipeline construction process and information flows and the development of a concept prototype. In order to achieve the architecture proposed, collaboration from all partners on information and process standards is required.

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APPENDIX A

ONSHORE GAS PIPELINE CONSTRUCTION FROM A PROJECT MANAGEMENT PERSPECTIVE

2.1 INTRODUCTION

This chapter describes onshore gas pipeline construction within the framework of engineering project management, as proposed by the American Management Association [AMA][Belanger95]. The AMA methodology distinguishes four phases or stages in the project management lifecycle; concept, planning, implementation and closedown. Onshore gas pipeline construction is described below with reference to these four phases. Section 2.2 describes the project concept phase of pipeline construction. Section 2.3 describes the planning phase, Section 2.4 describes the implementation phase, and Section 2.5 describes the closedown phase. Section 2.6 presents a summary of the chapter.

2.2 THE PROJECT CONCEPT PHASE

The concept phase starts with the emergence of an idea, perhaps from a self-managing team, an organization, or an engineer. If the idea seems feasible and meets selection criteria, it is more closely scrutinized by developing a preliminary project plan or a proposal that includes the approximate scope of the project. A minimum number of items that need to be considered include the problem or opportunity that spawned the project, a description, skills required to do the work, amount of time it will take, expected cost, profit, assumptions, and risks and benefits of completing the project. In many environments. projects that clear the hurdle are handed to a project manager, self-directed team, or manager.

The Gas Pipeline Construction Project Concept Phase

The concept phase steps or activities are summarized in Table 2.1 and discussed in detail below:

Table 2.1 Project Concept Phase

Identify Potential for Pipeline
Pipeline System

Gas Tariffs

Consult with Customer

Conduct Preliminary Evaluations

Conduct Detailed Evaluation

Opportunity Study

Preliminary Feasibility Study

Feasibility Study

Financial Modelling

Structuring of Investment

Investment Documentation

Market to Institutions

Funding Committed

Perform Site Inspection and Gather Testimonials

Sell Final Proposal

Project Contract

Gas Quality Specification

Gas Pipeline System

Gas Tariffs

Project Implementation

Identify Potential for Pipeline

There must be a reason for building a gas pipeline. The first thing that needs to be determined is whether there is a source of gas which will supply gas for a long time and is economical to do so. Another issue is whether there are buyers waiting for gas. Once you have a supply and a user there is potential. However, major consumers – industrial, commercial, and/or domestic need to be interviewed. This is to build up the load and determine the potential for pipeline growth. There is no government control as to the number of pipes allowed in Australia, however pipeline construction has to adhere to very strict government standards and ultimately economics dictate whether a pipeline is built. This will be discussed further below in 2.2.4

Consult with Customer – users, commercial, industrial, domestic

Once a potential has been identified, potential commercial, industrial, and domestic users are interviewed to determine the requirements. In small towns, council meetings are often held to discuss the advantages and disadvantages and any concerns that might arise. Part of these concerns is the risk of having a gas pipeline. Before design of the pipe can be undertaken, a risk assessment of the pipeline is carried out. Pipeline design descriptions are not part of this research and the reader is referred to other documentation, such as the APIA and Australian standards documentation for descriptions of design specification. These documents also contain methods for analyzing risk of pipelines in certain areas.

Briefly, there are potentially three types of risks which influence pipeline design. These are *societal, pipe, and fiscal*. The results of different types of risk analyses oblige the designer to vary the design to cope with these risks. For example, in societal risk, pipes are not allowed near hospitals, as people can't run away. Near schools people can run away but they need to be guided, whereas near factories adult workers can leave under there own steam. In natural gas there is no explosion per se, generally what kill s people is radial heat flux whereby 12 kilowatts/sq metre generally kills people. When the risk assessment is done, the risk contours vary with the type of risk. This can then be ameliorated by physical means, such as a concrete slab over the pipe, or by procedural means, such as the installation of a marker sign. All of this information is available in the AS285 risk assessment copy as code for pipeline construction. This documentation states the risks and the risk assessment method. There is also an APIA companion document which explains the ethos behind risk based code. The general feeling is if a pipe is safe, the population is safe. A well designed and maintained pipe is safe unless hit by machines, damaged by earthquakes, or deterioration caused by low maintenance of the pipe.

Conduct Preliminary Evaluations

Preliminary evaluations are carried out.

Conduct Detailed Evaluations

The detailed evaluation is conducted according to the following evaluation cycle:

Opportunity Study- Project identification and opportunity study

Preliminary Feasibility Study

Feasibility Study – economic, financial, operational.

Financial Modelling – Economic/ Financial Evaluations are undertaken. Cost-Benefit Analysis, Corporate-Divisional Discount Rate-Opportunity Costing, Reflects Risk, Real and Nominal Discount Rates, Present Value, Future Value, Discounted

Cash Flow, NPV, IRR, Accounting Rates of Return, Payback period, Sensitivity Analysis, Post Audits are all used as tools for financial modeling of the prospective pipeline. These are carried out before embarking on project.

Investment Structuring – How is the pipeline going to be financed? Usually potential owners go to big banks, such as World Bank, overseas banks or Wall Street, Asian Development Bank, Joint Venture [JV]. In Australia and South East Asia they are now using the Build Own Operate Transfer [BOOT] approach -build pipe, own pipe, operate pipe for 20 years then transfer to government, Build Operate Transfer [BOT], Equity per Feasibility, Debts or Bonds, or any mix of the above. Some companies like Duke Energy will carry their own finance or have their own investors.

Investment Documentation – Documentation, such as a prospectus has to be prepared and distributed on how the pipeline is to be funded.

Market to Institutions – The idea is then marketed to the various institutions in order to get the funding committed

Funding Committed

Perform Site Inspection and Gather Testimonials – shire council, townspeople

Do site inspection testimonials –‘if we have gas in this town we will thrive’. Everyone sees gas as positive, but to sell the idea, public meetings with the shire council and townspeople are held. Gas pipes have to be underground, and so a license to build prescribes where the pipe goes according to ASO or other relevant standards.

Conduct Engineering Survey and Environmental Impact Statement – engineers, surveyors

The engineering survey and environmental impact study are a continuing process throughout the construction of the gas pipeline. An initial study is undertaken before the project commences, however, as the construction gets underway, it may be the case that further studies have to be undertaken should the direction of the pipe change in any way.

Engineering Survey

The items addressed in the engineering survey are:

Engineering Survey Overview

Engineering Survey Field Work

Centreline Survey – Datum, Horizontal, and Vertical Surveys are carried out. AMGs and Control surveys are also conducted

A GPS [Global Positioning System] is used to link to the World Geoditic System.

A total Station/Data Recorder/ GEOCOMP is used for the engineering survey.

Drafting – Easement Diagrams

PSM Sketch

Schedules of Regulations

Permit Plan

Route Plans

Crossings – Road/River/Rail

Profiles

Hydrostatic Profile

Quantity Surveying. How much for progressive payments.

Recording – Mainline/City Gates/ Valves – where will they be placed on the pipeline. Where do the different pipeline subsystems begin?

As Builts – Route Plans, Crossings

Reinstatement Survey Markers – for land reinstatement, top soil, gates, fences etc

Environmental Statement.

Items addressed in the environmental impact statement are:

Permits to Own and Use Pipeline

Owners Schedule – List of people who own the properties through which the pipeline is built

Permit Plan- describes route including ownership

Advertising

EES – Determination by Minister EPBC

Changes to Zonings – Planning and Environmental Act Amendments

Delay by Objections

Objections

Compulsory Acquisition

Site Visit by Regulatory Authority

Prior to commencement working diagrams to regulatory authority

License Issued

Construction

"Fit To Operate" Issued

Confirmation of Markers, Security

Approval Regulatory Authority to Commission and Operate

Sell Formal Proposal

The formal proposal is presented and a Go/NoGo decision is made. Should the pipeline be approved, the next stage is the preparation of the Gas Pipeline Contract.

Gas Pipeline Contract

Typical aspects of a gas pipeline contract are:

Interpretations- There are different interpretations of a gas contract. A preamble contains definitions and terminology used in the contract.

Terms of Agreement – This refers to the length of time of the gas service/supply.

Charges – How the customer is charged for the gas. The charges which apply are commodity charge, maximum hourly demand charge, maximum daily demand charge, minimum charge, price variation, and price variation due to government charges. Maximum demands are important because the pipe is sized on demand eg Say a customer requires 100000 cubic feet of gas per day and 25000 cu ft are required in the first hour. That is, a quarter of the load in the first hour then basically nothing for the rest of the day. The financial balance depends on how much is put through the pipe; the cost of the pipe is dependent on the size of the pipe. There is a minimum charge for the gas and there is a facility for price variations. Price variation also depends on government charges.

Method of Payment – This states how the gas is going to be paid for. This can be in money, bags of rice, other goods and services, US dollars, AUS dollars.

Gas Pressure – The client nominates the pressure. The pipeline design is influenced by gas pressure; the flow rate depends on pressure. How much pressure the pipe has influences the gas tariffs as well as the design of the pipe.

Maximum Quantities Buyer to Take- provisions if buyer takes more than max daily or hourly quantity; can be more than one customer; max daily quantity spec limits

Billing Periods-how long between bills, what time gap between meter readings generally daily

Measurement of Gas. Gas is measured by sellers meter at buyer's premises. In the gas industry the seller owns the meter. Meters measure volume of gas sold by energy ie the customer buys kilojoules of gas conversion factors so you pay for joules of energy that you use, The supplier must control the calorific value of gas. Previously this control was done by government examiners when gas services were owned by state governments in Australia, now the quality assurance ie ensuring that heating value is of appropriate standards is now done by private industry. Meters measure volume gas sold by energy so many joules conversion to pay on joule of energy but sold by meter, gas process strictly controlled, government gas examiners ensure gas up to quality private examiners now done by sellers

Supply if Equipment- Seller to install meter/ pressure regulator. Conversion to MJ for purposes of payment. Daily Meter reading. The seller installs the meter and pressure regulator. Gas is supplied to the buyer's property boundary at a higher pressure, then the pressure is cut at buyer's premises to what is needed. The buyer supplies the electricity, phone, phone lines for SCADA, and security. The seller installs the service pipe, ie provides gas to the property line, then the buyer pays as of property line eg factory, domestic, commercial.

Sellers Right to Install and Inspect Equipment –Contract specifies this.

Title to Equipment – who owns it

Recovery of Equipment and Service Pipe – if customer decides not to continue buying gas.

Property and Risk – ownership and risk.

Termination- Termination can be by right, termination by breach, termination due to bankruptcy, termination due to liquidation/.receivership. The seller has rights if buyer vacates and ceases business. These are aspects of typical gas contract

Conditions and Warranties – This refers to the prescribed term that the contract runs for. For major contracts this is generally 20 years for major gas contracts, however in recent times, 10 year contracts are not unusual to grab short term customers. Other warranties negated by these warranties are also addressed here. Buyers' equipment must conform to standards

Liabilities – You can't sue for everything. The owner is liable for the value of the contract, but not megabucks. There are limitations and liabilities of a gas contract, indemnity and share of negligence

Force Majeure- How to deal with causes beyond control, such as earthquake and hurricane. In this case, the party is not entitled to benefits, so gas charges are adjusted if unable to deliver. There are obligations of the party claiming Force Majeure .If you can't supply due to Force Majeure the contract is in limbo. Force Majeure also covers strikes and lockouts but this is a grey area

Emergencies – The gas contract will contain a section on how emergencies are to be dealt with for a gas emergency - who to notify etc

Notices –This specifies how notices are to be delivered eg in writing, how to determine if a notice has been received or delivered, authorization of notice, invoices – is an invoice a notice what is an invoice eg is an electronic invoice an invoice or must it be delivered as a hard copy.

Waiver

Assignments

Governing Law

Interest

Security – What bank guarantees are required to install a gas service

Disconnection – Reasons must be given for disconnection eg through default of payment. There must be a notice of disconnection. There can be a suspension of services in specific circumstances. The seller is not liable for disconnection. What is the process for reconnection ie what fees are applicable. The process of disconnection and reconnection is applicable to any type of pipe

Entire Agreement – The contract is the same for large pipes with a huge gas supply right down to small domestic services.

Variations – Some slight variations occur depending on service but in general the aspects of the contract are the same regardless of gas service.

Gas Quality Specifications

Gas Quality Specifications

As part of a gas contract the gas quality specifications are provided. These address the components of the gas to ensure that gas will not contain elements which may cause danger to persons such as asphyxiation, or not provide them with the level of energy required.

Hydrocarbon Dewpoint at Xkpa –This is the temperature at which liquids in gas start to drop out. This can cause problems if gas is cooled and if its got a high hydrocarbon dewpoint. This causes things like lpg, butane, propane - you get slugs of liguid. It is essential to have a maximum and minimum hydrcarbon dewpoint, as pipes operate within certain temperature ranges.

Oxygen – There are limits on the amount of oxygen in the gas.

Sulphur – Must be limited as this can cause problems by blocking up edges of meters.

H2S – This is poison

Mercaptan Sulphur – Gas is normally odorless so odorizers need to be included in the gas for public to smell in case of leakage. These are the mercaptans.

Delivery Temperature of Gas - needs to be specified. You can't have freezing cold gas because pipes become brittle causing pipe breakage, which is the problem which occurred with ESSO in Victoria.

Calorific Value –refers to the amount of heat or energy level

Water – Amount of water in gas

Wobbie Index – This is the index of gas

Odours and Solids -

Gas Pipeline System

The main components of a gas pipeline system are:

Transmission Pipelines – These are the main pipelines that carry gas under pressure to city

Pressure Reduction Stations – These stations reduce the pressure of the gas for local usage

Distribution Pipelines – Gas goes from pressure reduction stations to the distribution pipeline at 1000 kpa. These pipelines run in the streets past and under houses or factories

Customer Meter Regulators – These are the gas meters in houses, factories etc. They range from very small to huge meters for large installations or even series of meters.

Customer Fitting Lines – These lines run from the meter reading to the customer appliance, such as boiler, furnace, stove.

Customer Burner Trains - The burner trains are where the flame is actually ignited

Gas Tariffs

Gas tariffs are discussed from the point of view of *Objectives, Levels,* and *Shape* below.

Objectives

Capital attraction to Gas Company - Gas tariffs are highly variable and competitive – ie what you pay for your gas is highly competitive. Gas tariffs are the main reason for constructing a pipeline because they attract capital to the gas company. If people see a favourable gas tariff they may invest. So the reason for building a pipeline is that it is a good capital investment - owning a pipeline can bring you money but there has to be a return on investment

Efficiency – There must be an incentive to optimize capital spending - smart gas companies don't over capitalize.

Ease and Efficiency of Administering Tariff - It's no use having a complex tariff for an individual consumer . Major consumers are different, as they hire experts to deal with their tariffs. Basically an individual consumer wants a really simple tariff but a company can have a more complex tariff as they pay people to interpret them

Consumer Ration Objective – The price of gas is positioned to deter waste of the product, so to prevent waste , the consumer must pay a marginal cost of the product. If say, a consumer wanted to use gas to heat a pool then they would be charged accordingly. This was a government objective, now commercial companies will sell anything if the price is right.

Income Redistribution – When gas was owned and operated by the government the tariffs system for companies and people was that they paid the same price in city and country [not like petrol]. Gas was priced the same all over the state therefore in a way some people subsidized others. Once again with gas services owned by private companies they may not be seen to have these 'higher motives' and charge accordingly. No doubt gas does improve the quality of life of residents in a town possibly when they are in some remote areas.

Level of Tariff

The level of gas tariffs is influenced by

Purchase Price and Operation and Maintenance Costs to deliver gas

Return on Investment - This is a contentious issue between regulatory authorities and industry. Everybody knows what you pay for gas, so gas companies try to jiggle their operations and maintenance costs. Price control people are nailing them for this. This is a political thing- the level of gas tariffs has to do with income redistribution, not to do with selling gas

Efficiency Incentives and Cpi. This can give an efficiency incentive cpi – x. The gas company will endeavour to provide gas to the general public at say cpi % - 1%. That is if cpi% is 4, then the tariff of gas will be 3%. This keeps the tariffs of the gas company below this price index.

Shape of Tariffs

The shape of gas tariffs depends on:

The Metering Technology and Frequency of Reading – Readings can be demand charge or fixed charge. Where the customer pays on demand ie if you use 10 you pay for 10. It can be a fixed charge up to a certain level then if you go over level then pay more. Customers can opt to pay maximum hourly demand [MHD] charge or a maximum daily demand [MDD] charge. They may also pay a commodities or usage charge, a fixed sum plus x dollars to have gas on then pay for gas you use.

Distance- Based Tariffs – Tariffs may be charged according to distance as in a postage stamp tariff – ie where the rate is the same for different post codes; a zone gate tariff, where the different zones or sections [as in tram and bus fares] have different rates; and also a Gigajoules per kilometer rate. This is for customers with huge demands. The tariffs tie in with the contract demand type. The guaranteed MDQ or MHQ is paid for. Those with high demands pay less.

Contract Demand – MDQ/MHQ - Take or pay.

Ramsay Pricing This is where gas is priced to someone who has a demand sensitive to the price of gas. eg brikette- fired boiler with auxiliary firing by gas. If the price of gas is high then they don't use any but if price comes down they use more of it.

2.3 THE PROJECT PLANNING PHASE

If the concept is approved, a full-blown project plan is developed. The planning phase includes a series of meetings with members of the project team, the customer, client, or owner and other stakeholders to refine the preliminary project plan, which was developed in the concept phase. Time and cost estimates are detailed, if they have not already been done in the concept phase. A lot of work still needs to be done in the planning phase before implementation begins. Success or failure of the project depends to a large extent on the quality of the project plan. The project plan is a working document developed as an aid to planning and managing the project. When used as a working document the plan is updated and revised several times during the project. A complete project plan consists of: Project Definition, Project goal and purpose, Project phases, Project milestones, Team requirements, Work breakdown structures, Activity network, Gantt chart, Assumptions, Risk Assessment, Documentation, Project Budget, Change Control Procedure. These components vary from company to company and from industry to industry.

- Establish the Project Infrastructure
- Recruit and assign human resources
- Compose first five sections of Project plan Project definition, Project goal and purpose, Project phases, major milestones, team requirements
- Construct a work breakdown structure – breaks all Project work into an outline. Decides on granularity of tasks and activities
- Estimate time required
- Create task network
- Produce Gantt chart
- Generate Resource Schedule
- Set project baseline
- Consult stakeholders
- Execute Plan

The Gas Pipeline Construction Planning Phase

The planning phase is undertaken before a sod is turned in the ground. It involves creating schedules for costs as well as activities and materials and procurement tracking. As such it requires close links with a number of systems including the manufacturing execution system [MES]; the materials and procurement, financial, survey. These must all be available during the planning and scheduling cycles. The elements of the planning phase are summarized in figure 2.3.1 and described in detail below.

Project Planning

Project Infrastructure

Project Scope and Objectives

Project Criteria

Project Controls

Project Organization

Consultants

Establish Project Team

Determine Reporting Process

Determine Standards, Codes, Regulations, Licensing Authorities

Change Management Procedures

Project Review and Audit

Establish Client Liaison and Involvement

Materials Management

Procurement

Inspection of Materials

Storage

Stores System

Issues System

Surplus Disposal

Project Manual

Project Activity Network

CTR Schedule

Review

Execute Plan

Establish the Project Infrastructure

Scope and Objectives of Project

Set out objectives a few very clear ½ page defined objectives at beginning of the project.

Project Criteria and Targets

The project criteria need to be determined, the stages of the project, the success measures, and the milestones.

Project Controls project manager, project leaders/supervisors-clients, contractors, and owners project managers

The project controls are the quality controls of the project, all reporting that needs to be done and when. project controls are imposed by the project manager. who uses the project team to impose control down the line. The project manager delegates to the project team. You're far better off kicking the backsides of the 10 project leaders of say 10 teams, than 300 individuals. Supervisors or project leaders then report to the project manager. The project brief refers to the responsibilities of the project team and is a combined statement of objectives, criteria, and controls of the project. The brief is applicable to all project managers - clients project manager, contractors project manager, and owners project manager.

Project Management /Organization – design, construct, manage, maintain

Project organization can be varied. The main project organization types are
a)Design and Project Management by Owner/Construction by Contractor and
b)Project Management by Owner/ Design and Construction by Contractor
c) EPCM – Engineering, Project Management , Construction, Maintenance by contractor.

Basically there are three main elements – design, construct, and project management. How these are split up depends on the company that owns the pipeline. In companies today there is a focus on core processes and outsourcing the rest, so if a gas company owns the pipeline they may not have engineers in house to design they may outsource

Use of consultants – can be used for any part of the project ie design, project management. Report back to owner

Project Team Establishment – project team is established. project manager, team purchasing manager, quality manager, quality engineer or inspector, stores manager, construction manager.

Reporting Process – how will reports be made. Normally made in writing on financial matters, design and construction process. Might report verbally loss time injuries matters not affecting progress not crucial elements to progress. The verbal reports will be minuted and therefore reports will be recorded in writing.

Role of standards, codes, regulations, licensing authorities. These all affect the purchasing of materials and the construction of the pipeline.

Change management procedures - There needs to be a policy to handle variations in the contract. The policy states how to deal with sharks when the construction contractor hits you with variations, such as how to deal with unexpected situations. Things happen - landslide, cow in trench, cow falls on top of pipe in trench.

Post Project Review and Audit

Client Liaison and Involvement

The line must be drawn as to who is a doing what to whom

For example, a contractor can get a client who wants to run the show. This can cause the contractor problems , or conversely clients don't want contractors going feral. There needs to be demarcations and levels of authorities, people have to know where they stand. The client sends a liaison officer, a client representative, company man, contractor or employee who is put on for the job of client liaison officer. They attend meetings to ensure that the client gets what they have paid for. Some of the inputs which a liaison officer will have on the project are:

Finalization and approval of detailed project designs

Initiation of Proposed Changes.

Review proposed changes including cost/time, minor issues done on site.

Review/Approval of principle drawings such as PIND,[piping and instrumentation drawings], PFD[process flow diagrams], Site Plans- special crossing drawings, assembly drawings, corrosion facilities, anode beds ie any drawing that is required in the field –

Coordination of Operations and Maintenance Groups. As the pipeline is pretty close to being built and the client has to decide who is going to operate and own pipeline, the owner has to start moving in his own operations and maintenance people. Those people who are going to own and operate the pipe have to bring people in to participate in the construction of the pipe. They need to be included in the planning stage, so they usually have a couple of people over from the client. They give them jobs as inspectors so that they get the feel of the pipe.

Attend Project Meetings and Report to the Owner.

Participate in post Project Review /Audit

Develop and Conduct Training in Operations and Maintenance

Coordinate Tie ins for Operational Facilities eg say there are three factories to be supplied belonging to the same company, there are off-takes, pressure reduction, and tie-ins to these factories. The client liaison officer needs to coordinate these activities, as the construction contractor's work terminates downstream as he is only responsible for the mainline. The tie-in contractor ties the two pipes together.

Assist in Preparation of Procedure Manuals for Operations and Emergencies. The client liaison person will be assisting in the operational side of the pipeline. That is, what the client will be doing on the pipe after the pipeline is built

Materials Management

Materials can be any items that become the operational parts of the pipeline. These can be equipment – turbines, compressors; sandbag skids to rest the pipe on, components -valves, filters, bits and pieces welded into the pipeline; general materials such as pipe fittings, small valves, company store items, consumable 'free issue' materials, and supplies. The contractor provides all equipment necessary to construct the pipeline, such as trucks, sidebooms, welding equipment, however, welding rods, propane torches, cutting tips etc are provided by the owner. For this reason there is a materials manager [purchasing manager]on site as part of the project team.

Procurement

Procurement is done to a specification. Procurement people have to follow drawings Each item of material or specific piece of equipment has its own data sheet. Each valve has its own data sheet eg valve no 29 hard seat Cameron valve. These data sheets are referred to as MTO's [Material Takeoff Lists] and represent a unique item of equipment. The MTO is a like a Bill of Materials data sheet. They represent a detailed description of the item as well as how to assemble and or operate this item. Procurement has to be done with codes to company engineering standards. The company purchases through approved vendors. In the quality manuals or quality systems you have a given list of approved vendors. Procurement has to also determine warranties - client demands and warranties. For example, the contractor has a 12 month defect liability period and this is provided in the contract.

Purchasing also takes care of items which have long lead times.

An important part of the procurement process is to expedite it, to determine where the item being purchased is at any time

Inspection of Materials

Inspection of materials is done on delivery and done to specification. This could be at the site but it is more likely to be overseas at the particular factory which is producing the item. For example, inspectors from the pipeline are sent overseas to watch a steel making process in order to ensure that the product is being produced according to the designated company standards. The general rule is that the quality engineer or tradesman [not the quality manager] goes overseas to inspect attributes of the equipment eg left hand and not right hand valve. The inspector also looks at compliance which is very important, and checks the composition, and test certificates, parts lists to ensure there are spare parts as required by construction contract. The inspector also checks whether any certification by an authority is required such as ASME/AS/British Standards. Payment is made on compliance to specifications not on good order. If deficiencies are detected that is non conforming to standards then the inspector will either accept item subject to conditions or request repair, change, or rework.

Storage

The materials for pipeline construction must be stored in a physically secure environment, such as a secure yard or shed to prevent theft. There must be shelter from the weather to ensure that items are not damaged by rain. Some items may not be exposed to the atmosphere such as humidity. The storage must also ensure separation or isolation of stores. For example a fuel dump must be stored away from oxyacetylene. Inflammables must be stored away from fire and so on.
Containment, such as shipping containers must also be catered for. There must also be storage receiving areas Some items may be delivered to different designated lay down areas when a delivery truck unloads items in certain areas such as a received stores area . Receiving areas move along with the pipeline or conversely the storage may be at the main site. Deliveries are taken at that point, laid down, and the stores people have it tracked, taken either into store or taken out to site and stored or issued directly. Everything comes onto the site with a number, which can track the items down line as the pipeline moves. It is the responsibility of the stores people to issue to the various locations either taken from area to store or taken to site stored on site or issued directly.

Stores System

Stores system has to have stocktaking reorder capability

Need separate stores field or central stores

Cranes handling facility on truck off truck in truck off truck forklift appropriate equipment, does it work in paddock

Use barcoding facility for tracking equipment – pipes are barcoded, can you use RFID

RFIDs are not standardized need set of radio frequency

Give off radio frequency so you can read the signal and pick it up

Use GIS to track

Issues System

Issue is done by authorized release documentation only.

The account codes [barcodes] determine which part of the job the item is charged to.

Items go to consignment store after inspection is carried out. For example, valves in Italy need to go here after going through customs. The question of transportation of these items must also be addressed ie how -open truck or container and who- owner or contractor . Before it comes off the back of the truck, the question of free on board or free in store arises ie does it stay on the truck or does it go to the store or where does it go and how will it be delivered. Liability after accidental damage, delegation or placement of responsibility must also be determined.

Surplus Disposal

Disposal of surplus materials must also be accounted for. The options for disposal are to give away to a local farmer, sell on the spot, return to where it was purchased, or backload to your own central store for use on another project. Your project has paid for it, so your project sells back to the company. Items must be classified as useable spares, scrap, or return for credit. The project manager needs to keep track of surplus. For example, contractors have their own yards, items are issued to contractors – say 2000 sleeves at $150.00 per sleeve were issued. Only 1000 sleeves were used. This leaves a surplus of 1000 sleeves ie 1000 x $150.00 =$150000.00 which can be recovered from the project costs.

Administration Issues

There are also many administration issues to be taken care of while setting up the project infrastructure. These are:

Accommodation The location desert, jungle, or city has bearing on the accommodation for people, such as compounds or housing.

Amenities if any are you going to have booze on the job or not. If they have behaved then ok, are there going to be field kitchens or are the workers going to get their own food etc

Communications Infrastructure –This is the hardware, radios, telephones, means of communicating. Radios are required along the route. You can get dead spots so radio towers along route on hills might have to be erected to facilitate communications along the pipeline.

Transport has to be catered for such as 4-wheel drives or sedan cars.

Petty Cash has to be secured on site

Special Arrangement s have to be made for fieldwork – have we got to feed the workers ie take the food to them, or will they come in at lunch

There could be military guarding on some pipes, portaloos may be required etc

Time Keeping - how are time sheets to be done, wages and overtime can run into huge amounts. The image of construction workers has changed from the rough construction workers to sophisticated tradespeople.

Establish Project Manual

In an autonomous project the project manual informs all parties what is going on. A typical project manual would contain the following entries:

Definition of Project Organization Structure, Organization Chart

Directory

Project listing by job and or function and or grouping eg welding crossings crew

Costing informs all parties about costings - by job, asset, function, or grouping

Audit requirements and or procedures

Job and Work Order Number System for control, accounting[accounting people]

HR Policy Instructions EEO, how you are going to deal with maternity leave, hire and fire people on site, what are grounds for dismissal, process of counseling and advising that they have done the wrong thing

IR _Industrial Relations Policy - how management will deal with unions, are there any awards and agreements in place, what unions will be on site

HSE Health Safety and Environmental Policy –environmental effects document, generally HSCMP/ENV policy in relation to disposal of wastes corporate policy, 1 page statement , policies for working over water, in the desert, in swamps etc

Engineering Policy engineering and technical standards as Australian standards and company standards

Purchasing Policy how many quotes eg 3 quotes over 50k 2 quotes over 10k

These are manuals in themselves. The purchasing manager makes use of electronic documents and modifies to suit the project

Contracts Policy – In large companies and corporations there is usually a contracts manager. The contracts policy reflects the corporate contracts policy.

Document Policy ISO 9000 – policy refers to quality manuals and work procedures, how to communicate costs etc

Relevant forms - Leave applications, sick notifications, standard forms with electronic copies as appendeces in the back of the manual, everybody applies on the same form

Communications Procedure- what is the chain of command - if a problem arises, see the foreman, then project engineer, then project manager- don't go straight to project manager

Reporting Procedures and Instructions - what has to be reported and how it has to be reported, how information has to flow

Project Finalizations Project closure how to close job - what is finished and when what has to be done to close it out. All of this is in the project manual possibly even more.

Project Activities and Activity Groups

Before beginning the detailed planning and scheduling process, the activities and activity groups are described. The activity groups comprise the resources of the project.

Activity Groups

Activities.

Australian onshore gas pipeline construction consists of the following stages or activities in a mainline pipeline construction project:

In small projects the project activities network and the CTR [cash time resources] scheduling are done together. They are described separately for clarification below. Other special areas of pipeline construction such as swamp or river crossing, valve insertion, require additional crews. In gas pipeline construction contractors may subcontract the special crews. Contractors also provide the equipment for pipeline construction. ::Before scheduling can begin, the project manager breaks down the pipeline construction project into logical activities. These are

Alignment Survey

Access to Site or Right of Way Access – A right of way easement or strip of land approximately 20 metres wide is created to allow enough room for the pipe as well as access to the site for vehicles. This often entails opening fences, creating cattle guards and bridges, cutting down trees and removing stumps from the easement. A continuous roadway supporting all vehicles must be constructed. This makes use of major and minor roads, as well as creating new roads to the site.

Cleansing and Grading

Cleansing and grading immediately follows. The survey team is the first team to go in. They put in pegs and hang coloured ribbons on fences to get a centerline of the trench. After the easement has been created the cleansing crew moves in to clean up. Depending on the level of clearing, grading may also be done. Bulldozers stockpile the topsoil to one side f the trench keeping an eye on the centerline. This can be replaced after the pipeline has been lowered into the ground and backfill has been done. If the pipeline is on a hill then the graders will have to level this. There is a working side of the trench and a stockpile side.

Stringing

Pipe is purchased by the owning company and shipped to points along the general path of the pipeline. As mentioned previously a number of different situations might exist as to how the pipes arrive at the site. The pipeline owner may assume responsibility for delivery of the pipe to the easement area; the contractor may subcontract the hauling and stringing to specialists; or the contractor may stockpile the pipe at convenient locations and string the pipe as required. The pipe is in pieces of 12 to 18 metres long. The stringing process lays the pipe out on skids on sandbags, offset, placed in order. At certain places extra wall will be needed so heavy wall pipes and double wrap pipes must be strung in as well. The stringing crew need to determine which pipes will be placed where according to the engineering drawings. They may also decide to lay 2x18 metre pieces of pipe as opposed to say 3x12 metre pieces. This would save on the welding and testing processes.

Trenching

A trench is made which is wide enough to contain the pipe and permit its being lowered in and backfilled without damage to the pipe and its covering. It is deep enough to permit the specified depth of cover, enough to ensure that it will not interfere with normal land usage. Trenches for large diameter pipelines have flat surface in the trench bottom to allow movement horizontally with line expansion. A minimum width in excess of pipe diameter is required. Under the most favourable conditions with only dirt to be removed from the trenches, one or two hydraulic excavators moving rapidly down the right of way following pegs that mark the location of the trench will suffice. A neat row of dirt to one side of the opening will be used to cover the pipe and backfill.

In wet dirt or swampy areas draglines and clamshells do most of the digging. Clamshells are also used to repair trench cave-ins and clean trenches when they are damaged by other causes. Rock trenching requires other tools and techniques. If the rock is of a type that can be loosened with a ripper this method is used. A ripper is an attachment pulled by a large bulldozer, consisting of one to three ploughs, adjustable to reach depths as large as regular trench dimensions. Some pipeliners use a ripper before trenching, even when rocks are not present. When dirt and rock are loosened, backhoes move the dirt and rock and stack it on the left sid of the trench as is done with other methods. If rock is too hard to permit ripping then blasting is used. Drills are suspended from sideboom tractors that bore holes in the rocks, charges are placed in the holes, and the trench is blasted. Backhoes then clean the ditch. Sometimes tractors will be used to hold backhoes in position if it is raining or terrain is steep.

Welding and NDT

Although the tasks performed under this heading sound simple, this is actually both a difficult and important phase of pipeline construction. When the pipe gang begins its duties the pipe is along the side of the trench. It may be necessary to move each joint appreciable distances in some cases where the pipe hasn't been evenly strung due to terrain. Pipe ends must be completely free of all dirt, scale or coating which will interfere with the making of a good weld . Cleaning is done by brushes and buffers. A pipe end may have to be cut off because of damage and a new bevel cut. The bevel or sloping part of the pipe end must be ground to remove all irregularities. The land or shoulder, generally about 1 mm in width, may need to be reduced almost to a featherhead edge, depending upon the welding method used. Pipe joints are added one at a time, using inside alignment clamps for pipe diameters larger than 30 cms and outside clamps on smaller diameter pipes. Internal line-up clamps are placed in the two joints of pipe where they come together; one set of expanders is in the end of the pipe already in place, the other in the pipe where they come together; one set of

expanders is hydraulic or pneumatic pressure. A steel rod for moving the clamps extends through the pipe being added. Pipe ends are brought into reasonably true roundness. For smaller pipe diameters outside clamps squeeze pipe ends down to matching roundness. Distance between pipe shoulders is controlled by spacers who secure uniform spacing around the circumference. The welding method used determines the width of the space. Molten metal from the electrode must fuse with the parent metal and penetrate into the inside root in the space between the lands. Two sideboom tractors are used by the pipe gang. One sideboom is used to position joints of pipe alongside the trench. The second sideboom picks up each length of pipe, moves it into position for alignment, and supports the pipe until the stringer bead has been completed. Then the pipe is lowered to rest on skids and 'hot pass' beads are made. Before each new bead is started, slag, glass deposits, or other irregularities are removed by grinding and brushing, or using other hand tools. The wall thickness of the pipe determines whether one or two hot pass beads are made. The hot pass bead builds up additional strength in the weld area before cooling has taken place. Internal clamps are moved into the new position and the process is repeated as each length of pipe is added. Self propelled air clamps are used in some large diameter pipe. In favourable terrain and good weather a pipe crew may complete 200 to 250 initial welds per day on 30 to 36 inch diameter pipe.
Firing line welders finish the work which was started with stringer beads and hot passes applied by the pipe gang. Again, the number of passes required on the firing line is dependent upon the wall thickness of the pipe and the welding method used.

The two welding methods used in pipe line welding on the right of way are distinguished by the general terms stick welding and wire welding. Both have as their purpose strong smooth welds.

Metal deposited in a V-shaped channel formed by two slope-beveled pipe ends must fill space between lands, or shoulders, and this metal must fuse with the parent metal of the pipe ends and the metal already deposited in prior beads. The thickness of the layer deposited is usually about 1/8" for each pass or trip around the circumference of the pipe. Thus depending upon wall thickness of the pipe, a completed weld will consist of from two or five passes variously designated as stringer bead, hot pass, filler beads, and cap bead.

Buttons, bead starts, high points, and heavy deposits of glass are removed by grinding before each new pass is begun. This was noted in the work of the line up crew. Stick welding utilizes an electric arc to melt and fuse the metal of the pipe ends with the metal of the stick electrode held by the welder. Stick electrodes are rods approximately 1/8 to ¼ " in diameter and from 9 to 18 inches long. The rods are coated with substances to reduce oxidation and to form a shield of slag at the weld. The electric power supply is of constant current type from tractor mounted generators called rigs. Voltage increases with the width of the arc used. Higher amperage is used for stringer beads and hot passes.

CO_2 wire welding is an adaptation of the electric arc method which has been developed within recent years. Various names are applied to it: shielded wire, microwire, mig, short wire welding, and wicky wire welding, as well as others. Deposit metal is wire of .035 to .45 inch diameter supplied from spools or real s of the welding gun. Protection from surrounding atmosphere of the melting parent metal and the continuously fed deposit-metal wire is by a shield of welding grade CO_2 gas, also fed continuously with the wire through the nozzle of the welding gun. Both flow of gas and quantity of wire fed are controlled by the welder. For wire welding a constant level voltage is supplied by ah generator; as the rate of wire feed is increased, more amperage is used. The gas shield has much the same function as the coating of the stick electrodes.

Two general classes of CO_2 wire welding equipment are in use. Semiautomatic equipment is very flexible and can be used for every welding task and found on a spread. It is commonly used for stringer beads, hot passes, tie-ins, and utility welding when other methods supplement it. Automatic CO_2 equipment is adaptable to making filler beads and cap welds on the firing line.

Yard welding of double joints is done by equipment of a somewhat different type. Submerged arc welding machines deposit large amounts of metal from above as the pipe is rotated. Automatic CO_2 equipment may be used in the pipe yard. One welding adaptation is the running of the stringer bead from a position inside the pipe. A welder rides on a track to the weld point and makes the bead.

Both stick welding and wire welding have their advantages. The building company may specify one or the other. The preference of the contractor is influenced by the availability of qualified welders.

Weld Testing/Non- Destructive Testing[NDT]

The critical nature of each weld in the construction of a pipe line is such that a very thorough inspection procedure is in effect at all times. Visual inspection can detect some flaws in welds.

X-Ray inspections of welds re made by pictures of the entire circumferences of the weld . Some x-ray pictures are taken inside the pipe at the weld area; others are made externally. Films are made, processed, and evaluated in the field.

It is customary to require radiographic inspection of 100 percent of the welds in highway, railroad, river crossings, and pipe which will be under water. The percent of pictures required in other areas is often from 15 to 30 percent but it is not uncommon to require 100 percent x-ray inspection in installations of high test or thin wall pipe. Repairs are made according to procedures specified by the company and complying with API standards 1104, which means that if welds are not ok they must be cut out and done again..

Joint Coating

Sideboom tractors lift the pipe from the skids here it was placed by the line up crew. Before any coating or wrapping is applied, the pipe must be cleaned. A self-propelled cleaning and priming machine travels along the pipe scrubbing the external walls of the pipe with rotating batteries of brushes and buffers. This process removes all mill scale, rust, dirt, and othe r foreign matter. A proiiming coat of quick drying enamekl is simultaneously applied which helps to bind a subsequent coating to the pipe. Workmen prime any spots not covered by the machine.

A coating and wrapping machine follows closely behind the cleaning and priming machine after the enamel primer has dried. It too is self-propelled. All dust is cleaned from the primed pipe before it is coated. The machine sprays a protective coating of coal tar or asphalt base over the entire exterior walls of the pipe. Rotating heads wrap a layer of glass fiber around the hot coating. Sufficient tension is maintained on the glass wrapping to embed it in the coating. A dope kettle drawn by a sideboom tractor supplies coating material to the coating machine through a flexible metal hose at temperatures of from 475 to 525 degrees Fahrenheit. The rotating heads also wrap a layer of kraft paper, asbestos felt, or tar paper which protects the coating from damage from skids, slings, or rocks during the lowering in and backfilling operations.

Sometimes the pipe is already coated at the factory. When yard-coated pipe is used different procedures result. Welded areas must be coated and wrapped. Field joints are wrapped with tape or bitumen coal tar, or asphaltic materials are used, and protective wrapping is applied. Moulds apply bituminous masting under heat and pressure to weld areas when this type of protection is needed. The coated line is placed on skids or dirt beams to permit cooling and hardening of the protective coating.

Lowering In – Backfill

Under some conditions pipe is lowered into the ditch in conjunction with coating and wrapping operations. This is called 'lowering in' the pipe. Cradling in reduces the amount of pipe handled by eliminating the two steps of lowering the pipe to skids and then picking it up later. Damage to the coating by skids is avoided.

Lowering in is usually done in the cool part of the day in order to get th e maximum amount of pipe into the ditch while the pipe metal is contracted. In effect this serves as a slack loop.

Crossing foreign pipe lines requires going under the pipe lines already in place. A section of pipe is walked into position. In some situations six or more sidebooms tractors may be used. Creek crossings and steep terrain also require the skillful maneuvering of sideboom operators as they move long sections of pipe into position.

Ditch cave-ins are repaired by removing dirt and rock with a clamshell or backhoe. In rocky terrain the pipe must be protected from rock damage by padding the bottom of the trench with loose dirt for padding must be hauled many miles. On steep slopes the pipe is anchored in place by covering with dirt.

Wet ditches must be dewatered. Ground water is found at the higher elevations in mountains as well as in swamps and marshes. Many types of swamp weights and anchors are available. Two methods of producing negative buoyancy are illustrated.

From three to ten sideboom tractors may be used to pick up pipe from the skids and lower it into the trench. Jeeps locate damage from skids or rock abrasions and it is repaired. In marshes and wet trench situations water is pumped from the trench and concrete weights or screw type hold down anchors are added to keep the pipe from floating.

Backfill

A part of backfilling has already been done by the lowering in crew as pipe was covered to anchor it in place during this activity.

Angle dozers make short work of covering the pipe where plenty of good topsoil is found. Compacting is done with crawlers of the tractor. Special tractor mounted backfiller attachments consisting of extendable booms, fast action winches and a mormon board are used on large diameter lines where there are wide spoil banks.

Where it is possible the topsoil is placed on last to permit restoration of normal surface vegetation.

In backfilling rock ditches the top and sides of the pipe must be padded with dirt before rock fill is placed in the ditch. To protect the coating from rock damage dirt is hauled long distances in some areas.

Installations of breakers made of concrete, sand bag or other materials are built in hilly terrain to keep the backfill from being washed out by rains and melting snow.

Part of the excess dirt is left over the ditch line to compensate for further settling; the rest is distributed over the right of way..

Reinstatement

During clean up the right of way is restored as nearly as possible to the conditions that existed when the spread began the clearing and grading operations. Fences are built. Irrigation ditches and tile, levees, and contours in farm lands and pastures are returned to original condition. Temporary structures and debris are removed. Rock fragments are removed or scattered according to contract agreements.

Loosening of topsoil with conventional farm tools, fertilizing, and seeding the right of way are becoming common practices.

Clean up of the right of way is important to public relations of both company and contractor. Future pipe line building can be anticipated along present pipe line alleys.

Testing

Completed sections of the line are pressure tested before the owning company accepts the line. The length of the test section is determined by company choice. Some lines are tested between valves. Longer sections can be tested but with larger diameter pipe the quantity of water or other testing fluid used is a factor. Gas or air is sometimes used in testing natural gas lines. Hydrostatic testing utilities filtered water more often than any other fluid.

A preliminary of pressure testing is running a scraper pig through the sections to be tested. Construction debris, rust scale, or dirt remaining in the line is removed by the scrapers. Then the line is filled.

Testing pressures used are based upon a predetermined percent of the minimum yield strength for which the pipe was designed. A representative step by step procedure is:

Pressure to 735psi, hold for one hour, drop pressure to 365 psi

Repressure to 735psi, hold for a second hour, drop to 365 psi

Repressure for a third time to 735 psi, maintain pressure for 24 hours, then drop to 365 psi

Finally repressure the pipe to 735 psi and hold for three hours. If the pressure is maintained within the specified limits, the test is completed and the section of pipe is accepted.

If any leaks are detected by pressure drops, the exact location of the leaks must be found, the faulty pipe or weld must be cut out and repairs made by replacement. The very high cost of making cut outs and replacements at this stage accounts for extreme care found in welding and inspection.

Tying In

Highway, railroad, and river crossings, as well as other loose ends required by the owning company, leave openings in the line. The tie in crew, a miniature spread within itself, joins these segments into one continuous line. At tie ins extra pipe is cut off and bevels are made. Welds are made and protective coating is applied. In some organizations tying in is done by the lowering in crew. Other situations may utilize two or more tie in crews.

Alignment Survey. The site is visited by regulatory authority prior to commencement Once license is issued you can start construction. That goes thru construction phase to completion of pipeline then you get a fit to operate certificate. Construction covers 10 volumes this is administrative process show where quality control and recording activities could be of use – radiography results pipe gets mill test - test pipe up to 90% of specified amount that is a quick test in mill to sort out any obvious failures but then tested as welded structure submit stmt of compliance letter certifies you've done what you are supposed to have done, pressure control details, corrosion control details, coating of pie demonstrated up to time that you've lowered into ground then pearson test and voltage gradient test tells you if defects in coating shows coating up to certain std if subsequent failure protected by an impress current system; drawings and has proper security once it goes in reg authority aggress then gives fit to operate permission

Eng survey overview locates pipe in ground computerized pretty well over the years All done by GPS and GIS methods total station survey data is fed into a modem and shot up to head office same day drawings done by cad, if you have to move pipe around farmer browns dam, move pipe 50 metres government gives permission to go through someones property take out easement 20 metres don’t alienate land try not take any more than have to 20 metre strip maintain it room for duplication in future aust map grid psm permanent survey marks GPS is used to tell property boundaries to 6mms little GPS tell you in refined way when you are moving around property, hand held GPS to do initial surveys good indication of how much distance follow route and that data is shown on GIS GPS gives coordinates gives coordinates tells where RFID emergency frequency EPERB on diff frequency used in aircraft boats bushwalking diff frequency

Centerline survey using total station surveying jargon GEOCOMP drafting total stn – distances elevation some sort of measurement drafting type is done by GEOCOMP or AUTOCAD easement diagrams

Alignment survey will give you easement boundaries, where the trench is, then get access to site when easement is created

Create the CTR schedule

Gives sequence and duration

Impacts time and cost

Construction scheduling

CTR Scheduling

Break project up into manageable sections

There must be a logical separation ie by geography, phase, department, crew

Examine objectives, milestones, criteria

Do not confuse resources with activities

Establish the project start and finish dates

Delegation by project manager to sub project level managers [activity groups]

Form activity groups

Determine single activities, number of activities, sequential, concurrent, and parallel activities

Identify dependent relationships

Work backwards and forwards to confirm logic

Mutually independent activities are in series

Develop the network logic diagram for activity descriptions and logical relationships/interdependencies

Evaluate activity in terms of duration and resource level required

Do not overload activities with resources to reduce time initially

In estimating duration involve parties to establish the appropriate time interval ie month week day hour

Identify time lags and or overlaps, do not modify duration

Be a little pessimistic

Avoid seat of pants estimates

Compare with existing project performances

Include delays for purchase enquiries, tenders, bid time, tender evaluation, contract approval, order placement, contractor establishment time, procurement lead times, drawing reviews, drawing approvals, regulatory authority approvals, purchase expediting, inspection, performance tests, training, curing time[concrete,epoxy etc]

Create the critical path and floats

Cost Schedule

Create cost breakdown and review against budget

Keep tight control to prevent overruns

Budget by single or multiple appropriations

Break down by project manager of appropriated funds on the same basis as the estimate

Reexamine the estimate – is funding adequate – do this soon after finalization of project brief

Create contingency sums

Withhold contingency sums from sub project managers

Perform project cost estimate for each activity

Use accounting system blocks, codes, job numbers

Reference these on all time sheets, purchase orders, payments, actual costs as well as budgeted costs reevaluate budget after milestones

Expenditure Profiles

Expenditure schedule

Cash flow system

Categories of costs – direct, indirect, contingent, fixed single amounts, ongoing fixed rates, ongoing variable rates, quantity proportional, s-curve

2.4 PROJECT IMPLEMENTATION PHASE

The project implementation phase covers the following broad areas:

- Begin work – start the actual project.
- Gather status information – Gather all information on schedule, budget and performance
- Update project files – update all project files as work continues. Combine data inputs and report status
- Analyze results
- Take corrective action
- Report results
- Tasks 2,3,4,5,6 are the control cycle which is repeated on a weekly or biweekly basis
- Project Tracking Monitoring and Control

Implementation of Gas Pipeline Project

Quality Assurance Activities

Assist with product procurement

Assess design requirements

Assist in purchasing dept in assessing tenders

Assist in preparation of specifications

Review quality documentation

Approve new products and materials

Evaluate potential suppliers/ manufacturers

Conduct supplier surveys

Audit accredited suppliers

Inspect goods from non accredited suppliers

Process Defective Materials Reports

O/S Inspection Reports

Assess quarry products, such as line pipe, coating, fittings, valves, actuators, hot formed bends

Inspection Duties and Reports for:

Pipe delivery

Handling of Coated Pipe

Pipe Transport

Stringing

Storage of Pipe

Prospecting Ahead

Grading of Pipeline

Trench Excavation

Excavated Soil

Trench Alignment

Trench Width

Bill Holes

Trench Bottom

Change of Direction

Drainage

Damage and Improvements

Interference to Existing Services

Permission Required of Public Authorities

Blasting

Disposal of Surplus rock and timber

Excavation at line valves

Unused Bores

Welding

Testing

Coating

Factory Coating

Xray Results

Field Coating Material

Sleeves

Surface preparation for joints

Double Coating

Repairs to coating

Above ground pipework

Testing of coating

Use of coating and testing equipment

Forms and reports

Monitor, Control, Track Cycle

Define Objectives

Determine specific targets

Prepare plan

Organize resources

Direct the work

Evaluate progress

Feedback Loop

Compare progress against target

Decide on corrective action

Implement corrective action

Validate or change by reevaluation of progress

Cost Control

You cannot manage if actual costing is only from payments that have been processed

Work on when the 'commitment' is made

Prepare cost control sheet for each segment or activity

As budgeted, continually update

Beware of work ordered on hourly rates or unit rate if it is estimated it can blow out

Use of pre printed forms and instruction for all costs and activities

Use accounting and project management software

Do expenditure reconciliation against commitments

Prepare cost reports

Must be compatible with budget allocation

And commitment s to allow cross checking [reconciliation]

Reconcile in CURRENT reporting period

PROJECT CLOSEDOWN

The project manual contains all details of reports and procedures to be followed for the closedown of a pipeline project

SUMMARY

In this chapter a description of the pipeline construction was presented from the framework of project management. This was as a background to establishing the design of a tool for use by pipeline construction engineers. It can be seen by a description of the process that a system will have to be distributed, mobile, and agile, catering for many sudden changes, be able to support any online real time data monitoring as well as near real time reports, data and information needs to be available at all times to all staff in the field with a variety of technical but not necessarily computer-sophisticated backgrounds, the system must be secure and robust, as well as easily transportable, the system must allow decision making for all members of the pipeline ie contractors, owners, designers, surveyors, subcontractors- with appropriate access levels. The systems must easily link to other areas such as accounting, MES, supplies, materials, quality management, as well as the project management system.

APPENDIX C
DESCRIPTION OF PROPOSED COMMERCIALIZATION PROJECT

L. Dunn and J. Norrish

Information Technology Systems for Pipeline Construction

Introduction

In the course of investigating the feasibility of mechanised girth welding of transmission pipelines in Australia a novel on line monitoring system has been developed. This computer based data acquisition system enables departure from the welding procedure and potential defects to be identified during welding. Post weld quality reports may also be prepared immediately after welding to assist in targeting non-destructive examination. A feasibility study has also been carried out to assess the possibility of linking this monitoring system to remote stations using internet technology and enhancing the system to include onsite data entry and weld tracking. This feasibility study (conducted by several third year computer science students at the University of Wollongong under the supervision of Dr Leone Dunn) resulted in a series of prototype systems and these are described below. The systems were demonstrated to representatives of the pipeline industry on the 24th of October 2000. The CRC for Welded Structures and the University are now seeking expressions of interest from potential sponsors who wish to support the development of this technology into an integrated package.

The components of the system

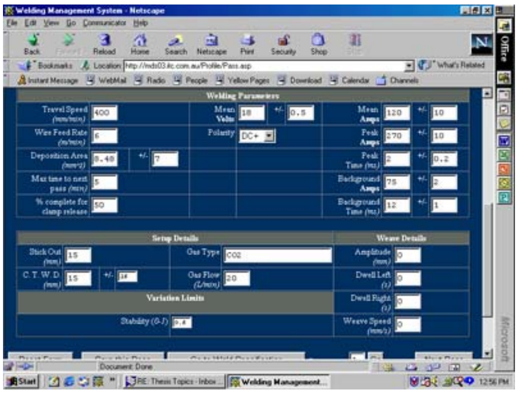
The proposed integrated system will consist of :

- A web based welding procedure database and facilities for downloading procedures to remote welding stations (internet)
- On line weld monitoring hardware/software
- Bar code and manual data entry in the field (wireless)
- GPS coordinate recording on site
- Facilities for uploading post weld quality reports from remote sites (internet)
- Video surveillance on site
- Possible interfacing with NDT systems

The system may be illustrated diagrammatically as below and the functions of the various components are:

Procedure database

This database is implemented on a web server **http://mds03.itc.com.au/**and the user can create, copy, edit or view (depending on security access level) welding procedures in the format normally employed by the pipeline industry (AS 2885). The stored procedures may be downloaded to the local monitoring system in order to set up process tolerance bands. A demonstration version of this system is operational. A typical screen from the remote data entry client is shown below:



On Line Weld Monitoring

A stand alone on line monitoring system was developed for this project and is known as 'PIPEWELD'. This consists of signal conditioning and isolation hardware, a high speed data acquisition (A/D) card and a laptop computer. In order to set up and analyse the data over the internet the basic data collection engine (WELDGUARD) has been used with modified input and output stages and communication interfaces.

Bar code and manual data entry in the field (wireless)

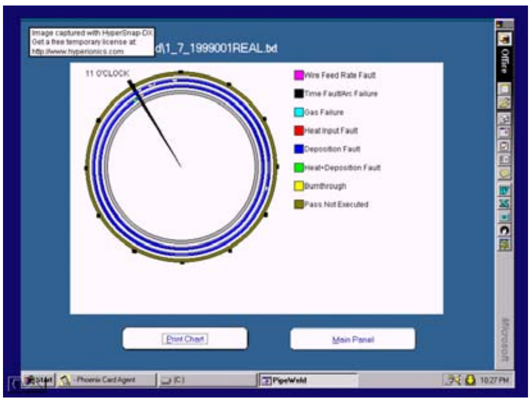
To improve tracking of the joint it is required to enter information such as the welders ID, and bar coded information supplied by the pipe supplier. This has been achieved by utilising a palm type data entry device (supplied by Symbol technologies) which has the added advantage of an on board bar code reader and wireless communications to the local server. Software has been developed to capture the data from the Symbol device in a database on the server. The wireless communication has also been tested in a welding environment.

GPS coordinate recording on site

In order to further identify the joint the GPS coordinates of the field welded joint are collected using a simple antennae and recorded together with the monitored data. The feasibility of this has been demonstrated with a low cost GPS system.

Facilities for uploading quality reports to remote clients (internet)

Once the weld has been completed the data collected from the on line monitoring device (GPS coordinates, welding parameters and defect identification), the manual data entry and bar code input can be accessed via the internet on a remote client. The facility also exists for statistical process control and the development of maintenance management data from these records.
This system has been demonstrated on separate servers but is yet to be integrated.



A typical screen from the remote client is shown on the right:

The concentric circles represent the weld runs and the potential faults are colour coded.

Video surveillance on site

A flexible video camera/computer interface with pan and tilt controls has been built. This allows streaming video and timed snapshots to be captured and relayed via the internet. Depending on the camera used the system is adaptable to general site surveillance or detailed recording of the weld pool.

Interfacing with NDT systems

The most recent automated ultrasonic test systems utilise many facilities which are common to the welding operation. The integration or cross referencing of NDT data and web based communication could be explored.

Wireless data communication

To date only short range (up to 200m) wireless data transfer has been tested for the hand held data entry device. The possibility of wireless data relay , satellite and long range data communication should also be explored.

Proposal

It is proposed to develop the system into an integrated package which enables the individual capabilities listed above to be exploited. This will involve:

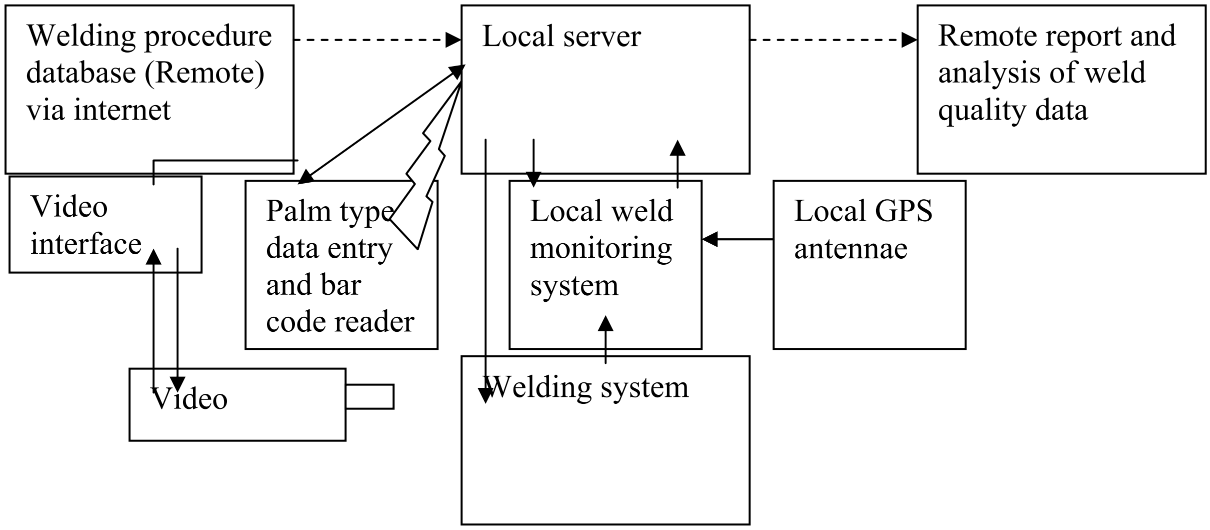
- A review of the current packages, user requirements and operating platforms.
- The development of hardware and software specifications.
- The building and testing and demonstration of a prototype integrated package

Benefits to the user

The user benefits expected from the development of this technology are:

- Improved traceability/recording
- Improved quality assurance
- Early warning of defects
- Early warning of adverse quality trends
- Reduced repair rates
- Improved productivity measurement

Figure 1, System outline



Costs

It is envisaged that the cost of integrating these packages into a field ready demonstration system within one year will be $300000. The CRC for welded structures is prepared to support the project on a dollar for dollar basis and industry funds of $150000 are therefore sought. A group of 6 sponsors each contributing $25k would be ideal.

Intellectual property

The CRCWS will own the intellectual property developed by this work but the individual project sponsors will be licenced to exploit the technology.

Interest in the proposal is currently being sought from:

Symbol Technology
Nortel
Nixon Communications
APIA
RMS Pipeline Technology
EPIC Energy
Duke International
Agility
One Steel

Further details of systems currently developed

Video monitoring

The system is was designed to allow remote monitoring of gas pipeline (or similar) mobile construction sites. It uses real time video streaming technology to allow the user to see what is happening at any particular point in time. To view a remote construction site, the user simply needs to log on to the secured web site, select which camera and site they wish to see, and real-time video of the site is presented on the computer screen.

Features of the system include:

- Multiple users can view the same camera at the same time
- Users can watch multiple sites at the same time.
- At regular intervals, the surveillance system cameras will take a ‘still photo’, which can viewed at a later time.
- Users will have the ability to remotely control a camera. From the web site, users can pan and tilt a camera around the site to see what is happening).
- The basic system can handle both general site views and welding head mounted cameras and is expandable for image analysis and weld pool monitoring.
- The system is based on standard TC/IP protocols which allows connectivity through any web connected computer.

Status:

- The prototype system hardware and software is built and tested and ready for demonstration.

Mobile Data communications

A Symbol SPT1740 handheld and Spectrum24 wireless network have been used to provide a mobile web-based environment for a pipeline inventory system. The SPT1740 allows pipe and weld barcodes to be scanned directly into web pages which are loaded over the wireless network by Symbol WebClient software. Manual data entry for textual fields is facilitated by the Palm Graffiti notation provided by the Palm operating system on the SPT1740. All data entered is sent directly across the network for validation and storage, meaning that live data is always available both in the field and at a central office (no synchronisation necessary) . The application being developed for the project includes facilities for welding personnel to enter welds, cuts, cut-outs, coats and testing data in the field. Facilities for reports and administrative functions are also provided through a web interface, allowing remote configuration of the system.

APPENDIX C

An Agile Project Management System for Pipeline Construction

Abstract

This paper proposes an agile, Internet-based real time system for the management of transmission pipeline construction. The architecture enables tight integration between the management and the production of the pipeline.

Its collaborative and distributed operational and project management framework allows selected parties discrete access to project management subsystems, electronic documents and structured real time information. A central feature of the architecture is the cooperative planner.

Users collaborate through project initialization, planning, and scheduling of the pipeline construction project. As job plans are executed, and their status updated accordingly, all information is used by the planner to notify managers of possible adjustments required to the plan. The responsible people can then decide the course of action required and make changes to the plan accordingly.

Because of the agile architecture, it is possible to set up multidimensional and temporary planning hierarchies, which are important for agile production processes. The system can also be used as a plan simulator, to assess risks involved with a proposed plan.

This paper presents an architectural overview and details of a prototype system. Although pipeline construction has been selected as a target application the approach is suitable for any distributed manufacturing or civil project.

1. Introduction

Many industries have traditionally been project-based. These are organizations that typically involve large civil 'products' which are produced over a number of years and possibly distributed over hundreds of kilometers. This type of project is common in aerospace firms, construction and building firms, minerals mining, road and rail construction. These companies have used the project type of organization for so long that it has become an institutionalized and permanent part of their organization structure, however, the traditional project management approach and software systems that support it are often not adequate for construction industry projects, especially today, with increased use of subcontractors, and the widespread distribution of these organizations. The project management approach traditionally utilized by these companies is not integrated with production and is in itself over-the-wall. That is, in the project lifecycle – from project initialization, planning, implementation, and closeout – are all undertaken by different subcontractor companies and they themselves make use of contractors. There is increasing volume of information produced in a construction process and this information is being passed 'over the wall' to the next phase of the project. Furthermore it is often in the form of a hard copy manual, and not accessible to all parties concerned. During the implementation phase of the project there is interaction with materials and supply chain, as well as the production process itself and the traditional project management information of cost, resources, and time. This aspect of information integration is not supported. That is, the current IT support for both project management and production is fragmented, causing islands of information and automation and a competitive arms length culture, rather than one of collaboration, which could be beneficial to all partners.

Linard and White [92] highlighted the differences between project management in different management environments by describing the activity of the project manager in the manufacturing or construction industry as being 'one who controls' the scheduling and allocation of resources to tasks in order to complete the job on time , on cost, and to the desired quality'. However, there is more to the management of projects than planning and control, although of course this dimension is an important component. Unfortunately, most IT support for construction projects, including pipeline construction supports a small part of construction by providing scheduling support in the form of PERT and CPM support only.

Traditional project management approaches [TPM] have failed to provide the agility required in today's manufacturing and construction industry. Project management approaches typified by the PMBOK [Project Management Body of Knowledge], worked well in stable and engineered projects in the past. However, engineered and mechanistic management must be replaced by creative and dynamic management as projects and organizations become more dynamic and creative (read complex). Project management is concerned with creating something new. It is about change, from the status quo to some desired new condition, within constraints [some known initially, others initially unknown]. Inherent in the various notions of project management, regardless of industry, is the understanding that project management deals with change in situations of complexity, both in the system being modified and in the larger 'containing' system. This understanding of complexity is evident in the pipeline construction project [eg Wallace01]. The work of the project management team is to not only ensure that the pipeline is built fit for its main purpose, but also that it will work within all its containing systems, or to instigate appropriate changes in those containing systems in an appropriate and timely manner. This also requires the ordering and purchasing of products and services, logistics support, supply chain management and so on as part of project management.

Setzer (2004) has identified a paradox in the construction industry, which could also be applied to pipeline construction. As Setzer points out, if IT is about managing complexity, and the average large construction project is a sink of complexity, why does the construction industry lag behind in its adoption of IT on a more widespread basis. Setzer (2004) and others have offered the following speculations with regard to the reluctance in adoption of IT. Firstly, the fact that construction projects are traditionally short term ie on a project by project basis, and this short term view might make them reluctant to add continuing overhead expenses, like IT staff. In addition, the construction industry in general is highly outsourced. Clients hire subcontractors who hire other subcontractors and this may inhibit the kind of information sharing that IT would facilitate. That is, there is a lack of trust amongst the partners in a construction project. Unger, CEO of Constructware, a US-based company, has stated that he feels there is a dark lingering suspicion in construction that “making information readily available and transparent could be troublesome”.

The construction industry in Australia with backup from the government is developing initiatives which facilitate the take up of IT in the construction industry (see the APCC Report, 2002). In this report the following key directions as being critical to the take up of IT have been identified:

- maximising access to shared learning across the construction industry and using knowledge from other industries;
- requiring information from suppliers in electronic form;
- expecting electronic procurement to be used in all phases of project procurement and facilities management;
- using advanced tendering systems which provide real time accessible information to all interested parties thereby facilitating speedier interaction;
- driving process re-engineering through structural changes in procurement processes of governments;
- working with industry to integrate IT throughout the entire supply chain;
- facilitating the use of project web sites;
- managing the use of ‘as built’1 information;
- capturing and sharing information to better understand life cycle costing;
- adopting systems that share information in a useable form; and
- resolving issues including design copyright, intellectual property rights, confidentiality and commercial advantage.

What is needed for construction industries is a construction management process that is adaptive. Where there is a focus on the whole of life products and systems [development, support and benefits realization], Where quality, project risk, and cost benefit are integrated into the planning and management process and not as an add-on to scheduling; where the process supports and recognizes team members as valued people who work together and collaborate to achieve project success, rather than treating members a s a resource that has costs and requires constant tracking and review]; with a focus upward and outward toward sponsors, stakeholders, and clients as well as team members and not just focusing on managing teams deliverables.

The project management of pipeline construction can be seen as a process of collaborative decision making, of assembling data and information and making decisions in a constantly changing environment.

In order to do this the appropriate tactical IT support must be provided.

2. Key Project Decision Making Activities and User Groups

Three main user groups have been identified in the Pipeline Construction Project Management Process. These are management, the project management team, and operations personnel. Management is not necessarily on site; the project management team are on site or at a site office in a local town; operations personnel are on site. The project management team are the team of collaborative personnel consisting of client liaison, project manager, issues and stores manager, materials and purchase manager, site supervisors. There are many elements to a pipeline construction project from preliminary feasibility to completion. These activities may be grouped as:

2.1 Project Initialization Phase
2.2 Project Planning Phase
2.3 Project Implementation Phase
2.4 Project Closeout Phase

The many activities associated with these phases are listed in Appendix I.

3.Important System Capabilities For Field Operations DSS

In order to properly manage these tasks the field operations decision support system must satisfy the following requirements:

- Assist in evaluating options
- Maintain records of decision making
- Sequence/schedule/tasks/events
- Conduct sensitivity analyses
- Assist in generating criteria

- Model cost/time
- List available options
- Model multiple scenarios
- Allocate resources to tasks
- Model processes
- Model information flows
- Manage contract information
- Manage market intelligence
- Manage private and public policies
- Manage stakeholder information
- Manage project information/plans/manuals/contracts
- Manage information for industry
- Manage progress reports

4. Systems Characteristics

In addition the system must be:

- Easy to use
- Available for different pipeline construction groups
- Allows decision making process to be reviewed
- Data management of structured and unstructured data
- Can be customized
- Is flexible and mobile
- Allows interoperability with other systems
- Available remotely
- Supports recurring decision making activities
- Provides security of data and models

5. System Overview

Field Operations Real Time Decision Support

Based on these requirements a prototype architecture has been designed and this is based on the following modules:

5.1 Portfolio Management

This facility provides information about multiple projects in the project portfolio. Statistical information in the form of reports and charts are provided. Links to portfolio management tools.

5.2 Project Information

This facility provides the links between the project team and management. This is largely a document management facility which contains information on the gas contract, quality specifications, tariffs, opportunity and feasibility studies, investment documentation and the project manual. All data types are considered form unstructured multimedia documentation in the form of drawings, video clips, geo-data, word documents, through to structured data. Facilities are also provided for document preparation.

5.3 Product Management

Product Management provides engineers with a facility to define and manage their product – ie the pipeline and its components. The facility enables engineers to identify all components of the pipeline with links to subcontractors who are providing parts and components, as well as design documents, training materials, operating instructions, and procedure setups. Engineers will be able to define a Product Breakdown Structure [PBS], which will be one of the key components of the FOPACS Model. Another key feature of the Product Management facility will be the Product Flow Diagram, based on the PBS, which will enable engineers to define a breakdown of the product [pipeline] into stages and quality checkpoints. The Product Management Facility also provides means to edit, add, delete, new products, components and parts. The Product Management Facility can be linked to other systems, such as the inventory system.

5.4 Resources

The Resources facility assists engineers to define and maintain information about all the resources associated with the project. For example, equipment, costs, personnel, materials. At the beginning of the project, the project team will be required to set up the resources database.

5.5 Financials

This facility contains links to the financial management system for purposes of calculating and tracking project costs.

5.6 Supplies

The supplies facility contains links to the supply chain management system, materials management and issues systems.

5.7 Decision Support

This facility assists managers in the decision making activities by providing access to such tools as risk assessment tools. Risks can occur with general pipeline design, initial project evaluations, and scheduling.

5.8 Situation Monitoring

The situation monitoring facility enables supervisors and managers to monitor site situations. These are such facilities as site surveillance video cameras, tracking through the GIS facility, SPC monitoring of jobs, SCADA links, GPS links, and so on.

5.9 Planning

Automated tools will provide assistance in many aspects of the planning and scheduling process. The planning ranges from links to WPS databases to activities planning and scheduling by means of MS Project.

5.10 Job Coordination

This facility links directly to the ‘plant floor’ by enabling job setup, execution and monitoring. Data gathering, including information from personnel in the form of reports, or real time data is collected and stored in the global database for acess by all members of the project.

5.11 Simulation and Training

The simulation and training facility will enable the support of the field operations by providing the operations staff and managers with training scenarios and 'what if' simulations. The simulation packages can link to any areas of pipeline construction, from manufacturing simulation to simulation of planning and scheduling of the pipeline construction project.

The main menu of the Field operations decision support system is shown in figure 1 below:

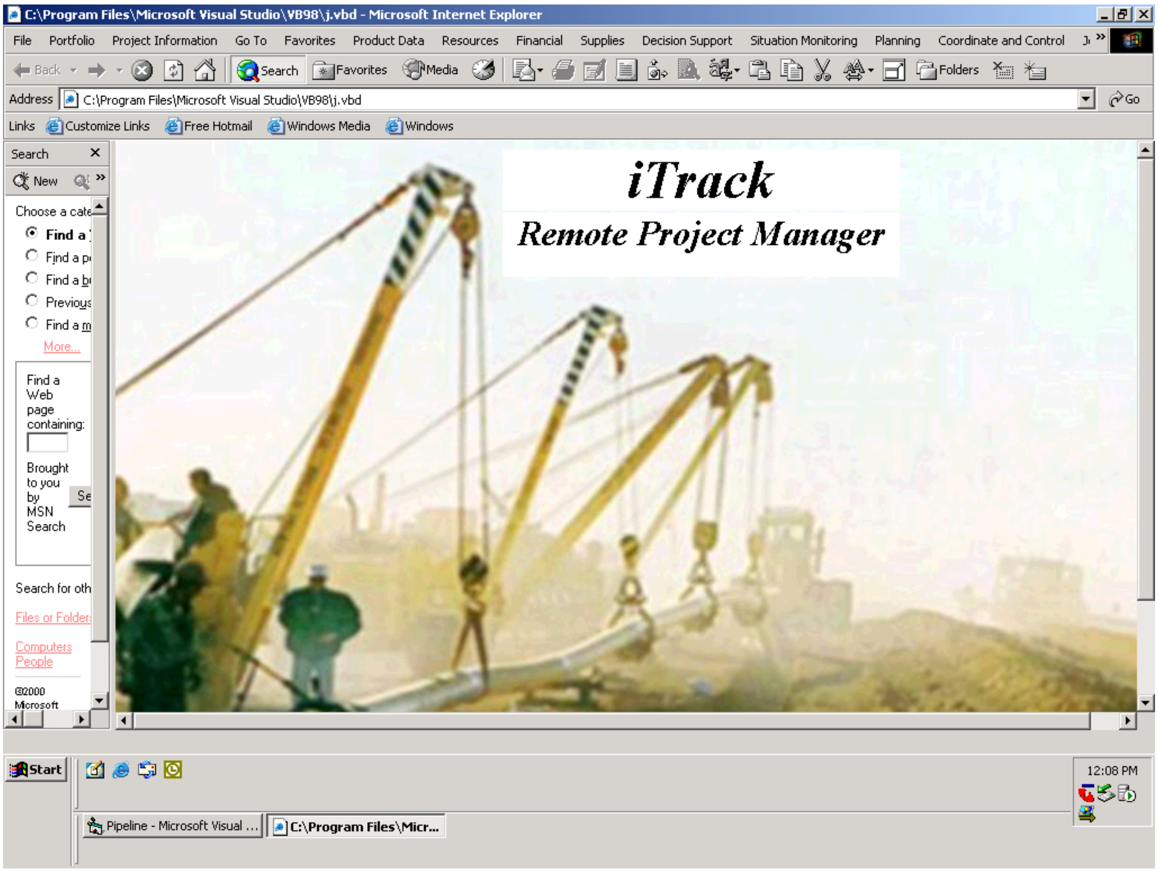


Figure 1: Field Operations Decision Support System Main Menu

6. Summary and Conclusions

This paper has presented an overview of work in progress on an agile IT framework for support of present day construction sites, which are geographically distributed, highly mobile, and subject to many changes from environment, as well as demographic. With the availability of a stable mobile internet platform it will be possible to implement an agile strategy and process. The current status of the work is that a proof of concept prototype for the real time planning has been completed. Feedback from pipeline construction industries is now required for refining requirements, as well as the development of /agreement on an open common data standard for pipeline construction information.

Pipeline Construction Project Management Activities

2.1 Initialization Phases of Project:

- Preliminary Evaluations
- Detailed Evaluations
- Opportunity Study – Feasibility study, financial modelling, marketing to institutions, investment documentation
- Site inspections and testimonials
- Engineering Surveys and Environmental Impact Studies – engineering survey, centreline survey, drafting, PSM sketch, schedules and regulations, permit plans, route plans, profiles, crossings details;
- Hydrostatic profiles;
- Owners Schedules;
- Advertising;
- Proposal
- Contract
- Gas Quality Specifications
- Gas Tariffs

2.2 Project Planning

Decision Support and Information Management Activities

Assist with product procurement

Assess design requirements

Assist in purchasing dept in assessing tenders

Assist in preparation of specifications

Review quality documentation

Approve new products and materials

Evaluate potential suppliers/ manufacturers

Conduct supplier surveys

Audit accredited suppliers

Inspect goods from non accredited suppliers

Process Defective Materials Reports

Produce O/S Inspection Reports

Assess quarry products, such as line pipe, coating, fittings, valves, actuators, hot formed bends

Produce Project Manual

Manage Team

2.3 Implementation Phase

Inspection Duties and Reports for:

Pipe delivery

Handling of Coated Pipe

Pipe Transport

Stringing

Storage of Pipe

Prospecting Ahead

Grading of Pipeline

Trench Excavation

Excavated Soil

Trench Alignment

Trench Width

Trench Bottom

Change of Direction

Drainage

Damage and Improvements

Interference to Existing Services

Permission Required of Public Authorities

Blasting

Disposal of Surplus rock and timber

Excavation at line valves

Unused Bores

Welding

Testing

Coating

Factory Coating

Xray Results

Field Coating Material

Sleeves

Surface preparation for joints

Double Coating

Repairs to coating

Above ground pipework

Testing of coating

Use of coating and testing equipment

Forms and reports

Monitor, Control, Track Cycle

Define Objectives

Determine specific targets

Prepare plan

Organize resources

Direct the work

Evaluate progress

Feedback Loop

Compare progress against target

Decide on corrective action

Implement corrective action

Validate or change by reevaluation of progress

Cost Control

You cannot manage if actual costing is only from payments that have been processed

Work on when the ‘commitment’ is made

Prepare cost control sheet for each segment or activity

As budgeted, continually update

Beware of work ordered on hourly rates or unit rate if it is estimated it can blow out

Use of pre printed forms and instruction for all costs and activities

Use accounting and project management software

Do expenditure reconciliation against commitments

Prepare cost reports

Must be compatible with budget allocation

And commitment s to allow cross checking [reconciliation]

Reconcile in CURRENT reporting period

2.4 Project Closeout

The project manual contains all details of reports and procedures to be followed for the closedown of a pipeline project