The Contribution of Enterprise Systems to Core Capabilities

The Case of Asset Lifecycle Management in the Utilities Sector

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Contents

List of Tables

List of Figures

I, Simon James Fitzgerald Woodworth, certify that this thesis is my own work and I have not obtained a degree in this university or elsewhere on the basis of the work submitted in this thesis.

Simon James Fitzgerald Woodworth

"Tell All The Truth

"Tell all the truth but tell it slant,
Success in circuit lies,
Too bright for our infirm delight
The truth's superb surprise;

"As lightning to the children eased
With explanation kind,
The truth must dazzle gradually
Or every man be blind."

Emily Dickinson

To Michelle, Alice and Seán.

For Derry, David and Terry,

Ar dheis Dé go raibh a n-anamacha dílis

Abstract

The desire to obtain competitive advantage is a motivator for implementing Enterprise Resource Planning (ERP) Systems (Adam & O'Doherty, 2000). However, while it is accepted that Information Technology (IT) in general may contribute to the improvement of organisational performance (Melville, Kraemer, & Gurbaxani, 2004), the nature and extent of that contribution is poorly understood (Jacobs & Bendoly, 2003; Ravichandran & Lertwongsatien, 2005). Accordingly, Henderson and Venkatraman (1993) assert that it is the application of business and IT capabilities to develop and leverage a firm's IT resources for organisational transformation, rather than the acquired technological functionality, that secures competitive advantage for firms.

Application of the Resource Based View of the firm (Wernerfelt, 1984) and Dynamic Capabilities Theory (DCT) (Teece and Pisano (1998) in particular) may yield insights into whether or not the use of Enterprise Systems enhances organisations' core capabilities and thereby obtains competitive advantage, sustainable or otherwise (Melville et al., 2004). An operational definition of Core Capabilities that is independent of the construct of Sustained Competitive Advantage is formulated. This Study proposes and utilises an applied Dynamic Capabilities framework to facilitate the investigation of the role of Enterprise Systems.

The objective of this research study is to investigate the role of Enterprise Systems in the Core Dynamic Capabilities of Asset Lifecycle Management. The Study explores the activities of Asset Lifecycle Management, the Core Dynamic Capabilities inherent in Asset Lifecycle Management and the footprint of Enterprise Systems on those Dynamic Capabilities. Additionally, the study explains the mechanisms by which Enterprise Systems sustain the Exploitability and the Renewability of those Core Dynamic Capabilities.

The study finds that Enterprise Systems contribute directly to the Value, Exploitability and Renewability of Core Dynamic Capabilities and indirectly to their Inimitability and Non-substitutability. The study concludes by presenting an applied Dynamic Capabilities framework, which integrates Alter (1992)'s definition of Information Systems with Teece and Pisano (1998)'s model of Dynamic Capabilities to provide a robust diagnostic for determining the sustained value generating contributions of Enterprise Systems. These frameworks are used in the conclusions to frame the findings of the study. The conclusions go on to assert that these frameworks are free - standing and analytically generalisable, per Siggelkow (2007) and Yin (2003).

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Glossary

This Glossary provides a brief expansion of the many abbreviations and acronyms that appear in this dissertation. In most cases such abbreviations and acronyms are fully explained in the main text where they are introduced.

Abbreviation	Expansion
ARA	Asset Register Administration
ARM	Asset Register Module
BPR	Business Process Reengineering
BW	Business Warehouse
CAPEX	CAPital EXpenditure
CBAT	Cost Benefit Analysis Tool
CER	Commission for Energy Regulation
CI	Customer Interruptions
CML	Customer Minutes Lost
CPI	Consumer Price Index
CRM	Customer Relationship Management
CU	Compatible Unit
DCT	Dynamic Capabilities Theory
DSO	Distribution Service Operator
DUOS	Distribution Use Of Service
DWMS	Distributed Work Management System
EAI	Enterprise Asset Integration
EAM	Enterprise Asset Management
EO	Engineering Officer
ERP	Enterprise Resource Planning
ES	Enterprise System
ESAMC	Enterprise System Asset Management
ESCF	Enterprise Systems Capability Framework
EV	Electric Vehicle
FMIS	Financial Management Information System
GIS	Geographical Information System
HR	Human Resources
HV	High Voltage, typically 38kilovolts and higher

Abbreviation	Expansion
HVDC	High Voltage Direct Current transmission line
ILRT	Integration, Learning, Reconfiguration and Transformation
IS	Information System
ISU	Industry Specific solution - Utility (SAP)
IT	Information Technology
IWM	Integrated Work Management
JIT	Just In Time
KPMG	One of the "Big Four" global professional services companies
kV	kilovolt, one thousand volts
LFAT	Load Flow Analaysis Tool
LIT	Lead Implentation Team
LV	Low Voltage network, typically 230v
LVU	Low Voltage Urban
MMIS	Materials Management Information System
MOIP	Market Opening Implementation Plan
MRP	Materials Resource Planning
MRPII	Materials Resource Planning, second generation
MV	Medium Voltage network, typically 10 or 20 kilovolts
MWh	MegaWatt-hour
NEBIC	Network Enabled Business Innovation Cycle
NITA	EnerDist second phase SAP development project
NRP	National Replacement Programme
NT	Network Technician
OCR	Optical Character Recognition
OMS	Operation and Management Subsystem
OPEX	OPerating EXpenditure
PARC	Palo Alto Research Centre (Xerox)
PHR	SAP Human Resources module
PM	Project Management
RAB	Return on Asset Base
RBV	Resource Based View

Abbreviation	Expansion
ROI	Return On Investment
RPM (xRPM)	Resource and Portfolio Management module (SAP)
RQ	Research Question
SAP	Systems, Applications and Products in data processing
SCADA	Supervisory Control And Data Acquisition
SCM	Supply Chain Management
SME	Small to Medium Enterprise
TA	Technical Authority
UK	United Kingdom
US	United States (of America)
V	Volt
VAX	Minicomputer manufactured by Digital Equipment Corporation
VCU	Virtual Compatible Unit, an abstracted Compatible Unit (CU) that can be modified and copied
VINER	Value, Inimitabilitity, Nonsubstitutability, Exploitability and Renewability
VRI	Value, Rarity and Inimitability
VRIO	Value, Rarity, Inimitability and exploitable by the Organisation
WACC	Weighted Average Cost of Capital
WBS	Work Breakdown Structure
WIP	Work In Progress. Jobs predating inception of IWM.
xRPM (RPM)	Resource and Portfolio Management module (SAP)

Chapter 1

Introduction

1.1 Introduction to the Study

The desire to obtain competitive advantage is a motivator for implementing Enterprise Systems (ES) (Adam & O'Doherty, 2000). However, while it is accepted that Information Technology (IT) in general may contribute to the improvement of organisational performance (Melville et al., 2004), the nature and extent of that contribution is poorly understood (Jacobs and Bendoly (2003) and Ravichandran and Lertwongsatien (2005)). Accordingly, Henderson and Venkatraman (1993) assert that it is the application of business and IT capabilities to develop and leverage a firm's IT resources for organisational transformation, rather than the acquired technological functionality, that secures competitive advantage for firms.

This Study sets out to examine the contribution of ES to Core Capabilities, specifically the case of Asset Lifecycle Management in the utilities sector. Dynamic Capabilities Theory (DCT) is utilised as a lens as it associates core capabilities with competitive advantage, per Mata, Fuerst, and Barney (1995). Consequently, examining the contribution of ES to Core Capabilities may yokel some insight to the role of ES in securing competitive advantage, in a sustainable fashion, for firms.

Application of the Resource Based View (RBV) of the firm (Wernerfelt, 1984) and DCT (Teece, Pisano, and Shuen (1997) in particular) may yield insights into whether or not the implementation of ES enhances organisations' core capabilities and thereby obtains competitive advantage, sustainable or otherwise. The

RBV is in itself problematic, however, in particular because it is difficult to determine until after the fact which capabilities are core capabilities. In addition the empirical application of the RBV and DCT, despite the success of Wheeler (2002), has been troublesome and open to challenge (Newbert, 2007). Therefore, an operational definition of core capabilities that is independent of the construct of sustained competitive advantage is needed.

One of the major decisions to be made when implementing an Enterprise System is how much of the system merely needs configuration to fit the business and how much needs to be customised to fit key processes. Customisation is by its very nature an expensive procedure and must be justified by a large return on investment. In addition, any Enterprise System implementation, customised or otherwise, tends to freeze processes at a particular point in time, simply due to the cost of reconfiguring post-implementation. This is the *"Iron Cage"* effect characterised by Gosain (2004). Even if the Enterprise system represents a core Capability at implementation, changing marked conditions may render it at best irrelevant or at worst a disadvantage over time, thus described as a "Core Rigidity" by Leonard-Barton (1995).

The literature is unclear on how ES affect Core Capabilities and whether the interaction between ES implementation, core capabilities and configuration and subsequent use has any bearing on sustainable competitive advantage and ROI. Therefore the objective of this study is to use an applied version of DCT as a theoretical lens through which to examine the use of a typical Enterprise System in Asset Management Lifecycle of a public sector energy distribution utility in a regulated environment. From this single case study, which was conducted from a post-positivist ontological viewpoint, it may be possible to logically infer some generally applicable means for investigating the role of ES in Core Capabilities.

The remainder of this chapter is organised as follows. Section 1.2 describes the motivation for the study. This is followed by Section 1.3, which introduces the Research Objective and Methodology. Finally, in concluding this chapter, Section 1.4 presents a Plan of the Study.

1.2 Rationale for the Study

This study is motivated by the desire to resolve some issues concerning the enormous cost of implementing Enterprise systems versus the reported low return on that investment, to demonstrate an empirically significant application of DCT and to extend some of the theoretical constructs around ES and DCT.

ES, defined in Chapter 2 as *packages of configurable and customisable modules, embodying best practices, that coordinate processes and integrate data, resources and functions across multiple organisational subunits in one or more organisations and provide central planning and control of those data, processes, resources and functions*, are large and complex suites of applications designed to provide a single solution for process automation and integration in an organisation (Shang & Seddon, 2003). They are typically expensive to purchase, license and maintain, and cover functions such as HR, payroll, accounts, production planning, manufacturing, supply chain management and customer relationship management (Shang & Seddon, 2003; Shanks & Seddon, 2000; J. Ward, Hemingway, & Daniel, 2005; Shang & Seddon, 2002). They are usually built around a unified application core and database management system (Davenport, 1998; Adam & Sammon, 2004). They offer distinct advantages, for example embodiment of best practices and lower maintenance cost, over older, disparate, legacy IT systems. Most notably, however, they provide a degree of process coordination not inherent in other Information Systems (Hitt, Wu, & Zhou, 2002; Giachetti, 2004).

In use, however, the experience of using ES is not always positive (Nah & Lee-Shang Lau, 2001; Davenport, 1998; Barker & Frolick, 2003; Gattiker & Goodhue, 2005; Huang, Chen, Hung, & Ku, 2004; Mabert, Soni, & Venkataramanan, 2001; Robey, Ross, & Boudreau, 2002; Scott & Vessey, 2002). The very embodiment of best practices in the system can become a straitjacket which makes it difficult and expensive for an organisation to adapt an ES to its needs (Gosain, 2004). Mismatches between tacit processes in the organisations and the explicit processes in the ES can lead to less than optimal results (Z. Lee & Lee, 2000). Additionally, it is not always clear how the use of an Enterprise System can allow an organisation to meet or exceed the goals set for it by its stakeholders and the market.

Stakeholder and market expectations and pressures can be explored in the public sector: Most public utilities operate in a tightly regulated open market where regulatory expectations are well documented. In addition, the expectations of other stakeholders, such as the state, are usually explicit. Consequently exploring Enterprise System usage with respect to those expectations may be yield some understandings on the relationship between them.

The use of ES in utility companies to meet or exceed state, stakeholder and regulator expectations in an open market, regulated and competitive environment needs to be studied to gain insight into the contribution of ES to the ability of the organisation to meet those expectations.

DCT (Teece et al., 1997) may be applied as a useful theoretical lens for examining the role of ES in enhancing an organisation's ability to meet stakeholder expectations. Since any analysis of ES implementation and its influence on competitive advantage requires an internally-focused model, this study discusses two internally focused views, namely the Resource-Based View and Dynamic Capabilities theory, which focus on an organisation's strengths and weaknesses (Rugman & Verbeke, 2002, p.770).

The history of DCT and its antecedent, the RBV (Penrose, 1959; Wernerfelt, 1984; Dierickx & Cool, 1989a; Mata et al., 1995), is examined. The RBV is a theoretical viewpoint that posits the organisation as an aggregation of resources, where those resources may be orchestrated with a view to obtaining superior rents (Penrose, 1959). DCT, as articulated by Teece et al. (1997), Teece and Pisano (1998), Eisenhardt and Martin (2000) and Wheeler (2002) is then introduced, with particular emphasis on the emergence of DCT as a means of addressing shortcomings of the RBV.

The study leverages terms articulated by Mata et al. (1995), Leonard-Barton (1995), Barney (1997) and Teece and Pisano (1998) to characterise the Asset Management Core Dynamic Capabilities in the organisation that is the object of the research. In particular, Mata et al. (1995) and Barney (1997) define a Core Capability as an aggregation of resources and routines that is *Valuable, Inimitable, Non-substitutable* and *Exploitable*. Thus, a capability that yields reduced costs or increased rents and is hard to copy or replace may obtain a sustained competitive advantage for the firm. However, for such capabilities to remain valuable over an extended period of time (Leonard-Barton, 1995), they must also be *Renewable*: Teece and Pisano (1998) provides a framework for examining dynamic and renewable capabilities, by decomposing them into *Processes* (learning, integration, reconfiguration and transformation), *Positions* (technological and human assets) and *Paths* (past history and future opportunities). Mechanisms of reconfiguration and transformation, as articulated by Eisenhardt and Martin (2000) and Pavlou and El Sawy (2010) are also discussed: These address the means by which Dynamic Capabilities renew themselves or other capabilities in the face of rapid or slow market movement.

One of the frequently cited problems with the RBV and DCT is the tendency towards circularity and tautology. This is typically manifested as a Core Capability being defined as an aggregation of organisational routines and asset positions that yields sustainable competitive advantage. However, Sustained competitive advantage is frequently determined in retrospect and those capabilities that have directly contributed to that advantage are then defined as Core Capabilities (Newbert, 2007). This Study seeks to demonstrate that ES play a significant role in Core Capabilities. At the same time, it actively seeks to separate Core Capabilities from sustainable competitive advantage. The study presents an examination of Core Dynamic Capabilities that does not fall prey to the accusation of circularity, utilising an applied framework that is logically generalisable to other settings.

The study thus examines the role of ES in Asset Management Core Dynamic Capabilities in a Public Utility company; the next section explores a Research Objective and Methodology that meets the rationale described here.

1.3 Research Objective and Methodology

The goal of the proposed research is to address the shortcomings in the extant literature in addressing the role of ES in Core Dynamic Capabilities. This section introduces the Research Objective and the Research Questions to be answered if that goal is to be achieved. The following Research Objective is proposed:

The Research Objective

To examine whether and how an Enterprise System transforms an organisation's Asset Lifecycle Management Core Dynamic Capabilities.

To meet this Research Objective, the asset lifecycle management activities of the target organisation must be understood. This includes understanding how asset lifecycle management contributes to the organisation's ability either to reduce costs or generate rents, as any resultant Dynamic Capabilities must at the very least be valuable to be considered core. Asset lifecycle management activities must then be decomposed into processes, organisational routines, technologies and less tangible resources such as the training, skill and knowledge of the actors involved. This is a prerequisite to determining what dynamic capabilities are inherent in the asset management lifecycle as these are in turn composed of processes, technological positions, people positions and paths. Therefore the history of asset lifecycle management and the histories of its component activities must also be delineated.

This yields a set of asset lifecycle management Dynamic Capabilities, decomposed into processes, positions (technological and people) and paths. Contingent on their value, inimitability, non-substitutability and exploitability (rarity is inferred), a determination can then be made as to which asset lifecycle management Dynamic Capabilities are Core. As the technological resources that partially compose these capabilities has already been determined, the *footprint* of the Enterprise System on those Core Dynamic Capabilities can then be determined.

The footprint of the Enterprise System on a Core Dynamic Capability is the extent to which the processes inherent in that dynamic capability are contingent on the ES itself. Determining the extent of this footprint is essential to determining the role that Enterprise System plays in that core dynamic capability. However the footprint is just a snapshot of the Enterprise System's influence at a point in time. In addition, the effect of the Enterprise System on the exploitability of that core dynamic capability will provide an indication as to whether the Enterprise System will contribute to how dynamic that core capability remains in the future.

With these issues in mind, the following research questions have been formulated to fully address the research objective of explicating the contribution of ES to Core Capabilities:

The Research Questions

Research Question 1: What Asset Lifecycle Management activities are evident in the organisation?

Research Question 2: What Dynamic Capabilities are evident in the Asset Management Lifecycle?

Research Question 3: What is the footprint of the Enterprise System on Asset Lifecycle Management Dynamic Capabilities?

Research Question 4: What effect do ES have on Exploitability and Renewability?

The study adopts an Post-positivist ontological viewpoint, and the Case Study as a predominantly qualitative research methodology. To fulfil the objectives of the study, a Single Case Study of one organisation is undertaken. The unit of analysis is the Dynamic Capability, and an element of cross-capability analysis is introduced in Research Question 4.

Limiting the study to a single case exposes it to criticisms of non-generalisability. However, this is addressed by carefully selecting a case where the specific circumstances of the case make it amenable to study using DCT as a theoretical lens. In particular the case is an energy utility company that has transitioned form being a cost-cased single supplier to a network distributer operating under proxy competition via a market regulator. The market conditions are thus very well defined and understood. The case is also interesting because of its unique history: New entrants to the same market are not similarly burdened.

In addition, the case study, while significant of itself, serves to illustrate two frameworks, informed in particular by Mata et al. (1995), Barney (1997) and Teece and Pisano (1998), that extend understanding of the relationship of ES to organisational performance and sustainable competitive advantage. These frameworks are freestanding: The case study serves to illustrate them but they are not dependent on it.

1.4 A Plan of the Study

The rest of this study is organised into several chapters, which address the Research Objective outlined in this Introduction.

Chapter 2 introduces ES and defines them as a subset of Information Systems. It describes some of the key characteristics of ES, especially with respect to their configuration, customisation and use. Experiences in using ES are described. The use of ES in public utility organisations is explored, primarily because stakeholder expectations in such cases are usually well defined and documented.

The chapter illustrates that ES are large and complex suites of applications designed to provide a single solution for process automation and integration in an organisation. It shows that they are typically expensive to purchase and maintain, and cover functions such as Human Resources (HR), payroll, accounts, production planning, manufacturing, supply chain management and customer relationship management. They are frequently built around a unified application core and database management system. They offer distinct advantages, for example embodiment of best practices and lower maintenance cost, over older, disparate, legacy IT systems.

In use, however, as shown in Section 2.4, the experience of using ES is not always positive. The very embodiment of best practices in the system can become a straitjacket which makes it difficult and expensive for an organisation to adapt an ES to its needs. Mismatches between tacit processes in the organisations and the explicit processes in the ES can lead to less than optimal results. Additionally, it is not always clear how the use of an Enterprise System can allow an organisation to meet or exceed the goals set for it by its stakeholders and the market.

Examining stakeholder and market expectations and pressures can be explored in the public sector, as Section 2.5 illustrates. Most public utilities operate in a tightly regulated open market where regulatory expectations are well documented. In addition, the expectations of other stakeholders, such as the state, are usually explicit. Consequently exploring Enterprise System usage with respect to those expectations may be yield some understandings on the relationship between them.

The chapter concludes by stating that the use of ES in utility companies to meet or exceed state, stakeholder and regulator expectations in an open market, regulated and competitive environment needs to be studied to gain insight into the contribution of ES to the ability of the organisation to meet those expectations. In addition it proposed the RBV as a useful theoretical perspective for conducting the study, per Melville et al. (2004).

Chapter 3 proposes DCT, an extension of the RBV of the Firm, as a useful theoretical lens for examining the role of ES in enhancing an organisations ability to meet stakeholder expectations. Since any analysis of ES implementation and its influence on competitive advantage requires an internally-focused model, this chapter discusses two internally focused views, namely the Resource-Based View and the later Dynamic Capabilities theory, which focus on an organisation's strengths and weaknesses (Rugman & Verbeke, 2002, p.770).

The chapter briefly examines the history of DCT and its antecedent, the RBV. The RBV is a theoretical viewpoint that posits the organisation as an aggregation of resources, where those resources may be orchestrated with a view to obtaining superior rents. DCT is then introduced, with particular emphasis on the emergence of DCT as a means of addressing shortcomings of the RBV.

In concluding, the chapter notes that a narrative that attempts to explain the role of ES in Dynamic Capabilities needs to clearly specify the Dynamic Capabilities that are relevant to the process. It then needs to specify the footprint of the Enterprise System on those Dynamic Capabilities as well as explaining how introducing the ES has transformed the future opportunities that form part of those capabilities. There are clues to the appropriate theory in Teece and Pisano (1998) and Wheeler (2002). Crucially, the chapter observes that the problem with DCT based narratives to date has been a tendency to analyse capabilities after the fact and reason that those capabilities which contributed most to value are the once that may be considered Core. This approach offers no predictive power and weds Dynamic Capabilities theory to the idea of sustainable competitive advantage in a manner that is not useful.

Chapter 4 specifies a suitable research approach so that the role of ES in Core Dynamic capabilities may be determined. Chapter 2 concludes by stating that the role of ES in achieving a competitive advantage is still poorly understood and that research on ES implementation in the public sector is sparse. Chapter 3 introduces the RBV and DCT as a suitable theoretical lens through which to investigate the issues raised in Chapter 2. In addition, Chapter 3 notes that DCT is a *molar* theory and therefore requires adaptation as an applied theory to be empirically useful.

Against this background, this chapter puts forward a Research Objective and Research Questions to examine the role of ES. As the research is exploratory and explanatory in nature, a case study approach is proposed. While DCT is a suitable theoretical lens for examining the role of enterprise systems in Core Capabilities, it is necessary to isolate examination of Dynamic Capabilities from the logic of sustainable competitive advantage. Many studies of sustainable competitive advantage lead to *post hoc* rationalisations of which dynamic capabilities produced an enduring advantage, well after the fact. This approach has little predictive power and is vulnerable to accusations of logical fallacy.

In order to discuss the application of DCT to the role of ES in Core Capabilities, it is useful to sidestep the logic of sustainable competitive advantage and examine a setting where the present and future competitive environment is relatively predictable. This chapter proposes that public sector utilities provide such an opportunity because of the highly regulated environment in which they operate. It illustrates that DCT is applicable to public sector organisations and concludes by showing that the study of an ES implementation in such an organisation, using DCT as a theoretical lens, can shed some light on the role of ES in contributing to the Value, Inimitability, Non-substitutability and Exploitability of Dynamic Capabilities.

Thus this chapter delineates an applied Dynamic Capabilities framework for examining the role of ES in the core dynamic asset management capabilities of a public utility organisation. Asset management is selected as an area of interest as public utilities are service rather than manufacturing organisations, where revenues are contingent on the asset base. As well as an applied framework, a research protocol is presented and the research questions are reviewed in the light of this protocol.

Chapter 5 addresses **Research Question 1** by describing the asset lifecycle management activities in EnerDist's Asset Management Lifecycle. The purpose of Research Question 1, and this chapter, is to articulate the asset lifecycle management activities in EnerDist. Understanding the asset lifecycle management activities is a prerequisite to understanding asset lifecycle management Dynamic Capabilities, the footprint of the Enterprise System and the role of the Enterprise System ion the Exploitability of any asset lifecycle management Core Capabilities.

A prerequisite to understanding asset lifecycle management activities, however, is understanding the background to EnerDist's current state. This chapter, therefore, sets the context of EnerDist, including some history of the organisation and its predecessor. In addition EnerCo's implementation of SAP/3 is briefly described. The regulatory structure within which EnerDist operates is outlined. EnerDist's asset lifecycle management structures are detailed. It also describes the EnerDist Asset Lifecycle as a specific case of Asset Lifecycles in general. asset lifecycle management processes are also described. The chapter concludes by describing value generation at different points of the EnerDist

Asset Lifecycle. These value generation activities are tied to regulatory pressures. Finally, the chapter states that an asset management organisation such as EnerDist needs to extract value from its regulated asset base to meet increasingly stringent regulatory requirements as well as make a profit. In this case EnerDist adopted an Information Systems - led approach by implementing SAP R/3, to manage its regulated asset base. However it is important to understand how the implementation of an Enterprise System such as SAP R/3 creates additional value or increased rents for EnerDist, especially given the considerable installation and maintenance cost of such a system.

Chapter 6 addresses **Research Question 2** by describing the dynamic capabilities in EnerDist's Asset Management Lifecycle. These Dynamic Capabilities are decomposed into their business processes, as well as the learning, reconfiguration and transformation processes that make them dynamic. The complementary positions (people and organisational structures) that comprise these capabilities are also described. Finally the value of these dynamic capabilities as well as their resistance to imitation and substitution is discussed. The chapter enumerates five distinct Dynamic Capabilities as follows:

1: ***Identifying New Assets*** covers the Plan phase of the Asset Lifecycle. It concerns itself with **What assets to create**.

2: ***Coordinating Asset Programmes*** covers the coordination of the maintenance and building of Network Assets on a large scale. It primarily covers the Plan and Maintain phases of the Asset Lifecycle, with influence on all other phases. It concerns itself with **When to create assets** and **What assets to create**.

3: ***Building New Assets*** covers the Build phase of the Asset Lifecycle and concerns itself with **How to create assets**.

4: ***Determining Asset Policies*** covers the Maintain and End of Life phases of the Asset Lifecycle. It concerns itself with **When to maintain assets**.

5: ***Servicing Existing Assets*** covers the Maintain phase of the Asset Lifecycle. It concerns itself with **How to maintain assets**.

The inimitability and non-substitutability of all the Dynamic Capabilities tends to be mainly contingent on the history of how those capabilities came into existence and the training and experience of the people executing their constituent processes. However, some of the history consists of the transformations and reconfiguration undergone by the tangible assets and processes that make up these Dynamic Capabilities. There is considerable evidence to suggest that these transformations are driven by data from the IT artefacts that also make up these capabilities.

The chapter concludes by stating that, while these capabilities are of varying strategic importance, all of these capabilities have inbuilt transformation processes. In addition evidence is seen of learning, integration and reconfiguration.

Chapter 7 addresses **Research Question 3** by describing the footprint of the Enterprise System on the asset lifecycle management Dynamic Capabilities. The chapter summarises the constituent business processes and integration, learning, reconfiguration and transformation processes of each of the five identified Dynamic Capabilities. This summary includes an identification of the Information Technologies used. The footprint of IT on the process inputs and outputs is clearly summarised as well as the footprint on the main body of the process. The relative intensity of the footprint at process start, middle and end is also mapped. For each Dynamic Capability, a short analysis summarises the footprint of the Enterprise System both on the business processes and the integration, learning, reconfiguration and transformation processes.

The chapter concludes by articulating that the footprint of the Enterprise System can be evaluated in strategic terms. Summary Enterprise System footprint data is overlaid on Asset Lifecycle Dynamic Capabilities as documented in Research Question 1. Combining data from Research Question 1 and Research Question 2 reveals what role the Enterprise System plays in strategically important activities in the organisation. The chapter remarks that the Enterprise System plays a significant role in one activity that is both value generating and strategically important. Also, the Enterprise System plays a significant role in the organisational routines that permit a Dynamic Capability to remain dynamic and renew itself. The larger the role of the ES in these processes, then the more dependent the continuing value and flexibility of that Dynamic Capability is on the ES. EnerCo Network's ongoing ability to adapt itself is thus directly dependent on the Enterprise System in these cases.

Chapter 8 addresses **Research Question 4** by describing the effect of the Enterprise System on the exploitability of the asset lifecycle management Dynamic Capabilities. The extent to which ES facilitate the Dynamic Capabilities is explored, as well as identifying how the ES contributes to the future development of a Dynamic Capability, compared to what has happened in the past.

The chapter demonstrates the effect of ES on the Exploitability of asset lifecycle management Dynamic Capabilities. The Exploitability of these Dynamic Capabilities is enhanced as the Enterprise System facilitates the relevant business processes. However for a Dynamic Capability to remain Core under changing regulatory or market conditions, it must be renewable. In other words, the Dynamic Capability must posses transformation and reconfiguration routines that permit the organisation to rearrange assets to meet the changed conditions.

The chapter describes how the effect of ES on Renewability, is a key influencer on Dynamic Capabilities dynamic and a key preventer of Core Capabilities transforming into Core Rigidities through increasing irrelevance. This chapter demonstrates that two mechanisms are manifested in ES enhancing Renewability. First, ES modules make process and asset data available that permit the relevant actors to modify those processes to achieve greater performance within the criterial laid down by the regulator. In essence, these renewal mechanisms provide new opportunities to increase rents. Second, the Enterprise System serves as an integrator for previously disjoint processes. This integration process has a transformative effect in that it provides a coherent view of the asset lifecycle from design to end of life.

Finally, the chapter notes that, through the planning, design and build phases, SAP R/3 Integrated Work Management (IWM) and the Compatible Unit provide a unified yet multidimensional view of the assets and materials concerned, which permits more precise project budgeting. This in turn allows EnerDist to ensure that regulatory demands to be met or exceeded, in effect allowing the organisation to generate rents by reducing costs and targeting expenditure. A major cost reducer is the resultant transformation of inventory control, reducing working capital and moving to something much closer to a just in time model.

Chapter 9 concludes the study by reflecting on the findings of Research Questions 1 through 4 and drawing some overall conclusions from those findings. In particular the chapter assesses whether the Research Objective has been met. In addition this chapter assesses the suitability of Dynamic Capabilities theory as a theoretical lens and evaluates any resultant extensions to that theory. The chapter assess the implications for IS research, Strategic research and finally for IT practitioners.

The findings suggest that significant conclusions may be drawn about the impact of ES on the Dynamic Capabilities of an organisation. Furthermore, these conclusions show that it is possible for an Enterprise System to directly influence those characteristics that make those Dynamic Capabilities Core. The conclusions drawn by this chapter are:

1: Asset Life Cycle Management is a Core Dynamic Capability

2: ES *directly* influence the Value, Exploitability and Renewability of Core Capabilities.

3: ES *indirectly* influence the Non-substitutability and Inimitability of Core Capabilities.

4: The chief mechanism through which ES *directly* influence Core Capabilities is through *revealing data* rather than *reshaping processes*.

The chapter also puts forward revisions to Mata et al. (1995)'s VRIO (Value, Rarity, Inimitability and explOitability) model and offers a framework, informed by Teece and Pisano (1998), for analysing Dynamic Capabilities where ES play a role. The chapter outlines the implications for theory and practice, as well as highlighting limitations of the study and possible issues relating to generalizability. The chapter concludes with suggestions for further research and a summary.

The next chapter, Chapter 2, introduces ES, defines them and highlights some of the issues with ES use.

Chapter 2

Enterprise Systems

2.1 Introduction

This chapter introduces Enterprise Systems (ES) and defines them as a subset of Information Systems. It describes some of the key characteristics of ES, especially with respect to their configuration, customisation and use. Experiences in using ES are described. The use of ES in public utility organisations is explored, primarily because stakeholder expectations in such cases are usually well defined and documented.

ES, as defined in Section 2.2, are large and complex suites of applications designed to provide a single solution for process automation and integration in an organisation. In particular, they provide process coordination at an organisational level, a distinctive feature that other Information Systems do not possess. Section 2.3 explores their integrative characteristics further and then goes on to illustrate that ES are typically expensive to purchase and maintain, and cover functions such as HR, payroll, accounts, production planning, manufacturing, supply chain management and customer relationship management. They are frequently built around a unified application core and database management system. They offer distinct advantages, for example embodiment of best practices and lower maintenance cost, over older, disparate, legacy IT systems.

In use, however, as shown in Section 2.4, the experience of using ES is not always positive. The very embodiment of best practices in the the system can become a straitjacket which makes it difficult and expensive for an organisation to adapt an ES to its needs. Mismatches between tacit processes in the organisations and the explicit processes in the ES can lead to less than optimal results. Additionally, it is not always clear how the use of an ES can allow an organisation to meet or exceed the goals set for it by its stakeholders and the market.

Stakeholder and market expectations and pressures can be explored by examining ES use in the public sector, as Section 2.5 illustrates. Most public utilities operate in a tightly regulated open market where regulatory expectations are well documented. In addition, the expectations of other stakeholders, such as the state, are usually explicit. Consequently exploring ES usage with respect to those expectations may be yield some understandings on the relationship between them.

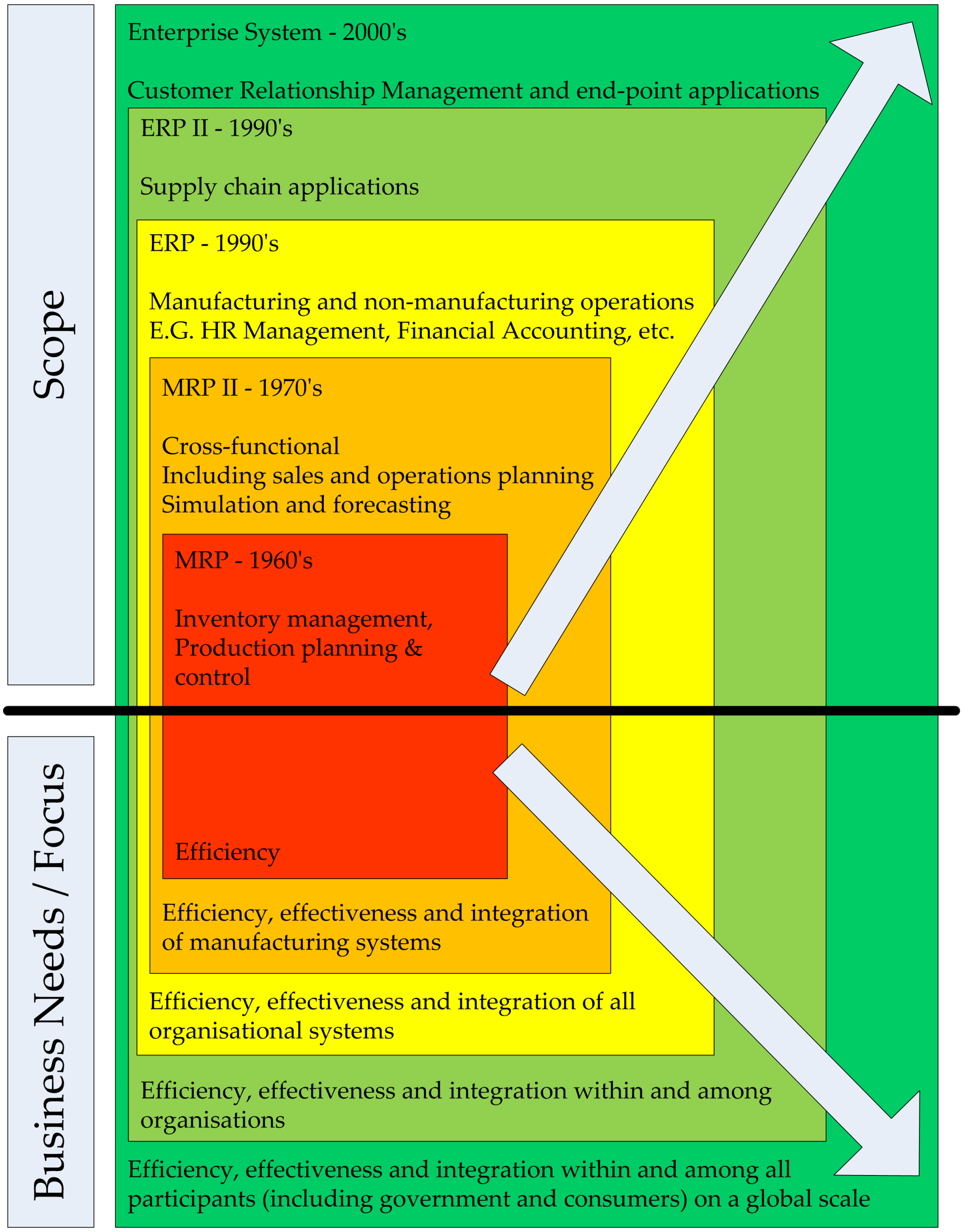
Section 2.6 concludes this chapter by stating that the use of ES in utility companies to meet or exceed state, stakeholder and regulator expectations in an open market, regulated and competitive environment needs to be studied to gain insight into the contribution of ES to the ability of the organisation to meet those expectations. This section proposes Dynamic Capabilities Theory, an inwardly - focused theory that views organisations as aggregations of potentially non-tradeable resources, as a useful theoretical lens for examining the role of ES in meeting or exceeding these expectations.

2.2 ES Defined

This section briefly discusses the history of ES and extracts a set of common themes when examining definitions of ES in the literature. The section concludes by offering a revised definition of ES that is synthesised from existing descriptions in the literature.

ES are one of the most significant information technologies to emerge into corporate use in the 1990s (Shang & Seddon, 2003; Davenport, 1998). They are large-scale systems, spanning whole organisations (Shang & Seddon, 2003), that include, but are not limited to, Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), Supply Chain Management (SCM) and Enterprise Application Integration (EAI) applications (Seddon, Shanks, & Willcocks, 2003; Shanks & Seddon, 2000; J. Ward et al., 2005; Shang & Seddon, 2002). ERP systems, regarded by Shang and Seddon (2003) as the most significant type of ES, are characterised by Legare (2002) as linking all operations across the corporation. These operations include manufacturing, planning, inventory control, human resources, accounting, vendor management and sales (Legare, 2002).

Modern corporate ES evolved from the earliest batch processing systems that automated repetitive and time-consuming operations such as payroll generation (Mabert et al., 2001). These early systems were further developed to allow the tracking and planning of materials consumption (Mabert et al., 2001) - hence *Material Requirements Planning* (MRP) systems - and were further enhanced to support manufacturing, leading to *Manufacturing Resource Planning* (MRP II) systems (Shanks & Seddon, 2000). Competitive pressures on the implementing organisations provided the impetus for these MRP II systems to be extended further to incorporate other corporate functions such as sales, human resources, purchasing and finance, thus leading to *Enterprise Resource Planning* (ERP) systems (Shanks & Seddon, 2000; Murphy & Simon, 2001; Barker & Frolick, 2003). The evolution of ERP systems is illustrated in Figure 2.1.



(After: Watson and Schneider (1999, p.7), Adam and Sammon (2004, p.4) and McGaughey and Gunasekaran (2007, p.32))

Figure 2.1: Evolution of ERP Systems

A definition of ES is required so that ES may be meaningfully discussed in an organisational context. In particular, ES must be distinguished from other Information Systems used in the same context. Table 2.1 below summarises some of the definitions found in the literature as well as highlighting the interchangeability of the terms ERP and ES.

While the term ERP reflects the manufacturing roots of such systems, their scope has been extended so much that Davenport (2000) regards the term ERP as somewhat obsolete and the term *ES* (ES) as more appropriate. There is evidence to suggest that ES as a term did not emerge in academic literature until after 1997 (Lorenzo, 2004). Lorenzo (2004) notes Davenport (1998)'s work as one of a group of *"pioneer works"* on ES. Since then, the term Enterprise System (ES) has gained some currency in the literature, as evidenced by Seddon et al. (2003); Shanks and Seddon (2000); J. Ward et al. (2005); Shang and Seddon (2002) and Gattiker and Goodhue (2005). However, a significant amount of literature, for example Arnold (2006), Somers and Nelson (2003) and Sutton (2006) regards the terms ERP and ES as interchangeable, as evidenced in Table 2.1:

Table 2.1: ES Definitions

Definition of ES	**Source**	**Themes**
ES: Another term for ERP systems	Arnold (2006); Howcroft, Newell, and Wagner (2004); King and Burgess (2006); J. C. Lee and Myers (2004); Lorenzo, Kawalek, and Wood-Harper (2005); Nah and Lee-Shang Lau (2001); Pan and Tan (2005); Rikhardsson and Kraemmergaard (2006); Robey et al. (2002); Somers and Nelson (2003); Sutton (2006)	Interchange-ability of terms ERP and ES
ES: Include one or more of the following: ERP, SCM and/or CRM systems	Hendricks, Singhal, and Stratman (2006)	Suite of applications, including ERP, all part of ES
ES: Solutions such as MRP, MRPII, ERP, SCM and CRM	Turner and Chung (2005, p.119)	
ES: Include ... ERP and SCM systems	Maroofi, Sadeghi, and Mojoodi (2011, p.356)	
ES: Extended ERP including SCM and CRM	Adam and Sammon (2004, p.7)	
ES or ERP with SCM, CRM, DW and AI added	Shakir (2003, p.151)	
ERP: From a base in manufacturing and financial systems, ERP systems may eventually allow for integration of inter-organisational supply chains	Markus, Axline, Petrie, and Tanis (2000, p.245)	
ES: Packages of computer applications that support many [or] most of an [organisation's] information needs	Davenport (2000)	Suite of applications

Continued on next page

Table 2.1 – *Continued from previous page*

Definition of ES	Source	Themes
ES: Configurable, off-the shelf software packages that provide an integrated suite of systems and information resources for operational and management processes across a broad range of business activities	Brehm, Heinzl, and Markus (2001); J. Ward et al. (2005)	
ES: Large-scale organisational systems built around packages of enterprise system software	Shang and Seddon (2002)	
ES: Integrated, enterprise-wide, packaged software applications that impound deep knowledge of business practices accumulated from vendor implementations in many organisations	Shang and Seddon (2003)	Standardisation; Embodiment of best practices
ES: Involve ... the standardisation of processes	Davenport (1998, p.127)	
ERP: The real benefits ... are its ability to standardise business processes	J. Lee, Siau, and Hong (2003, p.57)	
ERP: A means for standardising ... specific processes, hence reducing variation in processing practice, time, and error	Bendoly and Cotteleer (2008, p.25)	
ERP: Reduce[s] equivocality through business process standardisation that helps ensure information is presented in a consistent manner.	Stratman (2007, p.206)	
ERP: Offer[s] the integration of business processes and functions across the organisation based on a way of working deemed "the best" for particular industries by software vendors, management consultants and industry-based experts	Wagner and Newell (2004, p.306), citing Z. Lee and Lee (2000) and Shanks and Seddon (2000)	
ES: A method for the effective planning and controlling of all the resources needed to take, make, ship and account for customer orders in a manufacturing, distribution or service company	Rikhardsson and Kraemmergaard (2006) citing Rashid, Hossain, and Patrick (2002, p. 37)	Centralised database, planning and control
ERP, aka ES: Tools used to manage all the enterprise data, and to provide information to those who need it when they need it	Somers and Nelson (2003)	
ES: Involve the centralisation of control over information	Davenport (1998, p.127)	

Continued on next page

Table 2.1 – *Continued from previous page*

Definition of ES	Source	Themes
ERP: Enterprise wide resource planning systems (ERP systems) attempt to integrate all corporate information in one central database	Dechow and Mouritsen (2005, p.692)	
ERP: At the heart ... is a central database that draws data from and feeds data into a series of applications supporting a wide range of company functions	Kraemmergaard, Moller, and Boer (2003, p.339)	
ERP: A typical system integrates all these functions by ... centralising all information in a single database accessible by all modules	I. J. Chen (2001, p.377)	
ERP: A means for ... centralising specific processes, hence reducing variation in processing practice, time, and error	Bendoly and Cotteleer (2008, p.25)	
ERP: All decisions are made centrally and communicated to local operations for execution ... Central database and one or more applications servers ... Centralised architecture	Markus, Tanis, and Fenema (2000, pp44-45)	
ES: Enable the integration of transactions-oriented data and business processes throughout an organisation	Lorenzo et al. (2005) citing Markus and Tanis (2000)	Integration of processes, organisational functions and data
ES: Support common, global business processes and therefore facilitate data integration across the enterprise	Scott and Vessey (2002)	
ES: Commercial software packages [that] promise the seamless integration of all the information flowing through a company	Davenport (1998); Gattiker and Goodhue (2005)	
ES: Process-based applications that facilitate integrated business process and information flows across the organisation	Grant and Chen (2005)	
ES: Commercial software applications that support and integrate organisational processes across functional boundaries	Elmes, Strong, and Volkoff (2005)	
ERP: Comprehensive, packaged software solutions [that] seek to integrate the complete range of a business processes and functions in order to present a holistic view of the business from a single information and IT architecture	Gable (1998)	

Continued on next page

Table 2.1 – *Continued from previous page*

Definition of ES	Source	Themes
ES, aka ERP: An integrative mechanism connecting diverse organisational units by shared data and software modules	King and Burgess (2006); Davenport (1998)	
ERP: A business management system that comprises integrated sets of comprehensive software, which can be used to manage and integrate all the business functions within an organisation with a rationalised data architecture characterised by core process integration and shared product and/or customer databases	Schlichter and Kraemmergaard (2010, p.487) citing Ross, Weill, and Robertson (2006)	
ERP: Large complex Information Systems that integrate and streamline the organisation's business process across departmental borders.	Nafeeseh and Al-Mudimigh (2011, p.185)	
ERP: Enterprise Resource Planning (ERP) software systems integrate key business and management processes within and beyond a firm's boundary.	Hitt et al. (2002, p.71)	
ES. aka ERP: Based on a suite of integrated software modules and a common central database.	Laudon and Laudon (2014, p.369)	

The interchangeability of the terms ES and ERP, as evidenced in Arnold (2006); Howcroft et al. (2004); King and Burgess (2006); J. C. Lee and Myers (2004); Lorenzo et al. (2005); Nah and Lee-Shang Lau (2001); Pan and Tan (2005); Rikhardsson and Kraemmergaard (2006); Robey et al. (2002); Somers and Nelson (2003); Sutton (2006) and Shakir (2003) is at odds with the view expressed by Hendricks et al. (2006); Turner and Chung (2005); Maroofi et al. (2011); Adam and Sammon (2004) and Shakir (2003), where ES is defined as a suite of applications encompassing ERP, SCM, CRM and possibly Data Warehousing and Artificial Intelligence. Large application suites such as Customer Relationship Management and Supply Chain Management have traditionally been defined as systems separate from ERP. However, Markus, Axline, et al. (2000, p.245) noted that ERP systems might evolve from their base in manufacturing and financial systems to ultimately include inter organisational supply chains. One of the precedents of Markus, Axline, et al. (2000)'s observation is Davenport (1998, p.124), who draws the typical ERP system as extending to include supply and service applications. This is illustrated in Figure 2.7. Thus there is justification for defining ES as encompassing CRM and SCM as well as

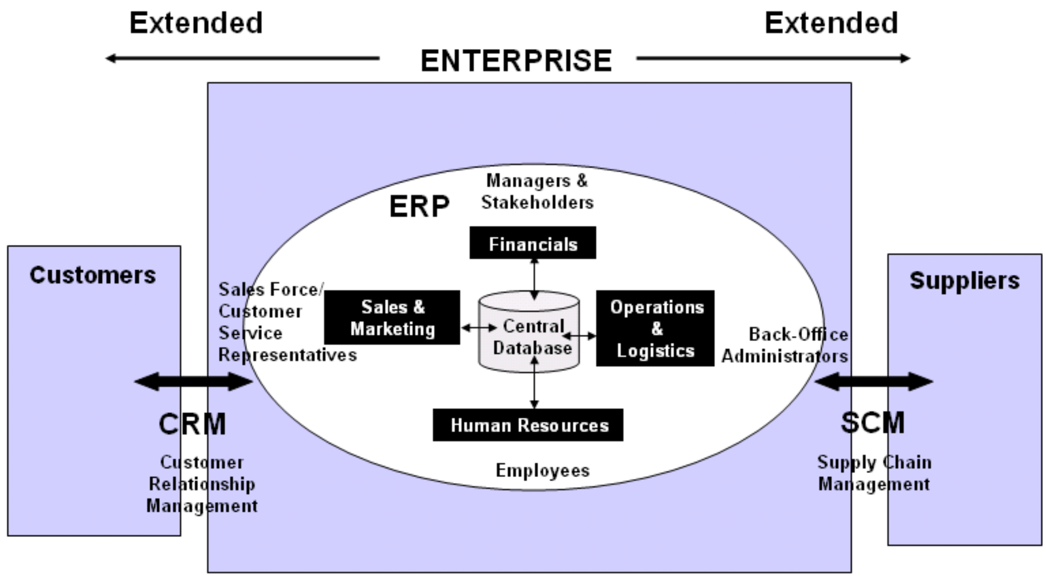
ERP, as all of these systems span multiple business processes and functions.

To define ES as inclusive of SCM and CRM as well as ERP, it needs to be demonstrated that CRM and SCM are also defined as organisation wide systems or at least as parts of an organisation wide (or intra-organisational) system. Such inclusion is explicit in McGaughey and Gunasekaran (2007), Adam and Sammon (2004) and Laudon and Laudon (2014). McGaughey and Gunasekaran (2007) in particular hold that the evolution of the ES (as shown in Figure 2.1) progresses beyond the "traditional" view of the scope of ERP to include activities such as SCM and CRM and even regulatory activities as well as supply-chain activities extending to the consumer (McGaughey & Gunasekaran, 2007, p.32).

This evolution of ERP into the ES is driven by common Data Warehousing platforms enabling the extensive sharing of data (and thus process and function integration) and also by the explosion of the various forms of e-commerce over the internet (McGaughey & Gunasekaran, 2007, pp28-30). Similarly, Adam and Sammon (2004, p.7) remark that ERP has evolved from manufacturing and production support applications to include back-office operations such as HR and Finance as well as front-office operations such as Sales and Marketing. Ultimately such integration extends to include SCM and CRM; this is implied in Figure 2.7 and illustrated in Figure 2.2.

As well as the issues of the interchangeability of ES/ERP and ES as a term inclusive of ERP, SCM and CRM, Table 2.1 suggests a number of other common themes when ES or ERP are defined: The dominant themes are ones of *process, function and data integration* across the organisation, followed by *centralised planning and control*, *standardisation and embodiment of best practices* and *the ES as a suite of applications*. These themes are explored in more detail in Section 2.3.

Thus, a complete definition of an ES (ES) needs to encompass these major themes identified from the literature, as they demonstrate characteristics that uniquely distinguish ES from other Information Systems.



(Adam & Sammon, 2004, p.7)

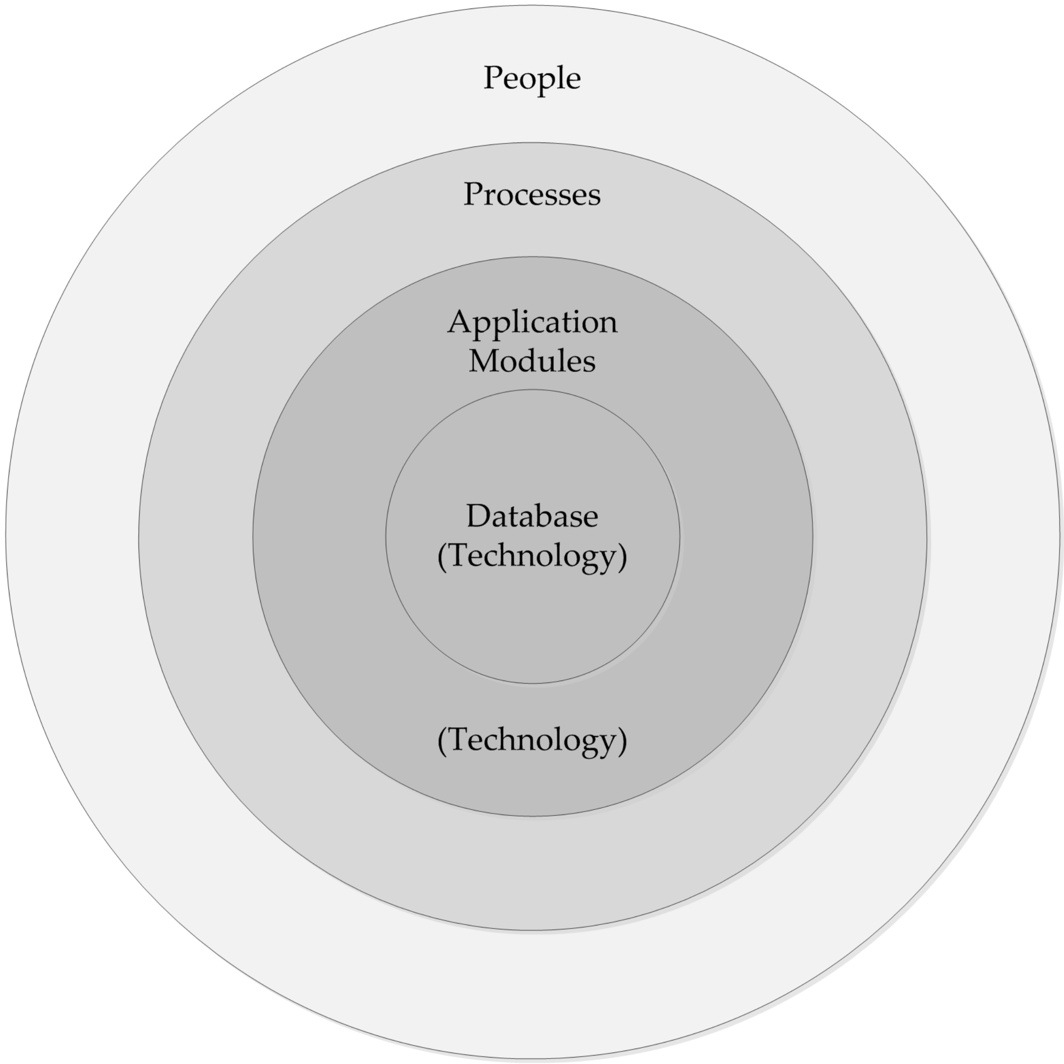
Figure 2.2: The Extended ERP System

Therefore, an ES may be defined as,

> **A package of configurable and customisable modules, embodying best practices, that *coordinates* processes and *integrates* data, resources and functions across multiple organisational subunits in one or more organisations and provides central planning and control of those data, processes, resources and functions.**

This definition may include ERP, SCM, CRM and Data Warehousing as necessary, as all these application suites demonstrate considerable integrative and organisation spanning characteristics similar to ES.

While ES are a subclass of Information System, comprising of technological artefacts, the people that utilise the technology, and the processes embedded in the system itself and also used by the people involved (Figure 2.3), they have a reach, depth, scope and complexity that sets them apart from other Information Systems. In particular the integrative nature of ES is singular: Laudon and Laudon (2014, p.83, p.369), clearly referring to Hitt et al. (2002) illustrate this by describing how a single event such as a customer order triggers processes spanning inventory control, order fulfilment, manufacturing and finance.



(After: Davenport (1998, p.124) and Alter (1992))

Figure 2.3: The ES as a subclass of Information System comprising of People, Process and Technology

The distinctive and highly integrative nature of ES, as evidenced by Lorenzo et al. (2005), Davenport (1998), Gattiker and Goodhue (2005), Laudon and Laudon (2014), Hitt et al. (2002) and others, has implications for how ES are used, the role they play in organisations and on the role they play in allowing those organisations to outperform their competitors and outperform the expectations of their stakeholders and any regulatory bodies. Unlike other Information Systems, the scope of the ES is the organisation (and sometimes beyond); thus, the use of an ES has to be considered in the context of the different organisational functions that use it and the interactions between those organisational functions.

The next three sections explore this further by discussing the nature of ES, how their breadth and scope imbues them with unique characteristics and the implications of this for their use in both private sector and public utility organisations. Some of the defining characteristics of ES and their implications are explored in Section 2.3, while Section 2.4 discusses experiences of ES use. Section 2.5 focuses on Enterprises Systems use in public utility organisations where the regulator and competitive environment, as well as stakeholder expectations, are well documented.

2.3 Characteristics of ES

2.3.1 Introduction

While Section 2.2 defines an ES as *"a package of configurable and customisable modules, embodying best practices, that integrates data, processes, resources and functions across one or more organisations and provides central planning and control of those data, processes, resources and functions,"* this does not address the complexities associated with ES selection, implementation and use. Nor does it address the costs and expected returns associated with ES. This section discusses the characteristics that distinguish ES from other Information Systems.

The section is divided into subsections as follows: Subsections 2.3.3, 2.3.4 and 2.3.5 expand on the characteristics inherent in the definition arrived at in the previous Section 2.2: Process, data and function integration, central planning and control and embodiment of best practices. Subsection 2.3.2 continues by discussing the ES as a suite of modular applications, followed by Section 2.3.6, which outlines the configuration vs customisation choice faced by ES implementors. This is connected to implementation cost and process fit within the organisation, as discussed in Subsection 2.3.7, which concludes this section by commenting that, given the cost, the contribution of ES to organisational performance is poorly understood.

2.3.2 Suite of modular applications

The definition of an ES as a suite of applications implies a discrete set of computer programs connected using a common database core. Thus ES are modular, which makes them amenable to configuration, in that only the modules appropriate to the business need be deployed (Davenport, 1998, p.125). A typical example is SAP R/3, where the number of modules installed is typically at the discretion of the customer. Each module typically corresponds to a business functional area (Hitt et al., 2002, p.7) with integration between the various modules achieved via a central database (Davenport, 1998, p.125). The modularity inherent in SAP R/3 is illustrated in Figure 2.6.

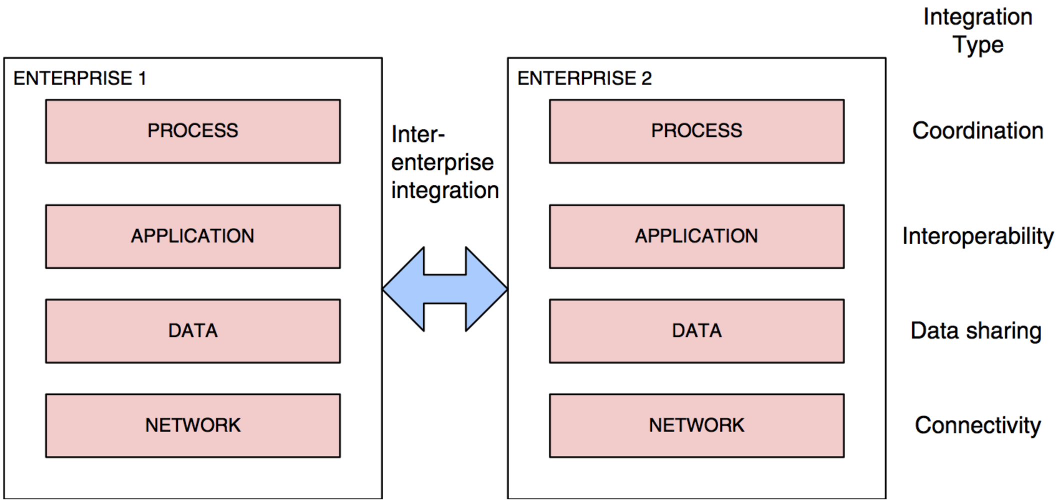
2.3.3 Integration of processes, data and functions

Davenport (1998) describes ES as *"a dream come true,"* as they promise the *"seamless integration of all the information flowing through a company."* Legare (2002) uses similar language and states that *"ERP systems have near magical effects,"* but adds the important proviso that this is only when they work as promised. Gattiker and Goodhue (2005) state that some organisations have achieved *"impressive"* benefits from their ERP systems; Robey et al. (2002) assert that ERP systems are beneficial because of their integrative nature, and also point out that it is frequently easier to replace disconnected legacy systems with a single integrated system rather than upgrade them individually.

Hitt et al. (2002, p.73), in stating the evident attraction of ERP systems, note that unlike earlier systems that performed many of the functions of ERP, the *"standardised and integrated"* Enterprises System environment achieves a hitherto unrealised level of interoperability. This is vividly illustrated as follows:

> *"For example, when a salesperson enters an order in the field, the transaction can immediately flow through to other functional areas both within and extemal to the firm. The order might trigger an immediate change in production plans, inventory stock levels, or employees' schedules, or lead to the automated generation of invoices and credit evaluations for the customer and purchase orders from suppliers."* (Hitt et al., 2002, p.73)

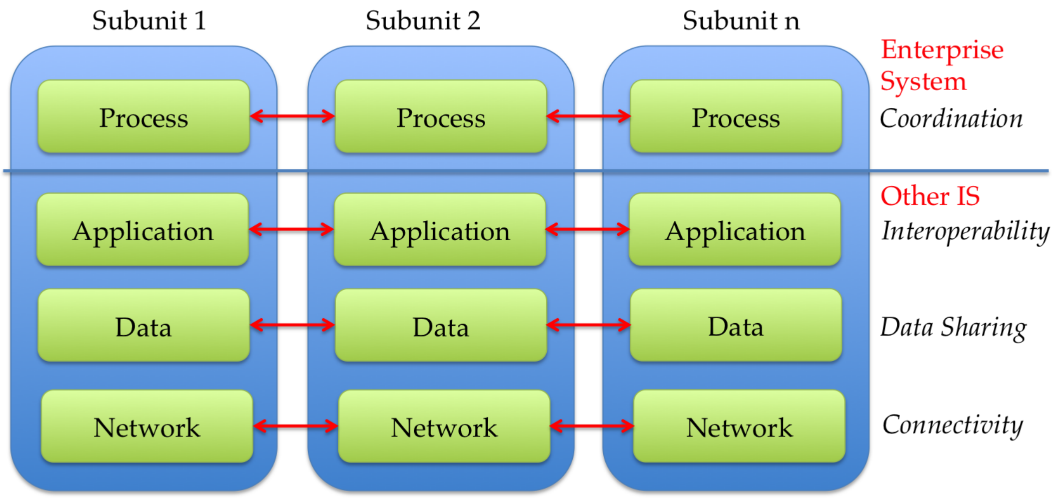
Thus ES present the alluring prospect of integration across several business units. In an effort to more clearly articulate how such integration can be characterised, Giachetti (2004, p.1151) offers the following *Enterprise information integration framework*, presented in Figure 2.4:



(Giachetti, 2004, p.1151)

Figure 2.4: Enterprise Information Integration Framework

With reference to Hitt et al. (2002), Laudon and Laudon (2014) and Davenport (1998) in particular, Giachetti (2004)'s framework may be appropriated to illustrate the distinction between ES and other organisational Information Systems. In particular, ES uniquely coordinate processes across organisational subunits in a manner illustrated in Figure 2.5.



(After Davenport (1998), Hitt et al. (2002), Giachetti (2004), Adam and Sammon (2004), Laudon and Laudon (2014) and freesaptutorial.com)

Figure 2.5: ES as Process Coordinator

Figure 2.5 illustrates, that, while ES integrate at several levels in the organisation, they are distinctive in that they integrate at the level of process coordination in a way that other organisational Information Systems do not.

Thus an organisation using an ES will expect ordering, manufacturing, fulfilment, inventory and finance subunits (for example) to be coordinated by processes that span all of those subunits.

(www.freesaptutorial.com)

Figure 2.6: The SAP Integration Model

Thus Figure 2.2 and Figure 2.6 both present an Extended ERP and the SAP R/3 ES as large systems that integrate different organisational processes and functions. In both cases there is a central database at the core. ES integrate both processes and data, that is, they provide a unified view of data across organisational boundaries and they permit business process to span those same boundaries (McGaughey and Gunasekaran (2007, p.24), Gattiker and Goodhue (2005, p.559) and Huang et al. (2004, p.101)). In addition ES integrate different functional areas and even different sites and organisational entities within multinational firms (Adam & O'Doherty, 2000, p.306). Figure 2.1, Figure 2.5 and Figure 2.2 show how the ES has evolved into a package of applications that can extend across all functions in every organisation in the supply chain from the end consumer all the way back to suppliers. This distinguishes ES from other Information Systems.

2.3.4 Central Planning and Control

Figure 2.7 illustrates the central role the database place in any ES. While ES consist of discrete applications, they all have a central database in common. This is a fundamental difference between ES and older, disjointed legacy systems. Figure 2.7 also shows that reporting applications are tied to the same central database. Per Davenport (1998), managers and stakeholders make use of these reporting applications to monitor production and to plan at the operational, tactical and strategic levels in the organisation.

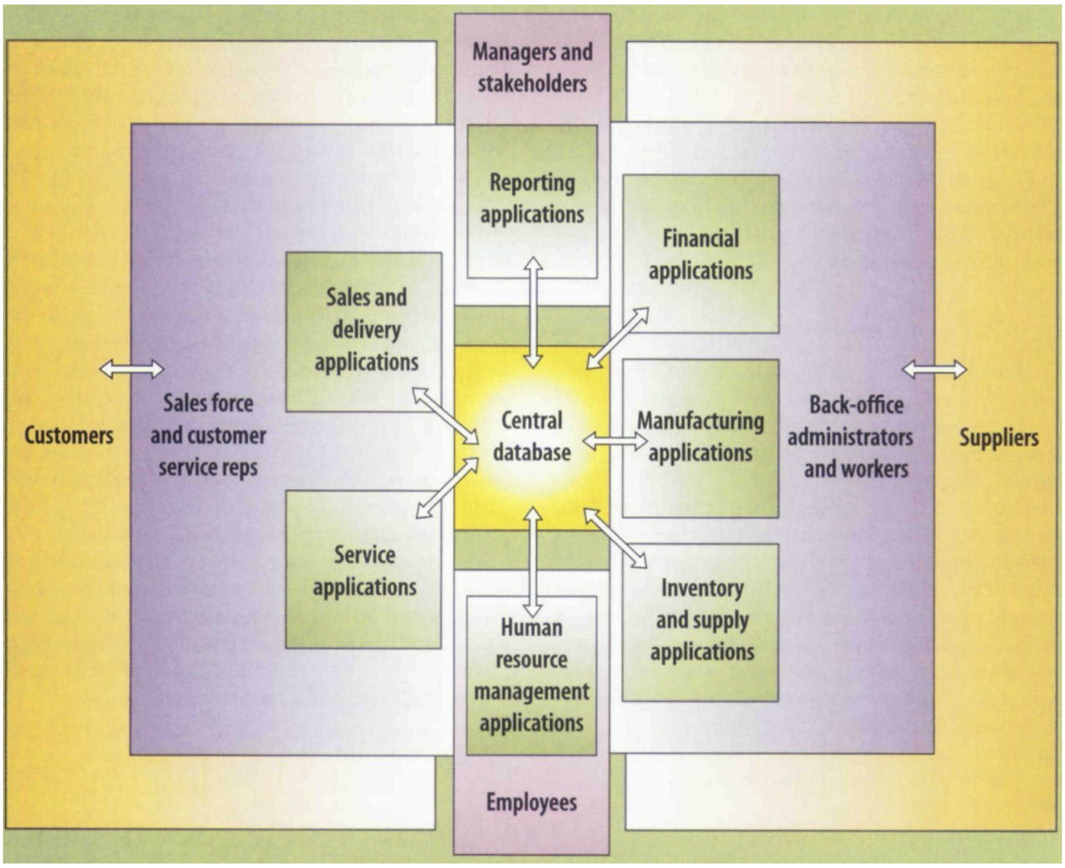
Centralised databases and reporting facilitate centralised control and planning in a manner not facilitated by legacy systems. Managers can make comparisons between different sites and operational units in the organisations. Consistent targets can also be set. In some cases ES are implemented to allow centralised control to be imposed on an otherwise disjointed organisation.

Other centralised control opportunities present themselves subsequent to ES implementation: Streamlined and centralised procurement processes become possible, as well as centralised inventory management.

2.3.5 Standardisation and embodiment of best practises

ES are credited with improving process efficiency (Davenport, 2000) and for establishing or importing best practice (Seddon et al., 2003) and standardisation of processes (Adam & O'Doherty, 2000) into the organisation. Standardisation is closely associated with centralisation and is probably most evident in multisite organisations where processes may vary. Imposing a unified, centralised ES endures that all sites in the organisation are using the same processes. This may be problematic with sites where significant cultural differences or variations in the business environment exist. A decision must be made whether to impose standardised processes or permit some process variation to accommodate variations in environment.

Embodiment of best practices is not necessary for either central control or standardisation. Nevertheless, this is another possible motivator for ES implementation. The vendor will present its ES as encapsulating all that it has learnt from previous implementations. The ES thus represents, in principle, the very best of possible business processes. The organisation implementing the ES is



(Davenport, 1998, p.124)

Figure 2.7: The SAP integration model

thus reassured that the processes explicit in the ES are by definition better than what it has already.

Reality suggests that this rosy situation is not always the case. Z. Lee and Lee (2000) describe two sets of *canonical* (formal, documented) processes and *non-canonical* (informal, actual) processes which to varying degrees dictate how an organisation works. Thus an organisation implementing an ES may choose to customise the ES to its existing, well-documented (and thus canonical) processes at considerable cost. Conversely, it may discard its own processes in favour of the canonical processes embedded in the ES. In either case, the risk exists that non-canonical processes are not adequately documented and implemented in the new ES. Consequently, regardless of customisation effort, the resultant ES may not represent how the organisation actually works or is supposed to work. Subsection 2.3.6 discusses issues with customisation and configuration further.

2.3.6 Configuration and customisation

Figures 2.1, 2.2, 2.6 and 2.7 show how the ES has evolved into a package of applications that can extend across all functions in every organisation in the supply chain from the end consumer all the way back to suppliers. At the level of an individual firm within this supply chain, achieving such a broad and extensive level of integration can be a complex task both at organisational and technical levels (Huang et al., 2004, p.101).

Unlike smaller Information Systems which may be tailored to an organisation's processes and structures, ES are built around packaged enterprise application software which requires *configuration* or *customisation* to meet the organisation's business needs (Shang & Seddon, 2003). Brehm et al. (2001) define configuration as, *"setting system parameters,"* and customisation as, *"making changes to ERP software code."* Customisation by its nature is a significantly more complex and costly activity than configuration (Z. Lee & Lee, 2000), unless it is the relatively simple form of customisation by module selection described by Davenport (1998, p.125).

Configuration and customisation may be described as proceeding in three stages:

Customisation by Module Selection This stage involves identifying which ES modules are to be purchased and implemented. The number and type of modules purchased dictates how much of the organisation's (or supply chain's) functional units and processes are to be supported or even automated by the ES.

Customisation by Code Modification Customisation, as defined by Brehm et al. (2001), involves making changes to the program code in one or more of the ES modules. While this stage may be regarded as optional, it may regarded as desirable to ensure a close fit between organisational processes, functions and the ES itself. Customisation at this level is, however, a costly and time-consuming processes with ongoing costs every time the affected ES software is upgraded.

Configuration Stage This stage is limited to setting and altering the system parameters for each module of the ES being deployed. This is also a time-consuming process but considerably less expensive than code modification. However configuration presents less opportunity for ensuring a close fit between business processes and the ES being deployed.

As suggested in Subsection 2.3.5, customisation becomes important if the organisation wishes to accurately model its existing (understood) processes as against merely adopting the processes packaged in the ES. The performance of the resultant ES is dependent in part on this process fit, but customisation carries a considerable implementation cost. Subsection 2.3.7 expands on the issue of implementation cost versus performance further.

2.3.7 Implementation Cost and Contribution to Performance

Adam and O'Doherty (2000) state that the prime motivator for managers to implement ERP projects appears to be the attainment of competitive advantage over other organisations. As competitive advantage can be secured either creating more value than competitors or undercutting competitors costs, any such ES investment must cut costs or generate value. As it costs money to implement and operate an ES, the return on that investment must consistently yield cost savings, or increased returns in value, or both.

Subsection 2.3.6 briefly outlined the configuration and customisation options open to the ES implementer. It also observed that customisation, while producing better process fit, is a much more expensive option. It is not sufficient, however, to represent the decisions surrounding ES implementation as a simple dilemma between customisation and purchasing off-the-shelf. Z. Lee and Lee (2000) describe two sets of *canonical* (formal, documented) processes and *non-canonical* (informal, actual) processes which to varying degrees dictate how an organisation works. If an ES is perceived as the embodiment of a set of business knowledge (and therefore canonical processes) then Z. Lee and Lee (2000) suggest that an organisation's ability to obtain competitive advantage from an ES implementation is dependent on its ability to merge those canonical processes with its own, existing, non-canonical processes.

The customisation dilemma thus becomes a deeper problem of how far the organisation is willing or able to adapt itself to obtain competitive advantage from an ES implementation. In addition, Johannessen, Olaisen, and Olsen (2001) note that any resulting competitive advantage is also dependent on the organisation's ability to explicate its tacit (or non-canonical) processes as part of the ES implementation. Given the cost of customisation, frequently the implementation of an ES requires the organisation to adapt to the ES package's functionality (Lorenzo et al., 2005). The packaged nature of ES thus forces organisations to decide between a costly customisation process or substantially changing their own business processes.

In conclusion, some of the very advantages of ES - integration, standardisation, centralisation, application of best practices and customisation - may also prove to be their greatest drawbacks. Tales of costly failure are abundant. The next section briefly discusses some of the difficulties of ES implementation and then goes on to cite some examples illustrating the difficulties encountered.

2.4 Experiences with ES

Some of the advantages of ES - integration, standardisation, centralisation, application of best practices and customisation - may also prove to be their greatest drawbacks. Tales of costly failures and *"horror stories"* are abundant (Davenport, 1998, p.123). This section discusses some of the difficulties in brief and then goes on to cite some illustrative examples.

2.4.1 Implications of ES implementation

Organisations report many difficulties and failures in implementing ES (Nah & Lee-Shang Lau, 2001; Davenport, 1998). For example, mixed success with ERP systems is documented in Barker and Frolick (2003); Gattiker and Goodhue (2005); Gosain (2004); Huang et al. (2004); Mabert et al. (2001); Robey et al. (2002) and Scott and Vessey (2002). In addition, problems have been reported with CRM and SCM systems (Dickerson, 2003; Kale, 2004). Yeo (2002) comments in a broader context that many Information Systems projects have in fact failed, either by exceeding budget and schedule or by failing to meet users' requirements (Yeo, 2002). Barki and Pinsonneault (2002) support this view by noting that, while there are many success stories, half of all ERP projects fail to achieve their expected benefits. In addition, many ERP benefits take much more time, money and effort to realise than originally anticipated (Barki & Pinsonneault, 2002). Some of this cost and effort may be attributed to the very high cost of customising the ES to meet the organisation's needs (Z. Lee & Lee, 2000).

Both Figure 2.1 and Figure 2.2 show how the ES has evolved into a package of applications that can extend across all functions in every organisation in the supply chain from the end consumer all the way back to suppliers. At the level of an individual firm within this supply chain, achieving such a broad and extensive level of integration can be a complex task both at organisational and technical levels (Huang et al., 2004, p.101) with failures at the technical level evident when attempts are made to customise the system being deployed (Themistocleous, Irani, & O'Keefe, 2001, p.202).

ES are by their nature process-focused systems. They both embody and integrate business processes and the implementation process can have a dramatic transformative effect on those processes. Part of the ES implementation may involve a BPR (Business Process Reengineering) exercise where an organisation examines, explicates and transforms its internal processes and possibly replaces those processes with some of the best practices embodied in the ES.

The impact of this on the organisation should not be underestimated. An effective BPR exercise as part of an ES implementation should involve a thorough examination of both tacit and explicit processes and and a deep understanding of how those processes affect core competencies and thus the organisation's competitive position. However the exigencies of ES implementation (including grappling with the complexity and scale of the system being implement) dictates that this is frequently not the case.

The integrative nature of ES means that any processes therein are shared across an organisation. This has implications for multi-site organisations where similar functions are supported by different business processes in different locations. These differences may be attributed in part to cultural and values differences, as well as different histories (path dependency) for different locations. However the centralised data base of an ES and the necessity to standardise common processes across an organisation forces different sites to share a common data source and to use the same processes. This may not always be advantageous.

The ES as embodiment of business processes and best practices has deeper implications. Gosain (2004) asserts that as an ES is implemented, such processes and practices become standardised and frozen, an effect described as the *"Iron Cage."* This may not be such an issue in the short term if the most effective processes and practices are frozen. However, the changing external environment may make them less relevant and useful over a longer period of time. Worse still, an ineffective ES implementation may embody, or freeze, ineffective or

Table 2.2: Overview of ES implementation impact in selected companies

Organization	Baseline	Main stated impacts of ES
LEGO	Financial crisis, complicated business processes; many old legacy systems	Streamlined business processes Better integrated processes Changed business practices
The Municipality of Copenhagen	Old fragmented IT architecture; ineffective accounting processes	Increased business process efficiency Increased IT literacy Increased flexibility regarding adapting to political decisions
Martin Group	Management crisis and old legacy systems	Better integrated processes Tool for the new management
Hydro Automotive Structures	Old non-integrated legacy system, low user acceptance	Increased transparency of processes Increased data quality
Bang and Olufsen	Many old legacy systems, Y2K problems	Reduced stock Increased flexibility
Fritz Hansen	Strategic change, old non-integrated system	Better support of business process Better support of stratetgic initiatives Better supplier control

(Rikhardsson & Kraemmergaard, 2006, p.45)

even harmful processes and practices.

2.4.2 Some Implementation Experiences

This subsection examines some examples of ES implementation from the literature, with the objective of illustrating where some of the limitations of ES implementations lie. Table 2.2 illustrates the stated impacts of an ES implementation in selected Danish companies (Rikhardsson & Kraemmergaard, 2006).

This summary highlights some of the stated impacts as more streamlined and integrated processes, increased data quality, inventory reduction, changed business practices and improved business efficiency (Rikhardsson & Kraemmergaard, 2006, p.45). These findings are in keeping with the benefits of ES stated in Section 2.3.

Rikhardsson and Kraemmergaard (2006, pp45-46) also point out that ES, while directly contributing only negligible advantage over other companies (they had implemented ES too), are a necessity for being competitive in the market at all. None of the companies in Rikhardsson and Kraemmergaard (2006)'s study cited the ES as the direct cause of superior competitive performance.

A 2003 study of 217 manufacturing companies is similarly informative. Botta-Genoulaz and Millet (2005, p.579) articulate a wide range benefits ob-

Table 2.3: Benefits of ES implementation

	% Expected	% Realised	% Expected/% realised
Direct benefits			
Control of flows of goods	70.0	70.0	100
Information flows control	76.7	73.3	96
Financial flows control	73.3	63.3	86
Services/department opening up	50.0	50.0	100
Information reliability	83.3	66.7	80
Uniqueness of information	86.7	80.0	92
Organisation clarification	36.7	43.3	118
Common view across the company	60.0	46.7	78
Process benefiting from ERP			
Cost control	76.7	56.7	74
Lead-time control	83.3	43.3	52
Inventory control	80.0	66.7	83
Customer service improvement	70.0	70.0	100
Supplier relationship improvement	46.7	40.0	86

(Botta-Genoulaz & Millet, 2005, p.579)

served from ES implementations; this is shown in Table 2.3. Some benefits are notable for the low level at which they have been realised - in particular the establishment of a common view across the company, clarification of the company's structure, the opening up of departments, improvement in supplier relationships and control of lead times and costs.

Botta-Genoulaz and Millet (2005, p.580) also enumerate the traps observed by the survey participants; these are shown in Table 2.4. Especially, lack of planning, no process reengineering and poor requirements definition are cited as problems that may be encountered during ES implementation.

These experiences in ES implementation, as summarised by these two studies, illustrate the various benefits and pitfalls experienced by private sector organisations. In some cases the benefits attained fell far short of those expected; in others, expectations were low to start with. None of the examples referenced in the studies above represents an outright failure. Davenport (1998) noted, however, that. *"The growing number of horror stories about failed or out-of-control projects should certainly give managers pause"*. Barker and Frolick (2003) describes the case of a failed ERP implementation at a bottling company, a failure attributed to poor communication and lack of management support (Barker & Frolick, 2003, p.47). Xue, Liang, Boulton, and Snyder (2005) cite five significant failures in China; the reasons for failure ranged from standards mismatch to lack of preparation to inability of the system to adapt to organisational change.

Table 2.4: ES implementation traps

Traps	%
Lack of re-engineering before ERP project	40
Lack of project planning	30
Gap in the requirement definition	30
Under-estimation of the importance of the choice ERP	23
Specific software development, too much customisation	20
Lack of training	19
Lack of planning post-go-live, gap in stabilisation phase management	13
Lack of communication and implication of the management	13
Under-estimation of data-migration risk	13

(Botta-Genoulaz & Millet, 2005, p.580)

2.4.3 Analysis

The studies cited show that failures in ES implementation are well known and have multiple causes. In addition, while ES implementation has proven benefits, one study indicates no clear link to competitive advantage and another study shows that improvements in cost control are only realised in 56% of cases Botta-Genoulaz and Millet (2005). Therefore ES implementation may be described as risky and its effect on competitive position is, at best, poorly understood. This is due in part to the tendency of different organisations to implement similar ES (Beard & Sumner, 2004, p.129). Instead, Beard and Sumner (2004, p.129) suggest that, amongst other reasons, competitive advantage may be obtained from the successful alignment of an ES with an organisation's strategy, once implementation is complete and usage is under way. This is echoed by Botta-Genoulaz, Millet, and Grabot (2005, p.515), who state that the resultant productivity gain is contingent on the *usefulness* of the ES. Finally, Uwizeyemungu and Raymond (2012, p.84) uses a Dynamic Capabilities Theory approach to show that the business value of an ES design is influenced by its intended use and its level of integration, flexibility and transversality. These are design considerations that ultimately effect how the ES can be used and how closely this fits the overall business strategy.

In all of the cases and studies mentioned in this section, the ES implementation is invariably described in the context of supporting a manufacturing operation and thus any improvements in competitive position are also described in that context. While extensive research has been done on ES implementation in the private sector, the public sector has been relatively ignored. Public sector and public utility organisations are by their nature more service focused. Given the growth in importance of the service sector, some examination of ES implementation in this context is justified. The next section describes some of the characteristics of public utilities and the implications for ES implementation.

2.5 ES and Public Utilities

ES research to date has focused on the private sector primarily, with relatively little research done on ES in public utility companies (Spano and Bello (2011, p.2) and Botta-Genoulaz and Millet (2006, p.203)). Spano and Bello (2011) refers to M. A. Ward (2006), which presents a table of 2002 public and private sector IT rankings. ERP, SCM and CRM rank 5.5 in the private rankings but only 18.5 in the public sector (M. A. Ward, 2006, p.53). It is unclear whether lack of opportunity or lack of interest is the root cause of the relative paucity of research in this area. Nevertheless, public sector utilities present some useful opportunities for examining ES usage.

Public sector ES implementations differ from the private sector in that, unlike private sector organisations which may be involved in manufacturing, public sector organisations are almost exclusively service - focused (Byrne (2008, p.20), citing Schiflett and Zey (1990)). Thus the MRP component of private sector ES is missing from public sector ES (Botta-Genoulaz & Millet, 2006, p.219). Public sector organisations can also have more complex management structures then private organisations (Wagner & Newell, 2004, p.4). In addition, procurement processes will also be different (Blick, Gulledge, & Sommer, 2000, p.X). However, Blick et al. (2000) also assert that the technical difference between the later phases of public and private ES implementations are mostly similar; Wagner and Newell (2004, p.4) confirms this.

Like private organisations, public sector organisations see integration as a benefit of ES. Other motivations for the public sector are increasing efficiency, increasing effectiveness, improving processes, removing duplication and reducing costs (Chang, Gable, Smythe, and Timbrell (2000, p.494), (Hurbean, 2009, pp8-9) and Harrison (2004, p.7, p.41)). In addition, Mandal and Gunasekaran (2003, p.278) cites replacement of costly and poorly integrated legacy systems the major motivator for the implementation of SAP R/3 in a water utility, while Solis, Putnam, Gemoets, and Almonte (2002, p.1112) cites Miranda (2000) and Sclafani (2000) in emphasising the attractiveness of using ES to connect previously disjoint government departments.

While achieving competitive advantage appears to be a less relevant concern for the public sector, the regulatory environment within which public utilities operate is very well documented. Public utility organisations have transitioned from being state-funded single operators to open regulated markets with some degree of competition, whether directly or by proxy. Consequently their work is very closely and publicly regulated. Public sector organisations have different stakeholders than private sector organisations, in particular one of those stakeholders remaining the state. The regulator, also a stakeholder in the public utility, can specify what it can charge, what to earn on its asset base, and what regulatory standards it must meet.

The motivations for implementing ES in the public sector are cost reduction, establishment of central control and enforcement of standards. The need for competitive advantage is substituted by a requirement to meet or exceed stakeholder expectations. This includes delivering a utility service at a price determined by the regulator, at a cost equal to or lower than that allowed by the regulator.

2.6 The Challenge of Using ES to Meet or Exceed Stakeholder Expectations

ES are large, complex packages of software whose reach extends beyond traditional functional and organisational boundaries to integrate processes, data and functions across the whole supply chain. As such they are expensive to implement, difficult to configure and failures both on the organisational and technical level are frequent.

The sheer size and reach of ES dictates that they are of necessity complex suites of applications. The hardware and networking challenges are enormous, to the extent that the implementation focus of a lot of organisations is reduced to getting the system running as distinct from an optimal deployment. It is possible that this complexity makes it difficult to link the investment in ES to business performance (Jacobs & Bendoly, 2003, p.234).

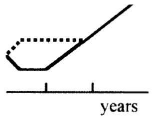
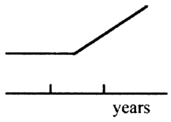
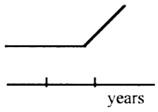
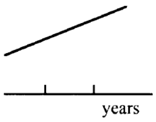
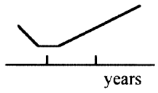
It is not surprising, therefore, that it is difficult to perceive how implementation or use of an ES can lead to competitive advantage, especially when high-profile commentators such as Carr have asserted that the exact opposite is the case, namely that information technology in general "corrodes" competitive advantage (Carr, 2004).

It is clear from the literature that ES are perceived as beneficial due to their integrative nature (Davenport (2000), Hitt et al. (2002) and Laudon and Laudon (2014)), their customisability and the embodiment of best practices and process efficiency (Seddon et al., 2003). Shang and Seddon (2002) categorise the perceived benefits of ES as follows: Operational, Managerial, Strategic, IT Infrastructure and Organisational (Shang & Seddon, 2002, p.290). The way these benefits develop over time is illustrated in Table 2.5. Significantly, no short-term strategic benefits are identified and it is also suggested that a loss of competitive advantage may occur when competitors use similar processes (Shang & Seddon, 2002, p.290). This is an argument advanced also by Carr (2004, pp82-83), who asseverates that the generic processes embodied in an ES, while encapsulating the state of the art of relevant business practice, provide little opportunity for an organisation to set itself apart from its competitors.

Consequently, while it is accepted that Information Technology in general may contribute to the improvement of organisational performance (Melville et al., 2004), the nature and extent of that contribution is poorly understood (Jacobs & Bendoly, 2003; Ravichandran & Lertwongsatien, 2005). Carmeli and Tishler (2004) underline this argument by suggesting that *"measuring core resources and their effect on organisation performance is often difficult."*

It is unclear whether the benefits of ES are brought about by the technology itself or the implementation process. For example, Alvarez (2002) asserts that, in the case of an organisation's values, the implementation process itself is far more influential than the actual technology implemented. In addition, Henderson and Venkatraman (1993) assert that it is the application of business and IT capabilities to develop and leverage a firm's IT resources for organi-

Table 2.5: Patterns of perceived net benefit development

Dimensions of ES benefits	Operational benefits	Managerial benefits	Strategic benefits	IT infrastructure benefits	Organizational benefits
Path of ES benefit development					
Early benefits	Automation benefits from savings in labour and time	Quicker decision making using real-time information	No immediate strategic benefits	Replacement of legacy systems	Immediate drop in employee morale
Problems	Extra time and labour in data entry	Rigidity in resource allocation because of tightly linked system integration	Loss of competitive advantages when competitors use similar processes	Inflexible system changes Frequent system upgrades	Low employee morale due to extra work, mismatched processes, data errors and change pressures
Explanations for benefits and problems	Business process change ES modifications Organizational learning	Enhanced reporting functions Accumulated data Organizational learning	ES technology upgrading	Attain, expand and extend ES	Business and system changes Organizational learning
Pace of benefit development	1–2 year plateau for busines changes and organizational learning	1–2 year plateau for system enhancement and organizational learning	Depends on business strategies of ES use	Gradually increased with system expansion. Significantly increased when system use achieved economies of scale	2–3 years for users to forget initial problems and to build system knowledge

(Shang & Seddon, 2002, p.290)

sational transformation, rather than the acquired technological functionality, that secures competitive advantage for firms.

Melville et al. (2004) and Bharadwaj (2000) also highlight the uncertainty surrounding the link between IT and organisational performance but offer a research blueprint as a means to gaining knowledge about the impact of IT on organisational performance. This blueprint - based on the **Resource Based View (RBV) of the firm** - treats the firm as *"a bundle of idiosyncratic resources and related capabilities, the interplay of which delivers competitive advantage"* (Butler, 2003). Melville et al. (2004) recommend the RBV on the grounds that it provides a *"robust framework for analysing whether and how IT may be associated with competitive advantage."*

Understanding the performance of an organisation is critical if the role of an ES in affecting that performance is also to be understood. For private sector organisations, organisational performance may be expressed in terms of market performance, profits and rents gained and returns to shareholders. However, the details are likely to be unclear. Conversely, a public sector utility's organisational performance can be expressed clearly in terms of its ability to meet or exceed the expectations clearly laid down and documented, in considerable detail, by the regulator.

Thus, public sector utilities present an opportunity for further research on the role of ES in improving organisational performance by increasing their ability to meet or exceed the expectations of their stakeholders. First, stakeholder expectations for a public utility in a regulated open market are well defined by virtue of the regulator publishing extensive documentation on the parameters within which the utility must perform. Second, the literature on ES implementation and use in the public sector is far more limited in scope and extent than similar literature on ES usage in the private sector.

As the Resource Based View of the firm treats the organisation as an aggregation of distinctive resources (Butler, 2003) and provides a solid basis for examining the role of IT in enhancing organisational performance (Melville et al., 2004), it provides a useful theoretical basis for examining the role of ES in enhancing the performance of a public utility, notably because the parameters under which that performance is measured are documented in considerable detail.

Chapter 3, therefore, introduces and discusses the Resource Based View and Dynamic Capabilities and suggests how this theoretical approach might be applied to the examination of the role ES in enhancing the ability of public utilities to meet or exceed stakeholder expectations.

Chapter 3

The Resource Based View and Dynamic Capabilities

3.1 Introduction

This Chapter introduces and discusses the Resource Based View (RBV) and Dynamic Capabilities Theory (DCT) and suggests how this theoretical approach might be applied to the examination of the role of Enterprise Systems (ES) in enhancing the ability of public utilities to meet or exceed stakeholder expectations.

As the Resource Based View (RBV) of the firm treats the organisation as an aggregation of distinctive resources (Butler, 2003) and provides a solid basis for examining the role of IT in general (and ES in particular) in enhancing organisational performance (Melville et al., 2004), it provides a useful theoretical basis for examining the role of ES in enhancing the performance of a public utility, notably because the parameters under which that performance is measured are documented in considerable detail.

Environmental models of firm performance and competitive advantage, such as Porter (1980)'s "five forces" model, are dependent on two simplifying assumptions, namely, that organisations within an industry possess similar resources and pursue similar strategic goals and that any resource heterogeneity that is introduced into this industry is short-lived because those resources are freely tradable (Barney, 1991a, p.100). The problem with these assumptions is that they exclude the possibility that firms may possess idiosyncratic resources and that those resources may be immobile (Barney, 1991a, p.100-101). Such resource heterogeneity and immobility is well documented in Penrose (1959), Rumelt (1984) and Wernerfelt (1984).

This chapter proposes Dynamic Capabilities Theory (DCT) as a useful theoretical lens for examining the role of ES in enhancing an organisations ability to meet stakeholder expectations. Since any analysis of ES Implementation and its influence on Competitive Advantage requires an internally-focused model, this chapter discusses two internally focused views, namely the RBV and DCT, which focus on an organisation's strengths and weaknesses (Rugman & Verbeke, 2002, p.770).

It starts by briefly examining the history of DCT and its antecedent, the RBV. The RBV is a theoretical viewpoint that posits the organisation as an aggregation of resources, where those resources may be orchestrated with a view to obtaining superior rents.

DCT is then introduced, with particular emphasis on the emergence of DCT as a means of addressing shortcomings of the RBV.

This chapter is structured as follows: Section 3.2 discusses in brief the origins of the RBV and introduces the concept of nontradeable or inimitable resources. The section concludes by articulating a framework relating these resources to competitive advantage. Section 3.3 frames valuable, rare and inimitable resources as distinctive resources and introduces the related concepts of core capabilities and core competences. Section 3.4 presents a framework for resource - based analysis. Section 3.5 raises criticisms of the Resource - Based View, leading to Section 3.6, which addresses some of these criticisms by introducing DCT. Finally, Section 3.7 examines the applicability of DCT to ES implementation.

3.2 The Emergence of the RBV

The RBV challenges the assumptions of resource tradability and similarity and focuses the search for competitive advantage inwards, to a firm's internal resources. The RBV was originally articulated by Penrose (1959) and Wernerfelt (1984). Penrose (1959) articulates the concept of the organisations as *"a collection of productive resources."*, which are subdivided into *physical resources* and *human resources* (Penrose, 1959, p.24). Penrose (1959) goes on to state that:

> *"It is never resources themselves that are inputs in the production process, but only the services that the resources can render ... resources consist of a bundle of services and can, for the most part, be defined independently of their use, whereas services cannot ... it is largely in this distinction that we find the source of the uniqueness of each individual firm."* (Penrose, 1959, p.25)

Penrose (1959) thus lays the foundation for the RBV and, in some respects, anticipates the later DCT. However Wernerfelt (1984, p.171) notes that Penrose's work received little attention. Wernerfelt (1984, p.172) defines a resource as *"anything which can be thought of as a strength or weakness of a given firm."*, clearly establishing the RBV as focused internally on the organisation rather than on the organisation's environment. As well as introducing the term *Resource Based View*, Wernerfelt (1984) goes on to introduce the concept of the *resource position barrier*, that is, when one organisation already holds a resource, it will adversely affect the costs or revenues of later acquirers of that resource (Wernerfelt, 1984, p.173). However, if substitute resources are available, then returns to a holder of a given resource may be eroded (Wernerfelt, 1984, p.173). Much of this analysis is based on the Five Forces Model from Porter (1980) and it introduces the concepts of *resource substitutability* and *resource heterogeneity*. In addition, Wernerfelt (1984, p.172) hints at the concept of *resource value* by discussing "attractive, high profit yielding" resources, which are associated with resource position barriers.

Further development of the RBV was made by Barney (1986): This paper makes two significant contributions. First, organisations seeking to obtain above normal returns from implementing product market strategies need to look inwardly to exploit resources already under their control (Barney, 1986, p.1239). The converse of this is that organisations that do not exploit resources under their control can expect normal returns at best (Barney, 1986, p.1239). Second, organisations that do enjoy above normal returns may do so because of *unique insights and and abilities* within their control when they selected the strategies that led to high returns (Barney, 1986, p.1240). While this is suggestive of the later emerging concepts of *resource immobility* and *resource rarity*, Barney (1986, p.1240) does suggest that luck also might be a factor.

However, Dierickx and Cool (1989a, p.1506) take issue with *"strategic factor markets"*, Barney (1986)'s concept of freely tradable resources, stating that such resources are unlikely to lead to a *sustainable competitive advantage*. Not all resources need be freely tradeable: Dierickx and Cool (1989a, p.1507) go on to discuss the concept of *critical* or *strategic* asset stocks, which, for the purposes of this discussion, may be regarded as analogous to resources. To achieve a sustainable competitive advantage, such asset stocks must be nontradeable (hence they may be considered rare or heterogeneously distributed) but in addition they must be resistant to threats of substitution or imitation (Dierickx & Cool, 1989a, pp1507-1509). Therefore, any asset stock (or resource) must be *rare, inimitable* and *non-substitutable* to confer a sustained competitive advantage on an organisation in any given market.

The inimitability of an asset stock is contingent upon the process by which such stocks are accumulated, namely the role of history, critical mass effects, asset interdependencies and causal ambiguity (Dierickx & Cool, 1989a, pp1507-1509). The role of history, or *time compression diseconomics* (Dierickx & Cool, 1989a, p.1507) refers to the idea that certain stocks require a certain irreducible amount of time to acquire. Critical mass effects or *asset mass efficiencies* implies that when a certain quantity of a particular stock has been acquired, it becomes easier to acquire further quantities of that stock (Dierickx & Cool, 1989a, p.1508). Also, the accumulation of asset stocks may depend on the accumulation of other stocks; additionally, the process by which certain stocks are accumulate may be unclear (Dierickx & Cool, 1989a, p1508-1509). This is described as *causal ambiguity* by Rumelt (1984, p.562). Finally, *asset erosion* also servers as a barrier to imitation in that asset stock with slower "decay" rates will preserve any asymmetry between organisations the longest (Dierickx & Cool, 1989a, p.1508).

To summarise, Dierickx and Cool (1989b) argue that Barney (1986)'s strategic factor market view of the tradability of strategic assets is not useful for determining the sustainability of competitive advantage (Dierickx & Cool, 1989b, p.1514). This argument concerning *sustainable competitive advantage* is significant as it attempts to identify the characteristics of resources that might lead to a superior market position that can be retained over competitors in the long term.

In a paper that Newbert (2007) describes as the first to present the RBV as a comprehensive framework, Barney (1991a) points out that environmental models of firm performance and competitive advantage (for example Porter (1980)'s "five forces" model) are dependent on two simplifying assumptions, namely, that organisations within an industry possess similar resources and pursue similar strategic goals and that any resource heterogeneity that is introduced into this industry is short-lived because those resources are freely tradable (Barney, 1991a, p.100). Neither of these assumptions is useful within the resource based view of the firm, as is indicated by Dierickx and Cool (1989a). Instead, two alternative assumptions are substituted: First, it is assumed that organisations within an industry may be heterogeneous with respect to the resources they control and second, these resources may be imperfectly mobile across organisations and thus any heterogeneity may be sustained (Barney, 1991a, p.101). These assumptions, at the core of the RBV, are emergent from Wernerfelt (1984), Rumelt (1984), Barney (1986) and Dierickx and Cool (1989a).

Several additional useful concepts are defined in Barney (1991a), who cites Daft (1983) in defining *Resources* as:

> *"all assets, capabilities, firm attributes, information, knowledge, etc. controlled by a firm that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness"* (Barney, 1991a, p101)

Barney (1991a, p.106) notes that such resources are considered *valuable* only if they permit an organisation to execute strategies that improve its efficiency and effectiveness. Only valuable resources can be a source of *competitive advantage* or *sustained competitive advantage* (Barney, 1991a, p.106). An organisation enjoys a competitive advantage when it is *"implementing a value creating strategy not being implemented by any current or potential competitors"* (Barney, 1991a, p.102). This competitive advantage is said to be sustained when the other firms are *"unable to duplicate the benefits of this strategy,"* (Barney, 1991a, p.102). Barney is at pains to point out that no specific duration is implied in the definition of sustained competitive advantage; whether the advantage is sustained is entirely contingent on the ability of current or future competitors to duplicate the strategy (Barney, 1991a, p.103). Finally, resources are considered *rare* if they are not possessed by large numbers of competing firms in the industry (Barney, 1991a, p.106). This follows from (Barney, 1991a)'s definition of competitive advantage; it is not possible for a valuable resource to confer competitive advantage on a firm if every other firm has access to the same resource (Barney, 1991a, p.106).

Barney (1991a) also extends Dierickx and Cool (1989a)'s views on what attributes make asset stocks, or resources, inimitable. As well as time compression diseconomics, asset mass efficiencies, causal ambiguity and asset erosion already described by Dierickx and Cool (1989a), Barney adds *social complexity* to the list of antecedents of inimitability and points out that the inimitability of certain resources may be dependent on very complex social phenomena, which may be difficult or impossible for the firm to systematically manage or influence (Barney, 1991a, p.110). Peteraf (1993) draws an important distinction between causal ambiguity and social complexity: A firm may not be able to identify its own strategically significant resources due to uncertainty of their origins or value. However, a resource whose inimitability is grounded in social complexity rather than causal ambiguity, while difficult to exploit, is still exploitable because its origins and value are understood (Peteraf, 1993, p.187). The distinction here is informational: Causally ambiguous resources confer no informational advantage to a firm over its competitors, even though they still offer a competitive advantage, whereas socially complex resources confer a considerable informational advantage as no competitor will be able to determine or duplicate the social conditions antecedent to those resources (Peteraf, 1993, p187-188).

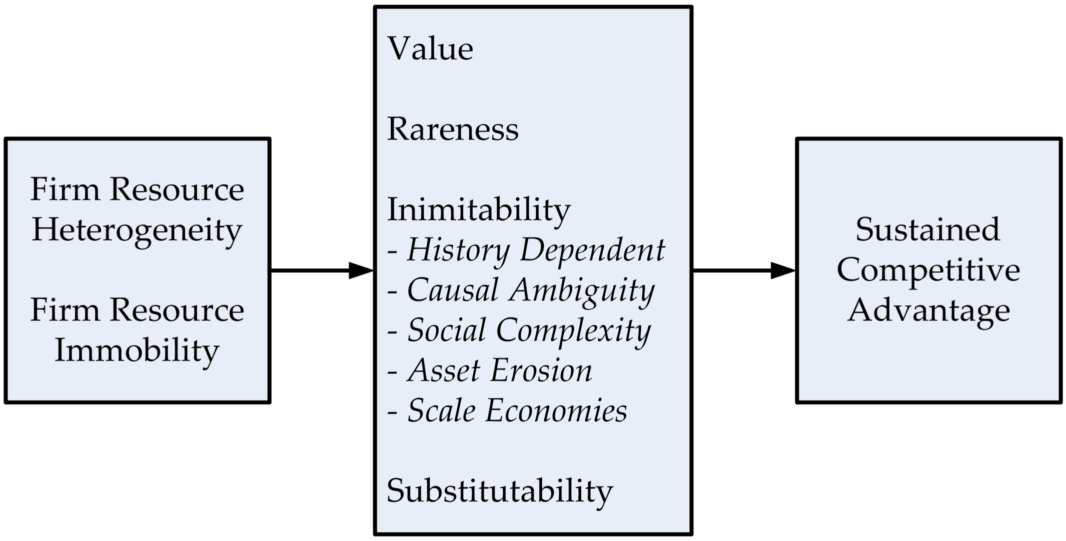
From the concepts developed in Barney (1991a), and the earlier concepts developed in Penrose (1959); Wernerfelt (1984); Rumelt (1984); Barney (1986) and Dierickx and Cool (1989a), it is possible to build a framework as follows:

- A *competitive advantage* may be obtained from resources which are *valuable* and *rare*.
- This competitive advantage may be *sustained* if those resources are also *inimitable* and *non-substitutable*.
- The inimitability of resources is contingent on *causal ambiguity, the role of history, asset erosion, economies of scale* and *social complexity*.

This is summarised in Figure 3.1.

3.3 Core Capabilities and Core Competencies

Resources that are rare, valuable, inimitable and non-substitutable can be said to be *distinctive*; that is, such resources set an organisation strategically apart from its competitors in the marketplace and allow it to gain a sustained competitive advantage. Leonard-Barton (1992, p.111) asserts that *core capabilities*,



(Barney, 1991a; Dierickx & Cool, 1989a)

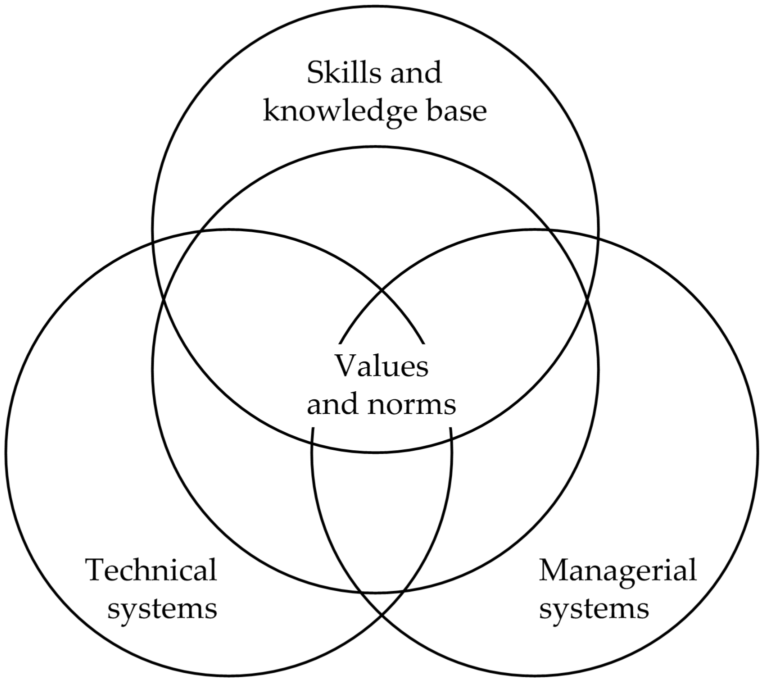
Figure 3.1: Antecedents of Sustained Competitive advantage

also known as *core competencies* (Prahalad & Hamel, 1990, p.70), also differentiate a company strategically. While the concept of core capabilities predates the RBV (Leonard-Barton, 1992, p111-112), their distinctive nature and their relationship to strategy makes them amenable to the the same treatment as resources or asset stocks within the RBV. For example, Prahalad and Hamel (1990, p.84) state that core competencies should be difficult to imitate. In addition, they anticipate the subsequent DCT by pointing out that:

> *"The real sources of [competitive] advantage are to be found in management's ability to consolidate corporate-wide technologies and production skills into competencies that empower businesses to adapt quickly to changing opportunities."*
>
> (Prahalad & Hamel, 1990, p.81)

Leonard-Barton (1992, p.113) defines a core capability as *"the knowledge set that distinguishes and provides a competitive advantage."* There are four dimensions to each core capability - its content is embodied in (1) employee knowledge and skills and embedded in (2) *technical systems*. In addition, (3) *managerial systems* guide the process of knowledge creation and control and the organisation's (4) *values and norms* are embodied in the other three dimensions (Leonard-Barton, 1992, p113-114). This is illustrated in Figure 3.2.

Core capabilities become institutionalised over time and become part of an organisation's accepted reality (Leonard-Barton, 1992, p.114). This is similar

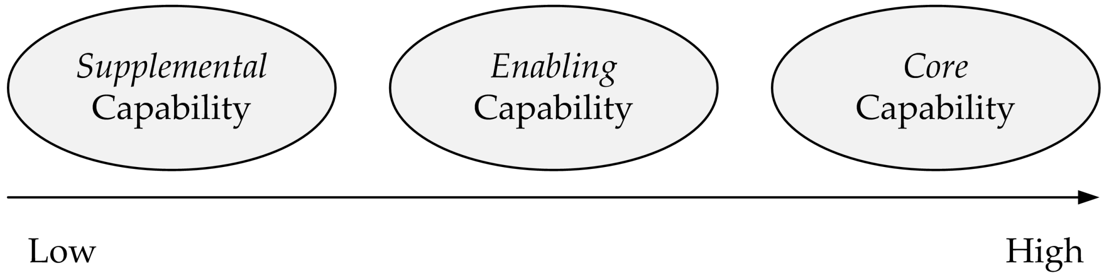


(Leonard-Barton, 1992, p.114)

Figure 3.2: The four dimensions of a core capability

to Dierickx and Cool (1989a)'s time compression diseconomics - an inimitable resource takes time to acquire; similarly, a core capability forms from *"an accretion of decisions made over time and events in corporate history."* Thus, like inimitable resources, core capabilities are not easily imitated by competitors. (Leonard-Barton, 1992, p.114).

However, core capabilities may lose their relevance as the organisation's external environment changes. Values, skills, managerial systems and technical systems that were useful in the past may not only become irrelevant but become an active hindrance in the future (Leonard-Barton, 1992, p.118). In this instance *core capabilities* become *core rigidities* and "actively create problems" for the organisation (Leonard-Barton, 1992, p.118). Any or all of the four dimensions can contribute to a core rigidity (Leonard-Barton, 1992, p118-119); in particular, for the technical systems dimension, *"skills and processes captured in software or hardware become easily outdated"* (Leonard-Barton, 1992, p.119). The process by which core capabilities become core rigidities is similar to the process of asset erosion described by Dierickx and Cool (1989a). All asset stocks erode, or decay, over time if they are not maintained; this can happen due to technical obsolescence or changes in the external market, for example (Dierickx & Cool, 1989a, p.1508).



(Leonard-Barton, 1995, p.4)

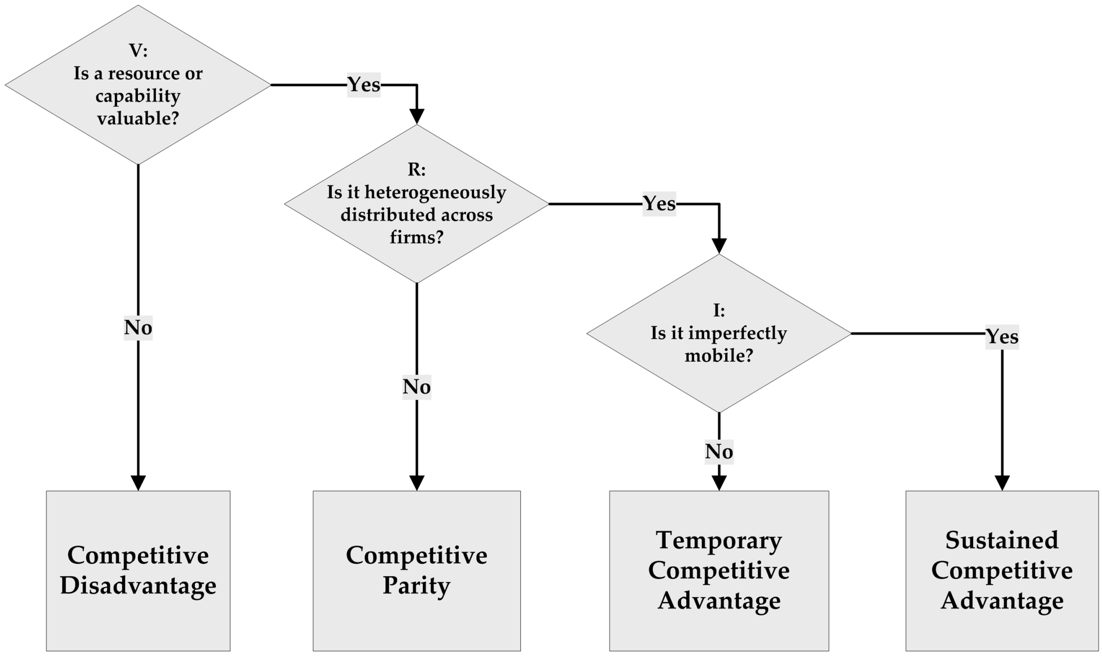
Figure 3.3: Strategic Importance of Capabilities

Leonard-Barton (1995) provides a clear correspondence between capabilities and competitive advantage: Core capabilities are directly related to sustained competitive advantage, as they are accumulated over time and are inimitable (Leonard-Barton, 1995, p.4). *Supplemental* capabilities add value to core capabilities but are prone to imitation (Leonard-Barton, 1995, p.4); consequently, any competitive advantage attained is likely to be temporary in nature as other firms catch up. Enabling capabilities, while necessary, are not sufficient in themselves to distinguish a firm from its competition (Leonard-Barton, 1995, p.4). The strategic importance of core, enabling and supplemental capabilities is shown in Figure 3.3.

3.4 A Framework for Resource-Based Analysis

The preceding discussion on resources, capabilities and competitive advantage suggests a model, or framework, by which competitive advantage can be determined. The evolution of this model can be clearly seen in Barney (1991a), Mata et al. (1995) and Barney (1997). Barney (1991a) is illustrated in Figure 3.1. This model is useful in that it explicates both the antecedents of sustained competitive advantage but also the antecedents of resource inimitability. However, the model is limited in that it does not explicitly include scenarios where temporary competitive advantage or competitive parity may results, nor does it explicitly take account of resources that are imitable, substitutable, not valuable, nor particularly rare. Mata et al. (1995) usefully extend the model in Barney (1991a) by taking these into account. This revised model is illustrated in Figure 3.4.

This VRI (Value, Rarity and Inimitability)model encapsulates the arguments in the literature concerning the value, rarity and imitability of resources and



(Mata et al., 1995)

Figure 3.4: A Resource-Based Model of Competitive Advantage

whether any competitive advantage can be obtained. If a resource is not valuable then any costs incurred in developing a strategy to exploiting it are likely to result in competitive disadvantage, as they cannot bey recovered (Barney, 1986, p.1231). This is because such a strategy will neither reduce a firm's costs nor will it increase its revenues (Mata et al., 1995, p.489).

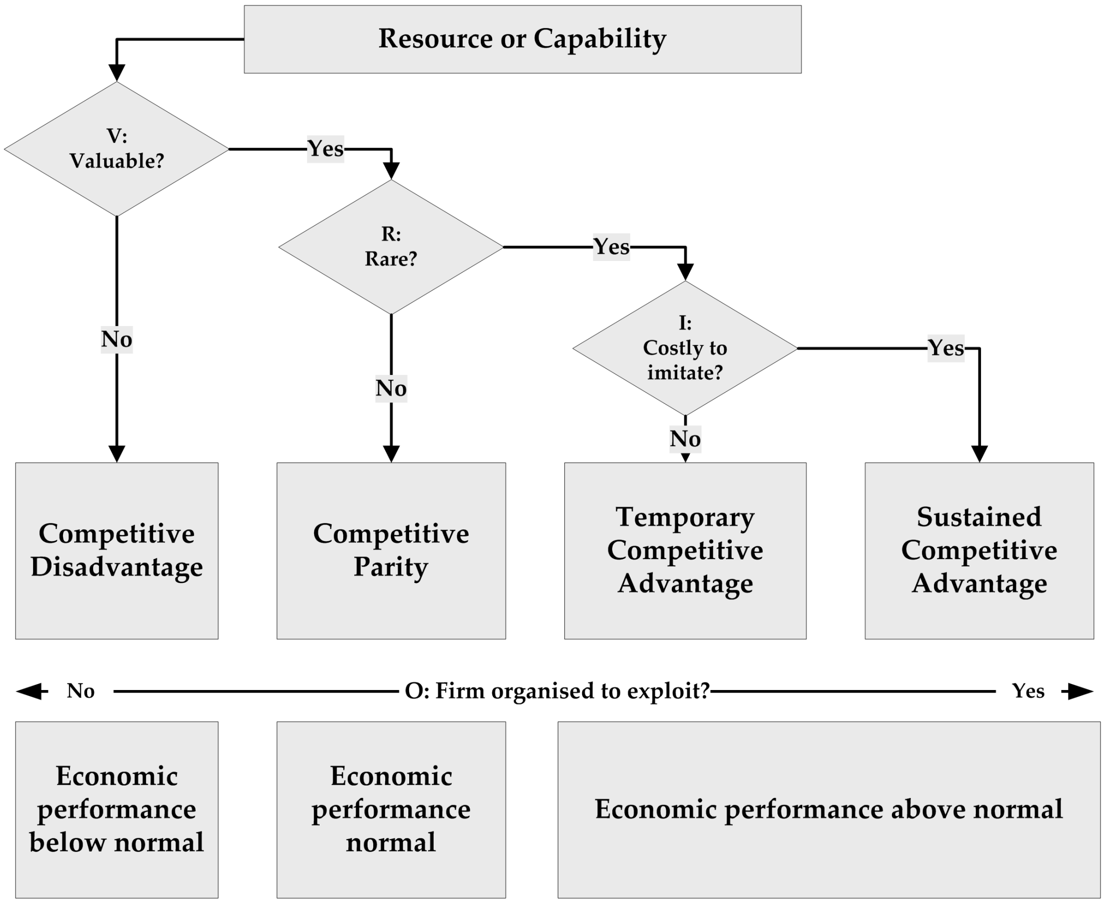
If a resource (or capability) is valuable but not rare, or evenly distributed across firms, then no competitive advantage can be achieved as every firm will be exploiting it (Barney, 1991a, pp103-104); all that can be achieved is competitive parity (Mata et al., 1995, p.489). If a resource is valuable and rare then a temporary competitive advantage will be achieved (Barney, 1991a, p.106) but, unless the resource (or capability) is resistant to attempts to imitate it or substitute it, then such advantage will only be temporary. Sustained competitive advantage is necessarily dependent on value, rarity, imperfect imitability and resistance to substitution (Barney, 1991a, p.112). The issue of substitutability is not explicitly addressed in Mata et al. (1995), but it is clearly asserted that a firm enjoys a sustained competitive advantage when it implements a strategy not simultaneously implemented by many competing firms and also when those firms face significant disadvantages in acquiring the requisite resources needed to implement the same strategy (Mata et al., 1995, p.488). Such resources may only be acquired through imitation or by substitution of different, but strategically equivalent resources. An *"imperfectly mobile"* resource (or capability) as described in (Mata et al., 1995) would by its nature be resistant to attempts to imitate it or substitute it.

Further refinements of Mata et al. (1995)'s VRI model are made in Barney (1997), as shown in Figure 3.5 as the *VRIO framework* (Value, Rarity, Inimitability and explOitability). Slight changes are noticeable in the model: Resource rarity is explicitly referenced rather than resource heterogeneity. In addition, the I in VRIO refers specifically to the inimitability or resources or capabilities, rather than imperfect mobility. This appears to specifically exclude the risk of substitution of valuable and rare resources.

Also, Barney (1997, p.173) introduces an additional dimension to Mata et al. (1995)'s VRI framework. Regardless of the value, rarity and inimitability of a resource or capability, the firm must be in a position to exploit that resource to generate a competitive advantage and achieve above normal economic performance (Barney, 1997, p.174);(Newbert, 2007, pp123-124). This is the O in the VRIO framework. Xerox's failure to capitalise on the innovations of its Palo Alto Research Center (PARC) is offered as an example (Barney, 1997, p.172): PARC developed a series of now-familiar technologies such as the mouse and laser printer but Xerox was not organised to exploit these resources and generate a competitive advantage, thus ceding the advantage to other firms (Barney, 1997, pp172,174).

In addition the VRIO framework depicts a relationship between competitive position and economic performance. Not surprisingly, a firm operating at a competitive disadvantage will experience below economic performance, but a firm operating with either a temporary or sustained competitive advantage will enjoy economic performance above normal, compared to its competitors.

A more detailed VRIO framework can be synthesised from Clemons and Row (1991); Leonard-Barton (1995) and Barney (1997). This is shown in Figure 3.6. It combines Mata et al. (1995)'s and Barney (1997)'s frameworks with Leonard-Barton (1995)'s definitions of core, supplemental and enabling capabilities, as well as incorporating the antecedents of core capabilities from Barney (1991a) and the relationship between competitive advantage and economic performance from Barney (1997). The concept of *competitive parity* is superseded by the idea of *strategic* or *competitive necessity* (Clemons & Row, 1991, p.275), where an Enabling Capability is necessary to stay in the market, but not sufficient to confer any advantage or even parity.

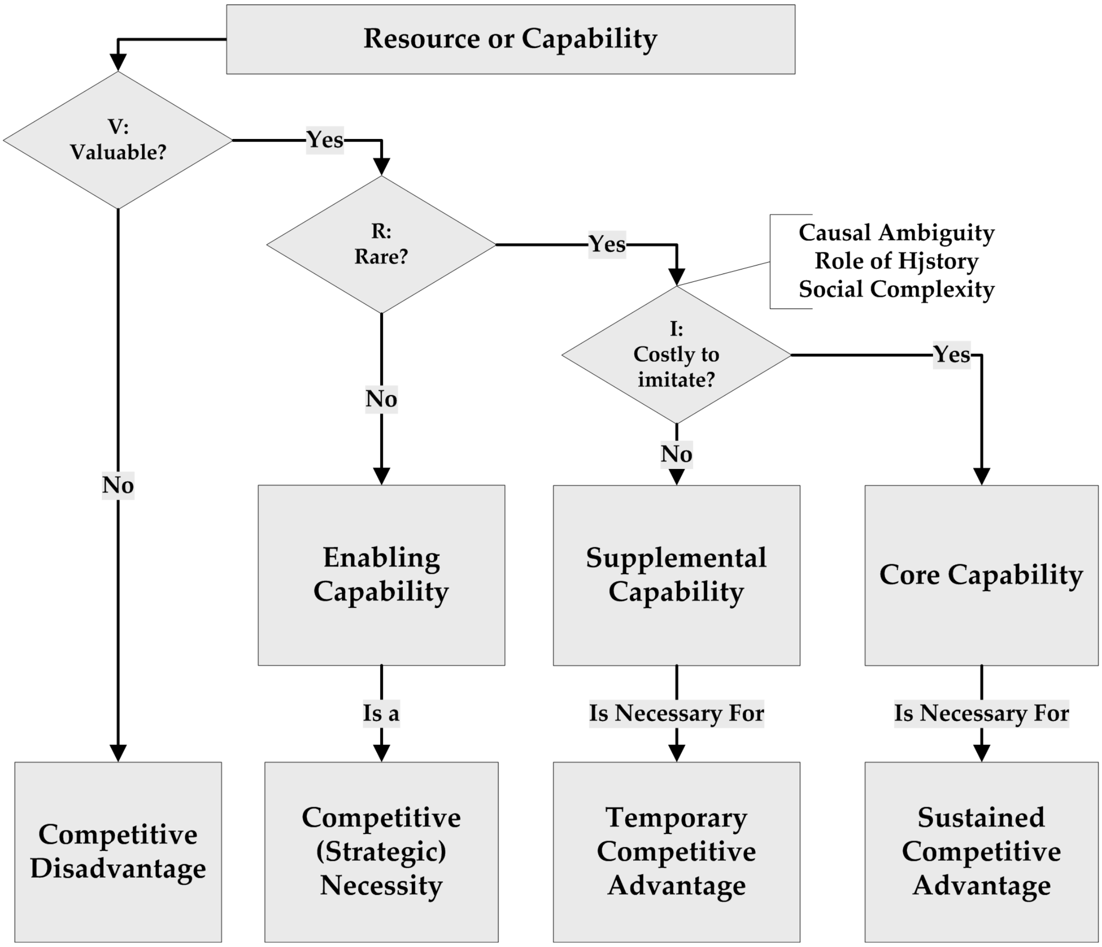


(Barney, 1997, pp173-174)

Figure 3.5: VRIO framework

The framework also delineates the relationship between the type of capability *(enabling, supplemental, core)*, the resultant competitive advantage *(temporary, sustained)* and economic performance. However, it is limited to expressing which capabilities are necessary, but not those which are sufficient, for competitive advantage. It is possible that sustained competitive advantage not only requires the successful exploitation of core capabilities but it may also be dependent on certain enabling and even supplemental capabilities, as suggested by Leonard-Barton (1995, p.4).

Figure 3.6 represents a comprehensive representation of the RBV, as understood at the time. The RBV is appealing to researchers because of its usefulness as a theory in elucidating the connection between IT resources, the organisational capabilities needed to develop them and the resultant success of the organisation in the marketplace (Butler & Murphy, 2005). In addition the Resource - Based View provides a useful springboard for analysing the strengths and weaknesses of organisations (Rugman & Verbeke, 2002, p.770).



(After: Clemons and Row (1991, p.275),Leonard-Barton (1995),Barney (1997))

Figure 3.6: Extended VRIO framework

However, the RBV also presents a number of serious issues for the researcher and numerous shortcomings of the RBV have been identified in the literature. Its largely static view of resources, capabilities and competitive advantage presents challenges for the researcher. This and other shortcomings of the RBV are addressed in the next section.

3.5 Shortcomings of the RBV

This section outlines some of the criticisms of the RBV and thus delineates the rationale for expanding the RBV into DCT. The RBV has been criticised for being removed from reality, prone to ambiguity and tautology, static in its viewpoint, prone to a tendency to simplify its assumptions and tending towards use in a post-hoc context. Thus the RBV might be described as having useful descriptive characteristics but limited in predictive power.

This section starts by enumerating these limitations. It then explores some possible remedies and concludes that a more dynamic viewpoint is required.

The shortcomings of the Resource - Based View may be summarised thus: The RBV has been accused of being removed from empirical reality; the terms it refers to it are defined ambiguously and used interchangeably; the definitions it relies on are tautologous; analyses relying on RBV theory tend to rely on post-hoc reasoning and, finally, its viewpoint is static. Table 3.1 collates and summarises these shortcomings under these four headings.

On the surface, the RBV appears to have little empirical utility or predictive power, perhaps leading Priem and Butler (2001b, p.57) to suggest that it was *"not yet a theory."* For example, the RBV is accused of being removed from reality, a theory whose empirical underpinnings are unclear (Newbert, 2007, p.121).

Table 3.1: Issues with the RBV

Statement	Source	Theme
Little critical evaluation of the RBV as a theoretical framework or of its contributions to strategic management	Priem and Butler (2001a, p.22)	Removed from empirical reality
Not yet a theory	Priem and Butler (2001b, p.57)	
No systematic assessment of the RBV's level of empirical support has been conducted.	Newbert (2007, p.121)	
Framework was never designed to be tested directly, with measures of value, rarity, imitability and substitutability as independent variables and firm performance as a dependent variable.	Barney (2005, p.298)	
Firm resources include all assets, capabilities, organisational processes, firm attributes, information, knowledge, etc. controlled by a firm that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness.	Barney (1991a, p.101), citing Daft (1983)	Ambiguity of terms
The term competencies often appears in the literature, sometimes preceded by the adjectives core and distinctive, sometimes not, sometimes used interchangeably with the term skills, which is frequently preceded by the adjective, core	Fahy (2000, p.97)	

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Table 3.1 – *Continued from previous page*

Statement	Source	Theme
A confusion of terms *resource* and *capability*, which should be treated as distinct concepts	Butler and Murphy (2005). Examples in Barney (1997) and Mata et al. (1995)	
Terms underlying the RBV have not been adequately defined. Subsequent research work extending Barney (1991a)'s framework has failed to formally specify (or respecify) the original terms underlying the Resource-Based view; instead, researchers have merely defined any new terms of interest	Priem and Butler (2001a, p.23)	
Terms are defined without reference to external phenomena	Priem and Butler (2001b, p.58)	Tautologous definitions
[The RBV] has been called conceptually vague and tautological, with inattention to the mechanisms by which resources actually contribute to competitive advantage.	Eisenhardt and Martin (2000, p.1106)	
Barney (1991a, p.106) states that a firm achieves competitive advantage when 'implementing a value creating strategy not simultaneously being implemented by any current or potential competitors.' Eisenhardt and Martin (2000) reckon that Barney (1991a)'s definition suggests that [valuable, rare, inimitable and non-substitutable] resources that drive competitive advantage are identified by observing superior performance and then attributing that performance to the unique resources that the firm appears to possess - this makes the definition of the RBV tautological.	Wang and Ahmed (2007, p.33)	
The RBV lacks *empirical content* because it is possible to make analytical statements which are true by definition and thus without recourse to determining their truth based on empirical data	Wang and Ahmed (2007), citing (Priem & Butler, 2001a, pp27-28)	
Teece et al. (1997)'s definition of a core competence is very nearly circular ... It comes perilously close to saying a core competence is a competence that is core	Williamson (1999, p.1093)	

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Table 3.1 – *Continued from previous page*

Statement	Source	Theme
There being no apparatus by which to advise firms on when and how to reconfigure their core competences, the argument relies on ex post rationalisation: show me a success story and I will show you (uncover) a core competence. (Or show me a failure and I will show you (uncover) a missing competence)	Williamson (1999, pp1093-1094)	Post-hoc analysis
Performance heterogeneity simply reflects the fact that the realised competitive environment favours some strategies and some resource bundles over others. Such a critique implies that the cases which motivate so much of our strategy research, and indeed even some of our theoretic frameworks, are roughly equivalent to ex post accounts of the way in which a winning gambler chose to put her money on red rather than black at the roulette table	Cockburn, Henderson, and Stern (2000, p.1124)	
[Valuable, rare, inimitable and non-substitutable] resources that drive competitive advantage are identified by observing superior performance and then attributing that performance to the unique resources that the firm appears to possess	Wang and Ahmed (2007, p.33)	
Identification and measurement can only be done in hindsight because, without knowledge of the historical context in which a firm's competences were deployed, it cannot be known whether it did indeed deliver important customer-perceived benefits and confer a distinctive advantage over rivals ... Empirical identification of a core competence relies partly on knowledge that is known only **after** a strategic decision is made, and therefore to which executives do not have access when making their decisions	McGuinness and Morgan (2000, p.212)	
The RBV has not generated the kinds of empirical studies of adoption that are crucial both to fleshing out a full response to Stinchcombe (2000)'s critique and to building a richer understanding of competitive advantage	Cockburn et al. (2000, p.1128)	

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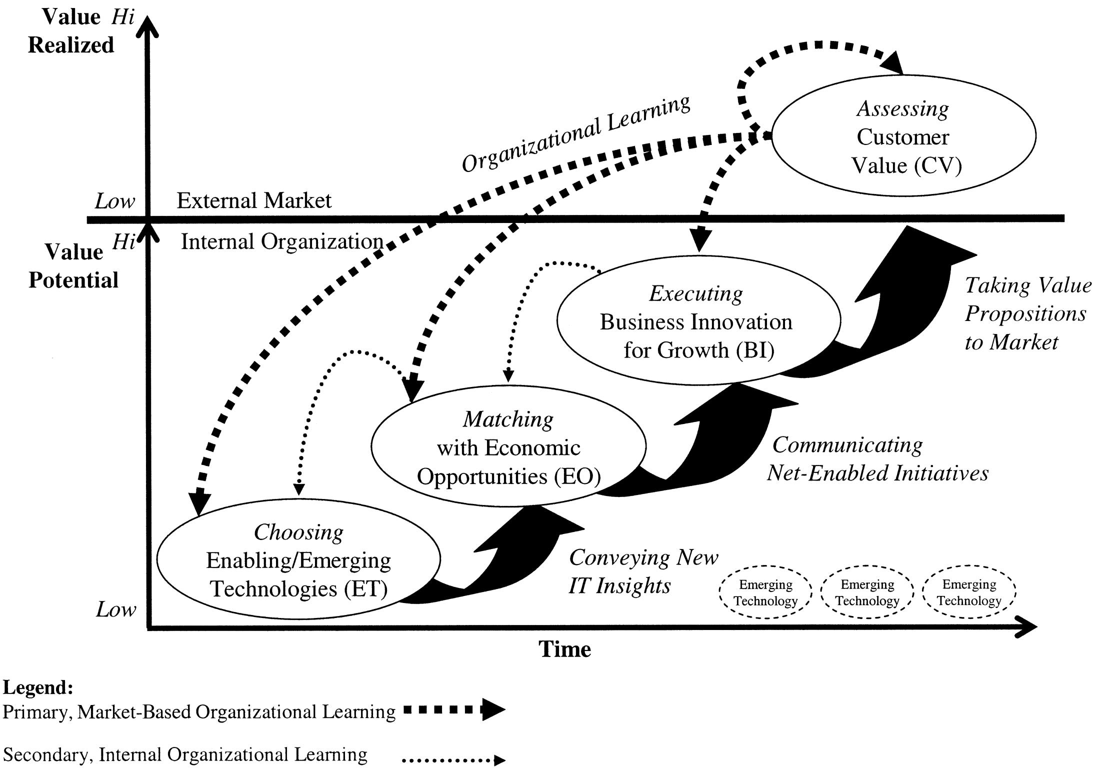
Table 3.1 – *Continued from previous page*

Statement	Source	Theme
The predictive power of the RBV as a theory is thus limited	(Williamson, 1999, p.1093)	
The RBV has been criticised for being static ... [it] fails to address the influence of market dynamism and firm evolution over time	Wang and Ahmed (2007, p.33)	Static viewpoint
Static approaches relegate causality to a "black box"	Priem and Butler (2001a, p.22)	
"Although the RBV began as a dynamic approach . . . much of the subsequent literature has been static in concept." They continue by noting that in Barney's interpretation of the RBV , "the processes through which particular resources provide competitive advantage remain in a black box"	Newbert (2007, p.123), citing Priem and Butler (2001a, p.33) and Barney, Wright, and Ketchen (2001, p.33)	

Instead, Barney (2005, p.298) contends that the RBV is intended to guide researchers into an empirical examination of those attributes of resources that make them valuable, rare, inimitable and non-substitutable. In essence it is a *molar theory* that requires development of an applied theory to guide empirical research (Wheeler, 2002, p.129). In fact, the RBV and the later Dynamic Capabilities perspective has been successfully operationalised in Wheeler (2002)'s *Net-Enabled Business Innovation Cycle (NEBIC)* theory.

NEBIC articulates a useful means of understanding an organisation's ability to create value through the use of digital networks. It posits four "simple" capabilities, namely *Choosing Emerging and Enabling Information Technologies (ET), Matching Economic Opportunities with ET, Executing Business Innovation for Growth* and *Assessing Customer Value* (Wheeler, 2002). In short, Wheeler (2002) theorises that the strengths of these simple capabilities and their interconnecting routines and communication processes distinguish organisations' abilities to turn "net-enabled" business innovations into customer value (Wheeler, 2002). This is illustrated in Figure 3.7.

Specifically, Wheeler builds an empirically-testable theory based on the Dynamic Capabilities perspective by adopting Eisenhardt and Martin (2000)'s position that empirical falsification can be achieved by identifying specific processes in terms of their functional relationship to resource manipulation (Eisenhardt & Martin, 2000, p.1108). Eisenhardt and Martin (2000) maintain that this approach directly addresses Williamson (1999)'s accusation that dy-



(Wheeler, 2002)

Figure 3.7: Net-Enabled Business Innovation Cycle

namic capabilities are not empirically grounded. Thus the criticism of separation from empirical reality may be addressed by suitable research design and theory formulation (Butler & Murphy, 2008, p.7).

Attempts have been made to deal with the definitional problems with the RBV. An example is Fahy (2000, p.98)'s attempt to to organise resources (as defined in very broad terms by Barney (1991a)) into three categories: *Tangible assets, Intangible assets and Capabilities.* Fahy (2000, p.97), like Barney (1991a), advocates the use of the label *resources* as an all-embracing term in an effort to reduce ambiguity, though acceptance of resources as a global term is by no means universal. For example, Butler and Murphy (2005) treats resources and capabilities as distinct terms. Fahy (2000)'s attempts to classify resources are summarised in Figure 3.2.

Related to the definitional issues is the issue of tautology. This issue, where some of the definitions underlying RBV are circular, is countered by Barney, who states that Priem and Butler's criticism can in fact be levelled at strategy theory in general. Barney, in a manner recalling Cockburn et al. (2000)), goes on to assert that all theories in strategic management are tautological in the

Table 3.2: A classification of the firm's resource pool

	The firm's resource bundle		
Author	**Tangible assets**	**Intangible assets**	**Capabilities**
Wernerfelt (1989)	Fixed assets	Blueprints	Cultures
Hall (1992)		Intangible assets	Intangible capabilities
Hall (1993)		Assets	Competencies
Prahalad and Hamel (1990)		Core competencies	
Itami (1987)			Invisible assets
Amit and Schoemaker (1993)			Intermediate goods
Selznick (1957); Hitt and Ireland (1985); Hofer and Schendel (1978)			Distinctive competencies
Irvin and Michaels (1989)			Core skills

(Fahy, 2000, p.98)

manner that Priem and Butler (2001a) describe ... *the ability to restate a theory in ways that make it tautological provides no insights about the empirical testability of the theory whatsoever.* (Barney, 2001, p.41).

Barney goes on to make the point that it must be possible to parameterise at least some elements of any theory in such a way as to make it possible to generate empirically testable assertions (Barney, 2001, p.42). Barney, who clearly regards himself as a theorist (*"If I had felt compelled to include an empirical test for every theoretical paper I have written, there would been not much theory developed."* (Barney, 2005, p.298)) thus leaves it to the researcher to determine empirically meaningful definitions of valuable, rare inimitable and non-substitutable resources. Therefore it falls to the researcher to resolve any issues of ambiguity and tautology.

Tautology also exhibits itself as circular reasoning concerning the antecedents of sustainable competitive advantage. This circularity is explicated by Wang and Ahmed (2007, p.33), who argue that core capabilities are identified by observing superior performance and then attributing that performance to a capability or capabilities that are then deemed to be "core." Williamson (1999, pp1092-1094) succinctly states the underlying problem that the RBV is based on ex post rationalisation. This constrains the RBV to being a descriptive framework with little predictive power.

A final criticism of the RBV, as represented by the framework illustrated in Figure 3.6, is that it only represents a single moment in time. It does not encompass the development and maintenance of capabilities, nor does it explain how core capabilities may become core rigidities if the firm's external environment changes. This reflects the view in the literature that the RBV is rather static (Priem and Butler (2001a, p.22), Newbert (2007, p.123), and Wang and Ahmed (2007, p.33)). This static view evolved despite discussion in Dierickx and Cool (1989a) of the the accumulation, maintenance and erosion of assets over time and Leonard-Barton (1992, 1995)'s discussion of core capabilities and their transformation, over time, into core rigidities. Given a static set of valuable, rare, inimitable and nonsubstitutable resources, nevertheless Sustained Competitive Advantage is unlikely in rapidly changing markets (Eisenhardt & Martin, 2000; Wang & Ahmed, 2007) because changes in the external environment can make core capabilities irrelevant (Wang & Ahmed, 2007; Leonard-Barton, 1992).

In conclusion, the usefulness of the RBV would appear to be limited by its rather static viewpoint and its assumption of an unchanging external environment. In addition the RBV appears to suffer from definitional problems where resources, capabilities and sustained competitive advantage tend to be defined in rather fuzzy and circular terms. On the face of it, this makes the RBV impractical for application at the empirical level. In its original form it is not practical for application to the issue of ES implementation and competitive advantage. In short, there is a need for an applied theory that is empirically testable and that avoids the criticisms of the RBV. A useful development of the RBV is the Dynamic Capabilities Framework, which directly addresses the definitional issues, simplifying assumptions and static viewpoint of the RBV. DCT in turn leads to the development of empirically relevant applied theory.

The next section explores DCT and its development from the RBV.

3.6 DCT

This section addresses DCT as both a development of the RBV and a solution to some of its shortcomings. It starts by briefly introducing DCT and the VRIO framework as answers to some of the criticisms of the Resource Base View.

It goes on to question whether the VRIO is sufficient to deal with the static nature of the RBV and synthesises a slightly different framework where rarity is contingent on inimitability, non substitutability and time.

Two approaches have extended and emerged from the RBV framework to address apparent shortcomings: The first approach is described by Teece et al. (1997), who address some of the criticisms of the RBV by introducing a *Dynamic Capabilities* (DC) perspective which builds on the previous work of Schumpeter (1934), Penrose (1980), Barney (1986) and others. In addition to its conceptualisation of *resources* as firm-specific assets that are difficult to replicate, the DC framework also encompasses *products, organisational routines* and *dynamic capabilities* (Teece et al., 1997). Dynamic capabilities are *"the firm's ability to integrate, build and reconfigure internally and externally focused competencies to address rapidly changing environments"* (Teece et al., 1997).

The rationale behind Teece et al. (1997)'s Dynamic Capabilities Framework is that the accumulation of valuable and hard-to-copy resources is not of itself sufficient to procure increased rents over an extended time (Teece et al., 1997, p.515). Firms that are responsive to market changes, that can innovate new products quickly and that possess the management skill to redeploy their capabilities are most likely to succeed in the marketplace (Teece et al., 1997, p.515). It is thus possible to discuss an organisation's competitive potential in terms of its ability to use its own Dynamic Capabilities to reconfigure its resources and other capabilities to accommodate and take advantage of external environmental changes.

Teece et al. (1997)'s Dynamic Capabilities Framework thus moves away from the static nature of the RBV by positing Dynamic Capabilities that can modify other resources and capabilities and are themselves changing over time: A Core Capability can avoid the ultimate fate of becoming a Core Rigidity by reconfiguring itself as and when changes in external conditions demand it (Leonard-Barton, 1995). Eisenhardt and Martin (2000) expand on Teece et al. (1997) by further defining Dynamic Capabilities as those strategic and organisational routines which managers use to modify the resource base (Eisenhardt & Martin, 2000, p.21). This addresses some of the definitional vagueness surrounding the RBV.

Furthermore, Eisenhardt and Martin (2000, p.1106) make several observations about Dynamic Capabilities which seek to address the criticisms which have been levelled at the RBV. Namely, in an effort to address Priem and Butler

(2001b)'s criticisms, Eisenhardt and Martin (2000) assert that Dynamic Capabilities are neither *"vague nor tautologically defined abstractions."* This position is justified by stating that,

> *"Dynamic capabilities consist of* ***specific strategic and organisational processes*** *like product development, alliancing, and strategic decision making that create value for firms within dynamic markets by manipulating resources into new value-creating strategies ... [they] consist of* ***identifiable and specific routines*** *that often have been the subject of extensive empirical research in their own right outside of RBV"* (Eisenhardt & Martin, 2000, p.1106, p.1107)

(Researcher's emphasis)

The second approach is Barney (1997, p.173)'s VRIO framework, illustrated in Figure 3.5 and extended in Figure 3.6 by reference to Clemons and Row (1991) and Leonard-Barton (1995) . If an organisation exploits a resource or capability that is not valuable, then the effort expended may put that organisation at a competitive disadvantage. However, if that resource or capability is valuable, then at the very least it may be deemed a competitive necessity.

If the resource or capability is fairly common, i.e. the organisation's competitors also possess it, then at best the resource will be necessary to stay in competition but not sufficient to achieve superior rents . However, if the resource or capability is rare as well as being valuable, then the organisation may gain a temporary competitive advantage from using it as, at the very least, its competitors will have to catch up.

It is possible that other organisations may be able to imitate a rare resource or capability, in which case any competitive advantage obtained is temporary. However, if the resource or capability is also difficult or expensive to imitate or substitute, then then the competitive advantage is sustained as it will be difficult if not impossible for competitors to imitate it or find a suitable substitute for it.

However, Barney (1997, p.172) points out that it is not sufficient for an organisation to possess *Valuable, Rare* and *Inimitable* resources (the VRI in VRIO) to gain Sustained Competitive Advantage. In addition, that organisation must possess the capability to deploy and (re)configure those resources in an ever-changing environment to ensure that Competitive Advantage is achieved and sustained. Barney (1997) also states that, as well as possessing the appropriate resources and capabilities, the organisation must be in a position to exploit them (the O in VRIO) (Barney, 1997, p.173). This point is emphasised by Newbert (2007), who states that as well as possessing the requisite valuable, rare, inimitable and non-substitutable resources and capabilities, an organisation seeking a competitive advantage must also be able to reconfigure them so that their full potential is realised (Newbert, 2007, p.124). Eisenhardt and Martin (2000) agree, stating,

> *"The potential for long-term competitive advantage ... lies in using dynamic capabilities sooner, more astutely, or more fortuitously than the competition to create resource configurations that have that advantage ... Long-term competitive advantage lies in the resource configurations that managers build using dynamic capabilities, not in the capabilities themselves. Effective dynamic capabilities are necessary, but not sufficient, conditions for competitive advantage."*
>
> (Eisenhardt & Martin, 2000, p.1117)

Both Teece et al. (1997)'s and Barney (1997)'s approaches have been shown to address the issues of static viewpoint and some issues of definition. Teece and Pisano (1998) decompose Dynamic Capabilities into their constituent processes (or routines) and resources (or assets). They also provide a perspective that the *history* of a Dynamic Capability is important. In particular Teece and Pisano (1998, pp193-212) posit that Dynamic Capabilities are identifiable and specific; they further to outline a framework for identifying those Dynamic Capabilities.

Teece and Pisano (1998)'s Dynamic Capabilities Framework splits dynamic capabilities into three categories: **Processes, Positions** and **Paths**. Managerial and organisational **processes** as "the way things are done" in the organisation. **Positions** are the organisation's current stock of technological and intellectual assets, as well its establishes relations with its customers and suppliers. Finally, **paths** are the strategic options currently open to the organisation as well as the attractive opportunities which lie before it (Teece & Pisano, 1998, p.197). Table 3.3 summarises Teece and Pisano (1998)'s argument concerning processes, positions and paths and their significance for dynamic capabilities.

Teece and Pisano (1998, p.197) set their Dynamic Capabilities Framework in the following context: Capabilities are encompassed by a firm's processes and positions; some are production line, others are more strategic and others cover how functions or processes are integrated. Capabilities that are difficult (or costly) to copy are distinctive. As there is no market for distinctive capabilities, they cannot be bought and must be built over time. Distinctive capabilities that are valuable are said to be Core (Mata et al., 1995). Dynamic capabilities are the subset of all capabilities that allow the firm to create new products and processes and respond to changing market conditions (Teece & Pisano, 1998, p.197).

Table 3.3: Teece's Dynamic Capabilities model and its antecedents

Element	Detail	Comment	Source
Processes	Integration, Coordination	Integration of suppliers and customers. Coordination of production processes.	Teece and Pisano (1998, p.198,200,201), Leonard-Barton (1995)
	Learning	Repetition and experimentation yield effectiveness and efficiency gains as well as creating new production opportunities	
	Reconfiguration, Transformation	Needed to respond to changing environment. Prevent core competencies from becoming core rigidities	
Positions	Technological Assets	Technology that in itself unique or unique in its usage. Patentable assets. Also difficult to trade knowledge assets	Teece and Pisano (1998, pp201-202)
	Complementary Assets	Necessary supplements to technological assets in development of new products and services	
	Financial Assets	Cash positions, leverage	
	Locational Assets	Unique geographical sites, e.g. favourable supplier clustering	
Paths	Path dependency	Role of history: Transformation to rigidity arises if learning processes are disrupted (e.g. change too large)	Teece and Pisano (1998, pp202-203), Leonard-Barton (1992)
	Technological Opportunity	Firm specific opportunities not available to rest of market	

Using Teece and Pisano (1998)'s Framework, a Dynamic Capability can be expressed in empirically relevant terms by referring to its constituent processes and positions, by elucidating its history and by establishing the technological opportunities that it provides. This is discussed further in the following three Subsections.

3.6.1 Processes

Processes can be decomposed into those *explicit* work routines that have been documented by the organisation, the imposed work routines inherent in some Information Technology and the *tacit* work routines that are not documented but may be elicited by observation and interview. This distinction between explicit and tacit processes is articulated in Z. Lee and Lee (2000, p.282). The concept of work routines, or *organisational routines* is a concept described by Nelson and Winter (1982) and articulated in Butler and Pyke (2004). Such organisational routines are the carriers of the organisation's operational knowledge and delimit the organisations capabilities (Butler and Pyke (2004, p.174), Nelson and Winter (1982, p.99)).

Furthermore, Teece and Pisano (1998) distinguish between business or operational processes - the processes that directly produce the products or services the firm offers - and those *integration, coordination, learning, reconfiguration* and *transformation* processes (Teece & Pisano, 1998, p.198,200,201) that contribute to the dynamicity of Dynamic Capabilities by enabling those capabilities to renew themselves. These processes are important in preventing otherwise valuable Core Capabilities becoming Core Rigidities, per Leonard-Barton (1995).

Pavlou and El Sawy (2010), in distinguishing between *Operational, Improvisational* and *Dynamic Capabilities*, provide some guidance on exploring the nature of such reconfigurations in both turbulent and relatively static market environments. First, *Operational Capabilities* are defined as the ability to derive new products by executing the firm's day-to-day activities (Pavlou & El Sawy, 2010, p.447). Per Leonard-Barton (1992), core rigidities are those operational capabilities that have become outdated. Improvisational and Dynamic Capabilities are then stated as those Capabilities which reconfigure or transform Operational Capabilities (Pavlou & El Sawy, 2010, p.451). Similarly, Cepeda and Dusya (2007, p.426) clearly delineate Operational Capabilities as *"how you earn your living"* and Dynamic Capabilities as *"how you change your operational routines."*

While Pavlou and El Sawy (2010)'s paper focuses on New Product Development capabilities, their discussion of the distinction between Improvisational and Dynamic Capabilities and the varying modes of reconfiguration therein is significant when considering reconfiguration and transformation processes as laid out by (Teece & Pisano, 1998). Table 3.4 articulates the difference: Pavlou

Table 3.4: Improvisational and Dynamic Capabilities, Market Velocity and Reconfiguration Modes

	Improvisational capabilities	Dynamic capabilities
Dealing with the environment ("storms" versus "waves")	Unanticipated environmental events, storms, surprising events, failures, and crises	Predicted and anticipated waves and opportunities in the environment
Nature of prior planning	Planned spontaneity	Disciplined flexibility
Nature of activities	Highly unstructured, urgent, emergent, intuitive, and impromptu activities	Judicious, systematic, stable, and disciplined activities
Logic of competitive action	Logic of "spontaneous responsiveness"	Logic of "planned opportunity"
Time gap between planning and execution	Small gap between planning and execution, narrow "window of opportunity," and inadequate time for formal planning	Sufficient time gap between planning and execution that allows adequate time for formal planning and execution
Limits of action	Acting outside of existing formal plans	Preplanned range of contingencies
Nature of reconfiguration of operational capabilities	Spontaneous and intuitive reconfiguration of new operational capabilities using available existing resources to respond to an urgent, unanticipated, and novel situation	Planned and deliberate reconfiguration of new operational capabilities using predetermined existing resources that related to an anticipated opportunity
Major vulnerabilities	Extreme caution, unwillingness to take risk, extreme confidence in acting without plans	Unwillingness to deal with rigidities, extreme confidence in formal planning
Common misconceptions	Chaotic activities that are completely different from other organizational capabilities, not repeatable, and cannot be enhanced with practice	All capabilities that reconfigure operational capabilities fall into the realm of dynamic capabilities
Déjà vu versus novelty	Novel situations cannot be readily dealt with using existing resources and require creative leveraging for the novel situation	Novel opportunities can be largely addressed with existing resources that are programmed for specific situation
Reliance on individuals	Individual initiatives have a substantial impact on improvisational capabilities	Individual initiatives have a lesser impact on dynamic capabilities
Desirable people qualities	Resilience and recovery skills, creativity, spontaneity, and intuition	Disciplined flexibility, ability to learn and act quickly and judiciously
Analogies	Jazz, improvisational theater, rugby	Race car driving, football

(Pavlou & El Sawy, 2010, p.452), researcher's emphasis

and El Sawy (2010) contend that Improvisational Capabilities apply in turbulent environments, where market velocity is high, while Dynamic Capabilities apply where market turbulence is low. Eisenhardt and Martin (2000, p.1115) also distinguish between dynamic capabilities in moderately dynamic versus high velocity markets, noting in particular that Dynamic Capabilities in turbulent markets tend to be simpler.

It follows, then, that the reconfiguration and transformation processes to be observed as a component of Dynamic Capabilities are different depending on the velocity of the market. In Table 3.4, the nature of reconfigurations in less turbulent markets tend to be systematic, disciplined, preplanned and related to anticipated changes in the market (Pavlou & El Sawy, 2010, p.452). Conversely, in turbulent markets, reconfigurations are spontaneous (though not unplanned), intuitive and framed as responses to urgent and unexpected situations (Pavlou & El Sawy, 2010, p.452). Examination of reconfiguration and transformation processes therefore must be informed by the nature and velocity of the market in which the organisation operates.

3.6.2 Positions

Positions can be classified as novel or unique technological assets (including IT) and the knowledge required to function effectively within the organisation, by performing certain work routines and utilising certain technological assets. Dierickx and Cool (1989a, p.1505) refer to such assets as *firm-specific* and nontradeable, going on to point out that such assets are required for the successful implementation of a strategy. In addition, because these assets are nontradeable, they must be accumulated internally (Dierickx & Cool, 1989a, pp1505-1506). In the case of technological assets, these could be patented technologies developed over time, for example. For complementary assets, these could be the knowledge and experience of employees, accumulated over a period of years.

Positions may be subdivided into *tangible assets* and *intangible assets* (Butler and Murphy (2008, p.6), citing Butler and Murphy (1999)). Butler and Murphy (2008) note that while certain technological assets may confer no strategic advantage (Carr, 2003), the knowledge that created and configured those assets may in fact be firm - specific (Nordhaug, 1994) and any novelty in their configuration (Wade & Hulland, 2004) may give them strategic value Butler and Murphy (2008, p.6). Crucially, Butler and Murphy (1999) note that *"while an IT architecture is a tangible asset or resource, the knowledge used to build, operate and maintain this resource may be conceptualized as an intangible complementary asset"* (Butler & Murphy, 2008, p.6). Thus the particular usage of an Information System (including an ES) within an organisation may be construed as an intangible asset that may in itself be valuable if that usage is novel and specific to that organisation.

3.6.3 Paths

Paths are subdivided into *Path Dependencies* and *Technological Opportunities*. **Path Dependence** is a concept of Evolutionary Economics introduced by David (1985). The concept of Path Dependence is quite broad in scope (David, 2007): Both Teece and Pisano (1998, p.203) and David (2007) note that the term Path Dependence is closely associated with the phrase "History Matters." However such a broad application of the concept of Path Dependence, while trivially true, is not useful for analytic purposes.

Beyer (2010) neatly summarises David (1985)'s introduction of the concept of Path Dependence by articulating the concept as a potentially suboptimal long-term stabilisation of a technological innovation, even if the rationale for that innovation has long since become redundant (Beyer, 2010, p.2). The technology is thus locked in by historical events (Arthur, 1989). Furthermore, technologies that gain an early advantage may benefit from a positive feedback loop where early small advantages increase the rate of adoption, which in turn extends the advantage and thus drives further adoptions (Arthur, 1989, p.116). Learning and coordination effects can also reinforce that technology's advantage (Beyer, 2010, p.1).

While Arthur (1989) attributes increasing rents as the sole factor in path-dependent stabilisation, David (1986) attributes such stabilisation to economies of scale, technological interdependencies and also the non reversibility of certain changes, mainly for economic reasons (Beyer, 2010, p.2). Teece and Pisano (1998, p.203) contend that an organisation's future activities are dictated by its previous investments and the routines it has developed to date. While the history of a dynamic capability may dictate how costly it is for other organisations to copy, path dependence effects may make it prone to becoming a core rigidity (Teece and Pisano (1998, p.203), citing Leonard-Barton (1992)).

3.6.4 Summary

DCT clearly contains a time - dependent element that is missing from the RBV: Teece and Pisano (1998)'s inclusion of Path Dependencies, Technological Opportunities, Learning, Reconfiguration and Transformation Processes indicates that the history and future of a Dynamic Capability are both important, as well as those organisational routines that permit a Dynamic Capability to reconfigure a firm's resources (and itself) to meet changing market and environmental conditions. This a Core Dynamic Capability, as well as being valuable, rare and expensive to copy, must also possess the means to keep itself valuable, rare and hard to copy over an extended period of time. The minute a Capability ceases to be Dynamic, it becomes a Rigidity (Leonard-Barton, 1995) and becomes at risk of losing its value, rarity and inimitability. In other words, it ceases to be Core.

DCT has predictive power: Teece and Pisano (1998) asserts that a firm's **strategic capability** at any point in time is dependent on its processes, positions and paths. Furthermore, it is asserted that the organisation's performance given certain environmental changes is predictable once all of these components and their relationships are understood. The firm's strategic capability is essentially the sum of the opportunities and constraints imposed upon it by its dynamic capabilities, namely its processes, positions and paths (Teece & Pisano, 1998, p.204).

Any activity that affects a firm's dynamic capabilities, i.e. its processes, positions and paths, is likely to affect its strategic capability and by inference its ability to gain and maintain a competitive advantage in the marketplace. In other words, distinctive dynamic capabilities yield competitive advantage if they are difficult to imitate. Furthermore, if these capabilities and the routines, assets, paths and skills on which they depend are valuable, they will yield a competitive advantage and generate rents Teece and Pisano (1998, p.205) and Mata et al. (1995). These capabilities, which may be described as Core Dynamic Capabilities, will yield sustainable competitive advantage if the constituent learning, reconfiguration and transformation processes enable them to adapt to market change.

In conclusion, DCT extends and improves the RBV by introducing the concept of capabilities that change both assets and themselves over time in order to meet the demands of a changing market. DCT also provides a resolution to the problem of Core Capabilities become less relevant over time: A Core Dynamic Capability avoids irrelevancy by driving resource reconfigurations both elsewhere and within itself to remain both valuable and rare. Its inimitability is maintained because of the history it has accumulated which makes it in turn costly to copy.

The next section addresses the role of ES in Core Dynamic Capabilities as a means to understanding how an ES implementation affects stakeholder expectations..

3.7 Conclusion: Towards Understanding the Role of ES in Core Dynamic Capabilities

This section articulates the need to understand the role of ES in the core dynamic capabilities of an organisation. In trying to understand how an ES implementation influences whether stakeholder expectations are likely to be met, the interplay of the organisation's capabilities and the changes wrought by the use of a new ES needs to be understood.

3.7.1 Configuration, Customisation and Capabilities

Leonard-Barton (1995) argues that *Core* capabilities deliver competitive advantage for firms, since they have been built up over time and cannot be easily imitated. *Supplemental* capabilities add value to core capabilities but are imitable and so will diminish as distinctive value-creators over time. *Enabling* capabilities are necessary but not sufficient to distinguish an organisation from its competitors and effectively constitute the body of activities required to stay in the market.

As has already been seen, an ES implementation can be either configured or customised. ES customisation, which is expensive, ensures a much closer fit with canonical processes whereas ES configuration tends to be cheaper. Therefore an ES should only be customised to fit those processes which embody the core capabilities of an organisation. These core capabilities are likely to yield a sustained competitive advantage, thus maximising a return on investment.

An ES by its nature may also influence supplemental capabilities. Supplemental capabilities yield only a temporary competitive advantage and so the scope for a large return on investment is more restricted. Therefore, extensive customisation of an ES to fit with supplemental capabilities is likely to be a waste of money.

Enabling capabilities are those capabilities required to stay in the market. They are not rare, nor are they imperfectly mobile and they can be imitated. They, are, however, valuable and they may lead to competitive parity. An ES implementation should not negatively influence enabling capabilities, but nor should it attract excessive expenditure in this area. Any ES implementation is likely to yield a low ROI (if any) if only enabling capabilities are affected.

3.7.2 ES Implementation Issues

Several issues concerning the implementation of ES, namely integration, customisation and institutionalisation, were raised earlier. There is also an issue of the commoditisation of IT (Carr, 2003) and the encapsulation of best practices in convenient software packages (Z. Lee & Lee, 2000). In short, it is not clear how the implementation of an ES, with its tendency to impose prepackaged processes and eliminate variation, can allow an organisation to develop its distinctive competencies in a manner that permits it to sustainably create and capture value. This problem was highlighted in Chapter 2, where the possibility of examining ES post - implementation usage was mooted.

If the implementation of an ES transforms an organisation's Core Dynamic Capabilities, then the organisation has gained the ability to capture and generate value over an extended period of time as those capabilities are valuable, inimitable, non-substitutable and exploitable (Barney, 1986). However, if the ES implementation only transforms enabling capabilities, then, while they may be necessary to maintain competitive advantage, they will not be sufficient. Finally, if only supplemental capabilities are transformed, then the competitive advantage gained will only be short-term as those capabilities, while valuable, are imitable. If an ES commiditises processes that were previously unique, then any dependent competitive advantage is by definition no longer sustainable.

The implication of DCT is that an organisation that enhances its core capabilities will therefore improve its competitive position in the marketplace, perhaps even enhancing its ability to maintain a sustained competitive advantage over its competitors. In the case of public sector organisations, this can be observed as an enhancement in the organisation's ability to meet or exceed the targets set down by the regulator.

3.7.3 Core Capabilities

One of the key issues at the centre of DCT is Core Capabilities and their influence on Sustained Competitive Advantage. Studying (or even defining) Core Capabilities poses a knotty issue for researchers, as by their nature they are difficult to both identify and define. Accusations of vagueness, tautology and circularity have been levelled at the RBV, and to a certain extent, DCT. A typical argument is that Dynamic Capabilities are defined as those capabilities that lead to Sustained Competitive Advantage. The problem with this definition is that it limits the researcher to ex post analyses of ES implementation and in addition it exposes the researcher to accusations of cherry picking those capabilities that led to the subsequent sustained competitive advantage and thus labelling those as core.

Core capabilities are inherently sticky and hard to spot, otherwise they would not be inimitable. Paradoxically, this may present an opportunity for the researcher to successfully identify them in the field without resort to examining any presumed subsequent sustained competitive advantage.

3.7.4 ES and Core Dynamic Capabilities

Any ES implementation is contingent on an examination and possibly a re-engineering of existing business processes. In addition an ES implementation project needs to determine early on whether the tacit processes inherent in the ES are going to be adopted wholesale or whether an extensive customisation exercise will be undertaken to match the ES to existing business processes. Consequently there are a number of forces at work here:

- Explication of internal tacit processes as part of the BPR exercise associated with ES implementation;
- Adoption and integration of tacit processes as part of the ES bundle;
- Re-engineering of internal tacit and explicit processes;
- Customisation of ES bundles to match desired processes.

A narrative that attempts to explain the role of ES in Dynamic Capabilities needs to clearly specify the dynamic capabilities that are relevant to the object of the study. It then needs to specify the footprint of the ES on those Dynamic Capabilities as well as explaining how introducing the ES has transformed the future opportunities that form part of those capabilities. There are clues to the appropriate theory and application in Mata et al. (1995), Teece and Pisano (1998) and Wheeler (2002). However the problem with DCT based narratives to date has been a tendency to analyse capabilities after the fact and reason that those capabilities which contributed most to value are the once that may be considered Core. This approach offers no predictive power and weds DCT to the idea of Sustainable Competitive advantage in a manner that is not useful.

To sidestep such *post hoc* reasoning, such a narrative can examine the influence of ES on the reconfiguration and transformation processes inherent in Dynamic Capabilities. In low turbulence markets, observable reconfiguration and transformation mechanisms will include planned and deliberate rearrangement of existing resources to meet expected opportunities (Pavlou & El Sawy, 2010, p.452). Such reconfigurations must be considered in light of the inherently integrative and coordinating nature of ES.

Finally, Besson and Rowe (2012) make a number of recommendations for research in the area of Organisational Transformation (OT), in particular, *IS-enabled OT* (Besson & Rowe, 2012, p.103). OT is described as a process, not a staged diffusion model (Besson & Rowe, 2012, p.108) and it is suggested that IS research around such transformations should focus on such transformation processes (Besson & Rowe, 2012, p.114). Thus any study built on DCT as stated by Teece et al. (1997), Teece and Pisano (1998), Eisenhardt and Martin (2000) and Pavlou and El Sawy (2010) should focus on these processes. This echoes the need articulated by Ray, Muhanna, and Barney (2005) and Pavlou and El Sawy (2006) to conduct future studies at the process level of analysis.

The next chapter therefore proposes an examination of public sector organisations, where market forces and competitive pressures are embodied as regulatory pressures and thus well defined and represent a relatively low turbulence market. In this case core capabilities can be defined in part as those capabilities that allow a public sector organisation to beat the demands of the regulator over time. Because the pressures applied by the regulator are well defined and articulated, core capabilities may be identified without resorting to longitudinal searches for sustained competitive advantage. In addition, reconfiguration mechanisms (that keep Capabilities Core and prevent them from becoming Rigidities) may be examined at the process level, as well as the role of the ES in facilitating those mechanisms by coordinating and integrating process across functional boundaries. The next chapter explores the possibility of evaluating the role of ES in Core Dynamic Capabilities in this context and presents a research approach and framework for doing so.

Chapter 4

Research Methodology

4.1 Introduction

This chapter specifies a suitable research approach so that the role of Enterprise Systems (ES) in Core Dynamic Capabilities may be determined. Chapter 2 concludes by stating that the role of ES in achieving a competitive advantage is still poorly understood and that research on ES implementation in the public sector is sparse. Chapter 3 introduces the Resource Based View (RBV) and Dynamic Capabilities Theory (DCT) as a suitable theoretical lens through which to investigate the issues raised in Chapter 2. In addition, Chapter 3 notes that Dynamic Capabilities Theory (DCT) is a *molar* theory and therefore requires adaptation as an applied theory to be empirically useful.

Against this background, this chapter puts forward a Research Objective and Research Questions to examine the role of ES. As the research is exploratory and explanatory in nature, a case study approach is proposed. While Dynamic Capabilities Theory is a suitable theoretical lens for examining the role of ES in Core Capabilities, it is necessary to isolate examination of Dynamic Capabilities from the logic of Sustainable Competitive Advantage. Many studies of Sustainable Competitive Advantage lead to *post hoc* rationalisations of which dynamic capabilities produced an enduring advantage, well after the fact. This approach has little predictive power and is vulnerable to accusations of logical fallacy.

In order to discuss the application of DCT to the role of ES in Core Capabilities, it is useful to sidestep the logic of Sustainable Competitive Advantage and examine a setting where the present and future competitive environment is relatively predictable. This chapter proposes that public sector utilities provide such an opportunity because of the highly regulated environment in which they operate. It illustrates that DCT is applicable to public sector organisations and concludes by showing that the study of an ES implementation in such an organisation, using DCT as a theoretical lens, can shed some light on the role of ES in contributing to the Value, Inimitability, Non-substitutability and Exploitability of Dynamic Capabilities.

Thus this chapter delineates an Applied Dynamic Capabilities Framework for examining the role of ES in the core dynamic asset management capabilities of a public utility organisation. Asset management is selected as an area of interest as public utilities are service rather than manufacturing organisations, where revenues are contingent on the asset base. As well as an applied framework, a research protocol is presented and the research questions are reviewed in the light of this protocol.

This chapter is organised as follows: Section 4.2 states the Research Objective and Research Questions. This is followed by a discussion of the overall Research Strategy in Section 4.3. The chosen Research Strategy is implemented as a Research Design in Section 4.4. The object of the study is introduced in Section 4.5. The application of DCT is discussed in Section 4.6. Data Collection and Analysis are discussed in Sections 4.7 and 4.8. The Research Protocol is outlined in Section 4.9 and the chapter concludes in Section 4.10.

4.2 Research Objective and Research Questions

The goal of the proposed research is to address the shortcomings in the extant literature in addressing the role of ES in Core Dynamic Capabilities. This section introduces the Research Objective and the Research Questions to be answered if that goal is to be achieved. The following Research Objective is proposed:

4.2.1 The Research Objective

To examine whether and how an Enterprise System transforms an organisation's Asset Lifecycle Management Core Dynamic Capabilities.

To meet this Research Objective, the Asset Lifecycle Management activities of the target organisation must be understood. This includes understanding how Asset Lifecycle Management contributes to the organisation's ability either to reduce costs or generate rents, as any resultant dynamic capabilities must at the very least be valuable to be considered core. Asset Lifecycle Management Activities must then be decomposed into processes, organisational routines, technologies and less tangible resources such as the training, skill and knowledge of the the actors involved. This is a prerequisite to determining what dynamic capabilities are inherent in the asset management lifecycle as these are in turn composed of processes, technological positions, people positions and paths. Therefore the history of Asset Lifecycle Management and the histories of its component activities must also be delineated.

This yields a set of Asset Lifecycle Management Dynamic Capabilities, decomposed into processes, positions (technological and people) and paths. Contingent on their value, inimitability, non-substitutability and exploitability (rarity is inferred), a determination can then be made as to which Asset Lifecycle Management Dynamic Capabilities are Core. As the technological resources that partially compose these capabilities has already been determined, the *footprint* of the Enterprise System on those Core Dynamic Capabilities can then be determined.

The footprint of the Enterprise System on a core dynamic capability is the extent to which the processes inherent in that dynamic capability are contingent on the ES itself. Determining the extent of this footprint is essential to determining the role that Enterprise System plays in that core dynamic capability. However the footprint is just a snapshot of the Enterprise System's influence at a point in time. In addition, the effect of the Enterprise System on the exploitability of that core dynamic capability will provide an indication as to whether the Enterprise System will contribute to how dynamic that core capability remains in the future.

With these issues in mind, the following research questions have been formulated to fully address the research objective of explicating the contribution of ES to Core Capabilities:

4.2.2 The Research Questions

Research Question 1: What Asset Lifecycle Management activities are evident in the organisation?

This question is exploratory in nature as it seeks to identify exactly what processes, assets and resources are committed to Asset Lifecycle Management within the organisation. In addition it seeks to identify how some of these assets, processes and resources are related. Finally it seeks to propose a set of *Tentative Asset Management Capabilities* for examination in subsequent Research Questions.

Research Question 2: What Dynamic Capabilities are evident in the Asset Management Lifecycle?

This question is exploratory in nature as it seeks to identify exactly how processes, assets and resources in Asset Lifecycle Management are aggregated into Core Capabilities. This includes determining those integration, learning, reconfiguration and transformation processes that make those capabilities Dynamic. The question builds on those tentative capabilities identified in Research Question 1.

Research Question 3: What is the footprint of the Enterprise System on Asset Lifecycle Management Dynamic Capabilities?

This question is exploratory in nature. Its purpose is to determine the extent of the influence of the Enterprise System on a particular set of Dynamic Capabilities. As these Dynamic Capabilities decompose into Processes, Positions and Paths, this research question consists of mapping the intensity of Enterprise System usage on the start, body and end of each process that composes a Dynamic Capability. As a result the question seeks to clearly delineate the footprint of the Enterprise System.

Research Question 4: What effect do Enterprise Systems have on Exploitability and Renewability?

This question is explanatory in nature: It seeks to isolate those mechanisms by which ES enhance the Exploitability and Renewability of Asset Management Core Dynamic Capabilities. In doing so the questions seeks to identify the mechanisms by which ES make Core Capabilities Dynamic.

To meet the Research Objective and answer the Research Questions, a research methodology must be selected and a sampling strategy determined. The determination of these needs to be set against a background of understanding some of the key issues of Information Systems research, in particular the selection of an appropriate Research Paradigm and the consequences thereof. The next Section 4.3 addresses the Research Strategy to be followed; this is then implemented as a practical Research Design in Section 4.4.

4.3 Research Strategy

This section discusses the strategy to be adopted for successfully answering the Research Questions and thus meeting the Research Objective. The section starts by discussing Information Systems research paradigms in Subsection 4.3.1. The next subsection (4.3.2) discusses the application of a Molar Theory to inform the study. A suitable Research Approach is selected and justified in Subsection 4.3.3. The section concludes by stating the need for the Research Strategy to be implemented as a Research Design.

4.3.1 Information Systems Research Paradigms

This subsection briefly discusses the inquiry paradigms available to the Information Systems researcher, highlighting the distinguishing characteristics of each. The subsection continues by highlighting the significance of the positivist - interpretivist debate for Information Systems research and concludes by discussing the dual nature of Information Systems research and its impact on research approaches.

Information Systems research strategies can be based on a number of different methodological paradigms, some of which are listed in Table 4.1. Historically, the conventional view of science in Western culture has been a **positivist** view which asserts a reality independent of the observer. Galliers (1991) notes that this viewpoint asserts beliefs, emerging from the search for regularity and causality, and then examines them through empirical testing.

The positivist view contends that there is an objective reality, which exists independently of the observer's ability to appreciate it (Galliers, 1991) and can be described by measurable properties that are independent of the researcher

(Myers, 1997). However, a relativist or **interpretivist** view holds that reality is a subjective construction of the observer's mind (Galliers, 1991); the researcher's point of view influences what and how the researcher observes.

While a positivist approach prevailed in the early years of IS research, criticisms of this approach led to the emergence of the intepretivist approach in the 1980s (W. Chen & Hirschheim, 2004). Thus, while a paradigm may be defined as a set of beliefs that represents the researcher's world view (Guba & Lincoln, 2000), it is evident that there is more than one worldview to choose from. The challenge for the researcher is to select the worldview, and all its consequent implications for research strategy and design, that best serves the needs of the proposed study. Guba and Lincoln (2000) seek to clarify the research paradigm question by summarising the basic beliefs that comprise a particular research paradigm as responses to three basic questions of ontology, epistemology and methodology. These are summarised in Table 4.1:

Table 4.1: Basic Beliefs of Alternative Inquiry Paradigms

	Positivism	**Post-positivism**	**Critical Theory *et al.***	**Constructivism**	**Participatory**
Ontology	Naïve realism - "real" reality but apprehensible	Critical realism - "real" reality but imperfectly and probabilistically apprehensible	Historical realism - virtual reality shaped by social, political, cultural, economic, ethnic, and gender values; crystallised over time	Relativism - local and specific co-constructed realities	Participative reality - subjective - objective reality, co-created by mind and given cosmos
Epistemology	Dualist/ objectivist; findings true	Modified dualist/ objectivist; critical tradition/ community; findings probably true	Transactional/ subjectivist; value- mediated findings	Transactional/ subjectivist; co-created findings	Critical subjectivity in participatory transaction with cosmos; extended epistemology of experiential, propositional, and practical knowing; co-created findings

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Table 4.1 – *Continued from previous page*

	Positivism	Post-positivism	Critical Theory *et al.*	Constructivism	Participatory
Methodology	Experimental/ manipulative; verification of hypotheses; chiefly quantitative methods	Modified experimental/ manipulative; critical multiplism; falsification of hypotheses; may include qualitative methods	Dialogic/ dialectical	Hermeneutic/ dialectical	Political participation in collaborative action inquiry; primacy of the practical; use of language grounded in shared experiential context

(Guba & Lincoln, 2000)

Selection of an appropriate paradigm or viewpoint has some significance for Information Systems research. Understanding what constitutes an Information System can inform the researcher which inquiry paradigm and thus research methodology is most suitable.

Information Systems is still regarded as an emerging discipline; the positivist approach was adopted initially in an effort to enhance credibility and also because of the positivist background of early researchers in the field (Checkland, 1981). However, an examination of how an Information System is defined suggests that other paradigms are viable alternatives:

An **Information System** may be defined as,

> *"An aggregation of information technologies, work practices, people and information organised to accomplish goals in an organisation."*
>
> (Alter, 1992, p.7)

This aggregation,

> *"Assembles, stores, processes and delivers information relevant to that organisation in such a way that the information is useful and accessible to those that use it."* (Buckingham, Hirschheim, Land, & Tully, 1987)

Turban, Rainer, and Potter (2003, p.320) state that a *"computer-based Information System"* consists of hardware, software, a database, a network, procedures and people. Land (1991) echoes this point by stating that Information Systems depend on actors using and interacting with them.

Information Systems, therefore, cannot be considered without considering the people that form part of them. Consequently Information Systems is seen as being more closely related to the field of social reality (A. S. Lee, 1991), despite its concerns with new technology, and so sits somewhat uneasily across the engineering and social science disciplines (Avgerou, 2000).

The shift in Information Systems research focus from technological issues to behavioural and social issues brings questions concerning the suitability of research methods to the fore (Avgerou, 2000). The earlier positivistic approach was challenged in 1984 by the IFIP working group studying computers in organisations (Avgerou (2000), citing Mumford (1985)); this gave rise to the emergence of qualitative methods (such as case studies and action research) as against the older quantitative methods such as surveys (Avgerou, 2000).

However, the use of qualitative methods does not preclude a positivistic approach; Shanks and Parr (2003) in particular present a critical analysis of the positivist single case study approach and assert that *"[such] studies provide a sound and systematic approach for conducting research."* (Shanks & Parr, 2003, p.1). This study adopts a **post-positivist** research paradigm: Post-positivism is a modification of the positivist paradigm in that it acknowledges that reality is "real" but imperfectly perceptible (Guba & Lincoln, 2000). The post-positivist paradigm adopts the following positions with respect to the three questions posed by (Guba & Lincoln, 2000):

The ontological question: Reality is "real" but imperfectly and probabilistically apprehensible;

The epistemological question: Findings are probably true;

The methodological question: May include qualitative methods.

Hirschheim (1985, p.32) notes that post-positivism replaces the assertion of knowledge as indisputable with the assertion that *"knowledge claims are simply those that are accepted by the community."* Such claims have the power to convince the research community that they are an improvement of that community's previous understanding (Hirschheim, 1985, p.32). Thus this study seeks to improve the research community's understanding of the role of ES in Core Dynamic Capabilities. The study also seeks to utilise an applied version of DCT as a lens to enhance this understanding. In doing so the study also seeks to deepen the community's understanding of the application and empirical usefulness of Dynamic Capabilities itself. Therefore it is necessary to discuss how DCT, a molar theory as described by Wheeler (2002), may be applied in the case of this study. This is accomplished in the next Subsection 4.3.2.

4.3.2 Application of DCT

Chapter 2 concludes by proposing the RBV and DCT as a basis for examining the role of ES in enhancing organisational performance, as suggested by Melville et al. (2004). However, as is made clear by Wheeler (2002, p.129), an applied theory is required as a specific instance of DCT, which is a molar, or high-level theory. Thus Wheeler (2002) instantiates and presents *NEBIC* as a specific application of DCT.

For the proposed study, an applied framework is required, which derives from DCT, which allows the contribution of ES to Dynamic Capabilities to be examined. The following framework, titled **Enterprise Systems Capabilities Framework** (ESCF) is proposed and is articulated in Table 4.2. This framework is an extension of Teece and Pisano (1998)'s descriptive framework for Dynamic Capabilities in an organisational context, with the addition of the concept of Renewability from Shanks and Bekmamedova (2012), and also relies on a synthesis of definitions of Information Systems as presented by Alter (1992), Buckingham et al. (1987) and Land (1991). Finally, this applied framework draws on elements of the modified VRIO (Value, Rarity, Inimitability and explOitability) framework, presented in Chapter 3, Figure 3.6, and synthesised from Clemons and Row (1991), Leonard-Barton (1995), and Barney (1997):

Table 4.2: Enterprise Systems Capabilities Framework (ESCF)

Component	Observable	Sources
Business Processes	"Factory Floor" / Production / Service Processes directly related to the day to day operations of the organisation.	Teece and Pisano (1998, p.197)
Integration Processes	Combining organisational functions, tighter coupling of business processes across functions, enhanced data sharing. Inherent in ES.	Teece and Pisano (1998, p.198), Davenport (1998), Hitt et al. (2002, p.73), Giachetti (2004, p.1151), Adam and Sammon (2004), Laudon and Laudon (2014, p.369)

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Table 4.2 – *Continued from previous page*

Component	Observable	Source
Learning Processes	Changes to processes as a result of prior events, evidenced by improvements in performance indicators, outputs, value, etc.	Teece and Pisano (1998, p.200)
Reconfiguration Processes	Any process change or reorganisation of assets, especially as an adaptation to external pressures.	Teece and Pisano (1998, p.201), Pavlou and El Sawy (2010, p.452)
Transformation Processes	Replacement of older processes, structures, assets and IT artefacts with newer ones.	Teece and Pisano (1998, p.201)
Technologies	ES applications used. Other Information Systems and Information Technology.	Teece and Pisano (1998, pp201-202)
People	Training undertaken by people executing processes. Their knowledge, skills and experience.	Teece and Pisano (1998, p.202)
Path Dependencies	History of organisation, processes, people and technologies to this point.	Teece and Pisano (1998, pp202-203)
Future Opportunities	Future plans. Anticipated new technologies. Process and organisational changes. Expanded range of future choices due to changes made in the present.	Teece and Pisano (1998, pp203-204)
Value	Increased rents. Reduced costs. ES may also permit or drive valuable reconfigurations.	Penrose (1959), Nordhaug (1994), Mata et al. (1995, pp493-494), Butler and Murphy (1999), Wade and Hulland (2004), Butler and Murphy (2008, p.6)
Inimitability	Contingent on history of organisation and knowledge of its staff. May be contingent of level of customisation of ES or else on specific adaptations to ES.	Dierickx and Cool (1989a, pp1507-1508), Amit and Shoemaker (1993, p.39)
Non-substitutability	Highly specialised capabilities will have no direct substitutes.	Dierickx and Cool (1989a, p.1509), Amit and Shoemaker (1993, p.39)
Exploitability	Dependent on the organisation being in a position to effectively reengineer its processes as needed, to reconfigure its positions and to exploit new opportunities. ES may either hinder this through expense of reconfiguration or drive it by providing essential data.	Barney (1986, p.1240), Peteraf (1993, pp187-188), Barney (1997, pp173-174)
Renewability	A process of continuous reengineering, either facilitated or inhibited by the ES.	Shanks and Bekmamedova (2012)

This applied framework is context - free in that, while it is specific to ES usage, it is not dependent on a specific organisational context. However, organisational context is significant in evaluating responses to external stimuli in general and Value generating processes in particular. A context - specific version of this applied framework is presented in Section 4.4, which addresses the Research Design. Before this, with a post - positivist research paradigm selected and a tractable applied DCT proposed, the specific Research Approach must be addressed. This is discussed in the next Subsection 4.3.3.

4.3.3 Research Approach

In this subsection the process of matching research approach with research objective is discussed: How can the researcher select a methodology that best serves the goals and objectives of the study? The objective of the proposed study is to examine whether and how an ES transforms an Organisation's Asset Lifecycle Management Core Dynamic Capabilities; the purpose of the research is therefore exploratory and explanatory. In addition the research also seeks to elucidate some of the mechanisms through which ES transform Core Dynamic Capabilities; consequently the research methodology must permit the possibility of extension to and application of DCT and the RBV.

In order to identify a suitable research approach, it is necessary to refer to the Research Questions to determine what is being asked and how it is being asked. Understanding these issues will direct the researcher to the best possible approach to answering those questions. Benbasat, Goldstein, and Mead (1987) note that the most suitable research method is dependent on the problem being studied; namely, the type of knowledge required, and the resources that are available to the researcher. Yin (1994) notes that *"the first and most important condition for differentiating between the various research strategies is to identify the type of research questions being asked."*

The Research Questions presented earlier in Section 4.2 indicate that the proposed study is both exploratory and explanatory in nature. It serves the dual purpose of investigating little known phenomena and explaining the forces causing the phenomena in question (Marshall & Rossmann, 1989). Table 4.3, per Marshall and Rossmann (1989), matches appropriate research strategies to research purpose and thus to the Research Questions being asked.

Table 4.3: Matching Research Purpose with Research Methodology

Purpose of the Research	Research Question	Research Strategy	Examples of Data Collection Techniques
Exploratory. To investigate little understood phenomena. To identify / discover important variables to generate hypotheses for further research.	What is happening in this social programme? What are the salient themes and patterns in participants' meaning structures? How are these patterns linked?	Case Study. Field Study.	Participant observation. In-depth interviewing. Elite interviewing.
Explanatory. To explain the forces causing the phenomenon in questions. To identify plausible causal networks shaping the phenomenon.	What events, beliefs, attitudes and policies are shaping this phenomenon? How do these forces interact?	Multi-site case study. History. Field Study. Ethnography.	Participant observation. In-depth interviewing. Survey questionnaire. Document analysis.
Descriptive. To document the phenomenon of interest.	What are the salient behaviours, events, beliefs, attitudes and processes occurring in this phenomenon?	Field Study. Case Study. Ethnography.	Participant observation. In-depth interviewing. Document analysis. Unobtrusive measures. Survey questionnaire.
Predictive. To predict the outcomes of the phenomenon. To forecast the event and behaviours resulting from the phenomenon.	What will occur as a result of this phenomenon? Who will be affected and how?	Experiment. Quasi - Experiment.	Survey questionnaire (large sample). Kinesics / Proxemics. Content analysis.

(Marshall & Rossmann, 1989)

The proposed study requires depth and detail in exploring the role of ES in Dynamic Capabilities. In particular patterns are sought, where patterns of Dynamic Capability enhancement are correlated with patterns of ES usage. To date the relationship between ES usage and Dynamic Capabilities is poorly understood. Thus the framework outlined in Table 4.3 suggests that a case study or multi-site (multiple) case study is the most suitable strategy for the proposed exploratory / explanatory research as it allows the researcher explore what is happening in a particular organisational context.

A single case study approach, where *"the emphasis ... is to highlight a construct by showing its operation in an ongoing social context."* (Dyer & Wilkins, 1991, p.616) is proposed. Noting that more is not necessarily better, Yin (1994) argues that there is no ideal number of cases for any particular research initiative. While Benbasat et al. (1987, p.373) expresses a preference for multiple case studies in certain circumstances, they also note that *"a single case may be used to test the boundaries of a well - formed theory."*

If a single case is to be chosen for study, in order for the findings and conclusions to be meaningful, the sampling strategy must ensure that the selected case adheres to Yin (2003)'s justifications for a single case. Also, Siggelkow (2007) lays down some criteria for a persuasive single case study. In a nutshell, a compelling single case is either:

- A descriptive case that is so extraordinary and rare that it speaks for itself. This is described as a *"talking pig"* by Siggelkow (2007, p.20). Or,
- A case that provides some conceptual insight without necessarily relying on the descriptive aspects of the case itself. The case therefore motivates, illustrates or inspires the theory (Siggelkow, 2007, p.21).

Thus, a synthesis of Siggelkow's and Yin's positions suggests that **a single case study approach, to be compelling, must present an interesting case in support a of a theoretical viewpoint that is in itself freestanding**. In other words, either the case is critical, extreme, unique or exceptionally representative of the phenomenon it purports to describe. In addition that case must serve to reinforce a conceptual insight, while allowing that insight to exist without the case itself.

It remains, then to address the issues of replicability and generalisability, as outlined by A. S. Lee (1989). Single case studies are (wrongly, as A. S. Lee (1989) points out) particularly prone to accusations of being ungeneralisable. However, A. S. Lee (1989, p.41) asserts that a single case study can be generalised only on the basis of being confirmed by additional case studies. These additional case studies would confirm (or refute) the theoretical assertions underpinning the original case study. J. Lee et al. (2003, p.222) expand further on the issue of generalisability, observing that the statistical concept of generalisability is frequently misapplied to the non-statistical, non-sampling research that is carried out using case studies. A.S. Lee's arguments from 1989 and J. Lee's arguments from 2003 move the logic of replication and generalisation from the context and content of the particular case to the theory that the case seeks to confirm.

The naive view is that single case studies are not generalisable. However, Yin (2003, p.32) distinguishes between *"statistical generalisation"* and *"analytic generalisation"* and makes it clear that case studies should not be treated as statistically generalisable. This leaves analytic generalisation as the means by which the findings and conclusions of a single case study may be applied in other settings. Yin (2003, pp32-33) asserts that such generalisation is achieved by using *"Level Two Inferences"* as distinct from the *"Level One Inferences"* made by statistical generalisations. Such Level Two Inferences are made at the level of any theory developed during the case (Yin, 2003, p.31).

Finally, the researcher must determine which methodological approach (quantitative or qualitative) best serves the goals and research objectives of the study. The research questions formulated to meet the research objective imply that the study is both exploratory and explanatory in nature, requiring analysis of the phenomena with regard to the context within which they are observed. Applying a quantitative approach to this study may raise the issue of context - stripping, whereby a focus on one set of variables necessarily excludes another set of variables that may yet have some bearing on the outcome (Guba & Lincoln, 1994). This impairs the generalisability of the study because the findings of the study may only be applied in similarly context - stripped settings (Guba & Lincoln, 1994). A qualitative approach can address this issue by providing contextual information (Guba & Lincoln, 1994).

In conclusion, an analytically generalisable single case study with a post-positivistic viewpoint, informed by an applied version of DCT, is the selected research approach. If this single case study is to be deemed sufficient, **it must be a singular case which permits generalisation to future cases through its theoretical underpinnings**. In addition, if the case is to be replicable, the Research Protocol must be detailed and rigorous. The next Section 4.4 addresses Research Design in detail.

4.4 Research Design

In Section 4.3, a Research Strategy and Research Approach were outlined. The Research Strategy is to adopt a Post - Positivistic viewpoint and modify DCT so it can be applied to a real world setting. The Research Approach is a single case study which may be generalised and replicated on theoretical grounds. This section, in presenting a practical Research Design, addresses the issue of the Unit of Analysis in Subsection 4.4.1, followed by the Sampling Strategy in Subsection 4.4.2. The case itself is briefly introduced in Subsection 4.5, followed by further refinement of the applied Dynamic Capabilties Theory in Subsection 4.6.

Subsections 4.7, 4.8 and 4.9 address the conduct of the case study itself. In doing so they address issues of internal validity, external validity, chains of evidence and generalisability.

4.4.1 Unit of Analysis

In the case of the proposed research, the research approach is a post - positivistic single case study. Therefore, drawing from Galliers (1991), the possible objects of the proposed case study are: *Society, Organisations, Groups, Individuals, Methodologies, Theory Building, Theory Testing* and *Theory Extension*. As the objective of the study is to examine the roles of ES in a particular context, this narrows the range of choices to the *Organisation*, as ES, as defined, are invariably implemented and used in an organisational context. Additionally, case studies also well serve the purposes of Theory Building, Testing and possibly Extension (Galliers, 1991).

The research objective - To *examine whether* and *how* an Enterprise System *transforms* an Organisation's Asset Lifecycle Management Core Dynamic Capabilities - provides some guidance. The objective states clearly that the context is the Organisation. However, the purpose of this study is to focus on that Organisation's Asset Management Lifecycle. Chapter 2 concludes by asserting that the well documented competitive and regulatory environment of a regulated public utility may offer a suitable opportunity for study. As public utilities are service - focused, Asset Lifecycle Management rather than production becomes a major revenue - generating activity. The *pas55.net* website defines Asset Management as the optimum way to achieve a desired and sustainable result. In this case the desired result is increased rents. As Core Dynamic Capabilities are, by definition, value generating (Barney, 1997; Mata et al., 1995), the Unit of Analysis is the **Asset Lifecycle Management Dynamic Capability**, per Cetindamar (2009, p.238). This choice is further justified by the observation by Pavlou and El Sawy (2006, p.198), citing Ray et al. (2005), that a process level of analysis (as opposed to organisation level) is the best level for observing the strategic effects of Information Systems.

4.4.2 Sampling Strategy

In the previous subsection, the Asset Lifecycle Management Dynamic Capability was selected as the Unit of Analysis; this is to be studied in an organisational context. This subsection addresses the Sampling Strategy, namely, which sort of organisation will most likely permit the Research Questions to be answered and the Research Objective to be met. Selecting a case must be done so as to maximise what can be learned in the period of time available for the study (Tellis, 1997). Therefore careful attention must be paid to sampling to maximise what can be learned and to overcome some of the criticisms levelled at the single case study research approach. Patton (1990) offers a comprehensive list of sampling strategies; these are outlined in simplified form in Table 4.4 below. In addition, Patton (1990) states that:

> *"Purposeful sampling ... selects information-rich cases for in-depth study."*
> (Patton, 1990, p.169)

The objective of the sampling strategy is to identify a case that will permit as much generalisation and application as possible to other cases in the field. A **critical case** sampling strategy, which will facilitate generalisation, as described by Patton (1990), is proposed.

Table 4.4: Purposeful Sampling Strategies

Sampling Strategy	Description
Extreme or deviant case	Learning from highly unusual manifestations of the phenomenon of interest.
Intensity	Information - rich cases that manifest the phenomenon intensely but not extremely.

Continued on next page

Table 4.4 – *Continued from previous page*

Sampling Strategy	Description
Maximum variation	Documents unique or diverse variations that have emerged in adapting to different conditions. Identifies important common patterns that cut across variations.
Homogeneous	Focuses, reduces variation, simplifies analysis.
Typical case	Illustrates or highlights what is typical, normal, average.
Stratified purposeful	Illustrates characteristics of particular subgroups of interest; facilitates comparisons.
Critical case	Permits logical generalisation and maximum application to other cases as, if it's true of this case then it's likely to be true of all other cases.
Snowball or chain	Identifies cases of interest from people who know people who know what cases are good examples for study.
Criterion	Selecting all cases that meet some criterion.
Theory-based or operational construct	Finding examples of a theoretical construct of interest so as to elaborate and examine that construct.
Confirming and disconfirming cases	Elaborating and deepening initial analysis, seeking exceptions, testing variation.
Opportunistic	Following new leads during fieldwork, taking advantage of the unexpected.
Convenience	Saves time money and effort. Poorest rationale with lowest credibility. Yields information-poor cases.

(Patton, 1990, pp182-183)

The rationale behind selecting a critical case is to maximise the opportunity for logical, or theoretical, generalisation, as suggested in (Patton, 1990). Since the case is not likely to be a "talking pig," per Siggelkow (2007), it must fulfil other criteria, namely it must be a singular case that permits in-depth analysis. In addition, this case must be amenable to analysis using a context - bound application of DCT.

In its concluding paragraphs, Chapter 2 notes that the performance of a public sector utility can be expressed clearly in terms of its ability to meet or exceed the expectations clearly laid down and documented, in considerable detail, by the regulator. Thus, public sector utilities present an opportunity for further research on the role of ES in improving organisational performance by increasing their ability to meet or exceed the expectations of their stakeholders. Stakeholder expectations for a public utility in a regulated open market are well defined by virtue of the regulator publishing extensive documentation on the parameters within which the utility must perform. While DCT is largely an inwardly - focused view of firm performance, consideration must still be given to the environment in which the firm performs. As the public utility competitive environment is well defined and relatively stable, a public sector utility is an ideal candidate for study using DCT.

However, this is not sufficient to guarantee the case is critical or singular. Therefore, some consideration must be given to which public sector utility should be elected. The public utility market consists of established operators and newcomers. While there are many newcomers, in an Irish context, there is only one established operator. In the case of Ireland, this operator was the only electricity generator, distributor and supplier up until market opening in 2000. This operator is a singular, or critical case as the market opening process forced the organisation to separate its customer supply, generation, transmission and distribution operations. It is burdened and constrained by its history in a way that no other nervy company in Ireland is.

The selected case for study is therefore EnerDist, an electricity distributer and supplier which implemented the SAP R/3 Enterprise System in 2000 and onwards. The next Section 4.5 briefly introduces the case.

4.5 The Case of EnerDist

EnerDist is a public service electricity utility in Ireland. Its remit is to distribute electricity at 10 kilovolts (kV), 20kV and 38kV throughout Ireland. It is also responsible for connecting residential and commercial subscribers to the electricity grid. In addition, in some cases, it is responsible for connecting electricity generators to the grid. Electricity transmission at 110kV and higher is largely the responsibility of another public service utility, EnerTrans.

EnerDist's predecessor, EnerCo was set up in 1927 by government act in the same year. The first significant power generation project started two years earlier in 1925. This was the Ardnacrusha hydroelectric power scheme on the river Shannon, which is still operational at the time of writing. Other significant generating stations added subsequently were Turlough Hill pumped storage in 1974, Moneypoint coal in 1987, the Poolbeg gas upgrade in 2000 and the Aghada gas upgrade in 2010. As well as these large facilities, there are a number of smaller peat-fired generating stations in the midlands. As of 2013, a significant number of wind farms also exist.

EnerCo existed as a monolithic entity from 1927 until 1998. From its inception until 1998, the EnerCo was the sole generator, transmitter and distributor of electricity in the state. As part of a market opening exercise, EnerCo since 1998 has split into a number of separate companies with distinctly different briefs:

EnerCo Customer Supply Ltd Supplies electricity and gas directly to end users and so is the company in EnerCo Group most visible to consumers. As of 2010 it had 1.4 million connected customers.

EnerDist The object of this study, it is responsible for connecting customers and metering services, regardless of supplier. Also concerned with other customer services associated with the construction, operation and maintenance of the electricity distribution network. Thus EnerDist is a **Distribution Service Operator (DSO)**.

EnerCo International An international electricity company which is involved in the construction and operation of power generation infrastructure outside Ireland. Also involved in engineering design, construction management and strategic consultancy services to clients in Ireland (including EnerDist) and to the power sector worldwide.

EnerCo Power Generation Owns and operates generating stations in the Republic of Ireland with an installed capacity totalling approximately 6GW in 2013.

EnerCo Telecoms Existing to exploit telecommunications market opportunities, EnerCo Telecoms has built and owns a 1,300 km national fibre optic network, comprising a 48-core fibre wrapped around the EnerCo High Voltage Network that links various Metropolitan Area Networks in various mayor Irish cities.

EnerTrans Not an EnerCo Group company but a separate public service entity responsible for the 110kV and higher voltage transmission network as well as international connectors. EnerDist remains the Transmission Asset Owner for the transmission network, while EnerTrans acts as a Transmission Service Operator (TSO).

EnerDist, which is part of EnerCo Group and is the focus of this study, exists as a direct result of the market opening exercise conducted by the Irish government from 1998 to 2000. This includes the inception of an independent regulator, the Commission for Energy Regulation (CER). Given Ireland's small population of no more than 4.5 million people, introducing other electricity distributors into the market was impractical. Therefore the regulator established a price control and performance regulation mechanism by benchmarking EnerDist primarily against 12 similar Distribution Service Operators (DSOs) in the UK and comparable DSO in Europe and the US.

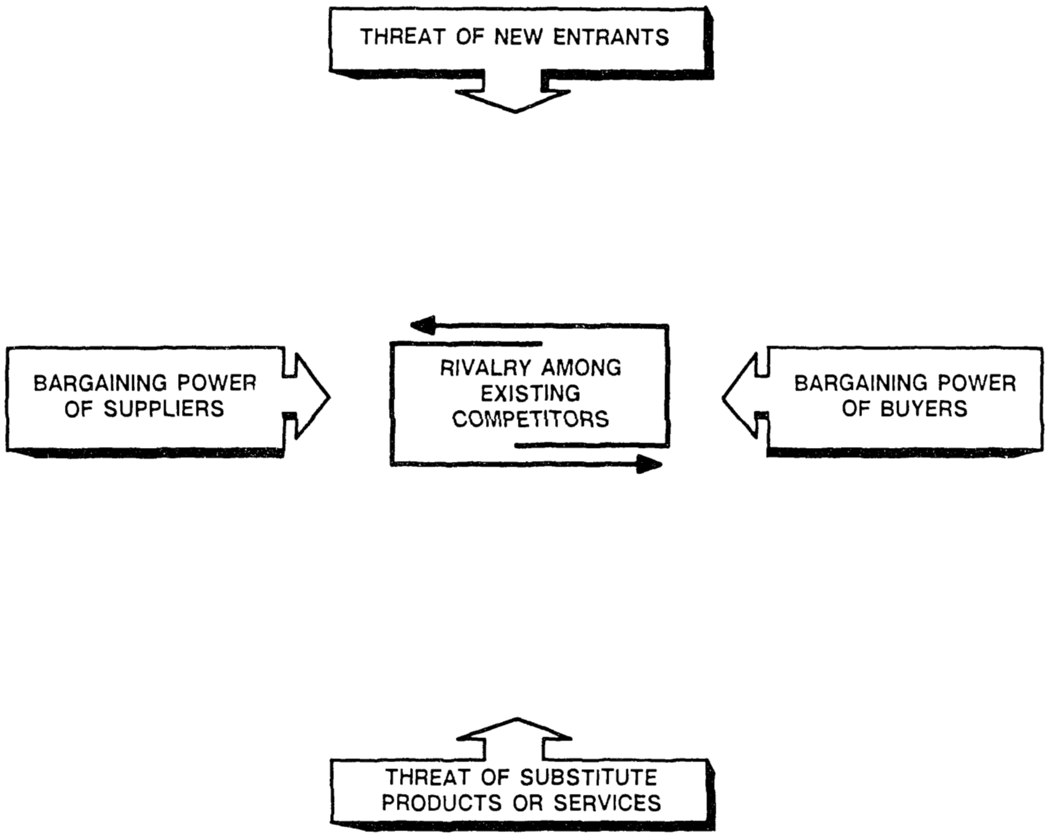
The CER effects competition by proxy by requiring EnerDist to meet or outperform price, reliability, performance and safety benchmarks synthesised from analysis of DSOs in the UK. The regulator mechanism is encapsulated a Pricing Round (PR) agreement, each of which has a validity of 5 years. To date there have been two complete pricing rounds, PR1 from 2000 to 2005 and PR2 from 2006 to 2010. PR3 runs from 2011 to 2015. The pricing rounds impose a maximum tariff for distribution that EnerDist can charge. In addition each PR mandates limits on operational and capital expenditure and returns on EnerDist's asset base.

It is important to understand the market context within which EnerDist operates. This is best illustrated using the **Five Forces Model**, as articulated in Porter (1980), Porter (1991, p.101) and elsewhere, and illustrated in Figure 4.1.

EnerDist's specific context is illustrated in Figure 4.2. It has already been noted that EnerDist has no direct competitors because of the small size of the Irish market. Therefore, as Figure 4.2 illustrates, there are no real threats either from new entrants or from substitute products or services: It is highly unlikely that a new entrant would go to the extraordinary expense of building a competing distribution grid and there is no substitute for that grid unless a hugely disruptive, paradigm - shifting technology emerges to supplant it.

Threats from suppliers and customers are moderated by the Commission for Energy Regulation (CER), as far as EnerDist is concerned. For suppliers, the cost of carrying their electricity on the distribution grid is fixed as Distribution Use Of Service (DUOS) and determined by the CER. For customers, the price paid per unit of electricity carried is also governed by the DUOS pricing mechanism, also determined by the CER. The CPI-X (Consumer Price Index minus an amount X) pricing mechanism also applies for customers. This determines the cost per unit of electricity that must be paid by those customers' domestic and commercial end users, who are in effect indirect customers of EnerDist.

The threat of rivalry among existing competitors is also moderated by the CER,

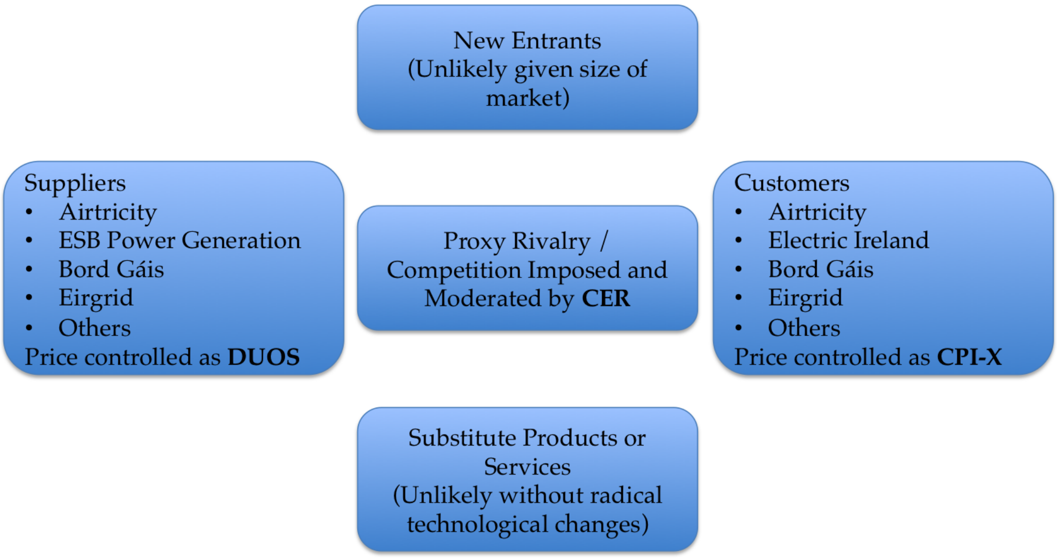


(Porter, 1991, p.101)

Figure 4.1: Porter's 5 forces: A summary of the key drivers

as EnerDist has no direct competitors. Such proxy competition is imposed by benchmarking the performance of comparable DSOs in similar markets internationally and imposing similar or better performance on EnerDist. The primary performance for EnerDist is thus the performance of its peers, as determined by the CER.

Market Opening, in imposing a hitherto unseen competitive environment on EnerDist, signalled a shift in strategy in the organisation from Network Operation to Asset Management. This was driven by additional regulatory constraints imposed by the CER on how much EnerDist could spend on building and maintaining its distribution grid. Emphasis moved from operating at a cost to operating at a profit. Thus EnerDist can generate rents by beating the regulator's benchmarks. In 2000 EnerDist started implementation of a SAP R/3 ES to replace legacy IT systems no longer considered adequate for operating in a regulated open market. The first phase of implementation was completed in 2001, with Human Resources (HR), Asset Management and Integrated Work Management modules being added in 2003, 2006 and 2009.



(After Porter (1991, p.101))

Figure 4.2: The pressures under which EnerDist operates

EnerDist is thus an extreme case: EnerDist, unlike like other DSOs entering the market in Ireland or elsewhere, is constrained by its singular history as the sole inheritor of the national distribution grid. EnerDist emerged from EnerCo Group, heretofore the only generator, transmitter, distributor and supplier of electricity in the state. While EnerDist is a comparatively new entity, its culture and workforce, in part, predate its inception. It possesses a large regulated asset base (and an obligation to maintain it) which no new entrant has. In the past the Regulator has intentionally skewed the pricing structure to permit any new entrants to compete. Its history, the constraints under which it uniquely operates and the clarity and detail with which its competitive environment can be examined make it an ideal case to study using an applied Dynamic Capabilities theoretical lens. Per Siggelkow (2007), EnerDist may be regarded as a special case; the researcher must tread carefully about the conclusions drawn from a case like this. However, the specialness of the case may permit insights to be drawn that can be generalised to other, more "normal" cases Siggelkow (2007, p.21).

However, further focus is required: As the shift in strategic focus is towards Asset Management, the case study is further targeted at EnerDist's Asset Lifecycle Management operations. The regulatory environment imposed on the EnerDist from 2000 onwards is focused on Asset Management and the Regulated Asset Base.To conclude, examining EnerDist Asset Management organisation, structures, processes, assets and people, in light of its implementation of SAP R/3, is most likely to yield answers to the Research Questions, thus fulfilling the Research Objective. As already stated, the theoretical lens is DCT. Subsection 4.6 refines the applied version of DCT introduced in Subsection 4.3.2 by applying it to Asset Lifecycle Management processes in a regulated public energy utility.

4.6 Application of DCT to Asset Lifecycle Management

The proposed study both utilises and extends an applied form of DCT and the RBV to examine the role of ES in Asset Lifecycle Management Dynamic Capabilities. This is discussed in Chapter 3. However, DCT is a molar theory (Wheeler, 2002) and so an applied version of the theory is required to facilitate a useful study. A framework for isolating and analysing Dynamic Capabilities as applied to the asset management lifecycle in the context of a regulated energy utility is required.

A useful definition of Dynamic Capabilities in this context is as follows:

> **A dynamic capability is an assemblage of organisational routines and resources that permits an energy utility to reconfigure its assets to create future value in the face of an ever-changing regulatory environment.**

This section briefly describes the competitive environment, how rents may be generated and what aggregations of resources are significant. The section concludes by presenting an applied dynamic capabilities framework to be used during the case study.

4.6.1 The competitive environment

As discussed in the previous section, Dynamic Capabilities decompose into processes, positions and paths which may be directly or indirectly affected by the regulatory framework. The aggregation of resources that a dynamic capability represents must be the driver of reconfiguration of its own resources. A valuable dynamic capability will reconfigure those resources in a manner that permits increases in future rents. An exploitable dynamic capability will not reconfigure resources in such a manner that forbids future reconfigurations. For the dynamic capability to provide extended value by "beating the regulator," it must be inherently non-tradable. In other words, other Distribution Service Operators (DSOs) must not be in a position to imitate or provide a substitute for that dynamic capability in a manner that permits the regulator to further raise the benchmark.

4.6.2 The regulatory environment and rent generation in the public utilities sector

All Dynamic Capabilities in a regulated utility operate under pressure applied by the regulator. Regulatory pressure is a proxy for the competition that would occur in a market in the private sector. If value is placed on reducing Capital Expenditure (CAPEX) and Operational Expenditure (OPEX), improving network reliability, safety and performance and maximising return on the Regulated Asset Base (RAB), then those are the value drivers for all core dynamic capabilities. A core dynamic capability will have processes that will create value by reducing expenditure, reducing penalties or maximising Distribution Use Of Service (DUOS) revenue.

Positions will be modified to facilitate creation of new opportunities to reduce expenditure, reduce penalties or maximise DUOS in the future. Paths will reflect current regulatory pressure but may open up opportunities in the future. Processes, constrained by paths, are influenced by positions and operate on those positions to create future opportunities. Therefore a regulated energy utility dynamic capability, informed by history to date, will employ processes to change its network asset positions to allow for future opportunities to reduce CAPEX, OPEX and risk and to create future opportunities to obtain rents. Such processes are influenced by the positions themselves.

Given the constraints imposed by the regulator, it is in the interests of the DSO to create new network assets at the lowest possible cost and to maintain those assets at a low cost. This must be done while maintaining safety standards and also continuing to minimise the frequency and duration of outages. Network load capacity must also be maintained.

By explicating the interactions between processes, positions and paths, an applied dynamic capability framework specific to regulated electricity utilities may be built. Following the logic of Eisenhardt and Martin (2000), all such dynamic capabilities will exhibit common features that may even be found in other energy utility companies. Such commonality, however, still allows for sufficient variation in the details to permit one dynamic capability to outperform another by generating more value.

4.6.3 ESAMC: An Applied DC Framework

The proposed study is substantially informed by several writings, namely Mata et al. (1995), Leonard-Barton (1995), Barney (1997), Teece and Pisano (1998) and Wheeler (2002). A synthesis of these yields a template for applying DCT in the field; this is explicated in Table 4.5:

Table 4.5: Enterprise System enabled Asset Lifecycle Management Capabilities: An Applied DCT Framework.

Component	Observable
Business Processes	Asset Lifecycle Management Processes
Integration Processes	Combining of disparate Asset Management and organisational functions directly impacting the Regulated Asset Base, tighter coupling of business processes across functions, enhanced data sharing.
Learning Processes	Changes to processes as a result of prior events, evidenced by improvements in performance indicators, as documented by the Commission for Energy Regulation (CER)
Reconfiguration Processes	Any process change or reorganisation of assets, especially as an adaptation to regulatory or market pressures
Transformation Processes	Replacement of older processes, structures, assets and IT artefacts with newer ones.
Technologies	ES applications used. Other Information Systems and Information Technology.
People	Training undertaken by people executing processes. Their knowledge, skills and experience.
Path Dependencies	History of organisation, processes, people and technologies to this point.
Future Opportunities	Future plans. Anticipated new technologies, both for Regulated Asset Base and also Information Technologies. Process and organisational changes. Expanded range of future choices due to changes made in the present.

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Table 4.5 – *Continued from previous page*

Component	Observable
Value	Reductions in capital expenditure and operational expenditure and penalties imposed by regulator. Increases in safety and reliability of Regulated Asset Base. Allows public utility to meet or exceed regulatory targets. ES may also permit or drive valuable reconfigurations.
Inimitability	Contingent on history of public utility company and knowledge of its staff. May be contingent of level of customisation of ES or else on specific adaptations by organisation structures and processes to ES.
Non-substitutability	Highly specialised capabilities will have no direct substitutes.
Exploitability	Dependent on the public utility being in a position to effectively reengineer its processes as needed, to reconfigure its positions and to exploit new opportunities. ES may either hinder this through expense of reconfiguration or drive it by providing essential data.
Renewability	A process of continuous reengineering and adaptation to increasingly stringent regulatory conditions, either facilitated or inhibited by the ES.

(After Mata et al. (1995), Leonard-Barton (1995), Barney (1997), Teece and Pisano (1998) and Wheeler (2002); also derived from Table 4.2)

For convenience, this application of DCT is titled ***ESAMC*** **(Enterprise Systems enabled Asset Lifecycle Management Capabilities)** and is an Asset Management specific instance of the ES Capability Framework (ESCF) outlined in Table 4.2 in Subsection 4.3.2.

ESAMC has two features: First, it decouples the logic of Competitive Advantage from that of Core Capabilities. Using this framework, Core Capabilities are assessed entirely on their own merits. Secondly, rarity is not longer an antecedent for core capabilities, but is rather assumed to be a consequence of inimitability, no substitutability and also the capability's own reconfiguration and transformation processes. However, the second feature introduces a limitation in that it is not immediately clear which are Supplemental Capabilities and Enabling Capabilities.

This subsection, in conclusion, posits an applied Dynamic Capabilities framework, titled *ESAMC*, specifically for use in the regulated public utilities sector. The framework specialises on the molar DCT and on the applied version introduced in Subsection 4.3.2 by specifying the circumstances under which value generation may occur. As DCT and its antecedent, the RBV, concerns itself with the organisation and accumulation of firm resources to generate rents, this applied framework may be used to direct data gathering and analysis in answering the Research Questions to meet the Research Objective.

The remaining three subsections 4.7, 4.8 and 4.9 address issues related to the conduct of the study. Specifically, the next Subsection 4.7 describes the data collection methods to be used.

4.7 Data Collection

The proposed research employs three main data collection methods, with the objective of maximising the validity of the study as much as is practical. Robson (1993) notes that there are two forms of validity to consider:

Internal Validity: The extent to which a study establishes that a factor has caused the phenomenon that is found.

External Validity: The degree to which findings can be generalised to some target population.

Miles and Huberman (1994) state that validity is enhanced if the researcher ensures that events and settings that are studied are uncontrived and unmodified by the researcher's presence and actions. External validity has already been addressed by using a single case study approach allied with analytical generalisability and with a stratified purposeful sampling strategy.

Additionally, Maxwell (1992) also considerably extends the discussion of validity in qualitative research by presenting several different types of validity that must be considered; these are illustrated in Table 4.6. While Maxwell (1992) attaches less importance to generalisability (Maxwell, 1992, p.295) as an issue in qualitative research, it is included here as the proposed study, while not generalisable in the statistical sense, is intended to be analytically generalisable via the theoretical constructs it uses and generates.

Table 4.6: Maxwell's Validities for Qualitative Research and steps taken in this study to address them

Validity	Issue it pertains to	Steps taken in this Study
Descriptive	The factual accuracy of the researcher's account	All interviews are transcribed in full. Observations integral to interview transcripts. Documents referenced back to source. Triangulation within and between sources.

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Table 4.6 – *Continued from previous page*

Validity	Issue it pertains to	Steps taken in this Study
Interpretive	The meaning of the researcher's account and the meaning of the actors' accounts.	Researcher must take account of participant's perspective and acknowledge that perspective in the study.
Theoretical	The theoretical constructions brought to the study or developed from the study. A higher degree of abstraction from the material than description and interpretation	ESAMC framework in this Chapter; Emergent frameworks to be addressed in Chapter 9.
Generalisability	The extent to which the researcher can extend the account of the study to other settings	Analyticially generalisable via theoretical construct of ESAMC and any emergent framework expressed in Chapter 9.

(After Maxwell (1992))

Internal validity may be enhanced by drawing on a number of sources of evidence; this is a process known as **triangulation**. Marshall and Rossmann (1989) note that using a combination of sources of evidence increases validity as the strengths of one approach can compensate for the weaknesses of another. The evidence collected from one source can be corroborated by evidence gathered from another source; any discrepancies that arise should alert the researcher to potential analytical errors.

Yin (1994) provides a summary of various sources of evidence, their strengths and weaknesses; these is illustrated in Table 4.7. Three sources of evidence will be used in this case study to aid triangulation and enhance internal validity. These are:

Semi-structured interviews, discussed in Subsection 4.7.1;

Direct observations, discussed in Subsection 4.7.2;

Document analysis, discussed in Subsection 4.7.3.

Table 4.7: Six Sources of Evidence: Strengths and Weaknesses

Source of Evidence	Strengths	Weaknesses
Documentation	Stable, can be reviewed repeatedly	Retrievability can be low

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Table 4.7 – *Continued from previous page*

Source of Evidence	Strengths	Weaknesses
	Unobtrusive, not created as a result of the case study Exact, contains exact names, references and details of an event Broad coverage, long span of time, many events and many settings	Biased selectivity, if collection is incomplete Reporting bias, reflects (unknown) bias of author Access may be deliberately blocked
Archival Records	(Same as above for documentation) Precise and quantitative	(Same as above for documentation) Accessibility due to privacy reasons
Interviews	Targeted, focuses directly on case study topic Insightful, provides perceived causal inferences	Bias due to poorly constructed questions Response bias Inaccuracies due to poor recall Reflexivity, interviewee gives what interviewer wants to hear
Direct Observations	Reality, covers events in real time Contextual, covers context of event	Time consuming Selectivity, unless broad coverage Reflexivity, event may proceed differently because it is being observed Cost, hours needed by human observers
Participant Observations	(Same as above for direct observations) Insightful into interpersonal behaviour and motives	(Same as above for direct observations)
Physical Artefacts	Insightful into cultural features Insightful into technical operations	Selectivity Availability

(Yin, 1994)

4.7.1 Interviews

The primary source of evidence for this study is the semi-structured interview. Patton (1990, p.278) describes the purpose of interviewing as *"To find out what* *is in and on someone else's mind ... to access the perspective of the person being interviewed."* Seidman (1991) notes that, *"At the root of in-depth interviewing is an interest in understanding the experience of other people and the meaning they make of that experience."* With these descriptions in mind, the goal of interviewing in the context of this case study is to understand the interviewee's perception of the business routines that they and others perform, the assets and resources affected by those routines, the history of those processes and resources and the role of SAP R/3 or any other Information Technology in facilitating, enhancing or inhibiting those routines. These are the *"perceived causal inferences"* that Yin (1994) refers to when highlighting the strength of interviews.

However Yin (1994) also notes that interviews are prone to bias, inaccuracy due to poor recall and reflexivity, where the interview gives what the interviewer wants to hear. The semi-structured interview in particular has its own problems, in that it requires more preparation and analysis than a fully-structured interview (Wengraf, 2001).

What then are the advantages of the semi-structured interview? For the purposes of this study, it permits the researcher to ask prepared questions centred on the Small to Medium Enterprise (SME)'s supply chain relationships with its customers, suppliers, partners and competitors; the structure of these questions emerges to some degree from the research questions. Having asked a set of structured questions, the researcher can then explore in an unstructured manner the specific issues the respondent has raised, to see what can be learned from the respondent's experience.

All the interviews were recorded with the respondent's permission and later transcribed in full, specifically to address issues related to poor recall on the part of the researcher (Yin, 1994). In addition, the researcher made handwritten notes to highlight key parts of the interview. Appendix A contains evidence tables detailing the significant data gathered at the interviews. Table 4.8 lists the 30 interviews conducted with 33 respondents across 8 locations in 5 major urban centres as the primary data gathering exercise between July 2009 and November 2010. Figure 4.3 maps these interviews to the Asset Management Lifecycle and also indicates the relevance of each interview to the core Activity of Asset Lifecycle Management.

Table 4.8: Interview Schedule

Date	Location	Respondent	Name	Remarks
17/07/2009	Cork	Senior Mgr	JOS	Not recorded
24/07/2009	Cork	Area Mgr	WH	High level
10/08/2009	Cork	Finance Mgr	FOB	
01/09/2009	Cork	Consultant	ABy	Accenture
03/09/2009	Dublin	Regulatory Mgr	PHi	
03/09/2009	Dublin	IT Team	JG, PM, CM	3 respondents
29/09/2009	Cork	Network Projects	BN	
05/10/2009	Cork	Planning (South)	JOD	
14/12/2009	Port Laoise	IWM LIT lead, Network Projects	PD	
15/01/2010	Cork	IWM LIT lead, Finance	JC	
18/01/2010	Dublin	NITA Project Mgr	KOC	
22/01/2010	Cork	Design Officer	OMcC	
25/01/2010	Dublin	IWM LIT lead, Asset Mgt	AB	
25/01/2010	Dublin	Asset Mgr	TL	
02/02/2010	Sligo	IWM LIT lead, Supply Chain	PHa	
02/02/2010	Galway	IWM LIT lead, Customer Services	PC	
01/02/2010	Dublin	GIS	CB	
01/02/2010	Dublin	Documentation	DB	
01/02/2010	Dublin	Asset Register Admin	EC	
08/02/2010	Cork	Construction Supervisor	MK	
06/04/2010	Cork	Materials Supervisor	JOL	
27/04/2010	Dublin	Asset Mgrs	LR, IC	2 respondents
10/05/2010	Cork	SCADA	CH	
10/05/2010	Cork	Planner	MS	
17/05/2010	Dublin	Asset Mgt Forum	HH	
19/07/2010	Dublin	HR	IM	
12/08/2010	Dublin	Asset Mgr and Procurement	COC	
24/08/2010	Dublin	Programme Mgr	BG	
24/08/2010	Dublin	Documentation	DB	Doc. followup
15/11/2010	Dublin	OMS	FG	

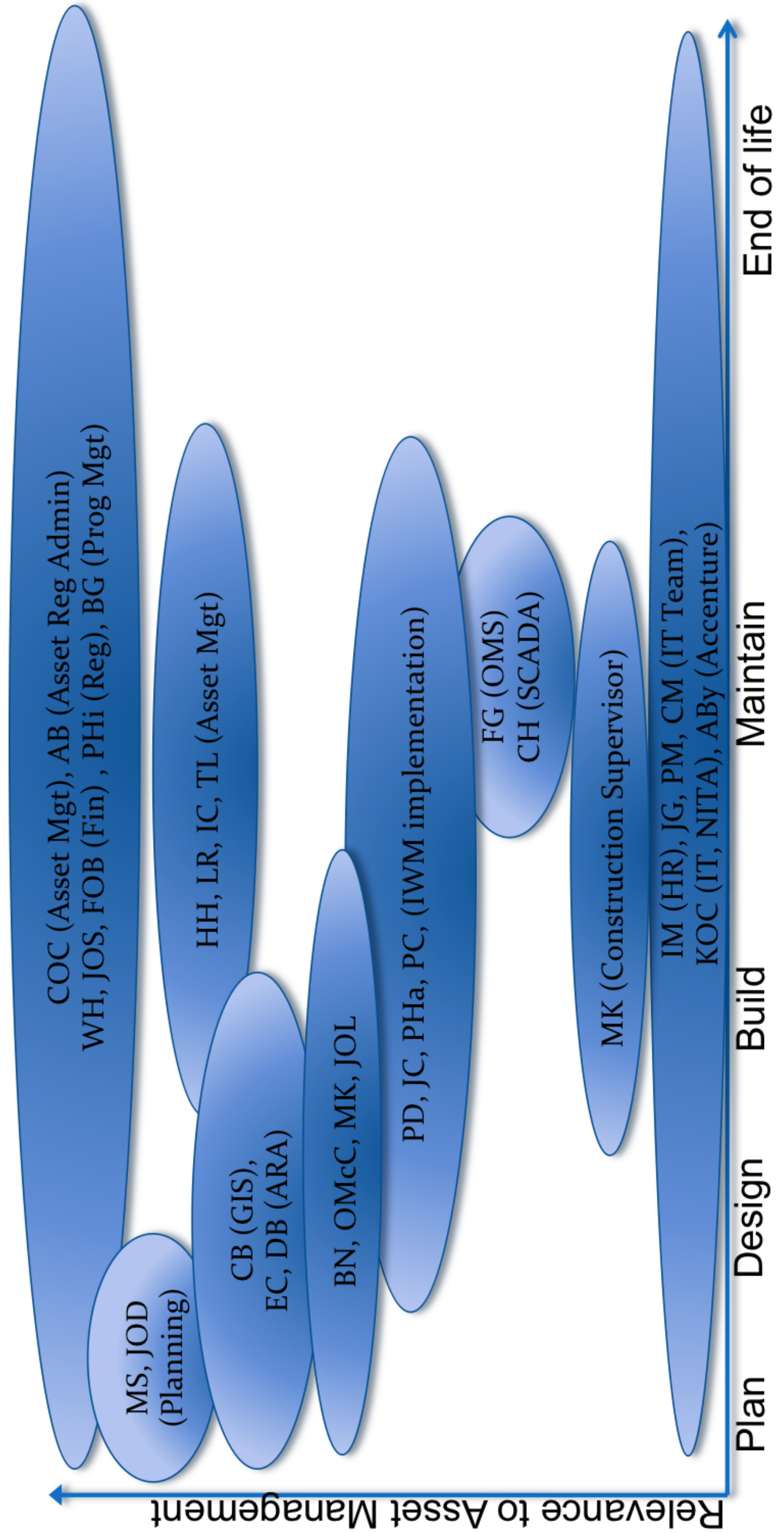


Figure 4.3: Interview coverage over the EnerDist Asset Maintenance Lifecycle

4.7.2 Observations

The evidence gathered from the semi-structured interviews was supported by direct observations and document analysis. In practice the direct observations consisted mainly of interview participants demonstrating work procedures on a computer using SAP R/3. These observations formed part of the interviews as the participant verbally described each step in the procedure.

Direct observations are characterised by Yin (1994) as allowing the researcher to *"cover events in real time."* However, Yin (1994) also considers them time consuming and selective. Patton (1990) also notes that observations may affect the phenomenon being observed in unknown ways. For this study, the direct observations are intentionally selective as they are focused specifically on work procedures as supported by the SAP R/3 ES. As the work procedures were explicitly embedded within the system, the system itself was not subject to observer effects. These observations allowed the researcher to clarify or confirm comments made by the respondent in relation to Asset Lifecycle Management processes during the semi-structured interview.

4.7.3 Document Analysis

Document analysis was utilised by the researcher to gain a deeper understanding of regulatory environment with which EnerDist operated and how that regulatory environment specifically affected certain processes within Asset Lifecycle Management Dynamic Capabilities. Examination of regulatory documents proved to be particularly fruitful as they proved to be extremely detailed and prescriptive. Thus it was possible to apprehend and understand EnerDist operating and regulatory environment in considerable detail.

Yin (1994) characterises documentation as a source of evidence as useful because documents *"can be viewed repeatedly."* They are also unobtrusive and stable (Yin, 1994). However, retrievability, accessibility and bias are possible problems with examining documentation (Yin, 1994). Accessibility problems were experienced with certain process documents, mainly because those documents had not been maintained in step with changes to the implemented ES. However, this was compensated for by using observations where needed. In addition, documents as outputs from processes were made available to the researcher.

The next Section 4.8 describes how the collected data are to be analysed.

4.8 Data Analysis

This subsection discusses how the data were analysed during the case study. The raw data sources were interview transcripts, observations embedded in those transcripts, the researcher's own notes and the documents obtained from the Commission for Energy Regulation and from EnerDist. The data analysis and expected output steps are documented in Table 4.4. A chain of evidence approach is adopted for this study, as exemplified by Beaudry and Pinsonneault (2005) and Williams and Karahanna (2013).

A coding process is adopted to drive the analysis from the raw data to the refined data visible in both the Findings (Chapters 5 - 8) and the Conclusions (Chapter 9). The coding process takes places in three stages - Open Coding, Axial Coding and Selective Coding. These stages are briefly described in subsections 4.8.1, 4.8.2 and 4.8.3 below:

4.8.1 Open Coding

Open coding refers to the labelling and categorising of phenomena as indicated by the data. Once interview transcripts were transcribed, analysis began with a line by line study of the content. This work was facilitated by the use of Microsoft OneNote to attach notes to both the audio recording and the transcript. Following Pare (2004), the ESAMC theoretical framework derived DCT was used to guide the process. The outcome from this process was a set of evidence tables, organised under headings suggested by ESAMC.

Table 4.9 provides a sample subset of the open codes and source interview transcripts and documents quotations relating to the *Determining Asset Policies* Dynamic Capability.

Table 4.9: Sample Open Coding used during Data Analysis

Source	Code
PH: *"We agree what the value of the asset base is and agree what return we are going to be allowed on the value of that asset base and how the asset base is going to be depreciated ... we also agree how much we are going to be allowed over the course of that 5 years to operate the system."*	Process, Business
IC: *"We have to include proposals for our maintenance ... [including] what the costs will be and the frequency that we would propose to do it. That's open to challenge from the regulator."*	Process, Business
TL: *"You're better off having as robust a policy you can have ... achieving 100%, as opposed to some aspirational policy ... only completing 40 or 50% of it."*	Process, Business
LR: *"The [policies] for the assets are our responsibility. But ... we work on five year cycles ... with the regulator. We recently made a submission for PR3 and we [had] to include proposals for our maintenance. That's open to challenge form the regulator."*	Process, Integration
TL: *"You literally can work through this specific job card and you're ticking in a lot more defined ranges or criteria ... [it] is fed into the system and it allows you to get a lot more focused ... moving towards condition based maintenance."*	Improvement
IC: *"ARM broadly replicated the database that was there."*	Asset Register

Table 4.10 illustrates the process of developing concepts from the codes by presenting a sample subset of those codes and concepts. These amount to descriptions of some of the underlying processes and assets referred to in interviews.

Table 4.10: Development of Concepts from Codes

Code	Concept
Business Process	Pricing round negotiation.
Process, Integration	Tight coupling of Pricing Round Negotiation and Policy Determination processes.
Improvement	ARM introduced flexibility to existing processes.
Asset Register, Database	SAP R/3 Asset Register (ARM). Replaces older standalone asset register.
Knowledge, Skills, Experience, Understanding	Asset Manager. Asset Manager's ability to formulate and rework maintenance programs contingent on knowledge and experience.

Table 4.10 illustrates a sample subset of the organisation of concepts into categories. The categories selected are informed by literature, in particular DCT as articulated by Mata et al. (1995) and Teece and Pisano (1998). While the cat-

egories are derived from the literature and from theory, as yet the groupings are descriptive rather than abstract. The following subsections on Axial Coding and Selective Coding introduce a degree of abstraction from the gathered data.

Table 4.11: Organisation of Concepts into Categories

Concept	Category
Pricing round negotiation.	Business Processes
Maintenance policy determination.	
Tight coupling of Pricing Round Negotiation and Policy Determination processes.	Integration Processes
Nominal controllable operating costs per unit distributed have dropped from 1.00c/kWh in 2001 to 0.87c/kWh in 2010.	Learning Processes
SAP R/3 Asset Register (ARM). Replaces older standalone asset register.	Technological Assets
DocuLite Repository for policies.	

4.8.2 Axial Coding

Axial coding refers to the process of developing main categories and their subcategories. This phase of coding allows the researcher to take the categories derived during open coding and classify them under higher level headings. This process helps to reduce the initial set of categories into a smaller set by merging categories of codes that are similar. In addition, a small degree of abstraction from the data begins to emerge. The end point of this process is the organisation of the evidence under five emergent headings representing five Asset Lifecycle Management Dynamic Capabilities. The evidence tables in Appendix A, in restructuring the data presented in the previous section on Open Coding, reflect this organisation. In addition, Table 4.12 illustrates the reduction of the Open Coding data to axial codes, representing distinct Dynamic Capabilities:

Table 4.12: Example of Axial Coding and emergent Dynamic Capabilities. This is a simplification and rearrangement of tables presented in Chapter 6

Business Processes	Integration Processes	Learning Processes	Reconfiguration, Transformation Processes	Axial Code (Dynamic Capability)
Solution identification	Assimilation and application of new network technologies.	Reduction in Customer Interruptions and Customer Minutes Lost	Introduction of CBAT, changes to Solution Identification process to exploit automatic switches.	Identifying New Assets
Materials ordering. Job design. Job execution.	Imposition of consistency across network. Tight coupling of stock and work processes via IWM and CU	Drop in working capital of €23m	Changes to structure of work orders. If additional work is required, it is performed as separate work order.	Building New Assets
Pricing round negotiation. Maintenance policy determination	Data integration via ARM. Asset Mgrs and Negotiators work jointly with CER.	Refinements and increase in granularity of policies as more asset data become available. Reduced costs.	Move to condition based maintenance.	Determining Asset Policies

4.8.3 Selective Coding

Selective coding refers to the integration of the categories under a single theme that has been developed to form the initial theoretical framework. During this process, previously identified core categories were regrouped to identify new categories describing the role of the ES in influencing Dynamic Capabilities. This is particularly evident in the summaries at the end of Research Questions 3 and 4 and is presented in simplified form in Table 4.13

Table 4.13: Illustration of Selective Coding showing Intensity and Extent of Asset Register (ARM) Footprint on Business Processes and Dynamic Capabilities. Presented in complete form in Chapter 7

Dynamic Capability	Process	Asset Register (ARM) Usage Intensity
Identifying New Assets	Solution Identification	H__
Coordinating Asset Programmes	Programme Negotiation	Hm_
	Programme Execution	HH_
	Programme Monitoring	HHH
Determining Asset Policies	PR Negotiation	H__
	Maint. Policy Determ.	_HH
Servicing Existing Assets	Annual Maint. Planning	HH_
	Maintenance Execution	__H
Module Intensity Of Usage		13

Table 4.13 illustrates the process of determining the overall intensity of usage of a particular ES module across previously established axial codes. In this case ARM usage intensity is estimated by referring to earlier coding efforts to determine the usage of that module at the beginning, middle and end of each process. The result is a picture of the relative intensity of usage of that module across all processes and capabilities. While Table 4.13 is of necessity a simplification to illustrate the coding process, Chapter 7 contains the complete tables displaying relative intensities for all ES modules.

Thus Research Questions 3 and 4 (Chapters 7 and 8 in particular are designed to drive analysis of common themes across all Dynamic Capabilities and Processes. In particular, the role of ES in enhancing (or otherwise affecting) Exploitability and Renewability is best addressed by seeking out these common themes. The output of this analysis is evident in Research Question 4.

The next Section 4.9 describes a research protocol that is guided the by the research objective, research questions, *ESAMC* and the data collection and analysis methods specified in this and the previous subsection.

4.9 Research Protocol

In order to fully address these research questions, the following additional questions need to be addressed in detail. These subquestions follow the Dynamic Capabilities framework as described in Teece and Pisano (1998), as well as the Core Capability framework based on Barney (1997), Leonard-Barton (1995) and Clemons and Row (1991).

Whether the Asset Lifecycle Management Dynamic Capabilities are core, supplemental or enabling is not determined until all four research questions are addressed.

A research protocol is proposed that will be followed throughout this study to ensure that the research questions are addressed. The protocol is required to ensure that the case to be studied provides sufficient information to facilitate a meaningful analysis across and within units of analysis. In addition the protocol serves as a high-level guide for interviews and document analysis.

Progression through Research Questions 1-4 is roughly sequential, however some loops are inherent as answering later questions yields new insights into earlier questions. Table 4.4 describes the research protocol: It outlines the data sources, the data gathering mechanisms and the expected outputs from each research step. In addition the research protocol is clearly mapped to the individual components of the research questions.

The protocol is an eight step process. Steps 7 and 8 are analytical steps that happen in parallel with Steps 1-6. Research Questions 2-4 are in part contingent on Steps 7-8 as well as Steps 1-6. Completion of all Steps 1 - 8 yield a set of Asset Lifecycle Management Capabilities, a determination if they are dynamic, a determination if they are core, the footprint of the ES upon those capabilities and the role of the ES in the Exploitability of those capabilities.

The protocol steps are summarised in Figure 4.4 and are described in as follows:

Step 1: Establish the context of the study

Before detailed document analysis and semi-structured interviews of identified participants take place, one or two overview interviews are required. The purpose of these interviews is to understand the business of the target organisation, the relevance of various business activities and the reasons why Asset

Lifecycle Management is important. In addition an overview of the organisation's ES and its implementation history is required. Finally these interviews provide a starting point for identifying other respondents within the organisation.

The primary data gathering mechanism is the semi-structured interview, followed by preliminary document analysis. Interviewees must be middle to higher management within the organisation so that a reasonably high level overview is obtained. Documents may be sourced from within the organisation or from without. Primary document sources are overview documents and presentations furnished by the organisation.

Step 2: Determine Asset Lifecycle Management Processes

The respondent describes the processes they are involved in and backs up their descriptions with documents if possible. This provides a rich description of relevant asset management processes as understood by those people actually executing those processes. The discussion expands into understanding how those processes evolved over time, how the respondent learnt those processes and how the respondent received training in their own position.

Step 3: Determine which IT artefacts facilitate these processes

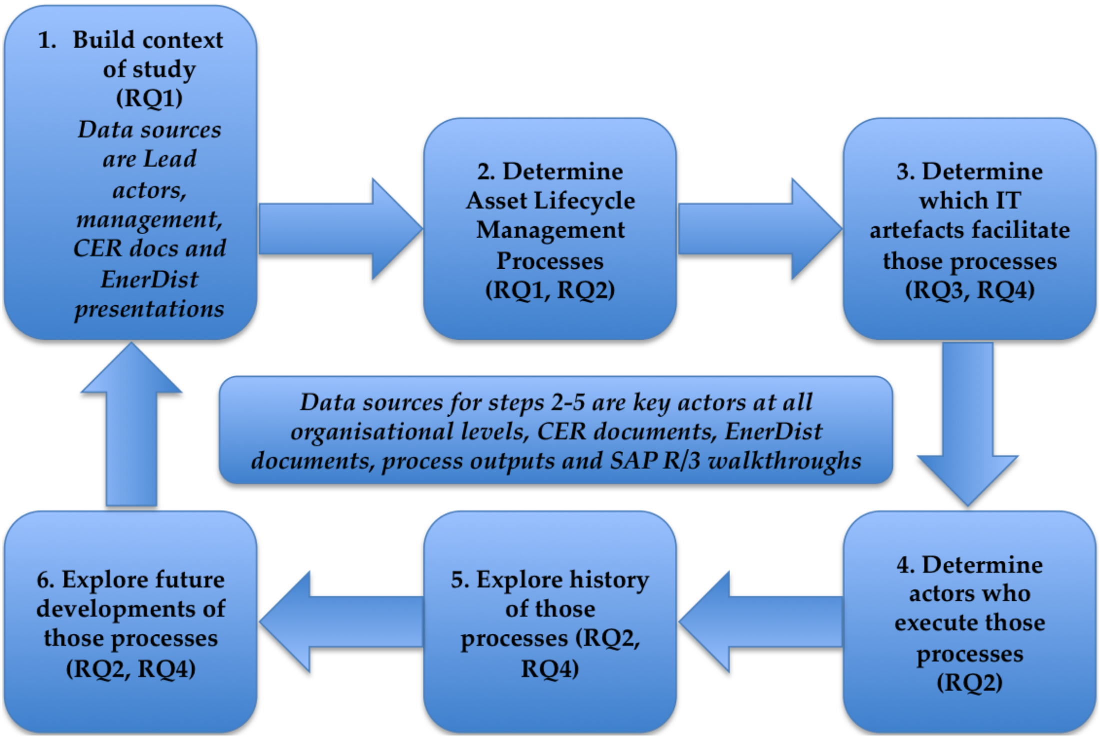
The respondent describes the information technologies used to support the described processes. The respondent is questioned to determine the boundaries of the Information Technology (IT) footprint on those processes. This discussion is supported by a demonstration of the relevant Information Technologies if possible. They are involved in and backs up their descriptions with documents if possible. The fit between the Information Technology and the processes is discussed with the respondent. For example, the respondent may be asked to comment on how well the current information technology facilitates their work processes.

Future possibilities for the technology are discussed.

Step 4: Determine actors who execute these processes

As well as describing the processes they are involved in (Step 2), the respondent also outlines who else is involved in the processes. (This may be a seed of further interviews.)

Step 5: Explore history of these processes



While progression from Steps 1 to 6 is roughly linear, looping from later to earlier stages is expected as preliminary analysis informs the earlier steps of later data gathering.

Figure 4.4: Research Protocol

The respondent describes how the processes have changed over time and also if those processes were influenced by the introduction of any IT systems. Another possibility is that the processes are emergent from the introduction of an IT system.

Step 6: Explore possible future developments of these processes

The respondent may indicate the processes are under development and further changes are expected in the future. In addition, the regulatory environment may be expected to change in the future and this may have an effect on the processes under discussion. Finally, the object of the study, EnerDist, may have business plans that involve developing its existing services further, retiring services no longer relevant, or developing new services. (Some of this may be mandated by the regulator.)

Step 7: Enumerate Dynamic Capabilities: Processes, People, Positions, Paths

Asset Lifecycle Management Dynamic Capabilities are emergent from the data gathering process and likely to structure themselves around the Asset Lifecycle itself. Those Dynamic Capabilities will be composed of the Processes identified in Step 2, the People (i.e. complementary assets) identified in Steps 1, 4 and 5, the Positions identified in Step 3 and the Paths identified in Steps 5 and 6.

Some Capabilities may have emerged as a result of recent development, or may have been present prior to the implementation of an ES. Therefore Capabilities should be classified as changed or emergent.

The Dynamicity of these Capabilities is determined by assessing whether Learning, Integration, Reconfiguration and Transformation processes (as articulated in Teece and Pisano (1998)) exist within these capabilities. In addition examination of Future Opportunities (Teece & Pisano, 1998) determines to what degree a Capability is likely to be *renewable*.

Step 8: Enumerate Core Capabilities: Value, Inimitability, Non-substitutability, Exploitability

Are the Dynamic Capabilities Valuable? To be valuable a Dynamic Capability must either generate rents for the firm or reduce costs. Inimitability and Non-substitutability may arise because how the capability was created is ambiguous, because the capability is the product of a unique history, because it is a function of the unique culture of the organisation os because the cost of copying or substituting that capability is too high for competitors.

Exploitability of the capability is the question of whether the organisation is well positioned to take advantage of it. Fit between information systems and the capability itself is a factor in this. A Core Capability will not remain valuable (and thus Core) unless it is possible to reconfigure that capability to meet future market needs. Otherwise it becomes a Core Rigidity.

4.10 Summary

This chapter began by stating the Research Objective and Research Questions. The nature of the Research Questions led to the adoption of a post - positivist single case study Research Strategy, which was then implemented in the Research Design. Both the Strategy and Research Design were also informed by two successive refinements and applications of DCT, which is a *molar* theory. The consequences of this is the ESAMC framework, which serves to describe and analyse ES enabled Dynamic Capabilities within an Asset Lifecycle Management context.

The Research Design initially addresses the unit of analysis and sampling strategy. The Unit of analysis is informed by the Research Questions, the Research Strategy and the Literature Review, leading to the conclusion that the appropriate Unit of Analysis is the Asset Lifecycle Management Dynamic Capability. The resultant Sampling Strategy seeks to identify an organisational context that is singular and that provides scope for considerable depth and breadth of analysis. EnerDist fits these criteria.

The latter stages of the Research Design deal with Data Collection, Data Analysis and the Research Protocol itself. In addition the issues of Internal and External Validity, as articulated by Maxwell (1992) and Yin (1994) are addressed. The Research Protocol, as described in Subsection 4.9 and in particular Figure 4.4, is emergent from the Research Questions, the Research Design, the ESAMC framework and the need to ensure Validity. In conjunction with the Data Collection and Data Analysis approaches described in Subsections 4.7 and 4.8, the Research Study to be conducted emerges.

The findings of this Research Study are discussed in Chapters 5, 6, 7, and 8. The Conclusions of this Research Study are addressed in Chapter 9. The next Chapter 5 addresses the findings from Research Question 1.

Chapter 5

Research Question 1: Understanding Asset Management Activities

5.1 Introduction

This chapter addresses **Research Question 1** by describing the Asset Management activities in EnerDist's Asset Management Lifecycle. Research Question 1 is restated below::

Research Question 1: What Asset Management activities are evident in the organisation?

The purpose of Research Question 1, and this Chapter, is to articulate the Asset Management Activities in EnerDist. Understanding the Asset Management Activities is a prerequisite to understanding Asset Management Dynamic Capabilities, the footprint of the Enterprise System and the role of the Enterprise System in the Exploitability of any Asset Management Core Capabilities. In particular, understanding the Asset Management Lifecycle will give an initial approximation of the Dynamic Capabilities evident in that Lifecycle.

The major findings of this Research Question are laid out in Figures 5.4, 5.5 and 5.6, and Tables 5.2 and 5.4. The structure of these findings is not informed by the ESAMC framework, rather they serve to indicate where the Asset Lifecycle Management Dynamic Capabilities may lie, and what external mechanism may drive their value generating activities.

A prerequisite to understanding Asset Management activities, however, is understanding the background to EnerDist's current state. This chapter, therefore, is laid out as follows: Section 5.2 sets the context of EnerDist, including some history of the organisation and its predecessor. In addition EnerCo's implementation of SAP/3 is briefly described. Section 5.3 sets out the regulatory structure within which EnerDist operates. Section 5.4 describes the EnerDist Asset Management structures. It also describes the EnerDist Asset Lifecycle as a specific case of Asset Lifecycles in general. Section 5.5 concludes by describing value generation at different points of the EnerDist Asset Lifecycle. These value generation activities are tied to regulatory pressures. Section 5.6 summarises and concludes this Chapter by providing a tentative map of what the Asset Management Dynamic Capabilities are; this in turn informs the findings of Research Questions 2, 3 and 4.

5.2 A history of EnerDist

This section describes a brief history of the EnerDist electricity distribution company and its predecessor, the EnerCo electricity supply company. It continues with a brief discussion of the changes EnerCo had to undergo to respond to the opening of the electricity generation, distribution, transmission and supply markets in Ireland to competition in 2000. It concludes by articulating some of the challenges EnerDist faced in managing its asset base in response to pressures from the national energy regulator.

5.2.1 Generation

EnerDist is a part of EnerCo Group, which also consists of EnerCo Generation, EnerCo Customer Supply and EnerCo International. Until 1998-2000, EnerCo Group was a monolithic energy vertical which had sole control of Ireland's electricity supply, from generation to the customer's meter. EnerCo, or the Electricity Supply Board, was established in the 1920's. Its first major generation project was a hydroelectric scheme, with generation diversified into oil, gas, coal and peat over subsequent years. An attempt to build a nuclear reactor in the southeast was abandoned in the early 1980's. Instead a large coal - fired generation plant was built on the west coast. At the same time, peat generation, which relied heavily on extensive midland bogs, was wound down with peat fired stations being decommissioned. These and other older generating plants have been supplanted by more modern and compact gas fired generating plants. The move to gas was in part driven by significant gas finds off the south coast, now being replaced by gas interconnectors to the UK. Since 2000 there has been significant investment in renewables with wind power starting to contribute to electricity generation.

National generating capacity was approximately 6 Gigawatts in 2009, with peak demand somewhat less than that.

5.2.2 Transmission and Distribution Networks

The Irish transmission and distribution is stratified into several levels. The HV (High Voltage) network is defined as 38KV and above, with transmission voltages reaching 220KV on a small number of high capacity lines. Interconnectors with Northern Ireland and Scotland exist, with a HVDC (High Voltage Direct Current) interconnector with Wales under construction. There is an extensive 10KV MV (Medium Voltage) network which distributed electricity from, 38KV substations to domestic consumers via 10KV-230V stepdown transformers. This MV network is characterised by long spurs especially in rural areas, though these are bing replaced by more robust ring distribution systems. Rural electricity in Ireland was characterised by frequent brownouts and outages until the early 1980s. The existing MV network will be upgraded to 20KV over the coming years, which will increase capacity fourfold.

5.2.3 Market Opening

Until February 2000, EnerCo group was the sole supplier of electricity in the Republic of Ireland. The Electricity Regulation Act, 1999, established the Commission for Electricity Regulation. In the late 1990's the Commission for Energy Regulation (CER) was established as national regulator, with a view to both opening up and regulating the energy market in Ireland. A consequence of this is that other companies are now permitted to compete in the generation sector. Airtricity and Bord Gais are now both established as alternative generators. Another consequence was that EnerCo had to split into several distinct units, covering generation, transmission and distribution and customer supply.

Elements of the HV transmission network were moved under the control of a separate entity called EnerTrans. However, given Ireland's small size, it proved impractical to further fragment the transmission and distribution networks.

The CER's stated objectives are to,

> *"ensure that the lights stay on, the gas continues to flow, the prices charged are fair and reasonable, the environment is protected, and electricity and gas are supplied safely."*
>
> Commission for Energy Regulation

As well as splitting into different organisations, EnerCo had to substantially change its structure and processes to meet the challenges imposed by the CER. In order to reduce its operational and capital costs, EnerDist had to identify ways of managing its asset base with greater efficiency and effectiveness. An essential part of this was understanding in detail what the asset base was. It became evident that the existing Information Systems were not fit for purpose and something new was needed. SAP R/3 was implemented over a period of 18 months, with the initial objective of meeting the basic demands of opening the energy market to competition. Subsequent SAP development included the addition of an Asset Register Module (ARM) in 2006 and an Integrated Work Management (IWM) module in 2009.

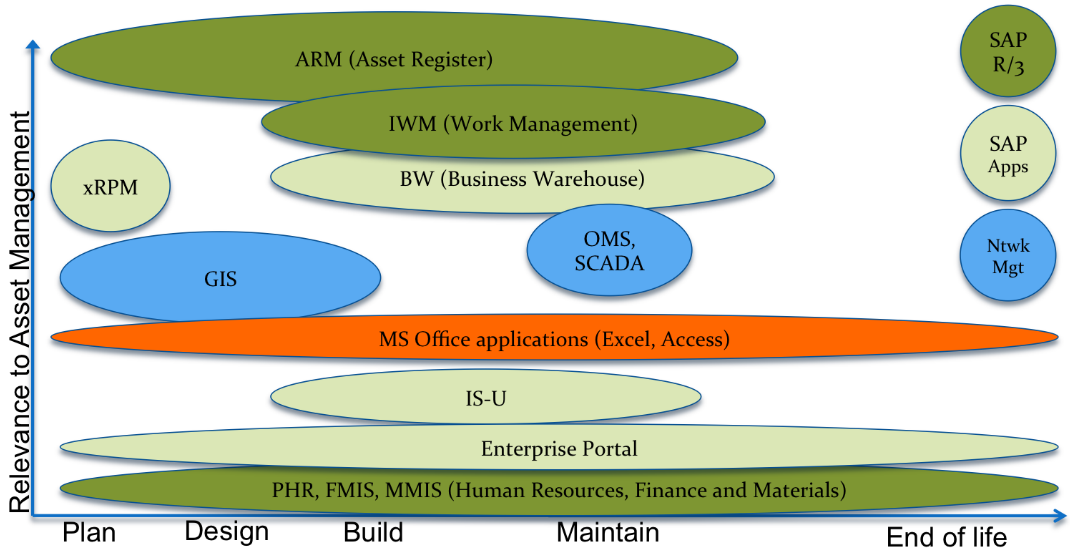
5.2.4 The EnerDist SAP Implementation Project

Table 5.1 shows the SAP implementation timeline relative to the Pricing Reviews conducted by the CER.

Table 5.1: SAP implementation timeline

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
CER Pricing Review			PR1					PR2					PR3
ESBN Programme	MOIP						NITA						
SAP Module Implemented	FMIS, MMIS, R/3 Core				PHR		IS-U	ARM			IWM		

Prior to the implementation of SAP, EnerCo and EnerDist had developed a set of bespoke Information Systems in-house. These included systems such as DWMS, a work management system. These systems were characterised by being very disjointed, with no ability to transfer data from one systems to another. In addition they were very costly to maintain. Any shortfall in the systems' capabilities was compensated for by short-term solutions such as Microsoft Access and Microsoft Excel. None of this sort of bricolage lends itself to consistent data sharing and integration.



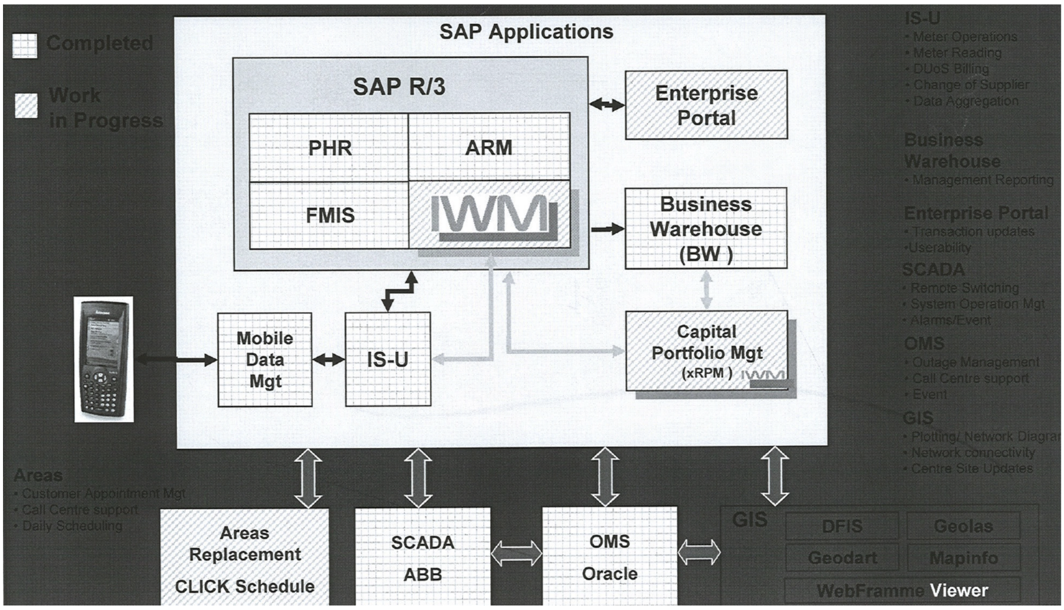
Dark green items items are part of the SAP R/3 Core. Light green items are other SAP applications. Blue and orange items are IT applications external to SAP.

Figure 5.1: The EnerDist IT footprint, post SAP implementation

The SAP system extant in 2009 was implemented in several distinct phases:

The first phase, characterised as the Market Opening IT Project (MOIP) by EnerDist, was implemented in 1999. This was a core SAP R/3 implementation covering Financials, Costing, Procurement, and Materials Management. As such, this R/3 implementation included FMIS (Financial Management) and MMIS (Materials Management). The Human Resources module, PHR, followed in 2003.

In 2005, the SAP IS-U (Industry Specific - Utility) module was implemented. This covers meter reading, billing, aggregation, meter asset management, meter operations and new connections. 2005 also signalled the launch of the Networks IT Applications (NITA) programme, which is still ongoing. Significant NITA rollouts are as follows: In 2006, the Asset Register Module (ARM) was implemented; In 2009, the Integrated Work Management module (IWM) was implemented.



(EnerDist Powerpoint presentation)

Figure 5.2: The EnerDist IT Landscape

As of 2009, EnerDist's implemented IT infrastructure was as illustrated in Figure 5.2. However, while documents suggested the 2005 NITA initiative was also to bring mobile devices to the field, this had not yet happened as of 2009. Conversations with Asset Managers reveal that a mobile platform was being trialled in Finglas, with funding for a full rollout planned for print round 3 (PR3), 2011-2016.

Figure 5.2 clearly delineates the SAP Applications both within and outside the core R/3 implementation. SAP MMIS is not included in this diagram, despite IWM having a significant impact on how inventory is managed and procurement is executed. Outside the SAP Applications, OMS, SCADA and GIS applications play significant roles and all exchange data with the SAP Application suite, albeit with manual assistance in some cases.

The stated rationale for implementing SAP was to use an industry standard Enterprise System that other systems could easily interface to. The perception was that SAP and Oracle are the main vendors in the utility sector and selecting SAP would avoid problems with systems integration later.

5.3 Regulatory mechanism and competitive pressure

Electricity generation, transmission and distribution in Ireland is regulated by the Commission for Energy Regulation (CER). Brought into force by the Electricity Regulation Act, 1999, the CER's remit is to both regulate and provide for an open energy market in Ireland. Since the electricity market was opened in 2000, a number of competitors have emerged in the electricity generation and customer supply sectors. However, competition for electricity transmission and distribution is constrained by Ireland's small size, the existence of an already-extensive national grid and the impracticality and expense of competitors entering the market to establish their own grids.

The need to maintain price competition in a small country also presented the CER with a problem as the market was too small to enable comparison with other distribution service operators. The CER considered a number of regulatory mechanisms in various markets worldwide and eventually selected a mechanism of consumer price indexed price caps with periodic reviews. This form of regulation is used in Argentina, Austria, Norway, Spain and significantly, the UK. The CER explains the regulatory mechanism as follows:

> *"Price capping with periodic reviews is a form of incentive regulation with profit sharing. Under this form of regulation, the regulated business is required to keep the increase in its prices to less than (or equal to) the increase in a specified general price index (e.g., the CPI), less X percent. If X is positive, this means that prices will fall by X percent in real terms. The level of the cap on prices reflects the anticipated levels of future operating costs and investment that might be incurred by the business and are set to provide a reasonable rate of return on assets, consistent with efficient performance. The price cap is therefore set at a cost-reflective level. The distinguishing feature of this form of regulation is that the price cap applies for a pre- determined period. So the regulated business keeps all the profits associated with unanticipated cost reductions in the period between regulatory reviews."*
>
> CER (1999, p.8)

The CER thus adopted a strategy of evaluating the energy sector in Ireland against similar markets in other countries. This is particularly applicable to

EnerDist, which exclusively operates the transmission and distribution networks below 110KV. EnerDist is benchmarked against 12 Distribution Service Operators (DSOs) in the UK. In effect this provides a form of competition by proxy as the CER requires EnerDist to compare favourably to these networks.

The chief regulatory mechanism applied by the CER is the Pricing Round, a negotiated 5 year contract that requires the network operator to meet certain targets on capital expenditure, operational expenditure, network availability and safety. The Pricing Round (PR) document describes in detail where expenditure may be targeted. To date the PR1 and PR2 cycles have been completed from 2000-2010, with the PR3 coming into effect in 2011. The Pricing Round mechanism imposes ever tightening expenditure constraints on the network operator, where expenditure over an agreed level represents a loss to the company.

If the network operator wishes to make a profit, or reduce it costs, it must perform within the constraints imposed by PR1-3 and future pricing rounds. In effect the CER imposes *competitive pressure* on EnerDist and other operators by contractually obliging them to perform better than their peers in other markets and jurisdictions. A characteristic of successive pricing rounds is that more an more precise constraints are applied to the organisation. As a form of competitive pressure, this regulatory mechanism uniquely differentiates itself from traditional outside forces as it has the capacity to directly influence and organisation's internal processes, assets and resources.

EnerDist, therefore is regulated by benchmarking performance against Distribution Service Operators (DSOs) in the UK. Over a five year period called a Pricing Round, EnerDist is expected to outperform similar DSOs in the UK. Failure to perform to the standards set by the CER result in both penalties and loss of revenue.

5.3.1 The regulatory environment and how it imposes competitive pressures on the DSO

The chief regulatory mechanism applied by the CER is the Pricing Round, a negotiated 5 year contract that requires the DSO to meet certain targets on capital expenditure, operational expenditure, network availability and safety. This is part of a regulatory framework based on price caps with regulatory reviews. The CER describes this as form of "incentive regulation with profit sharing" (CER, 1999).

The overall thrust of the regulation is to require the DSO to hold any increase in its prices to less than or equal to the consumer price index (CPI), less X percent, where X is determined by the regulator. If X is a positive number, then effectively the DSO's prices will fall by X percent in real terms. This price cap is held in place over a five year period called the pricing round. The CER asserts that the price cap takes into account future operational expenditure and any investment, or capital expenditure that might be incurred by the DSO. The price cap is intended to provide a "reasonable" return on assets, consistent with "efficient performance" (CER, 1999).

Within the pricing round, if the DSO can achieve efficiencies, savings and returns in excess of those anticipated by the CER, it benefits directly. The CER permits the DSO to retain any "unanticipated cost reductions" between the regulatory reviews which happen every five years (CER, 1999). At the end of the five year pricing round, and at the next regulatory review, the CER can impose further price reductions to capture those cost savings and pass them on to the electricity consumer. This regulatory mechanism is referred to in the regulatory industry as CPI-X.

The DSO thus operates under market conditions that effectively bring more pressure to bear every five years. For a given pricing round, the DSO must not only compete against benchmarked performance from the UK DSOs, it is also required to compete against its own performance in the previous five years. In this case, EnerDist is expected to improve its performance every five years if it wishes to obtain improved rents.

In summary, the pressures shaping the dynamic capabilities within a DSO may be subdivided into three categories:

External regulatory pressures These are broadly incentivised regulatory measures, where the detailed response is left up to the DSO.

External economic pressures In the case of EnerDist this can be characterised as the transition of the Irish economy from boom to bust. This affects the type of work that must be undertaken by the DSO. For example, during the boom, new connections were a priority, whereas the focus has now moved to reinforcement and maintenance and new generation connections.

Internal regulatory pressures These directly act on processes, positions or paths. While these are applied externally, they are internal in the sense that the regulator has authorised incentives or mandated activities that specifically affect particular assets, processes and positions.

Table 5.2 on the next page summarises the regulatory pressures as applied over three pricing rounds from 2001 to 2015. An examination of the three successive pricing round determinations shows an increasing attention to detail on the part of the regulator. In particular, the regulator defines specific areas where both capital and operational expenditure is to be directed. Any lack of detail in the 2001-2005 determination is in stark contrast to the very detailed prescriptions (the grey boxes in Table 5.2) of the 2006-2010 and 2011-2015 documents. Furthermore, the rows in this table illustrate the range of measures over which regulation is applied.

5.4 The Asset Base of EnerDist

The Regulated Asset Base of EnerDist consists in the main of transmission and distribution lines, substations, switching units, transformers and other ancillaries associated with the conveyance of electrical energy from a point of generation to a point of consumption. In addition the RAB also consists of those systems required to manage the network and the equipment and facilities needed to maintain it. A Network Asset is any piece of hardware, be it cabling, switching or transformers, that carries an electrical load. New network equipment does not become an asset until it is carrying load. An asset that ceases to carry load is not productive and in fact may incur a penalty to EnerDist if it contributes to an outage situation.

Network Assets have been built up over a period of time from the inception of EnerCo in the 20's, through the emergence of EnerDist in 2000 to the current day. This was an organic process where the transmission and distribution network grew solely to meet the demands on an evolving Western European economy. While safety was of paramount importance, the network was built with future asset base management in mind. EnerDist characterise the core focus of the business up until 2000 being solely to operate the network and meet growth in demand. Market opening and the advent of the CER represented a necessary move from a network operation focus to an asset management focus.

Table 5.2: Regulatory incentives

Regulatory limits and incentives.	PR1 2001-2005 (CER01/128)	PR2 2006-2010 (CER05/138)	PR3 2011-2015 (CER10/198)
Grey boxes indicate specific, detailed regulation measures and incentives that directly impact certain positions and processes.			
Maximum allowable revenues	€2273.3m	€2908.4m	€3794.9m
Operational expenditure limits	€918.1m, specifics but not very detailed.	€940m, specifies areas of expenditure including maintenance programmes.	€1086.9m, anticipates payroll reduction and specifies areas of expenditure.
Capital expenditure limits	€1546.7m, specifics but not detailed.	€2278m, specifies on what assets capital may be spent.	€2312.9m, specifies on what assets capital may be spent.
Operational efficiency	Not specified	Not specified	€-53m adjustment to CAPEX and OPEX.DSO expected to identify efficiencies.
Investment efficiency	Not specified	Not specified	
Network reliability	CML, external	Reduce CML from 252 to 201. Reduce CI from 201 to 171.	Reduce CML from 141 to 124. Reduce CI from 143 to 129. Specific work mandated.
Network capacity	Specific reinforcement programme including upgrade of 10kV network to 20kV.	Reduce electrical losses from 8.0% to 7.5% Specific reinforcement measures.	Reduce electrical losses from 7.5% to 7.1%. Specific reinforcement measures. Incentive capped at 4% of revenue or 0.4% additional return on capital.
Quality of supply			
Customer service	Not specified	Performance against customer charter.	
Regulatory asset base (RAB) opening value at start of pricing round	€1958.9m	€3370m, detailed breakdown of RAB.	€4974.5m, detailed breakdown of RAB.
Average Unit Price (AUP) per kWh from start to end of pricing round	2.59c to 2.18c	2.40c specified for 2006.	2.90c to 3.23c.

(After CER (2001, 2005, 2010))

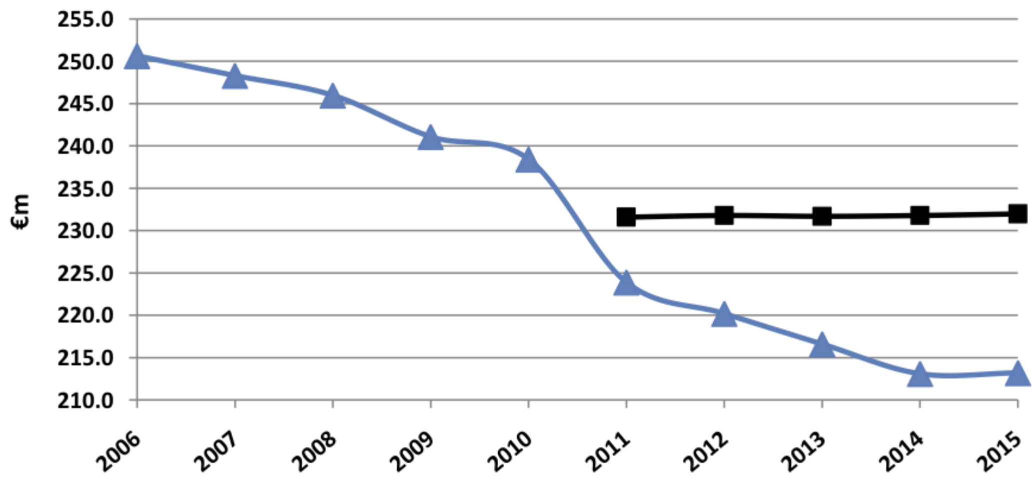
A consequence of the history of the growth of the network is that the asset base was not documented in sufficient detail to support the demands of the regulator. This was not because of a lax approach but rather it followed from two limitations in work practice. First of all, all tracking systems were paper - based and any IT systems which did evolve were not well connected and of course had no mobile element due to technology limitations. Second, any network technician working on assets in the field was more motivated to get the work done and move onto the next job rather than document fully the job just completed. This is especially the case with network repairs where time is of the essence:

> *"Keeping the asset data up to date is a nightmare, because people are quite happy and go out and do the physical work, but that extra little bit of getting the data, back into the system, we seem to be falling down on it. ... The guys are going like, it's [pouring] rain, we're putting up a pole mounted transformer, the last thing I want to be doing is getting up there and taking the number, yes but what happens if something happens to that, the manufacturers send us out a note saying all of these type are really highly dangerous there's a little problem and after three days something is you know, how are we going to figure out where they were? Well I know, Mickey Joe puts them up all the time. Mickey Joe might know that but the rest of us don't."*
>
> Asset Register Administration Manager

5.4.1 The Asset Base and Competitive Pressure

The Regulated Asset Base of EnerDist has to be developed and maintained in accordance with strict rules laid down with the CER. Development of assets requires capital expenditure and maintenance of those requires operational expenditure.

The competitive pressure imposed by CER on EnerDist is evidenced as follows:



Horizontal black line indicates limits requested by DSO, blue line indicates limits imposed by CER. The limits imposed are more restrictive than those requested for 2011-2015

(CER, 2010, p.7)

Figure 5.3: Operating cost limits imposed on DSO by CER

Figure 5.3 illustrates that operating cost limits imposed by the CER have decreased from €250m in 2006 to €239m in 2010. While the DSO requested that operating costs be pegged at €232m per annum from 2011 to 2015, the CER has imposed further reductions over this period from €224m to €213m.

Capital expenditure, also controlled by the CER, is also capped at a level lower than that requested by the DSO, as shown in Table 5.3. While allowable capital expenditure has increased dramatically from PR2 to PR3, most of this increase is attributable to the €500m allocated for the installation of smart meters at subscribers' premises.

Table 5.3: Capital expenditure limits, in €m, imposed on DSO by CER

€m, 2009 prices	2006 to 2010	2011 to 2015			
	Allowed PR2	DSO Requested	CER approved	Variance	
Net Capex	1,979.7	2,655.5	2,312.9	-342.5	-12.9%

(CER, 2010, p.8)

Finally, the CER requires that the DSO make efforts to improve quality of energy supply over PR3:

> *"The CER requires the DSO to improve quality of supply over the period - a reduction in customer interruptions by 11% and a reduction in the average annual interruption duration by 19%. In terms of customer service the current composite customer service target of 85% is required to be maintained whilst reducing operating costs. Electrical losses are expected to reduce from 7.5% to 7.1%."*
>
> (CER, 2010, p.11)

The DSO thus operates under the pressure of reduced OPEX, reduced CAPEX and the requirement to increase quality of supply. This requires the existing asset base to be extended and maintained at lower cost, while improving network downtime targets.

5.4.2 The EnerDist Asset Lifecycle

A typical Asset Lifecycle can be envisioned as a four-phase continuous loop, namely Plan - Build - Maintain - End-of-life, as pictured in Figure 5.4. However, the Asset Base in EnerDist, especially the Regulated Network Asset Base, has five distinct lifecycle phases: Plan, Design, Build, Maintain and End Of Life. This asset lifecycle is critical to the operation of EnerDist as an asset management focused utility as careful management of the network asset base is required to comply with regulatory requirements and to extract maximum value from the asset base to maximise rents to the company. The EnerDist asset lifecycle is further illustrated in detail in Figure 5.5. As can be seen in Figures 5.4 and 5.5, Programme Management is a coordinating function that impacts all phases of the lifecycle.

A piece of network equipment does not become an asset to the DSO until it is carrying an electrical load. Nonetheless the lifecycle of any given single asset starts at the planning phase when appropriate modifications and extension to the network are considered. Plans may be drawn up as a result of new load requests or else to remedy a network deficiency. The planning phase is complete when a solution is selected. During the design phase the solution is translated into a specific and detailed design which includes all bills of materials and necessary steps to implement that solution. This then feeds into the build phase where the design is actually built. At the end of the build phase, when the network changes are complete, all the affected equipment is energised and logged

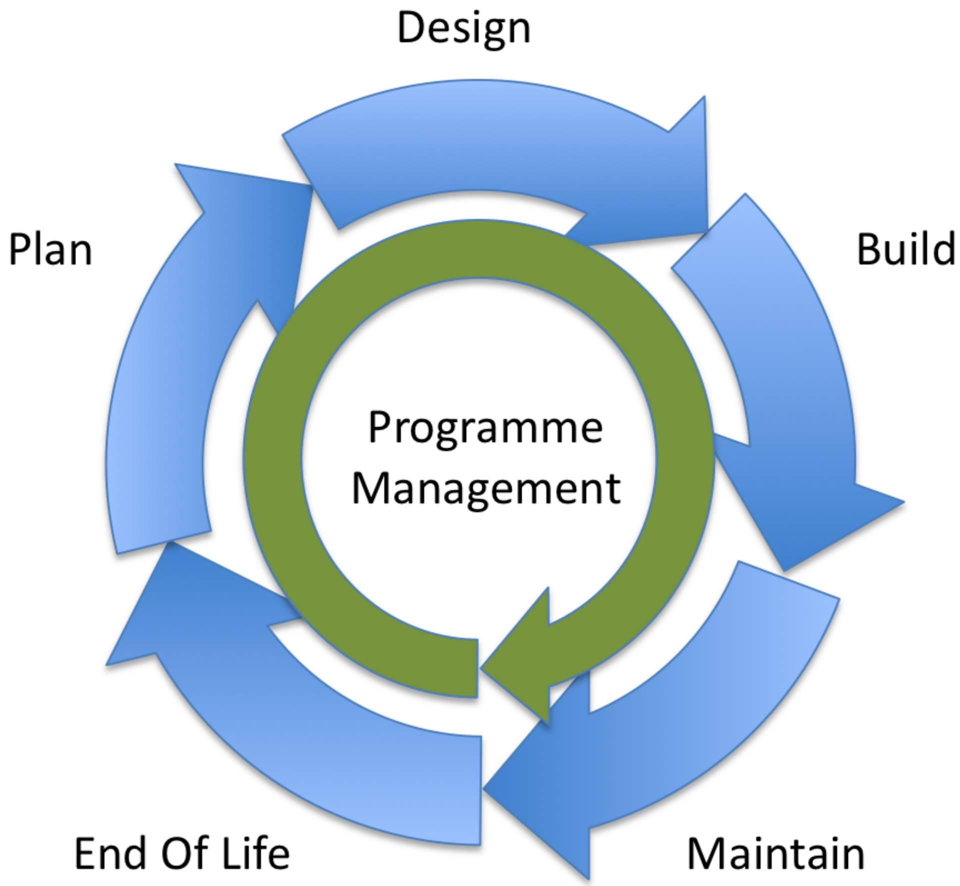


Figure 5.4: The Asset Lifecycle observed in EnerDist

in the Asset Register. At this point any new equipment is now regarded as an asset.

The maintenance phase of the asset lifecycle concerns itself with network assets that are carrying load. Assets are maintained according to different policies depending on equipment type: Some assets must be maintained according to a strict schedule, while others need only be maintained if their condition has actually deteriorated. The maintenance phase includes inspection regimes for all assets. As well as scheduled maintenance, an asset may have repair or maintenance work as a result of a network fault or where it is deemed economical to perform maintenance on that asset in conjunction with repair, maintenance or building work on other assets.

The end-of life phase of the asset lifecycle occurs when an asset reaches the end of its service life or has failed beyond economic repair. In some cases service life is long as forty to seventy years. One of the concerns of the end of life phase is asset decommissioning and disposal but it also feeds directly back to the planning phase, as new assets are required to replace those that have expired. Asset lifetime is significant as the regulator determines how quickly the value of an asset may be depreciated and allowances are made to the DSO for the declining value of the asset base.

The status of a Network Asset may be influenced by a number of events. First, outright failure will require a repair or replacement activity. Second, it may be upgraded or replaced as part of an activity to enhance network capacity and reliability. Third, the asset may be withdrawn from service at end of life due to age, unreliability or maintenance cost. Finally, end of life or other network expansion activities leads to the creation of new assets.

5.4.3 Summary: Management of the Regulated Asset Base

A significant requirement of the regulator is that each operator manage its asset base as effectively and efficiently as possible. Effective management is measured in terms of safety compliance and maximised network uptime. Network outages are penalised both for incidence and duration. Therefore assets must be maintained and developed at a level that minimises both the occurrence and duration of outages. However those assets must be maintained with no unnecessary outlay. The CER controls network operator costs by imposing limits on capital expenditure (CAPEX) and operational expenditure (OPEX). Asset replacement and development of new assets to increase capacity comes out of CAPEX and maintenance of existing assets comes out of OPEX.

The next subsection discusses value generation from the regulated asset base, given the regulatory constraints outlined above.

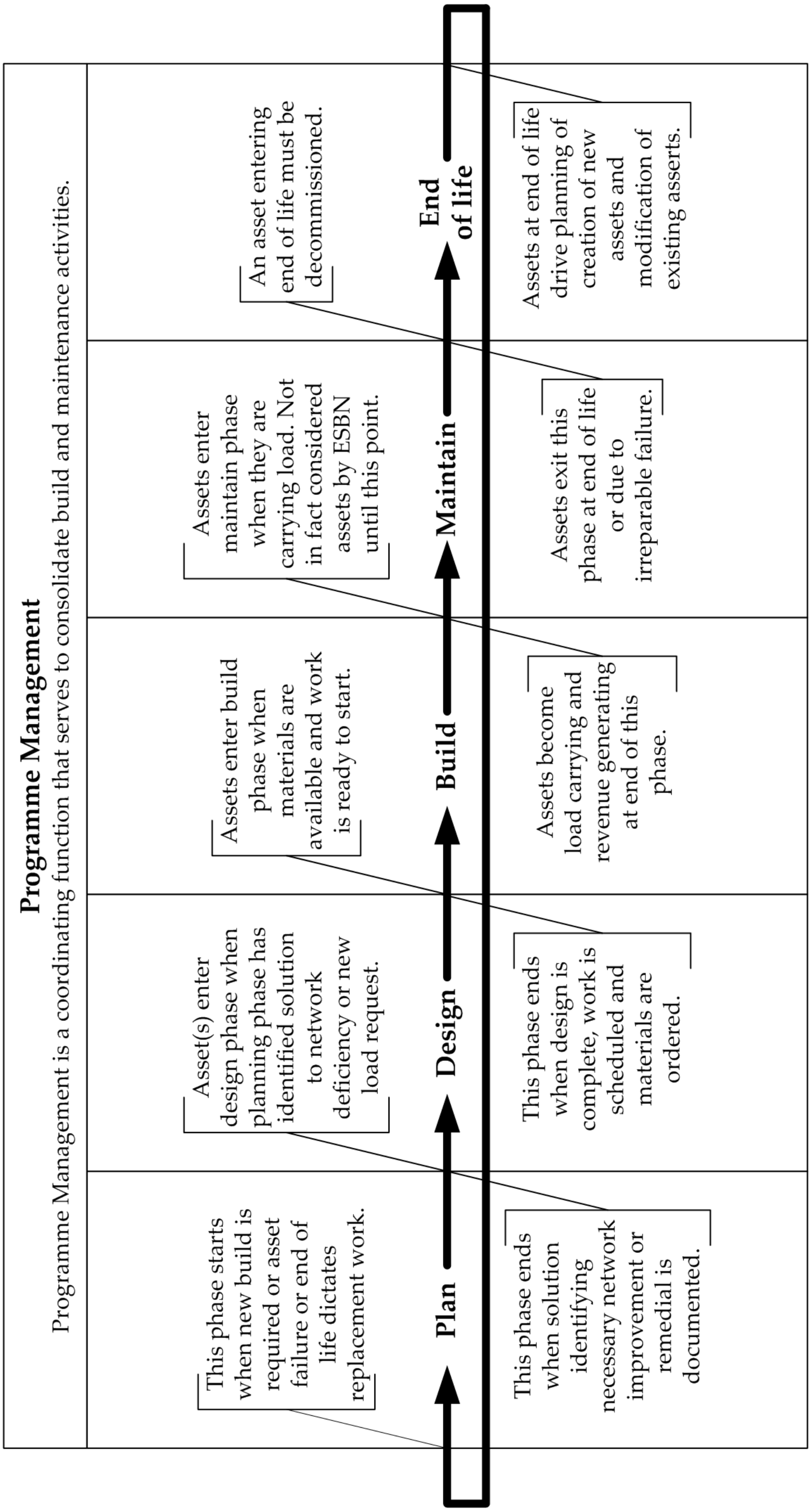


Figure 5.5: A detailed view of The EnerDist Asset Lifecycle

5.5 The Asset Base and Value Generation

Various opportunities exist for cost saving and value duration at different phases of the asset lifecycle, as illustrated in Figure 5.6:

Careful planning and solution selection minimises both the capital cost of installation but also future operational costs of maintenance. In addition a solution will seek to minimise penalty risk from outages and also to minimise future network expansion costs. There is a balance to be struck here between the initial capital cost of any new solution against the future operational cost of maintaining the resulting networks assets. For example, it may be advantageous in some cases to spend extra capital not to reduce future capital and operational expenditure as well as penalties.

The design and build phases benefit from a coordinated approach at the programme management level. An uncoordinated approach can result in multiple visits to the same site to perform inspections, maintenance, upgrades and additions. In addition it is possible activities at different points in the asset lifecycle may result in conflicting build instructions for the site in question. Process integration that results from programme management can deliver single design and build job which can address network expansion, maintenance and remedial objectives. Such an approach minimises material and on-site costs as well as unnecessary redesign activities.

End-of-life activities tend to merge into the planning phase of a new asset lifecycle. However, there are also value considerations here: Write-down values of assets are critical and are dictated in part by the regulator. In addition asset lifespans have been set in part by negotiation with the regulator, with some asserts having lifespans of 40 years. (In an extreme case, assets were recently retired after 70 years' operation.) If an asset's lifespan exceeds its write-down period then effectively that asset is generating revenue for free for the balance of its life.

5.5.1 Rent generation in regulated environment

The DSO generates income on its asset regulated base. There are three possible sources of income in a regulated environment. Two income streams derive from capital investment and the third derived from operational expenditure.

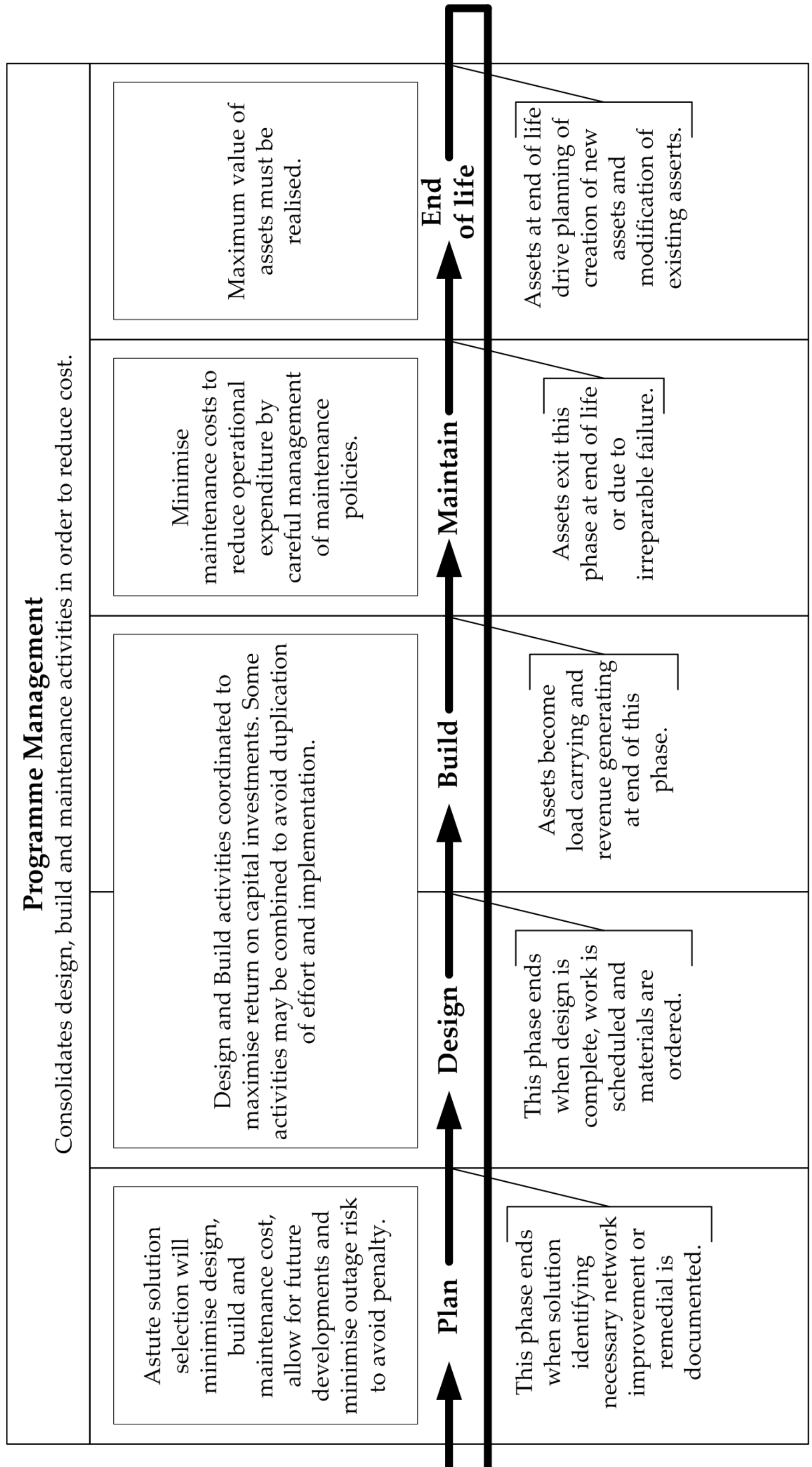


Figure 5.6: Value Generation in EnerDist Asset Lifecycle

The first capital income stream derives from depreciation of assets over the lifetime of those assets. The amount spent to procure the asset is recoverable as an annual payment of an amount equal to the asset value divided by its expected working life. Therefore an asset purchased for €1,000,000 with a lifetime of 20 years attracts a depreciation return of €50,000 per annum.

The second capital income stream is a return on the capital investment at a rate set by the regulator. The rate of return is referred to by both the DSO and the CER as the Weighted Average Cost of Capital (WACC) and is derived from a capital asset pricing model that takes into account both debt and equity costs. The WACC is allowed on any new assets plus the non-depreciated part of any older assets. Therefore the total allowed income on any regulated asset is the annualised depreciation plus the WACC return on the non-depreciated amount remaining on the asset.

The third income stream is the operational expenditure required to operate the network, maintain the assets in place and conduct all the other normal day to day activities of any organisation.

The CER stipulates that all expenditure is efficient and necessary. In an environment regulated by the CER, enhanced rents may be achieved by a number of means:

Reduction in CAPEX below PR targets Each pricing round sets limits on capital expenditure for the next five years. If spending is held below this ceiling by the DSO, then the difference emerges as additional profit. As the CER specifies different spending limits for different groups of assets, then the DSO may try to achieve significant value gains in one asset area or a number of areas. It may even be possible to compensate for overspend in one area by underspending in another, though this is subject to negotiation with the CER.

Reduction in OPEX below PR targets Each pricing round sets limits on operational expenditure for the next five years. If spending is held below this ceiling by the DSO, then the difference emerges as additional profit. As for CAPEX, specific spending areas for specific groups of assets are defined.

Minimisation of fines due to outages If the number and duration of outages are held to a minimum, this in turn minimises the fines imposed by the CER. In addition the CER defines specific incentives for improvements in network reliability and quality.

Exploitation of new opportunities The DSO may offer, or the CER may require, that new opportunities be pursued. For example, renewable energy initiatives, smart networks and EV recharging networks may be implemented. Such initiatives are undertaken to meet broader green energy policy targets. Research and development funding is allowed for as part of the overall OPEX.

These mechanisms of penalty and reward have a direct effect on the rents that the DSO can achieve from its assets. In turn this has implications for the management of the asset lifecycle. CAPEX restrictions constrain what new assets may be built. OPEX restrictions dictate how those assets are to be maintained. The outage penalty structure shapes how asset maintenance, repair and replacement is prioritised. New opportunities create environments where new sources of rents may be obtained; however such new opportunities are contingent on the asset infrastructure facilitating their exploitation.

A Dynamic Capability in a regulated utility is only valuable if it permits the utility to generate increased rents or reduced costs with the framework laid down by the regulator. In other words, a dynamic capability is valuable if it permits the utility to meet or exceed the regulator's expectations.

5.5.2 Implications for the Asset Lifecycle

In general, CAPEX is used to fund the Plan and Build portion of the Asset Lifecycle, while OPEX funds the Maintain phase. The CER lays down very specific directives concerning where CAPEX and OPEX is to be spent, going so far as to cap expenditure on specific types of assets. In addition the CER mandates that the DSO improve network quality and reliability by undertaking specific maintenance, reinforcement and improvement programmes. There is a progression from PR1, through PR2, to PR3, towards more detailed and specific directives. As part of the content of a Pricing Review document arises out of data provided by the DSO, this reflects a trend towards more detailed asset data becoming available as the DSO transitions complete to being an asset management business. Table 5.4 illustrates the extensive impact that the regulatory incentive environment may have on any Asset Lifecycle Management Dynamic Capabilities.

Table 5.4: Effect of regulation on Asset Lifecycle, DC and value

Regulatory limits and incentives	Part(s) of Asset Lifecycle affected	Impact on Dynamic Capabilities			Impact on rents
		Process Impact	Position Impact	Path Impact	
Grey boxes indicate specific, detailed regulation measures and incentives that directly impact certain positions and processes.					
Maximum allowable revenues, increasing from PR1 to PR3.	All				Caps rents from customers.
Operational expenditure limits, specifying areas of expenditure including asset maintenance programmes. PR2 and PR3 more detailed than PR1.	Maintain	Asset maintenance policies and processes.	Directly affects asset value over time.	Rents from preceding PR are priced into next PR.	Rent proportional to amount OPEX is below target.
Capital expenditure limits, specifying on what assets capital may be spent. PR2 and PR3 more detailed than PR1.	Plan, Build	Asset planning processes.	Directly affects asset accumulation.	Rents from preceding PR are priced into next PR.	Rent proportional to amount CAPEX is below target.
Operational efficiency, applying negative adjustment to OPEX. PR3 only.	Maintain			Influenced by previous PR.	Limits rent from OPEX
Investment efficiency, applying negative adjustment to CAPEX. PR3 only.	Plan, Build			Influenced by preceding PR.	Limits rent from CAPEX
Network reliability, specifying progressive reduction in CML (Pr1, PR2 & PR3) and CI (PR2). Specific work mandated in PR3.	Plan, Build, Maintain		Directly affects asset base.		Penalty avoidance. Requires specific OPEX and CAPEX.
Network capacity, Quality of Supply and Customer Service. Specified reinforcement programmes in PR1, PR2 and PR3 and reduction in electrical losses in PR2, PR3. Incentive capped at 4% of revenue or 0.4% additional return on capital in PR3.	Plan, Build, Maintain		Directly affects asset base.		Rent via incentive if targets met or exceeded. Requires CAPEX.
Regulatory asset base (RAB) opening value, increasing from PR1 to PR3, detailed in PR2 & PR3	All		Directly affects how certain assets generate rents.		Affects return (and rent gain) on RAB.
Average Unit Price (AUP) per kWh from 2.59c in PR1 to 3.23c at end of PR3.	All				Drops in real value of rents.

(After CER (2001, 2005, 2010))

Successive pricing reviews, therefore, impose more structure on the Plan, Build and Maintain elements of the Asset Lifecycle. If the DSO wishes to increase rent yield from different phases of the lifecycle then it has to operate within the limits specified by the CER for each phase. Capital expenditure during the plan and build phases must be weighed against operational expenditure during the maintain phase.

5.6 Summary of Asset Management Activities

An asset management organisation such as EnerDist needs to extract value from its regulated asset base to meet increasingly stringent regulatory requirements as well as make a profit. In this case EnerDist adopted an Information Systems - led approach by implementing SAP R/3, to manage its regulated asset base. However it is important to understand how the implementation of an Enterprise System such as SAP R/3 creates additional value or increased rents for EnerDist, especially given the considerable installation and maintenance cost of such a system.

The objective of this Chapter was to answer Research Question 1 by describing the activities within EnerDist's Asset Management Lifecycle. These activities are summarised within Figure 5.5. It is evident that there are six main phases to the observed Lifecycle. These are:

1. Programme Management
2. Plan
3. Design
4. Build
5. Maintain
6. End of Life

Programme Management is a special case as it covers all other phases of the Asset Lifecycle, listed 2-6 above. The End of Life phase has little significance for the purposes of this study as decisions as to when assets are retired are usually taken as part of the Maintain phase for individual assets, or as part of Programme Managements for large groups of assets that must be replaced as part of a Renewal Programme. Plan and Design can be treated as part of the same Lifecycle phase as the activities in both are rightly coupled and tend to be performed by the same groups of people.

The Maintain phase of the Asset lifecycle is critical to EnerCo Network's ability to generate value. This phase contains two important groups of activities: The first is negotiating Asset Maintenance Policies with the Regulator. How well these policies are negotiated significantly affects EnerDist's ability to generate rents over a five year Pricing Round period. Thus this group of activities, while only part of a lifecycle phase, warrants regard in its own right. The other part of the Maintain phase is the servicing of the assets themselves. Again, this is a significant value - generating activity which operates on the whole Regulated Asset Base of EnerDist.

This yields a revised list of Asset Lifecycle activities, adjusted using the considerations articulated above:

1. Programme Management
2. Plan and Design
3. Build
4. Negotiation of Maintenance Policies (includes End of Life issues)
5. Execution of Maintenance Plans

This list of activities forms the basis of a list of Dynamic Capabilities for consideration in Research Questions 2, 3 and 4. This list is illustrated in Table 5.5. The table illustrates how these Tentative Capabilities are drawn from different phases of the Asset Management Lifecycle and the major value - generating activities within Asset Management in EnerCo Newtorks. (As a consequence, the additional revenue streams generated by new connections are excluded.)

The next Chapter 6 articulates exactly what these Dynamic Capabilities are, and describes some of their characteristics, their constituent processes and assets.

Table 5.5: Findings of Research Question 1

Life Cycle Stage	Activities	Value Generating Mechanisms	Tentative Capability
Plan, Design	Planning and designing new network assets, solving network load problems, new connections	Reduce CI and CML by improving network reliability, so fear penalties	Identifying New Assets
All	Large scale renewal and maintenance projects	Savings on OPEX and CAPEX, reduction in penalties for CI and CML	Coordinating Asset Programmes
Build	Work orders, stock ordering, building on site	New assets on which to make a return	Building New Assets
Maintain, End Of Life	Pricing Round negotiation with Regulator	Successful negotiation leading to maximum CAPEX and OPEX, effieciencies	Determining Asset Policies
	Maintaining assets in the field	Efficiency gains, reductions in CAPEX and OPEX	Servicing Existing Assets

Chapter 6

Research Question 2: The Dynamic Capabilities of Asset Lifecycle Management

6.1 Introduction

This chapter addresses **Research Question 2** by revealing the Dynamic Capabilities in EnerDist's Asset Management Lifecycle. Research Question 2 is restated below:

Research Question 2: What Dynamic Capabilities are evident in the Asset Management Lifecycle?

These Dynamic Capabilities are decomposed into their business processes, as well as the learning, reconfiguration and transformation processes that make them dynamic. The complementary positions (people and organisational structures) that comprise these Dynamic Capabilities are also described. Finally the value of these Dynamic Capabilities as well as their resistance to imitation and substitution is discussed.

Five Dynamic Capabilities are identified, roughly (but not entirely) corresponding to the Asset Lifecycle Management phases referred to in Research Question 1. This Chapter, covering Research Question 2, addresses each of these Dynamic Capabilities individually. All of the Dynamic Capabilities are summarised in the Chapter Summary in Section 6.7, specifically in Table 6.2. The structure of this Table is informed by a subset of the ESAMC framework presented in Chapter 4. The findings of the Research Question also illustrate those Dynamiuc Capabilities in relation to the Asset Lifecycle Management environment, in Figure 6.7.

Consequently this Chapter is laid out in subsections, each addressing a different Capability. These are presented in approximate lifecycle order from the Plan and Design through to the End of Life phases. The final subsection of the chapter presents all the Dynamic Capabilities in relation to each other and the overall asset lifecycle.

The following Dynamic Capabilities are discussed in this chapter:

Section 6.2: ***Identifying New Assets*** covers the Plan and Design phases of the Asset Lifecycle.

Section 6.3: ***Coordinating Asset Programmes*** covers the coordination of the maintenance and building of Network Assets on a large scale. It primarily covers the Maintain and Build phases of the Asset Lifecycle, with influence on all other phases.

Section 6.4: ***Building New Assets*** covers the Build phase of the Asset Lifecycle.

Section 6.5: ***Determining Asset Policies*** covers the Maintain and End of Life phases of the Asset Lifecycle.

Section 6.6: ***Servicing Existing Assets*** covers the Maintain phase of the Asset Lifecycle.

Section 6.7 provides a summary of all the Dynamic Capabilities found.

Each subsection is laid out as follows: A brief overview introduces the distinctive capability. The business processes are then described, followed by integration, learning, reconfiguration and transformation processes. The relevant positions are articulated as technological and complementary assets. The paths, both in terms of relevant history and future implications, are described. The subsection concludes with a short analysis of the capability, summarising its dynamicity, value, inimitability, non substitutability and exploitability.

6.2 Identifying New Assets

6.2.1 Overview

Identify New Assets is a Capability that manifests itself during the Plan and Design phases of a particular regulated network asset or group of regulated network assets. The asset planning phase in EnerDist is executed by the Planning group, which is responsible for planning and designing changes and extensions to the existing electricity distribution network. Planning activities are undertaken for two main reasons: To accommodate customer requests for network load and to facilitate network expansion and reliability improvements. This Capability impinges directly on the regulated asset base of EnerDist.

Planning is undertaken if an electrical load of more than 630kVA is proposed. If the load exceeds 4MVA then EirGrid is also involved as the planning exercise may necessitate connection to or extension of the HV network under EirGrid's control. As a typical dwelling draws no more than 15kVA, it can be seen that the planning function is not involved in small scale improvements and expansions, such as connecting a small number of new subscribers to the network. In this case any required network changes are dealt with during the Design phase.

The goal of planning is to design the lowest cost technically acceptable solution that meets the requirements for a network change, either to accommodate extra customer load or to resolve a reliability and performance issue.

Considerations for the planner are the actual work to be undertaken, the feasibility of the solution and the cost versus benefit of that solution. Cost considerations include the cost of building the solution to a certain level of reliability versus the benefits gained by reducing the risk of fines from the regulator. Other constraints are imposed on any solution: While there is a basic requirement that the new equipment will carry a given load to a certain level of reliability, the physical and environmental constraints of the site may dictate a particular solution.

The output of the Planning phase is a completed Design or set of Designs. These are translated into Work Orders by an Engineering Officer, who then implements them as Work Orders in IWM.

6.2.2 Solution Identification Process

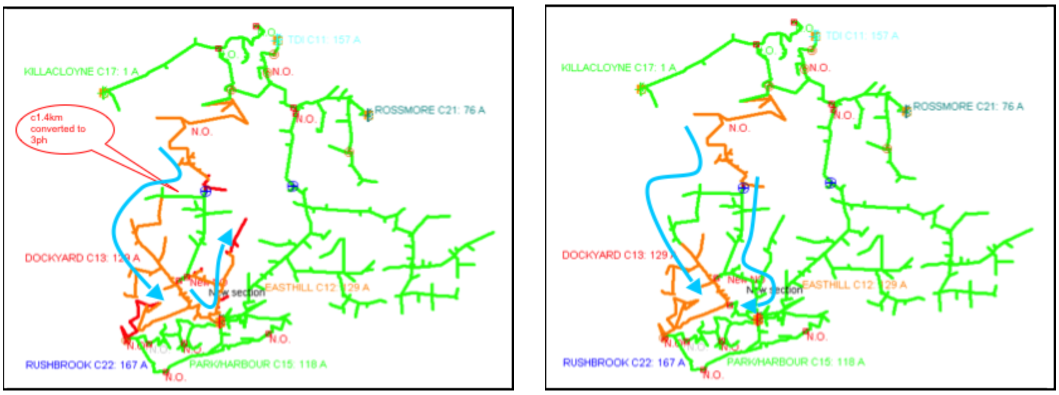
The solution identification process process starts when the planner is presented with a new load request or a request to alleviate a network reliability problem. This forms the starting point of the process to find an optimum solution to the problem.

The planner investigates and documents a number of solutions and then eliminates those which are either too costly or impractical for site specific reasons. As well as construction costs, the planner must consider network reliability and maintenance cost issues several years hence.

For example, an industrial customer may wish to set up operations in a certain area and requires an electricity supply to meet their needs. The planner determines how the extra network load will be carried to the customer and what changes to the network are needed. In the case of reliability improvements, the planning activity is undertaken to design a solution to network performance problems identified in a certain area. These problems might be characterised by excessive outages or under-voltage.

Figure 6.1 illustrates a situation where the planner determines a means to provide standby power to a certain point on the network, with the ultimate aim of improving network reliability. Provision of standby power ensures that power is still available if the main feed to that part of the network becomes inoperable. Such a change is desirable to improve service to the customer and also to improve compliance with regulatory requirements on outages. The planner must consider whether other parts of the local network can carry the extra load if the main feed is inoperable. Figure 6.1 shows successive attempts to devise a scheme to route standby load through an existing network. The planner refers to a **Distribution Load Flow Analysis** tool called Synergy to prepare the diagrams.

The optimum solution design processes is iterative and all the possible designs are collated in a single document. Each possible solution is graphically represented in a manner similar to Figure 6.1. The planner then writes an assessment of each solution in terms of practicality, cost and implications for future network expansion. The document concludes with a recommendation. The document does not present a single solution as a *fait accompli*. Instead each planning step and iteration are clearly delineated. Rejected solutions and their reason for rejection are documented.



(Sample EnerDist planning analysis and proposal)

Figure 6.1: Successive network plans to provide standby load

Once the planning document is complete and a solution decided upon, the solution is hand keyed into SAP IWM as a new work order.

> *"What most Planners do, we do up a Word document. It's a report that basically takes all the results of our studies and details exactly the work that needs to be done and it's cut-and-paste then into the system."*
>
> Planner

The planning process concludes once a design is made available to an Engineering Officer, who then draws up a work order in IWM. A new work order initiates the Build phase of the Asset Lifecycle and is the starting point for the processes in the Capability *Building New Assets*.

6.2.3 Integration Processes

Identify New Assets is in some respects a *factory floor* capability in that it directly impinges on the regulated asset base and does not integrate other processes or capabilities. However it does not happen in isolation; it is integrated with other asset lifecycle capabilities and processes via Asset Register Administration, Programme Management and Enterprise Asset Management. The integration of this Capability into those structures processes and capabilities is examined elsewhere.

6.2.4 Learning Processes

The solution selection process is the main business process evident in the Identifying New Assets capability. It is affected by enhancements in electricity distribution technology and this process has changed to accommodate those improvements. As reduction of future network outages is a regulatory requirement subject to penalty, any technology which minimises outage duration and occurrence is likely to be attractive. EnerDist has applied two significant technologies to reduce the impact of outages on rural MV networks. These are automatic reclosers and Soulé switches. The automatic recloser permits rapid clearance of transient faults where the fault condition no longer persists. The Soulé switch may be remotely operated via the SCADA system. Both allow EnerDist to rapidly reroute power around a failed part of the network. This allows the DSO to restore power after an outage without recourse to sending a network technician to a failure site. Outage time and the resulting penalty is thus reduced.

Automatic reclosers and Soulé switches were introduced into the network in 2006. As part of the introduction, the Planning department introduced a **Cost Benefit Analysis Tool** which shows the benefit of adding automated switches versus the increased cost of installing them in the first place. This process change permits the Planning department to model the long term operational benefit of such improvements. The operational benefit manifests itself as a reduction in customer minutes lost and therefore reduced penalties from the regulator:

> *"The reduction in fault CML [Customer Minutes Lost] since 2006 has been mainly due to the deployment of downline automatic reclosers and switches on rural MV feeders. These devices can be operated remotely from the two SCADA Control Centres ... They have the effect of reducing the number of customers affected by faults and permit faster restoration of supply."* (ESBN, 2010, p.25)

While EnerDist attributes the reduction in fault CML to an enhance timber cutting program me on the Medium Voltage network as well as the installation of automatic reclosers and Soulé switches, it assigns most of the credit for reduction to the installation of the switches and reclosers.

The learning process evident here is the process of **assimilating new technolo-**

gies (reclosers and Soulé switches), **devising new processes** (use of the Cost Benefit Analysis Tool) to exploit those technologies to full effect and the **integration** of those new processes into the Identifying New Assets capability. The positive outcome of this learning process is evidenced by the reduction in fault Customer Minutes Lost from 2006 to 2011. Measuring CML, while required by the regulator, is also part of the feedback loop required to determine the outcome of the learning process. In this case, technological and regulatory changes have driven process improvements and changes with a view to creating long-term value by avoiding regulatory penalties related to length of outage.

6.2.5 Reconfiguration and Transformation Processes

Identification of New Assets leads to reconfiguration and transformation of revenue-generating network assets to maximise returns and reduce regulatory penalties in the future. In essence this is a production-line process that has no direct impact on the Identifying New Assets capability itself. No transformation of organisational structures is evidenced at this level. Transformation of processes and technologies is evidenced by the introduction of automatic reclosers and Soulé switches. The introduction of these new technologies required a transformation of the Solution Selection process, where it now incorporates a cost benefit analysis on using the new switches. As well as transforming one of the processes in the Identifying New Assets capability, there has been a transformational effect on the technological assets (the switches and the cost benefit analysis tool) that form part of the capability.

6.2.6 Complementary Assets

Planning is an activity where well-defined rules concerning, for example, network load and safety are followed. However, it is clear that the job of the Planner is a learned skill:

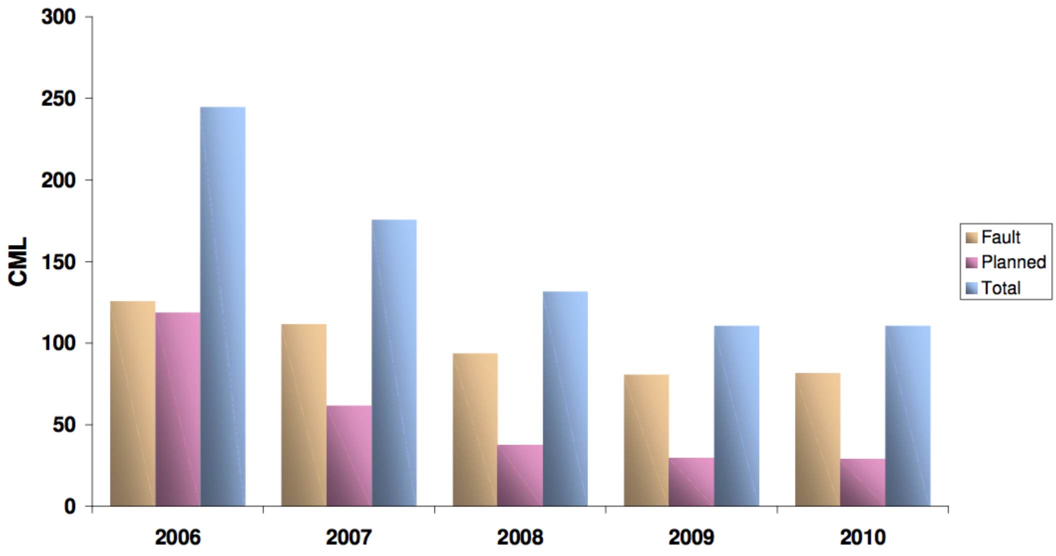
> *"It's kind of contingent on the experience of the Planner rather than the system. It's not like somebody new could walk in and do it really good then. No, that's the one thing about planning. There's quite a learning curve. There'd be at least six months, if not a year to when a Planner could kind of be confident in the kind*

> *of concepts that they're taking into account when they're planning and making sure that they had every angle covered"*
>
> Planner

The knowledge and training of the planner is a complementary asset that accumulates over time. Any planner that starts work in EnerDist is subject to a training and apprenticeship period where the specifics of the network itself and the planning and solution design processes are learnt. In addition, this training process is very much an apprenticeship, where tacit knowledge acquired by an experienced planner is imparted to the trainee. While the planner has rules to follow and an overall workflow is apparent, Solution Identification can not be automated, nor can it be performed by an inexperienced Planner simply by referring to the documentation and systems available.

6.2.7 Value

Identifying New Assets is valuable as it seeks to reduce the cost of network modification and expansion to the lowest level consistent with meeting the regulator's requirements for safety and reliability. The objective is to spend CAPEX to reduce future OPEX. This has the double effect of reducing future costs and penalties while increasing the opportunity to earn a return on CAPEX. As discussed in Subsection 6.2.4 and illustrated in Figure 6.2, value has been earned by reducing penalties for Customer Interruptions (CI) and Customer Minutes Lost (CML) over a period of years. Consequently, the ability to earn value from this Capability has improved as a results of the learning and reconfiguration processes inherent within the capability.



(ESBN, 2010, p.24)

Figure 6.2: Customer minutes Lost (CML) 2006-2010

The Commission for Energy Regulation (CER) notes that,

> *"With respect to Customer Minutes Lost ("CML") Ireland's network performance was benchmarked against over 40 comparable US utilities. The results show that Ireland's network performance is at an acceptable level. CML has improved from 371 in 2001 to an expected 275 in 2005 (i.e. a 26% improvement) reflecting the significant investment that has been made to the network during that period."* (CER, 2005, p.3)

Finally, the loss to EnerDist in revenue during an outage is approximately €7000 per MWh lost (CER, 2005, p.141). *Identifying New Assets* is therefore valuable both in terms of reducing the application of CER penalties and in reducing lost revenue.

6.2.8 Inimitability and Non-substitutability

The inimitability of this Capability is grounded in the extensive training and apprenticeship a planner must undergo to become proficient. This is a process that takes at least six months and up to eighteen months. Nor is it substitutable: While there is room for enhancement by providing more tailored systems to aid the process, the complexities and contingencies involved in solution identification do not lend themselves to automation or easy replacement by a different capability. In addition, identifying a final solution involves decision making both at the planner's lever and in other parts of the EnerDist organisation, as planning conflicts must be resolved and tradeoffs between current building cost and future network expansion must be weighed up.

6.2.9 Analysis

Identifying New Assets could be classified as an Operational Capability: It has little impact on EnerDist's overall strategy. However it is also in part a Capability as it directly impacts EnerDist's Asset Base. This alone is not enough to classify it as a Capability: The Solution Identification Process self-evidently modifies the Regulated Asset Base as the output of this process is a plan to modify, replace, repair or upgrade Network Equipment. However, reconfiguration and transformation processes manifest themselves in the processes of assimilating new types of Network Equipment, e.g the Soulé Switch, and then modifying the existing business process to use this new technology effectively.

6.3 Coordinating Asset Programmes

6.3.1 Overview

Coordinating Asset Programmes is a Capability that concerns itself with large scale asset and maintenance activities, as negotiated with the Commission for Energy Regulation. These are governed by the Programme Management function within EnerDist. Programme Management is responsible for coordinating and executing large scale works affecting the entire distribution network. Such works vary from tree cutting and pole replacement to the upgrade of MV substation transformers from 120kV to 20kV. The expected outcomes of these programmes are lower operating costs and increased reliability.

Programme Management is conducted against regulatory objectives laid out as follows:

> *"[Pricing Round 3 Objectives:] The DSO is able to maintain the distribution*

network to an adequate standard to meet customers' expectations; The interests of final customers are protected, in the short and long term, by containing tariffs to the maximum extent possible while delivering efficient network investment; The DSO is able attract the necessary level of capital investment to support the approved level of renewal and extension of the network. In doing so, the CER wants to ensure that the items of work included in the DSO?s investment plans are necessary and provide value for money for customers in terms of the benefits they add; Appropriate incentives are provided for the DSO to improve its efficiency where possible and that as much as possible of these savings are passed through to consumers." (CER, 2010, p.22)

The Programme Management function becomes involved when the extent of additions and improvements is system-wide. While a planning activity tends to be localised to one part of the network in one geographic location, programme management activities can impact the whole network over the whole country. An example is the current programme to upgrade the existing MV network from 10kV to 20kV. This requires replacing the pole mounted transformers which form part of the Irish rural landscape. By increasing the voltage on this network, capacity can be increased fourfold without having to replace any of the cables. As the MV network extends across the entire state, a localised planning activity is not sufficient to address this upgrade activity. Other programmes to be undertaken during PR3 include Smart Metering, Electric Vehicle (EV) supply points, upgrade of the 10kV network to 20kV, as well as general network reinforcement to improve reliability.

6.3.2 Programme Negotiation Process

A central part of each pricing round negotiation is agreeing with the regulator which groups of assets will be maintained, upgraded or replaced during the next five years. Every five years the distribution network is analysed to decide where refurbishments, reinforcements or replacements - including retiring existing assets - need to be done. All of this work is then justified internally on a business basis before presentation to the regulator as part of the negotiations for the next Pricing Round.

The regulated then reviews EnerDist's submission and examines the consequences of the proposed programmes for the price of electricity. The regulator may decide to curtail or refuse certain programme proposal in order to keep the price down. Alternatively, the regulator may mandate that the proposed work must be done but at a reduced price. Once a compromise is reached and agreed, EnerDist is expected to perform to the agreement; failure to perform may prejudice negotiations at future pricing rounds.

6.3.3 Programme Execution Process

The Programme Management team undertakes larger scale planning activities which form part of a network-wide initiative. These programmes are planned with a view to optimising the capital expenditure (CAPEX) allowed in a pricing round by the CER. Programme management upgrades of assets are undertaken on a three-year cycle. The three-year programme is intended to provide effective expenditure of the CER allowance, to provide one single plan, to allow the asset managers to prioritise work, and to provide transparency to the rest of the organisation. The purpose of this program is to provide one baseline plan so all users with differing requirements can see the bigger picture in the organisation. The program management team recognises that this is a big culture change for all users.

All programmes are continuously monitored and updated. Programme Managers spend about half their time ensuring that all the projects that form part of a programme are up to date:

> *"Most days [Coordinators] will be doing something with it ... it will take them probably a fortnight out of every month to get around to all their Supervisors to do the updating. They will do the final updating at the end of the month but there's certain information to be gathered and they'll be picking up the phone and ringing them and checking projects."*
>
> Network Projects Leader

Required work is then packaged and designed, and sometimes redesigned to adjust the scope of some of the projects. This part of the process involves the asset management organisation. Once this is complete the required site work can be carried out, to the design that is specified:

> *"They're doing their initial concept on IWM, to package the work to see what's being called for by other parties in asset management, and then package it, put it together, agree it around the asset management table, and then approve that work package over to the designers, because its happened before, stuff has been missed and its reworked, redesigned, and it gets delayed, so from a project scoping point of view, IWM will definitely help there, but from, and also my perspective, it's from programme management, its keeps everything in a package, its tightens up everything in for the designers in EnerCoI, to design properly, and also from a deliverability point of view, I can then, once the widgets are linked to the package over here, that package is closed, I can then, then report back on programme basis quite automatically"*
>
> Programme Manager

Other work programmes are not necessarily initiated by the regulator, but are asset replacement and refurbishment activities, the need for which is determined by EnerDist.

> *"Not all of the work programmes that we do on the assets are generated by the planners, which would be the new business end of it or new changes, some of it would be because of obsolescence reasons, we would be doing asset replacement, or refurbishment programmes."*
>
> Asset Manager

These internal programmes address asset end-of-life or maintenance issues that need to be dealt with on a large scale. These programmes are necessary to keep the regulated asset base up to date and functioning in a safe and economical manner.

Regardless of the origin of the programme, the required work packages are broken down into individual designs by Engineering Officers and then implemented as work orders in IWM. This starts the process of building new assets or servicing existing assets as needed.

6.3.4 Programme Monitoring Process

The Programme Management team undertakes larger scale planning activities which form part of a network-wide initiative. These programmes are planned with a view to optimising the capital expenditure (CAPEX) allowed in a pricing round by the CER. All programmes are continuously monitored and updated. Programme Managers spend about half their working time ensuring that all the projects that form part of a programme are up to date.

High level project reports are drawn from xRPM, with reporting also from BW and asset status from ARM. Completed project work will be shown in xRPM and completed work from IWM is reflected in updated asset status in ARM. BW provides a consolidated and integrated overview of project status.

Any outputs from the Programme Monitoring Process are status updates to projects in xRPM and possibly some asset status updates to ARM. Updates to GIS and IWM are not done here; those updates are solely as a result of design work and site work completed.

While Programme Monitoring is contingent on receiving accurate reporting form various systems, it is also dependent on the skill and experience of the Programme Manager to review large numbers of projects rapidly and provide succinct updates.

6.3.5 Integration Processes

Coordinating Asset Programmes has a number of integration processes, facilitated mainly by the SAP R/3 Business Warehouse (BW) which provides reporting visibility across a number of groups (Programme Management, Asset Management, Network Projects) in EnerDist. BW provides the connective tissue that interconnects some of the other SAP R/3 systems such as IWM and ARM:

> *"I'm not so sure that I, it depends on the extent to which it takes our existing systems and takes the information from them, right. I think it's as best as could be done because it was a major, major project and given the, the variation and the complexity in terms of what we do, depends on how well it sucks up the information, particularly the Business Warehouse end of it is the piece that I am interested in, not the IWM per se, or not the SAP element of it. Because that's the*

bit that we are depending on to interconnect all the systems that we are talking about. They were all developed independently, not communicating."

Network Projects Supervisor

The SAP R/3 Compatible Unit provides an interconnection between previously distinct processes and functions as it permits an asset to be treated as a functional module, a financial entity, a depreciating asset and a set of maintenance policies:

"You are using this compatible unit which isn't a set, it's a building block but it's multi-dimensional, it's got the financial side of it, it's got the asset side of it, it's got the materials you know so that whole thing of using an entity, a core component that has all of these different dimensions, that everybody uses and everyone feeds off, that's great strength in that but then when somebody wants to change something it can have knock-on, unintended consequences."

Finance Supervisor

The *multidimensionality* of the compatible Unit permits site work planning to be directly tied to stock ordering, as well as programme planning and financial management:

"I suppose probably a lot of regulatory stuff has changed that as well that the business now can no longer afford to be good at just one dimension and the business has to be multi-dimensional; really an electricity utility has got to have its finances right, its got to have its HR right, its got to have its asset base right, its got to not just be able to do the work, it's got to be able to record the work properly. In its systems it's got to have its data management right, its IT right and so on. So I think, I think that is just the progress that we have had over the last number of years has driven that so I suppose it's not just an EnerCo phenomenon I suppose all organisations now are probably a bit more flexible and a bit more, more kind of nimble and for finance people as well, there's not as many of us as there used to be and you just have to be more, I suppose, value adding, you know."

Finance Supervisor

6.3.6 Learning Processes

EnerDist reports annually to the Commission for Energy Regulation on the performance of its Distribution Network. These annual reports cover performance on the capital programme and also performance of the network in terms of CI and CML. Figure 6.3 illustrates performance of some capital programs against targets agreed with the CER for 2006-2010.

Learning effects are evidenced by EnerDist itself in reporting reductions in CI/CML and attributing those both to the introduction of downline reclosers (dealt with in Subsection 6.2) and also to various capital programs. Specifically, EnerDist states that,

> *"Major renewal programmes are programmes carried out under the price determination such as the MV overhead network renewal programme and LV Refurbishment programmes which have a significant effect on improving reliability."*
>
> (ESBN, 2010, p.24)

as well as noting that,

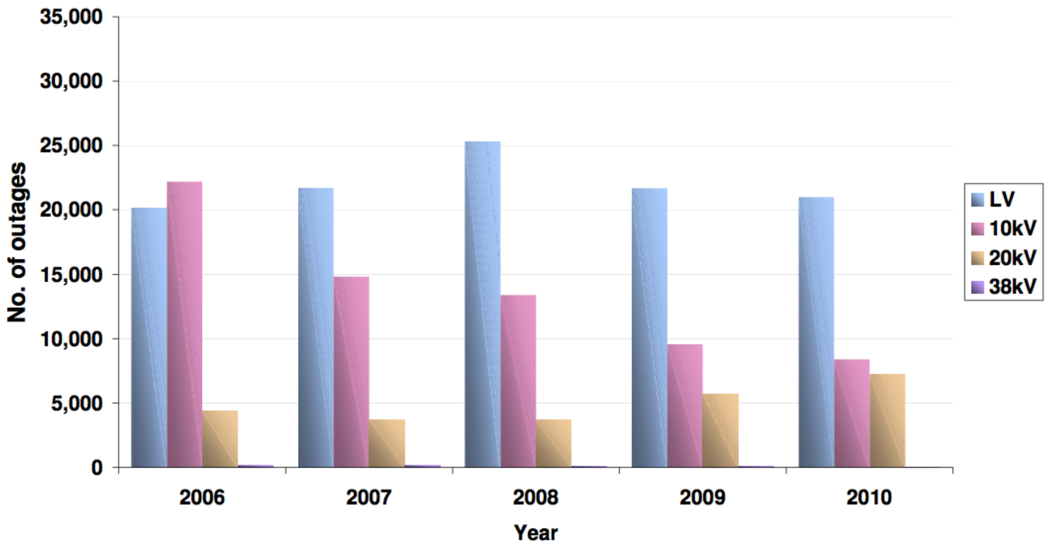
> *"The reduction in LV outages in 2009 and 2010 [is] due to ... more benign weather conditions during the spring of 2009 and 2010 compared to 2008 [and] further progress on the LV Rural and LV Urban refurbishment programs."*
>
> (ESBN, 2010, p.23)

Figure 6.4 illustrates the expected drop in outages from 2008 onward.

Description of criteria	Value	Progress Comment (In relation to 2006-2010 Targets)
HV Cable Replacement Programme in 2010		
110kV Oil filled cable completed (km)	4.5	100% of target
110kV Gas filled cable completed (km)	2.5	100% of target
38kV Pre 1945 Paper Insulated cable (km)	8.8	95% of target
38kV Fluid filled cable completed (km)	9	82% of target
Capacity added during 2010		
Increase in 110kV/38kV capacity	126 MVA	
Increase in 110kV/MV capacity	111.5 MVA	100% of target
Increase in 38kV/MV capacity	133 MVA	100% of target
Rebuild & Refurbishment of 50's copper 38kV line in 2010	374km	82% of target
MV Substations Asset Replacement in 2010		
1. Oil-filled Switchgear Subs (No.)	5	100% of target
2. Cast Resin Kiosks (No.)	606	100% of target
3. Metrovicker Units (No.)	6	100% of target
4. Stator Boards (No.)	3	100% of target
5. LV Panel Shrouds (No.)	326	100% of target
20kV Conversion in 2010 (km)	3,658	96% of target

(ESBN, 2010, p.19)

Figure 6.3: Performance of Pricing Round 2 capital programmes against target



(ESBN, 2010, p.23)

Figure 6.4: Number of Outages, 2006-2010

For Pricing Round 3 (PR3), which is in effect until the end of 2015, specific programmes have been targeted to further reducing Customer Interruptions (CI) and Customer Minutes Lost (CML); these are detailed in Table 6.1.

Table 6.1: PR3 activities related to CI and CML targets

Activity	Unit	2009	2010	2011	2012	2013	2014	2015
20kV conversion	km	7,500	3,579	3,000	3,000	3,000	3,000	3,000
MV overheadline cyclic conversion	km	2,980	3,579	9,000	9,000	9,000	9,000	9,000
Cut-out replacement	Cut-out	7,000	7,000	8,000	8,000	8,000	8,000	8,000
Minipillar replacement	Minipillar	21	300	320	320	320	320	320
LV urban overheadline refurbishment	Span	3,646	8,200	7,600	7,600	7,600	7,600	7,600
LV rural refurbishment	Group	6,569	10,535	5,000	5,000	5,000	5,000	5,000
Non-scheme new connections	Connections	12,848	9,867	10,110	10,352	10,594	10,836	11,079
Correction of voltage complaints	Jobs	1,798	2,000	2,000	1,850	1,700	1,600	1,500

(CER, 2010, p.110)

6.3.7 Reconfiguration and Transformation Processes

The new SAP R/3 modules have been utilised to transform Programme Management's understanding of how long jobs take and how much they cost:

> *"Because we contract them each month and quarterly and there are quarterly reviews when they look and say listen this is what we envisage we'll get done, did we or didn't we achieve and if we didn't, why didn't we, did we expect too much, or equally if things were moving better you can, they'd be look, saying we can add something on to the work programme at the end of the year you know. I remember*

> *one thing it gives us, it will give you a breakdown of your man years so you'll always know where you are during the year in relation to what manpower you have available to you. Whereas in the past we wouldn't have had that facility, we wouldn't have had, ... we would have been based on experience saying we expect that job will take 20 man years but no one knew exactly. Whereas now that has been developed that we have it fairly accurately built into the system that it will spill us out if we put in a work programme into it, it will say you don't have the resources to do that or this is what it is taking and you only have 90% of it you know. So there's, there's an element of that end as well that it all feeds into good planning now that gives us a far more refined plan."*
>
> Network Projects Manager

Increased visibility of the duration and cost of jobs enables increased control at the Programme Manager level and refined plans on an annual basis. This affects both the Programme Negotiation and Programme Execution processes. The Programme Execution process has been refined as the effort required to complete each job is now recorded in SAP R/3. This forms part of SAP R/3's Compatible Unit, which presents a multidimensional view of very asset. The refined Programme Execution process permits costs to be kept to a minimum and also enhances year-on-year planning.

In addition, the increased detail on job costs and efforts may be combined with actual data on job completion to feed into the Programme Negotiation process for the next Pricing round. This puts EnerDist in the position of understanding the exact cost of what it is required to do by the Regulator.

6.3.8 Complementary Assets

Coordinating Asset Programmes is dependent on a number of different roles and groups within EnerDist. **Programme Managers** are responsible for the design and monitoring of programmes. **Network Projects**, as a groups, executes some of the programmes formulated by the Programme managers. **Asset Managers** will be at least aware of what programmes are being executed and will have to take this into account when preparing specific maintenance schedules. This is because a large scale refurbishment programme may address the maintenance requirements of a group of network assets, that might otherwise need maintenance visits. Finally, **Engineering Officers**, **Construction Supervisors** and **Network Technicians** are responsible for executing and approving the specific work packages that are required as part of any programme.

Coordinators in Network Projects are responsible for direct supervision of the progress of Programme work:

> *"Well I suppose ... Projects or Coordinators would be in on it on a very regular basis. I won't say every day but most days they will be doing something with it you know if they're ... like it will take them probably a fortnight out of every month for them to get around to all their Supervisors to do the updating. They will do the final updating at the end of the month but there's certain information to be gathered and they'll be picking up the phone and ringing them and checking projects because we have, we have two sets of projects in, what we call WIP 'Work In Progress"'*
>
> Network Projects Manager

Coordinating Asset Programmes is heavily dependent on a large number of EnerDist staff, many of whom who have risen through the organisation to the positions they are in now. This has implications for inimitability and non-substitutability.

6.3.9 Value

The reduction in LV outages noted in Subsection 6.3.5 consequentially lead to a reduction in penalties associated with CI and CML. Coordinating Asset Programmes therefore at least adds value in this manner. However any asset replacement activity is inherently valuable as it increases the capital value of the asset base and a return on the capital is allowed by the regulator.

6.3.10 Inimitability and Non-substitutability

Coordinating Asset Programmes is contingent of the accumulated experience of (in rough order of decreasing seniority) Programme Managers, Asset Managers, Network Projects Coordinators, Engineering Officers, Construction Supervisors and Network Technicians. At the site construction end of the seniority scale, at least some of the work is subcontractable. This has already happened with pole replacement programmes and vegetation clearance and tree cutting programmes. If an asset replacement programme is focused on a single type of asset and the scale of the programme is large, then it may make economic sense to subcontract the work to an external supplier. However, the unionised culture of EnerDist is likely to mitigate against this.

While the actual physical asset replacement and refurbishment work may be subcontractable, the management of this work is not. Coordinating Asset Programmes is dependent on the interplay between Asset Managers, Programme Managers, Network Projects and the Regulator. During the interview process it was noted that several Asset Managers and Programme Managers had been promoted from within EnerDist. This suggests that the accumulation of experience and knowledge of the individuals concerned is difficult to replicate from outside; it is difficult to envisage a situation where a successful Programme Manager would be recruited form another energy utility. At the very least the requirement to become intimately familiar with the Irish distribution network would require a long acclimatisation and training period. This constitutes a costly barrier to entry.

6.3.11 Analysis

Coordinating Asset Programmes is a Capability of strategic significance. The Programme Negotiation Process establishes what large scale building, replacement and maintenance programmes will be performed on the Regulated Asset Base over the next Pricing Round. The Programme Execution Process ensures that this happens with the minimum of expenditure or penalty. As such these two processes directly impact EnerDist's ability to generate rents by keeping costs as low as possible and securing a return on the existing RAB.

There are highly evident and measurable learning effects: Reduction in Customer Interruptions, Customer Minutes Lost and the overall number of outages have dropped in most cases. In the case of the 20kV network, outages have, in contrast, risen. However this is a new network that is still being built and outages can be expected to stabilise and drop in future years.

Finally, the Programme Negotiation and Programme Execution processes have been transformed by the considerably increased detail on job costs, effort and completion that is now available since the introduction of SAP R/3. These processes have been refined and enhanced as EnerDist is now able to determine a much more precise picture of programme costs. This is of strategic significance as it improves EnerDist's position when negotiating pricing rounds with the Regulator.

6.4 Building New Assets

6.4.1 Overview

The Build phase of the asset lifecycle covers a number of different activities, all covered by Network Projects. All work on the network is covered by either Capital Expenditure (CAPEX) or Operational Expenditure (OPEX). Build activity breaks into three categories:

Load-Driven New Works Originate from SAP IS-U, which is used to to log requests from customers for new connections. The execution and closure of this work is carried out through IWM.

Non Load-Driven New Works Originated and driven from IWM, designed to rectify individual network deficiencies. These works originate from *Identifying New Assets*.

Replacement Programmes Originated and driven from IWM, designed to upgrade the network to meet programme requirements as agreed with the regulator. These works originate from *Coordinating Asset Programmes*.

While the first category is purely driven by customer need for additional or new load, the second and third categories are driven by the requirement to improve the network to increase capacity, improve reliability and to replace assets at the end of their useful lifetimes. The distinction between the second and third category is purely one of scale, where the second category covers individual network remediation and the third category covers larger programs which are costed and planned in agreement with the regulator.

6.4.2 Stock Ordering Process

The entry point for any site work process is a design executed from a set of plans by an Engineering Officer. The design is prepared as the end point of the processes in *Identifying New Assets* and *Coordinating Asset Programmes*. In addition a third starting point is a **Connection Design** which is prepared as a result of a connection request from an individual customer. The finished design is implemented as a Work Order in IWM, which serves as the starting point for the processes in *Building New Assets*

Stock ordering processes have changed dramatically as a result of the introduction of IWM. Prior to IWM, stock ordering was based on project requirements identified in xRPM and in SAP R/3's predecessors. The lead times for some large and complex pieces of switching machine were, and remain, very long. It is not unusual for some suppliers to require and 18 month lead on some items. Consequently, prior to SAP R/3 and, in particular, IWM, it was not unusual to stockpile some items as there was a degree of uncertainty as to when they would be needed.

All stock ordering is now driven by the Compatible Unit and IWM. Approval of an IWM Work order initiates automated stock ordering, where the Compatible Unit contains information not only about an asset, but also its cost and ordering lead time. Consequently stock does not arrive in a local depot until just before it is needed. Form the depot, the stock is transported to site just before a work order is actually executed.

6.4.3 Site Work Process

IWM work orders originate from the Programme Management and Planning activities earlier in the asset lifecycle, as well as connection requests from individual customers. The build process incorporates ordering and staging of raw materials, allocation of personnel, building and commissioning of infrastructure and documentation of the completed work. A piece of network infrastructure does not become an asset until it is carrying load.

IWM Work orders initiate a process whereby materials are drawn down from inventory or ordered from suppliers. The system is designed so that lead times for all items are taken into account. As the lead time for some large items such as transformers is quite long, it is not unusual for a work order to be initiated several months in advance of the work actually to be done. The process is described as follows:

"Integrated work management allows an engineering officer who is our designer

to go in and design work, having decided that is the total project, that's closed off by the supervisor and identified then as a work program for the crew, or crews and it allows it then to be scheduled within the system. So you schedule the crew to go out and do the work and having done the work and having charged all your costs to that work you close off or tick off that job within R3 and that allows you then to report back on the productivity or efficiency on which the job is done."

Finance Manager

6.4.4 Integration Processes

Process Integration is focused on the tighter coupling of stock ordering processes to the site work process. Prior to this integration work, stock ordering was somewhat independent of actual site work. Stock would be ordered as a contingency, resulting in considerable accumulation in some depots in EnerDist.

IWM acts as a bridge between the stock ordering and site work processes, by means of the Compatible Unit, which not only identifies the part required but also specifies its order cost and order lead time. As a result, when a work order is created, the site work is correctly scheduled and the required stock is ordered.

6.4.5 Learning Processes

The restructuring of the depot network and the introduction of IWM has resulted in a drop in stock levels for no more than four weeks' worth for most common items. This is seen as a significant change by EnerDist with a consequent drop in working capital. Four weeks is regarded as the minimum so it is unlikely that further inventory reduction will occur.

6.4.6 Reconfiguration and Transformation Processes

The changes to the stock ordering process have led to a restructuring and rationalisation of EnerDist's depots. There is a single large depot in Dublin with smaller depots situated at regional offices. Goods only arrive at depots when needed; the stockpiles of goods that used to be held in anticipation of work no longer exist.

> *"That's a complete turnout in the sense that the materials are ordered now specifically per job and, to a certain timescale rather than just having them on the shelf to suit, you know what I mean."*
>
> Materials Supervisor

The Site Work process has undergone some transformation as a result of the introduction of SAP IS-U. While the site work itself has not changed, IS-U permits the Network Technician to have more control over their own schedule on a daily basis. The apparent paradox is that, while IWM and IS-U have imposed some rigidities in how work is to be performed, IS-U now permits more flexibility in site work scheduling:

> *"A trend has developed for the [Network] Technician to self-schedule work, given there is confidence that the ERP will already have established that an order is ready to be done i.e. the management input of the [Construction] Supervisor is no longer required."*
>
> MBS thesis by EnerDist staff member

This has resulted in a transfer of responsibility for site work scheduling and completion from the Construction Supervisor to the Network Technician.

6.4.7 Complementary Assets

Construction Supervisors and **Network Technicians** are responsible for executing and approving the specific work packages that are required as part of any programme. The work packages originate from designed executed by an Engineering Officer to a set of plans provided by the planner or originating from Programme Management. Construction Supervisors are responsible for preparing paper work orders for Network Technicians to take to site. These are printed from IWM. The Construction Supervisor also has oversight of movements between depot and site. On return from site the Construction Supervisor needs to update IWM with the completed site work.

The Network Technician is responsible for executing all site work and reporting on completion. Network Technicians are typically very experienced, with new Technicians undergoing a considerable amount of apprenticeship. However a certain amount of site work its contractable.

6.4.8 Value

This Capability is valuable in the sense that no piece of network distribution equipment is an asset until it is carrying load. *Building New Assets* transforms costly stock (and working capital) into completed infrastructure on site. Once this infrastructure is commissioned by the Network Technicians it carries load. Once it carries load it is considered part of the regulated asset base and generates revenue both by carrying load and also because it generates return on the capital expenditure. Thus *Building New Assets* is valuable.

6.4.9 Inimitability and Non-substitutability

The structures associated with stock management have accumulated over a long period of time. In particular EnerDist's network of depots have built up over fifty or more years. As a result for the introduction of IWM, the depot structure has been rationalised and the number of depots reduced. However the experience and skill in managing inventory remains. It is unlikely that a new inventory manager would quickly familiarise herself with the existing depot structure. The stock management processes have also changed as a result of introducing IWM, but these changes are also a function of the pre-existing processes and the experience of the inventory managers. It is unlikely another DSO would attempt to replicate EnerDist's inventory management infrastructure as far too many physical assets are involved.

Inimitability and Non-substitutability is partially contingent on the training and experience of the Network Technician. There is no doubt that knowledge of the Network Technicians, accumulated over time, is costly to replicate. New Network Technicians have to undergo lengthy apprenticeships, Therefore the skills of the Network Technician are expensive and time-consuming to replicate.

However certain site work can be and is subcontracted. Tree-cutting, branch clearing and pole erection work is all performed under contract by organisations external to EnerDist. In addition, a certain amount of distribution and transmission network construction is done by the builders of wind farms, for example. The distribution assets associated with these are then taken over by EnerDist. Thus the Inimitability and Non-substitutability of *Building New Assets* is constrained by the amount and type of work EnerDist chooses to sub-contract.

6.4.10 Analysis

Building New Assets, like Identifying New Assets, could be considered an Operational Capability. As EnerDist is a public utility and effectively a service business rather than a manufacturing business, the closest analogues to factory floor processes are those processes that most directly impinge on its asset base. However, the Stock Ordering Process has been transformed by the introduction of SAP R/3 MMIS and IWM. EnerCo Network's internal supply chain has moved from a largely push-based system, with large amounts of inventory being stockpiled in numerous sites, to a demand-based system, where inventory orders are driven by creation of new work orders on SAP R/3.

Transformation of the Site Work Processes is limited to some degree to the Construction Supervisor's role. Once work moves from the EnerCo yard to the site itself, all tracking is paper-based. However, EnerDist has already piloted the use of mobile devices to tie onsite work back to the main SAP R/3 system. This is a future transformation that forms part of the Building New Assets capability.

This Capability holds some strategic significance as it impacts on inventory levels and also on how new work is planned.

6.5 Determining Asset Policies

6.5.1 Overview

Determination of Asset Policies, which applies to the Maintain phase of the Asset Lifecycle, is a Capability that involves two distinct but interdependent processes: Pricing Round Negotiation and Maintenance Policy Determination. At its core is the Asset Register, which provides detailed information on all of

EnerDist's network assets and facilitates both of the key processes. However the Dynamic Capability's distinctiveness is very much contingent on the skill, knowledge and experience of the Asset Manager, which is required to both productively use the Asset Register and understand the physical electrical distribution network.

6.5.2 Pricing Round Negotiation Process

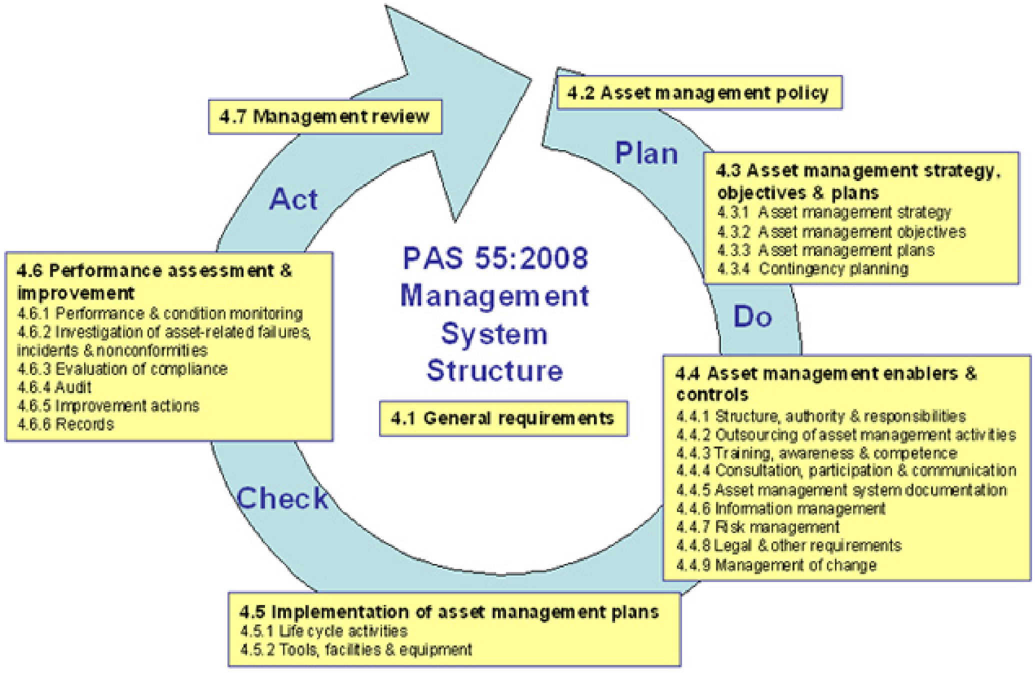
The periodic round submission by EnerDist to the CER includes a proposal for maintaining all the network assets for the upcoming five years. While in principle EnerDist prefers to continuously maintain all its assets, in practice such maintenance must be prioritised. The pricing round proposal includes a list of assets to be maintained and the estimated operational and capital cost of same. The initial proposal is based on researching the existing asset register. The regulator may challenge this proposal, based on information gathered on comparable asset maintenance intervals, from the UK or other markets. The amount allowed by the regulator for asset maintenance is frequently not that proposed by EnerDist. Consequently the final schedule of assets to be maintained and the expenditure allowed is a compromise.

6.5.3 Maintenance Policy Determination Process

The typical economic lifetime of a network asset is now forty years; all assets require maintenance to ensure reliable and safe operation and continuity of service. Any new asset that is acquired will either need to have an existing policy applied to it or have a new maintenance policy devised for it if the asset is of a type not previously installed in the network.

The job of determining new maintenance policies and revising existing maintenance policies falls to the Asset Manager. While safety, reliability and continuity are all issues, cost and regulatory requirements must also be taken into consideration. Any new maintenance policy must be drafted to ensure safe, reliable operation at minimal cost. The asset manager refers to the PAS55 standard, a framework for the optimised management of physical assets, as published by the British Standards Institute and developed by the Institute for Asset Management.

Figure 6.5 delineates the key features of PAS55:2008 and illustrates the context within which maintenance policies are drawn up.



(pas55.net)

Figure 6.5: PAS55:2008 Key Features

Devising a maintenance policy is done with reference to the PAS55 specification, manufacturer's recommendations, regulatory requirements and health, safety and risk reduction imperatives. Certain aspects such as the economic life of the network asset may be negotiated with the regulator. Existing maintenance policies are also subject to review and in some case challenge as older policies may be found to be either uneconomic or inappropriate. An example is the move from time-based to condition-based servicing.

A finished maintenance policy dictates how often assets are to inspected to ensure public safety and to minimise risk, how frequently assets must be inspected for deterioration and what actions are to be taken when a fault is found. New and updated policies are entered into the Asset Register (ARM) and applied to all the relevant assets. Thus the Asset Register contains up to date details on the maintenance and inspection requirements for every single asset, per the relevant maintenance policy. The sum total of all maintenance policies dictates the annual maintenance workload that must be planned for at the start of each calendar year.

Determination of Asset Policies involves two interlocking processes, Pricing Round Negotiation and Maintenance Policy Determination. These processes are codependent: The output of Maintenance Policy Determination helps set the scene for Pricing Round Negotiation for the next 5-year cycle, but it in turn is dependent on what was agreed during Pricing Round Negotiation for the current 5-year cycle. Both processes are dependent on the Asset Register (ARM) as both a repository of prior asset performance and future asset maintenance requirements. In addition the skill, knowledge and experience of the Asset Manager is required to both make sense of these data and to apply viable cost-effective policies for the future.

6.5.4 Integration Processes

The pricing round negotiation and maintenance policy determination processes are interdependent. Maintenance policies are set within the parameters of allowed maintenance spending within the current pricing round and negotiation on future pricing rounds is contingent on observed performance of prior pricing rounds. Both processes are dependent on ARM and the Asset Register forms the common data source that integrates those processes. However the processes are also integrated at the level of complementary assets, as Asset Managers will sit with those negotiating with the regulator to discuss what constitutes and effective maintenance policy that is also acceptable to the regulator.

6.5.5 Learning Processes

Reduction of controllable operating costs is a requirement of the regulator and EnerDist has demonstrated a drop in costs from one cent per kilowatt-hour distributed in 2001, to 0.89 cent in 2011. Controllable operating costs include planned maintenance, which is dictated by asset maintenance policy. As a more detailed view of the asset base has emerged, more astute maintenance policies can be applied, lowering controllable operating costs even further.

6.5.6 Reconfiguration and Transformation Processes

Asset maintenance policies have started to move from time-based maintenance to condition-based maintenance. This is with the stated aim of reducing controllable operating costs, by reducing unnecessary maintenance visits and combining maintenance visits with other site work. The implications for site work are dealt with under Work Management, but the transformation in site work scheduling is a direct consequence of revised maintenance policies.

Two reconfiguration and transformation themes emerge from the implementation of ARM: The increase in flexibility and the ability to introduce condition-based maintenance. The ability to replan during the year as a result of an enhanced Asset Register is already demonstrated and represents an opportunity to further reduce controlled operational expenditure. As such ARM enhances the flexibility of this capability.

6.5.7 Complementary Assets

The skills, experience and knowledge of the asset manager play an important role in both preparing for pricing round negotiation and determining maintenance policies. The asset manager is required to understand the asset register and to have a detailed knowledge of the asset data it contains. However, an effective asset manager also needs to understand the physical distribution network as well. It is not sufficient to be familiar with ARM; the asset manager has to possess two skill-sets: Information Technology and the Distribution Network.

6.5.8 Value

This capability is valuable as it allows EnerDist to continue saving on controllable operational costs.

Learning is demonstrated by the reduction in controllable operating costs per unit distributed from 2001 to 2011. This learning effect cannot solely be due to ARM as it was introduced in 2006. However interviews reveal that the regulatory requirements to reduce operating expenses due to maintenance have become much more fine-grained and specific, requiring a far more detailed knowledge of the asset base. It is unlikely that the costs per unit would have continued to drop without the introduction of ARM.

6.5.9 Inimitability and Non-substitutability

Determining Asset Policies is inimitable as it is contingent on the skill, experience and knowledge of the Asset Manager as well as those negotiating with the regulator. Accumulating the required knowledge is a barrier to entry and the tacitness of some of that knowledge makes it difficult to copy. The Asset Managers are promoted from within EnerDist and their skill as Asset Managers is contingent on that experience and accumulated knowledge. In addition the Asset Register itself and the Asset Register Administration group are assets that have accumulated over time. Neither is easy to replicate quickly. Specifically, while a competitor could purchase SAP R/3 ARM, the asset data still need to be built up and maintained over time. This is also a barrier to entry.

6.5.10 Analysis

Determining Asset Policies, like Coordinating Asset Programmes, has considerable strategic significance. EnerDist's ability to maintain its Regulates Asset Base at a reasonable cost, and in compliance with regulatory and safety standards, is significant when it comes negotiating the cost of network maintenance with the regulator. In addition, Servicing Existing Assets has undergone significant transformations since market opening and the introduction of SAP R/3. These transformations include the introduction of the Asset Register Administration group, which is a larger team responsible for maintaining the asset database. This work is significant as a more detailed and accurate database has enabled EnerDist to fine tune its servicing policies. Finally, the new found precision and accuracy has allowed EnerDist to respond in a far more focused fashion to regulatory pressure to report in far more detail on network maintenance. More reconfigurations and transformations are likely as more and more detail becomes available from the SAP R/3 Asset Register.

6.6 Servicing Existing Assets

6.6.1 Overview

Servicing Of Existing Assets is a Capability focused in the Maintenance phase of the Asset Lifecycle. Asset maintenance centres on the economic maintenance of existing network assets, where network assets are defined as those parts of the network that are carrying an electrical load. Maintenance is policy-driven with significant input from the regulator. Asset maintenance plans are drawn up on an annual basis as part of an overall maintenance programme. They operate within the constraints of the current pricing round. Maintenance activities may take place on a stand-alone basis or as part of other work. Like build activities, maintenance involves network technicians being deployed to work on existing assets or to deploy new assets.

There are two initiators for asset maintenance:

Maintenance originates from the SAP R/3 Asset Register (ARM). Driven by Asset Maintenance policies, which dictate when networks assets must be visited for inspection and possibly maintenance. Some of these policies are time based and some are condition based.

Faults originate from the Operations and Maintenance System (OMS), external to SAP R/3. Remedial work to rectify faults reported by OMS.

Asset maintenance can be time or condition-based. Time-based maintenance requires that a network asset is checked and, if necessary, serviced at regular intervals. Condition based maintenance limits servicing of assets only to when the asset actually needs it. Historically, most assets have been maintained on a time basis; more recently, however, the asset base has moved towards to condition based maintenance.

Efficient and effective asset maintenance is heavily dependent on an asset register as detailed information about the purchase cost, installation, operation and history of each and every asset is required. In this case the SAP R/3 ARM module provides comprehensive asset register functionality for all network assets.

Asset maintenance programmes are determined at the start of each year and the work is laid out by a small group of asset managers. The cost of maintaining the regulated asset base (RAB) is dictated by the CER. As allowed operational expenditure (OPEX) tends to decrease over successive pricing rounds, the asset base must be maintained at the lowest cost consistent with reliability and safety.

Assets are subdivided into:

Transmission Overhead lines 38-, 110-, 220- and 400-kilovolt(kV) line designed to transport load over longer distances.

Distribution Overhead Lines 38-, 20- and 10-kilovolt lines designed for local load transport.

Underground Cables Ranges from 400kV to 10kV but there are no 230v underground cables.

High Voltage (HV) Substations A Substation is any piece of equipment that effects a change in voltage. A HV substation steps the voltage down from 110kV to 38kV for transmission and from 110kV/38kV to 20kV/10kV for distribution.

Medium Voltage Substations Typically a transformer on a pole, an MV substation is used to transform 20kV and 10kV to 230V for delivery to domestic and small commercial consumers.

The ARM asset register is used by the asset managers to schedule work orders. These are then routed to the relevant construction supervisors who schedule the work with network technicians. The network technician takes a paper work order to the asset site. When the work is complete, the actual work undertaken is noted by the network technician. This is used to update the asset register when the work is technically completed.

Since Market Opening, Asset Maintenance and its related processes and capabilities (including Servicing Of Existing Assets) have become critical to the DSO's ability obtain rents under the regulation of the CER. This is because all network assets by definition carry load and generate revenue within the increasingly restrictive parameters laid down by the CER.

6.6.2 Annual Maintenance Planning Process

Servicing Of Existing Assets encompasses two business process, namely:

Annual Maintenance Planning. Based on defined policies, the output of this process is a set of annual maintenance plans for all network assets for the current year.

Maintenance Execution. Based on annual maintenance plans, this process is concerned with the scheduling and execution of the work required to service all network assets.

These processes are interdependent in that execution of maintenance cannot happen without annual planning, nor can the planning take place if there no policy in place. The processes do overlap, however; maintenance plans may be executed in parallel with policy determination and future annual planning. The processes are described in more detail in the following three subsections.

The **Annual Maintenance Planning Process** takes place at the end of each year and is effective for twelve months of the following year. The starting point for the maintenance planning process is the suite of existing maintenance policies, the outcomes of maintenance programmes from the previous year and maintenance programmes agreed with the regulator as part of the current pricing round. Maintenance programmers tend to be organised around a specific asset type. For example, a specific programme may involve tree and branch cutting to prevent interference with transmission and distribution lines.

The planning process starts immediately upon completion of budgeting for the upcoming year. A number of reports are run from ARM to show which assets require maintenance or inspection for the upcoming year. The Asset Register applies the appropriate maintenance policy to each asset, as well as inspecting that asset's maintenance history, to complete the report. As there is an operational cost associated with maintaining each asset, the stated maintenance requirements must be aligned with the constraints set down by the completed budget. In addition any work not completed by the end of the current year must also be taken into account for the upcoming year.

The final part of the Annual Maintenance Planning process takes place in early January, where the agreed work packages are compiled and distributed for execution. This set of work packages is designed to facilitate the execution of all the required maintenance, within the constraints of the operational budget for the year. These work packages are then entered into SAP R/3 IWM.

Some of the Annual Maintenance Planning Process is influenced by Programme Management:

> *"What they do is ... October every year, the Asset Managers and the Planners sit down with Programme Management and they look at what's planned for the next few years and Programme Management would say well listen, we feel this is what we have the resource to do what do ye want? They, they're the ones that drive what needs to be done, so we train that, they'll decide on what's feasible to be done in any one year based on the resource and based on the need. And sometimes you may have to up the resources if you haven't because there's some work has to happen and other work you have the opportunity to push it back say. Some of the refurbishments may not be as critical, especially now with the downturn in the economy, there was a lot of new stuff we were planning to do that we don't see necessary to do now at all, because the load growth is not there."*
>
> Network Projects Manager

6.6.3 Maintenance Execution Process

This process starts at the point that work orders are entered into SAP R/3 Integrated Work Management. The work order details all the materials that must be ordered - the ordering process is automated and lead times are allowed for. Some inspection procedures are very simple. For mini-pillars, which are street cabinets which distribute electricity, the typical hazard inspection is a simple walk-past where any defects that might expose the public to electric shock are noted. Any defective units are then scheduled for full maintenance and repair. Other maintenance and inspection procedures are more complex, depending on the type of asset being serviced.

If the Annual Maintenance Plans dictate large-scale maintenance of a a significant number of similar assets, then the execution of this maintenance is likely to be treated as a project in itself. Economies of scale may apply, where some of the work can be subcontracted at lower cost.

For each individual maintenance job, a Work Order is issued from IWM. This is printed on paper by the construction supervisor at a specific EnerDist site, and then issued to a network technician for completion. The network technician then travels to the maintenance site and performs the work. If additional issues arise, the network technician notes these and returns with the completed work order. IWM is updated from the paper copy by the construction supervisor.

This process completes the maintenance work for a particular asset. If mandated maintenance of a particular asset has not been carried out, this is reflected in the Asset Register and is picked up for the next Maintenance Planning session.

6.6.4 Integration Processes

Integration processes are evident both at the design phase prior to on-site work being carried out, during the execution of the site work itself and also across different organisational units.

At a higher level in the organisation, the Asset Management Forum integrates the design processes associated with building new assets and maintaining existing assets. This simplifies the design process as all on-site building requirements, regardless of source, are discussed in a single forum before the design is finalised.

The process of asset servicing and maintenance has been integrated with other on-site processes, such as building new assets, as a result of the activities of the asset register administration group and facilitated by the Asset Register. This integration works in two was: First, by identifying what assets are serviced in the normal course of other repairs and thus reducing the number of assets that need to be serviced independently. Second, by identifying collocated assets present at the site of other work, which can be serviced separately without a second trip to site. Integration of on-site work is effected by combining the required work into a single work order in IWM.

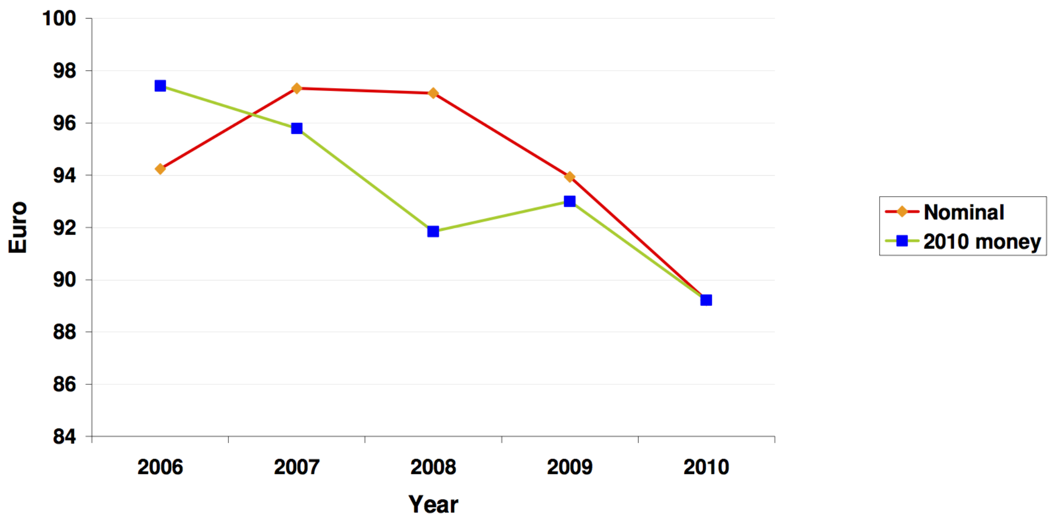
A third type of integration is integrating all the financial, supply chain and manufacturing processes into a single end to end process that runs from project proposal all the way to on-site execution.

Integration at all levels is enabled by the Asset Register (ARM) and Integrated Work Management (IWM).

6.6.5 Learning Processes

Maintaining the asset base at minimal cost requires understanding the location and condition of every asset in the network. The emergence of increased levels of detail about the status of the asset base has driven improvements in the way assets are serviced. The move to condition-based servicing and the integrated approach to design and asset servicing on-site, detailed above, have driven down operational costs associated with asset servicing.

In its annual reports for the CER, EnerDist reports on controllable operating costs per customer over the previous five years. Figure 6.6 illustrates the drop in costs for the years 2006-2010.



(ESBN, 2010, p.16)

Figure 6.6: Controllable Operating Cost per Customer 2006 to 2010

6.6.6 Reconfiguration and Transformation Processes

An underlying driver behind improvements to Asset Maintenance in EnerDist has been the increasingly detailed picture of its network asset base provided by the SAP R/3 ARM Asset Register. Not only has this had a significant influence on asset maintenance processes, it has enabled EnerDist to restructure its Asset Management organisational structures to maintain its asset base in a more effective and efficient manner. The Asset Register has driven process transformation and organisational reconfiguration.

As the Asset Register is vital to most, if not all, asset lifecycle processes, an Asset Register Administration organisation has grown up around the ARM itself.

Asset maintenance processes have been transformed as a result of a more detailed and consistent view of what is happening with the asset base. The integrated approach has emerged from this understanding, as well as recognition that some assets need not be checked as frequently. While asset servicing is very much part of the maintenance part of the asset lifecycle, the asset servicing processes, in their transformed state, have also become important to programme management activities where large scale asset replacement or maintenance activities are coordinated.

Another emergent structure is the Enterprise Asset Management Forum. This Forum was set up to oversee and coordinate multiple proposed changes to a single asset site. The Forum is designed to eliminate loops in existing design processes where multiple redesigns are required to resolve a range of divergent and even conflicting requirements. The EAM Forum permits all interested parties to discuss their requirements for changes to or additions to a network asset, so that a single solution can be identified.

6.6.7 Complementary Assets

Complementary assets are embodied here as the Asset Managers, the Asset Register Administration group and the Asset Management Forum.

The key actors in determining asset maintenance policy are the asset managers; their job is to examine existing network assets and determine the correct lifetime for those assets and also how they are to be maintained. Part of the policy determination process is to negotiate asset lifetimes with the regulator. This has financial implications as EnerDist is allowed an annual return on all of its assets.

Asset Register Administration is responsible for logging all new assets into the register and for building an accurate and detailed picture of the existing asset base. While this is an ongoing process, evidence suggests that the asset register administration group's efforts have already had some success. An example is the correct identification of oil- and gas- filled switches in the distribution network, whereas before the switch type was not recorded. The logging of these enhanced data enabled ARA to provide more detailed information to the asset managers, who in turn were able to devise more focused asset maintenance policies which in turn led to lower cost annual maintenance plans.

Asset maintenance in the past had been very dependent on the tacit knowledge of the network technician, with the technician effectively making a judgement on site on what work needed to be done. While this ensured that all necessary work was done thoroughly, more maintenance work than strictly necessary tended to be done. The knowledge and skills that network technicians acquired over years of training and service is still important. However the decision on exactly what work needs to be done has been moved to asset register administration and is now dictated by policy set by asset managers. Network technicians are now expected to perform tasks per a specific work order and simply to report any additional work that may need to be done. Servicing Assets base become less dependent on the tacit knowledge of the network technician and more dependent on the experience of the asset managers and those in asset register administration and the asset management forum.

The Asset Management Forum is a body set up to further integrate site work across different projects and also across the construction of new assets and maintenance of existing assets. Its stated aim is to reduce wastage, eliminate conflict and to identify site solutions that address the needs of several different projects at the same time.

6.6.8 Value

It is valuable as it reduces the cost of asset maintenance by consolidating site work, negotiating asset lifetimes and return on fixed assets and by moving from time-based to condition-based maintenance. The objective is to spend CAPEX to reduce future OPEX. This has the double effect of reducing future costs and penalties while increasing the opportunity to earn a return on CAPEX.

6.6.9 Inimitability and Non-substitutability

Its inimitability is inherent in the asset maintenance structures that have built up over the time, making the cost of imitation a barrier to entry. It is not substitutable: Replacing the existing Asset Registry Administration structures would involve an upheaval that would jeopardise EnerCo Network's ability to meet its regulatory obligations. Servicing Assets has become embedded within the organisation's structure.

6.6.10 Analysis

Servicing Of Existing Assets is a Capability as it has reconfigured and continues to reconfigure the processes and structures associated with the maintenance phase of the asset lifecycle. In particular it has led to the development of Asset Register Administration and the Asset Management Forum as organisational element. Learning is evidenced by the reductions in maintenance cost per asset. Reconfiguration and transformation is evident in the move from time-based to condition-based maintenance, as well as structural changes to the organisation to optimise asset maintenance.

6.7 Summary

Section 6.2: ***Identifying New Assets*** covers the Plan phase of the Asset Lifecycle. It concerns itself with **What assets to create**.

Section 6.4: ***Coordinating Asset Programmes*** covers the coordination of the maintenance and building of Network Assets on a large scale. It primarily covers the Plan and Maintain phases of the Asset Lifecycle, with influence on all other phases. It concerns itself with **When to create assets** and **What assets to create**.

Section 6.3: ***Building New Assets*** covers the Build phase of the Asset Lifecycle and concerns itself with **How to create assets**.

Section 6.5: ***Determining Asset Policies*** covers the Maintain and End of Life phases of the Asset Lifecycle. It concerns itself with **When to maintain assets**.

Section 6.6: ***Servicing Existing Assets*** covers the Maintain phase of the Asset Lifecycle. It concerns itself with **How to maintain assets**.

This Research Question has addressed the processes and complementary assets (people and structures) that comprise five Dynamic Capabilities. Furthermore, it demonstrates that these Dynamic Capabilities are valuable, inimitable and non-substitutable. The value of these Dynamic Capabilities is mainly manifested as an enhanced ability to meet regulatory demands, reduce capital and maintenance costs, enhance plans for the future and minimise penalty to EnerDist.

Table 6.2 summarises the findings of Research Question 2. The five identified Dynamic Capabilities of Asset Lifecycle Management are highlighted in yellow. Figure 6.7 maps all of the Dynamic Capabilities to the Asset Lifecycle. It is evident from this figure that Dynamic Capabilities span multiple phases in the lifecycle. In addition, as different groups in the organisation are responsible for different stages of the lifecycle, these Dynamic Capabilities, and their constituent processes, also span organisational and functional units.

The inimitability and non-substitutability of all the Capabilities tends to be mainly contingent on the history of how those capabilities came into existence and the training and experience of the people executing their constituent processes. However, some of the history consists of the transformations and reconfiguration undergone by the tangible assets and processes that make up these Capabilities. There is considerable evidence to suggest that these transformations are driven by data from the IT artefacts that also make up these capabilities.

In conclusion, EnerDist's Asset Lifecycle contains five distinct capabilities. While these capabilities are of varying strategic importance (Figure 6.7 illustrates this), all of these capabilities have inbuilt transformation processes. In addition, evidence is seen of learning, integration and reconfiguration.

In the analysis of each capability, it has been made clear that some of the transformative aspects of these capabilities arise from technological assets such as SAP R/3. Chapter 7 addresses Research Question 3 by focusing on the technological assets inherent in these capabilities. Finally, Chapter 8 will answer Research Question 4 by exploring the exploitability of these capabilities by examining their history, the technological opportunities presented and their exploitability in terms of how well the technological assets fit in.

Table 6.2: Findings of Research Question 2

Asset Life Cycle Stage	Dynamic Capability	Business Processes	Integration Processes	Learning Processes	Reconfiguration, Transformation Processes	Complementary Assets (People)	Value	Inimitability, Non-substitutability
Plan, Design	Identifying New Assets	Solution identification	Assimilation and application of new network technologies.	Reduction in Customer Interruptions and Customer Minutes Lost	Introduction of CBAT, changes to Solution Identification process to exploit automatic switches.	Planner, who has been trained and acquired experience over 6-18 months.	Reduction in penalties from regulator.	Embodied in knowledge and training of planner
All	Coordinating Asset Programmes	Programme planning. Work packaging. Asset replacement and refurbishment	SAP R/3 BW, ARM and CU all serve as integrators of data and thus processes	Reduction in outages due to refurbishments and capital programmes	New :- Asset Register Administration, Asset Management Forum, Enterprise Asset Management	Programme Manager, Asset Manager, Asset Register Admin	Outage penalty reduction, increase in value of regulated asset base	Embodied in organisational structures that have built up over time - Asset Register Administration, Asset Management Forum

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Table 6.2 – *Continued from previous page*

Asset Life Cycle Stage	Dynamic Capability	Business Processes	Integration Processes	Learning Processes	Reconfiguration, Transformation Processes	Complementary Assets (People)	Value	Inimitability, Non-substitutability
Build	Building New Assets	Materials ordering. Job design. Job execution.	Imposition of consistency across network. Tight coupling of stock and work processes via IWM and CU	Drop in working capital of €23m	Changes to structure of work orders. If additional work is required, it is performed as separate work order.	Construction Supervisor, Engineering Officer, Network Technician	Optimised stock ordering, reductions in inventory and working capital	Initially embodied in knowledge of Engineering Officer, Construction Supervisor and Network Technician. However NT work can be subcontracted. Locus moving to supply chain experience of warehouse managers.
Maintain, End Of Life	Determining Asset Policies	Pricing round negotiation. Maintenance policy determination	Data integration via ARM. Asset Mgrs and Negotiators work jointly with CER.	Refinements and increase in granularity of policies as more asset data become available. Reduced costs.	Move to condition based maintenance.	Regulatory Staff, Asset Manager, Asset Register Admin	Reduction in maintenance cost and optimisation of asset lifetime.	Embodied in organisational structures that have built up over time - Asset Register Administration, Asset Management Forum, Enterprise Asset Management Forum

Continued on next page

Table 6.2 – *Continued from previous page*

Asset Life Cycle Stage	Dynamic Capability	Business Processes	Integration Processes	Learning Processes	Reconfiguration, Transformation Processes	Complementary Assets (People)	Value	Inimitability, Non-substitutability
Maintain, End Of Life	Servicing Existing Assets	Annual maintenance planning. Maintenance execution	Integrate site design reflecting requirements of different groups. Maintenance integrated with construction.	Reduction in OPEX associated with asset servicing.	New organisation structures: Asset Register Administration, Asset Management Forum, Enterprise Asset Management	Asset Manager, Asset Register Admin	Reduction in maintenance cost	Buildup of ARA organisational structure over time is barrier to entry. Also difficult to imitate due to social complexity.

*For **Transformation Processes**, SAP R/3 and its modules and applications are replacements for older legacy systems such as DWMS, Main Saver, MS Access, MS Excel and paper systems. Also the regional EnerDist structure has been replaced with a centralised organisational structure. Little Transformation has been observed in* Identifying New Assets. *While new software has been introduced (CBAT), nothing has been replaced.*

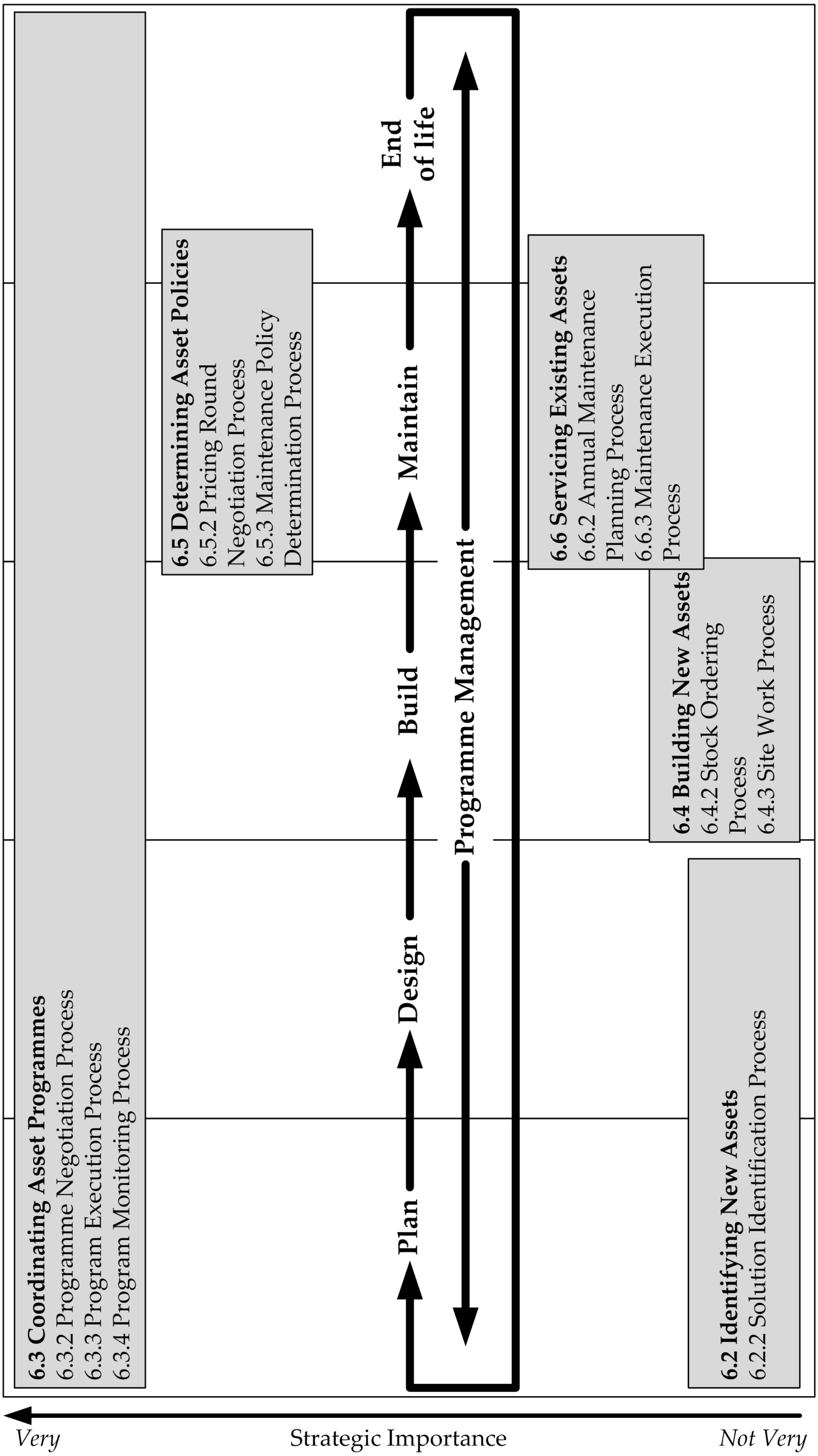

Figure 6.7: Dynamic Capabilities of the Asset Lifecycle

Chapter 7

Research Question 3: The Footprint of Enterprise Systems on Asset Management Dynamic Capabilities

7.1 Introduction

This chapter addresses **Research Question 3** by describing the footprint of the Enterprise System on the Asset Management Dynamic Capabilities. Research Question 3 is restated below:

Research Question 3: What is the footprint of the Enterprise System on Asset Lifecycle Management Dynamic Capabilities?

The Footprint of the Enterprise System (ES) on the five Asset Lifecycle Management Dynamic Capabilities is expressed as the degree of dependency of the component processes of those Dynamic Capabilities on the Enterprise System, or, if applicable, another artefact of Information Technology. This exercise is carried out, both for the Asset Lifecycle Management Business Processes and also for the Integration, Learning, Reconfiguration and Transformation Processes that make the Asset Lifecycle Management Capabilities Dynamic.

As well as the processes themselves, intensity of dependency on the Enterprise System at their inputs and outputs is also considered. These measures are neither absolute nor acquired quantitatively; they are intended as a relative indication of where the Enterprise System is relied on most within the Asset Lifecycle.

The findings of Research Question 3 are summarised in the Chapter Summary in Section 7.7 and particularly in Table 7.1. Further analysis of the findings is summarised in Section 7.7 in Tables 7.2 and 7.3 and Figures 7.16 and 7.17.

The chapter is laid out in sections, each addressing the footprint of the Enterprise System and any other Information Technology on a different Dynamic Capability. These are presented in approximate lifecycle order from the planning through to the end of life phases. The final subsection of the chapter summarises the overall footprint of the Enterprise System on all the Dynamic Capabilities in the Asset Management Lifecycle.

Section 7.2: ***Identifying New Assets*** covers the Plan and Design phases of the Asset Lifecycle.

Section 7.3: ***Coordinating Asset Programmes*** covers the coordination of the maintenance and building of Network Assets on a large scale. It primarily covers the Maintain and Build phases of the Asset Lifecycle, with influence on all other phases.

Section 7.4: ***Building New Assets*** covers the Build phase of the Asset Lifecycle.

Section 7.5: ***Determining Asset Policies*** covers the Maintain and End of Life phases of the Asset Lifecycle.

Section 7.6: ***Servicing Existing Assets*** covers the Maintain phase of the Asset Lifecycle.

Section 7.7 provides a summary of the footprint of the Enterprise System on all the Dynamic Capabilities.

As all of these Dynamic Capabilities operate on the Regulated Asset Base (RAB) of EnerDist, the regulated asset base is itself a technological asset for each of the capabilities.

Each section is laid out as follows: The constituent business processes and integration, learning, reconfiguration and transformation processes of the Dynamic Capability are summarised. This summary includes an identification of the Information Technologies used. The footprint of IT on the process inputs and outputs is clearly summarised as well as the footprint on the main body of the process. The relative intensity of the footprint at process start, middle and end is also mapped. Finally each section ends with an analysis which summarises the footprint of the Enterprise System both on the business processes and the integration, learning, reconfiguration and transformation processes.

7.2 Identifying New Assets

7.2.1 Solution Identification Process

The solution identification process process starts when the planner is presented with a new load request or a request to alleviate a network reliability problem. This forms the starting point of the process to find an optimum solution to the problem.

The planner investigates and documents a number of solutions and then eliminates those which are either too costly or impractical for site specific reasons. As well as construction costs, the planner must consider network reliability and maintenance cost issues several years hence.

The optimum solution design process is iterative and all the possible designs are collated in a single Microsoft Word document. Each possible solution is graphically represented using output from the Stoner Synergy load flow analysis tool. The planner then writes an assessment of each solution in terms of practicality, cost and implications for future network expansion. The document concludes with a recommendation. The document does not present a single solution as a fait accompli. Instead each planning step and iteration are clearly delineated. Rejected solutions and their reason for rejection are documented.

Once the planning document is complete and a solution decided upon, the solution is hand keyed into SAP IWM as a new work order. The planning process concludes once a design is made available to an Engineering Officer, who then draws up a work order in IWM. A new work order initiates the Build phase of the Asset Lifecycle and is the starting point for the processes in the dynamic capability *Building New Assets*.

7.2.1.1 Process Inputs

- SAP R/3 Industry specific Solution - Utilities industry (IS-U)
- SAP R/3 Resource Planning Module (xRPM)

- SAP R/3 Asset Register (ARM)
- Geographical Information System (GIS)
- System Control And Data Acquisition (SCADA)
- Operation and Maintenance System (OMS)

A new load request may originate from SAP IS-U if the load is relatively small. Typically domestic connections fall into this category; in this case, no solution identification process is needed and the process proceeds directly to the design phase. Larger new load requests, which do require solution identification, may originate from SAP R/3 xRPM.

In the event of the need to alleviate a problem, the required information may come from the SCADA, OMS and GIS systems, which provide a realtime operational interface to the distribution network. While SCADA and OMS are designed to provide operational control of and reporting on the various elements of the distribution work, the GIS provides a graphical view of the network, overload with its operational state. These systems are relied on heavily to form a picture of any fault that occurred.

7.2.1.2 Process Facilitators

- Stoner Synergy Load Flow Analysis Tool (LFAT)
- Cost Benefit Analysis Tool (CBAT)
- Microsoft Word (MS Word)

Once the solution identification process has started, three software applications are used. Microsoft Word is used to document and compare the alternative solutions for a load request or fault problem. The Load Flow Analysis Tool provides a graphical representation of the part of the network in question and allows the planner to test various alternative solutions where load is switched to different parts of the network.

The Cost Benefit Analysis Tool (CBAT) was introduced to accommodate Arc Reclosers and Soulé Switches. Arc Reclosers provide automatic reenergising of tripped network links and Soulé Switches provide remote manual control of network energisation. Both provide considerable reductions in network outage duration as they obviate the need to send Network Technicians out to manually close breakers. However, they are also considerably more expensive than manual breakers. CBAT allows the planner to weight the additional cost of automatic switching against the projected cost saving in reduced penalties from network downtime.

7.2.1.3 Process Outputs

- Geographical Information System (GIS)
- SAP R/3 Integrated Work Management

The output of the solution identification process is an agreed plan that is implemented as a design by an Engineering Office and then entered into IWM as a work order. Designs are drawn using the GIS and are then hand=keyed into IWM. Once the work order is in IWM and signed-off, stock ordering is initiated depending on lead time and implementation time and the processes associated with *Building New Assets* start.

7.2.2 Integration, Learning, Reconfiguration and Transformation Processes

Identify New Assets is in some respects a *factory floor* capability in that it directly impinges on the regulated asset base. While it does not directly integrate other processes or capabilities, it does not happen in isolation; it is integrated with other asset lifecycle capabilities and processes via the Asset Register Administration function and Programme Management.

EnerDist introduced Automatic Reclosers and Soulé Switches into the network in 2006, in order to reduce Customer Minutes Lost (CML) and the attendant penalties. As part of the introduction, the Planning department introduced CBAT which shows the benefit of adding automated switches versus the increased cost of installing them in the first place. This process change permits the Planning department to model the long term operational benefit of such improvements.

The learning process evident here is the process of assimilating new technologies, devising new processes to exploit those technologies to full effect and the integration of those new processes into the Identifying New Assets capability. The positive outcome of this learning process is evidenced by the reduction in fault CML from 2006 to 2011. Measuring CML, while required by the regulator, is also part of the feedback loop required to determine the outcome of the learning process. In this case, technological and regulatory changes have driven process improvements and changes with a view to creating long-term value by avoiding regulatory penalties related to length of outage.

The result of the learning effect is a transformation of the tools used to identify a solution and a reconfiguration of the associated systems. There is a reconfiguration and transformation of revenue-generating network assets to maximise returns and reduce regulatory penalties in the future. Transformation of processes and technologies is evidenced by the introduction of Automatic Reclosers and Soulé Switches. The introduction of these new technologies required a transformation of the Solution Identification process, where it now incorporates a cost benefit analysis on using the new switches. As well as transforming one of the processes in the Identifying New Assets capability, there has been a transformational effect on the technological assets (the switches and CBAT) that form part of the capability.

7.2.2.1 Process Inputs

- SAP R/3 Asset Register (ARM)
- Geographical Information System (GIS)
- System Control And Data Acquisition (SCADA)
- Operation and Maintenance System (OMS)

Any IS or ES that facilitates reporting on the outage state of the network serves as an input here. In this case, the immediate operational state is visible vis OMS, GIS and SCADA. ARM also serves as an input as it provides a history of what has happened to any asset.

7.2.2.2 Process Facilitators

Any integration activities are facilitated by organisational structures such as Asset Register Administration and Programme Management, rather than by any IS or ES. The learning process is a tacit process and has not been codified into any IS or ES. In this case the learning process has been an intellectual one, of examining what technological opportunities exist and how best to integrate them into the existing asset infrastructure and also into the attendant processes. However, the reach of the SAP R/3 Asset Register (ARM) is so extensive that it serves as a reference for almost any process involving the regulated asset base. It is inferred here that ARM serves as a low-intensity facilitator for any Integration, Learning, Reconfiguration and Transformation processes inherent in *Identify New Assets*.

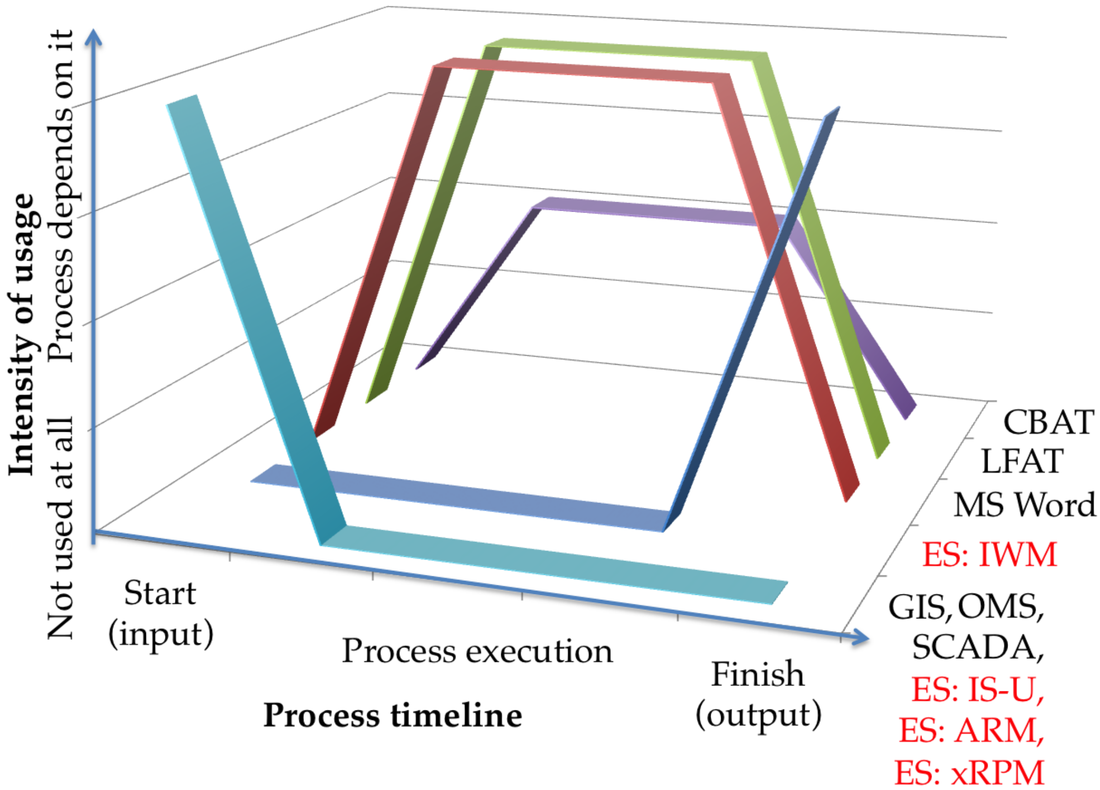

Figure 7.1: IS footprint for the Solution Identification process in *Identifying New Assets*.

7.2.3 Analysis

Figures 7.1 and 7.2 illustrates the intensity of IS application usage over the lifetime of the Solution Identification Process and the Integration, Learning, Reconfiguration and Transformation processes respectively. While the Solution Identification process start and finish are highly dependent on various applications, including SAP R/3 AR<, xRP and IWM, the bulk of the processes execution is dependent only on MS Word and LFAT and dependent only on CBAT when Arc Reclosers and Soulé Switches as part of the solution.

The ES footprint is limited to referring to ARM and xRPM at the start of the

Solution Identification Process and to entering the resultant work order into IWM at the finish. Usage of the ES is intense but brief relative to the duration of the entire process. If SAP R/3 were to be replaced with a different Enterprise System, as the process inputs and outputs are only manually coupled to the process execution, disruption would be minimal. Future integration efforts would make replacing SAP R/3 a much more difficult proposition.

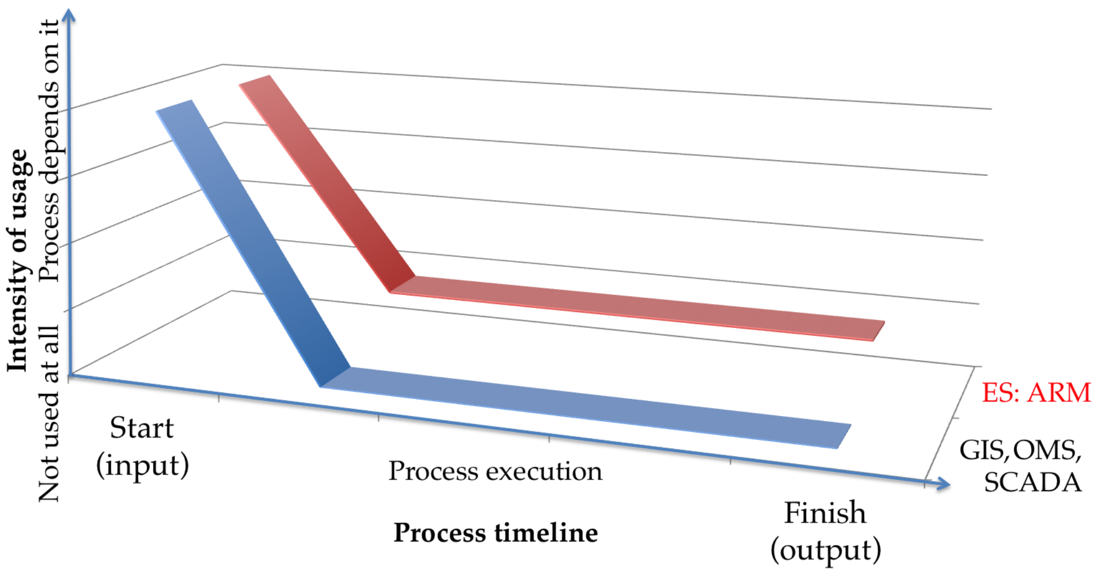

Figure 7.2: IS footprint for Integration, Learning, Reconfiguration and Transformation Processes in *Identifying New Assets.*

The Integration, Learning, Reconfiguration and Transformation processes here, while they draw on various information systems for input, are not dependent on most of them once the required data have been gathered. The exception is ARM, which serves as a reference for almost any process involving the regulated asset base.

Identifying New Assets is a dynamic capability whose IS/ES footprint is firmly focused on the Solution Identification process, with only a low-intensity IS/ES footprint for its Integration, Learning, Reconfiguration and Transformation processes. Therefore the Information Systems in general and SAP R/3 in particular do not contribute to those processes that make *Identifying New Assets* dynamic.

7.3 Coordinating Asset Programmes

7.3.1 Programme Negotiation Process

A central part of each pricing round negotiation is agreeing with the regulator which groups of assets will be maintained, upgraded or replaced during the next five years. Every five years the distribution network is analysed to decide where refurbishments, reinforcements or replacements - including retiring existing assets - need to be done. All of this work is then justified internally on a business basis before presentation to the regulator as part of the negotiations for the next pricing round.

The regulator then reviews EnerDist's submission and examines the consequences of the proposed programmes for the price of electricity. The regulator may decide to curtail or refuse certain programme proposals in order to keep the price down. Alternatively, the regulator may mandate that the proposed work must be done but at a reduced price. Once a compromise is reached and agreed, EnerDist is expected to perform to the agreement; failure to perform may prejudice negotiations at future pricing rounds.

7.3.1.1 Process Inputs

- SAP R/3 Business Warehouse (BW)
- SAP R/3 Asset Register (ARM)
- Geographical Information System (GIS)

Effective programme negotiation depends on a detailed, accurate and up-to-date view of the entire regulated asset base. Both the SAP R/3 Business Warehouse (BW) and Asset Register (ARM) provide detailed reports of all aspects of the asset base. This includes physical status, cost, currently applied maintenance policy, maintenance cost and depreciation curve. The Geographical Information System (GIS) provides information on the current topology of the network and as such presents a different view of the asset base in that it shows how everything is connected.

7.3.1.2 Process Facilitators

- SAP R/3 Business Warehouse (BW)
- SAP R/3 Asset Register (ARM)
- Geographical Information System (GIS)

The Information Systems (GIS) and ES modules (BW and ARM) provide updated reports during the negotiation process. However this is low intensity and the negotiations are not critically dependent on BW, ARM and GIS once the initial data are prepared.

7.3.1.3 Process Outputs

- SAP R/3 Resource Planning Module (xRPM)

The output of the Programme Negotiation process is a set of asset maintenance, repair and placement programmes. These are recorded in xRPM as programme work to be done. Part of the Programme Execution Process is to generate work orders in IWM for all the planned work.

7.3.2 Programme Execution Process

The Programme Management team undertakes larger scale planning activities which form part of a network-wide initiative. These programmes are planned with a view to optimising the capital expenditure (CAPEX) allowed in a pricing round by the Commission for Energy Regulation (CER). Programme management upgrades of assets are undertaken on a three-year cycle. Each three-year programme is intended to provide effective expenditure of the CER allowance, to provide one single plan, to allow the asset managers to prioritise work, and to provide transparency to the rest of the organisation. The purpose of each program is to provide one baseline plan so all users with differing requirements can see the bigger picture in the organisation.

Required work is then packaged and designed, and sometimes redesigned to adjust the scope of some of the projects. This part of the process involves the asset management organisation. Once this is complete the required site work can be carried out, to the design that is specified.

Other work programmes are not necessarily initiated by the regulator, but are asset replacement and refurbishment activities, the need for which is determined by EnerDist. These internal programmes address asset end-of-life or maintenance issues that need to be dealt with on a large scale. These programmes are necessary to keep the regulated asset base up to date and functioning in a safe and economical manner.

Regardless of the origin of the programme, the required work packages are broken down into individual designs by Engineering Officers, referring to and using GIS. The designs are then implemented as work orders in IWM. This starts the process of building new assets or refurbishing existing assets as needed.

7.3.2.1 Process Inputs

- SAP R/3 Resource Planning Module (xRPM)
- SAP R/3 Asset Register (ARM)

All programme work comes from xRPM and reference may be made to ARM for relevant asset maintenance policies and the status of the assets concerned. These data are used to generate work orders in IWM, a well-integrated and largely automatic process.

7.3.2.2 Process Facilitators

- Geographical Information System (GIS)
- SAP R/3 Asset Register (ARM)
- SAP R/3 Resource Planning Module (xRPM)

Design work is required for all new work prior to being confirmed in IWM. This is carried out by a Design Officer who, in effect, turns the large-scale programmes into real-world designs for each affected site. The Engineering / Design Officer will refer to xRPM for the programme requirements and also to ARM and GIS for existing asset status and layout. GIS is used to specify the design.

7.3.2.3 Process Outputs

- SAP R/3 Integrated Work Management (IWM)
- Geographical Information System (GIS)

The output of the Programme Execution process is captured in GIS as a completed design and also in IWM as a completed work order.

7.3.3 Programme Monitoring Process

The Programme Management team undertakes larger scale planning activities which form part of a network - wide initiative. These programmes are planned with a view to optimising the capital expenditure (CAPEX) allowed in a pricing round by the CER. All programmes are continuously monitored and updated, with the bulk of the reporting via ARM and BW. Programme Managers spend about half their time ensuring that all the projects that form part of a programme are up to date.

7.3.3.1 Process Inputs and Facilitators

- SAP R/3 Resource Planning Module (xRPM)
- SAP R/3 Asset Register (ARM)
- SAP R/3 Business Warehouse (BW)

High level project reports are drawn from xRPM, with reporting also from BW and asset status from ARM. Completed project work will be shown in xRPM and completed work from IWM is reflected in updated asset status in ARM. BW provides a consolidated and integrated overview of project status.

7.3.3.2 Process Outputs

- SAP R/3 Asset Register (ARM)
- SAP R/3 Resource Planning Module (xRPM)

Any outputs from the Programme Monitoring Process are status updates to projects in xRPM and possibly some asset status updates to ARM. Updates to

GIS and IWM are not done here; those updates are solely as a result of design work and site work completed.

7.3.4 Integration, Learning, Reconfiguration and Transformation Processes

Coordinating Asset Programmes has a number of integration processes, facilitated mainly by the SAP R/3 Business Warehouse (BW) which provides reporting visibility across a number of groups (Programme Management, Asset Management, Network Projects) in EnerDist. BW provides the connective tissue that interconnects some of the other SAP R/3 systems such as IWM and ARM. This is achieved by allowing EnerDist staff to design and run reports that draw on previously disparate areas. A single BW report can draw on data from xRPM, IWM and ARM, for example. This gives managers a unified view of a particular programme, showing what has been planned, what has been completed and how the asset base has been affected.

The SAP R/3 Compatible Unit (and therefore IWM) provides an interconnection between previously distinct processes and functions as it permits a network asset to be treated as a functional module, a financial entity, a depreciating asset and a set of maintenance policies. The *multidimensionality* of the compatible Unit permits site work planning to be directly tied to stock ordering, as well as programme planning and financial management.

Learning effects are evidenced by EnerDist itself in reporting reductions in Customer Interruptions (CI) and CML and attributing those both to the introduction of downline reclosers (dealt with in SubSection 7.2) and also to various capital programs. Specifically, EnerDist notes that major renewal and refurbishment programmes have a significant effect on reducing downtime. These learning processes are evidenced by reporting from OMS, which in turn can be correlated with reports from ARM and BW.

The new SAP R/3 modules have been utilised to transform Programme Management's understanding of how long jobs take and how much they cost. Increased visibility of the duration and cost of jobs enables increased control at the Programme Manager level and refined plans on an annual basis. This is contingent on data in xRPM and IWM.

7.3.4.1 Process Inputs, Facilitators and Outputs

xRPM, IWM(CU) and BW provide visibility of all the programme management processes and tie all of them together. There are no clear process inputs or outputs here, rather a continuous cycle of learning and improvement that is facilitated by these SAP R/3 modules.

7.3.5 Analysis

Figures 7.3, 7.4 and 7.5 illustrate the intensity of IS and ES usage over the Programme Negotiation, Programme Execution and Programme Monitoring processes. In addition, figure 7.6 shows the dependence of Integration, Learning, Reconfiguration and Transformation processes on ARM, MW and xRPM. *Coordinating Asset Programmes*, as a dynamic capability, is highly dependent on its Enterprise System Assets.

The Programme Negotiation processes is least dependent on the ES, except at the start, when accurate and comprehensive reporting on the current asset state is crucial. The Programme Execution and Programme Monitoring processes are highly ES - dependent, to the extent that at least some of the processes are embodied in the SAP R/3 systems. xRPM in particular is integral to the packaging of three-year programmes into projects, which can be broken down further into work orders using IWM.

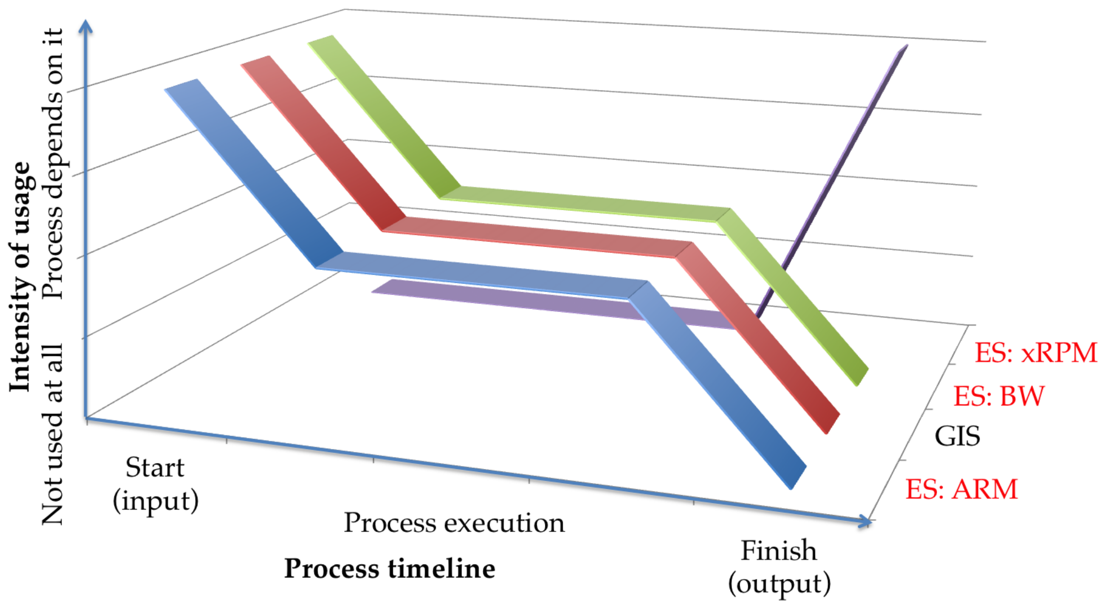

Figure 7.3: IS footprint for the Programme Negotiation process in *Coordinating Asset Programmes.*

The Programme monitoring Process, as illustrated in Figure 7.5 is intensely dependent on BW, xRPM and ARM for obtaining status on current Programme Management projects, with necessary status updates being outputted to xRPM and ARM.

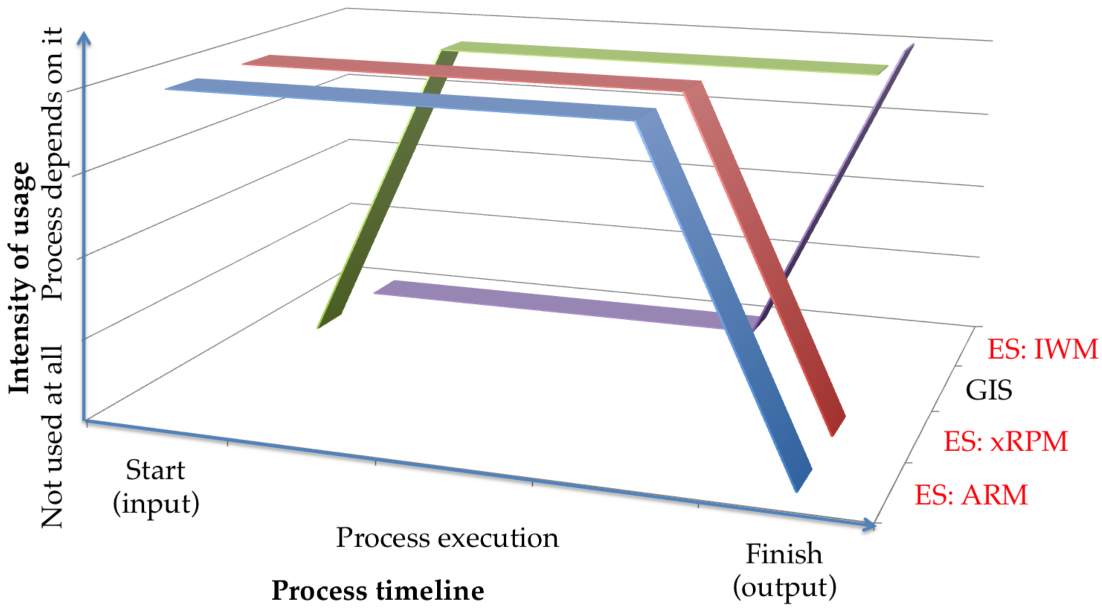

Figure 7.4: IS footprint for the Programme Execution process in *Coordinating Asset Programmes.*

In addition, the numerous SAP R/3 modules, and BW and the Compatible

Unit in particular, have provided EnerDist with far more control over its own processes and visibility of how those processes perform. Figure 7.6 shows a high degree of dependency on BW and xRPM to provide visibility of how well the other processes are performing and BW to integrate some of those other processes, especially at management level.

Coordinating Asset Programmes, in conclusion, is a dynamic capability that is highly dependent on its technological assets and shows intense ES usage across all its processes. This applies not only to the business processes but also to those processes that make this capability dynamic.

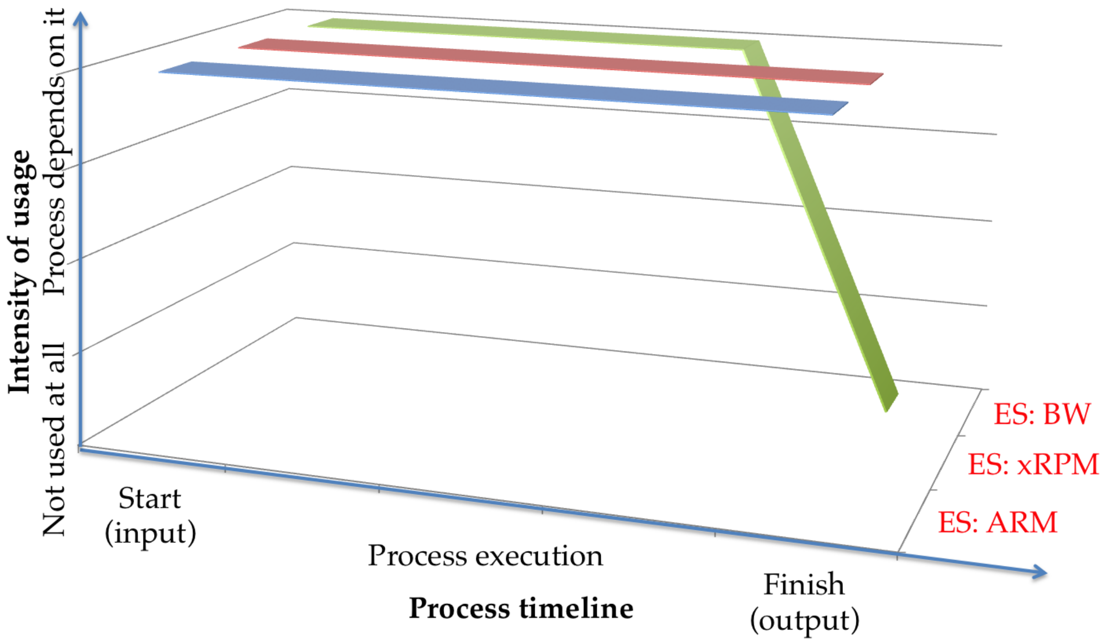

Figure 7.5: IS footprint for the Programme Monitoring process in *Coordinating Asset Programmes*.

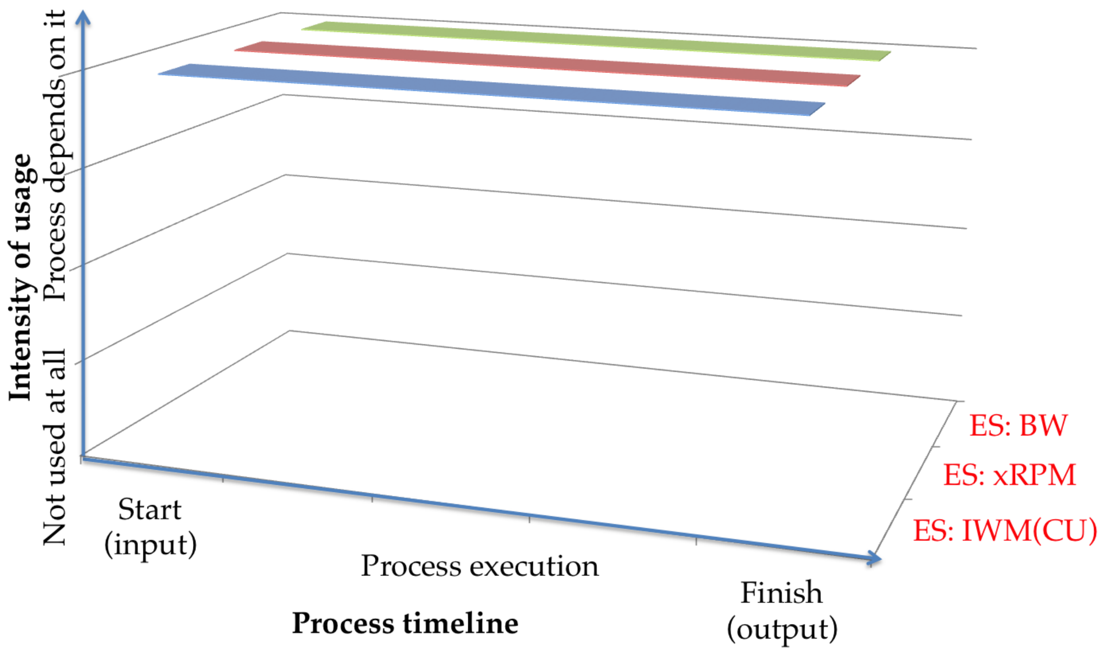

Figure 7.6: IS footprint for the Integration, Learning, Reconfiguration and Transformation processes in *Coordinating Asset Programmes.*

7.4 Building New Assets

7.4.1 Stock Ordering

Stock ordering is driven by the Compatible Unit and IWM. Approval of an IWM Work order initiates automated stock requisitioning via SAP R/3 MMIS (Materials Management Information System), where the Compatible Unit contains information not only about an asset, but also its cost and ordering lead time. Consequently stock does not arrive in a local depot until just before it is needed. From the depot, the stock is transported to site just before a work order is actually executed.

7.4.1.1 Process Inputs

- SAP R/3 Integrated Work Management (IWM)

IWM Work orders initiate a process whereby materials are drawn down from inventory or ordered from suppliers. The system is designed so that lead times for all items are taken into account. As the lead time for some large items such as transformers is quite long, it is not unusual for a work order to be initiated several months in advance of the work actually to be done.

All work orders originate from IWM. As soon as a work order is approved, stock ordering for all the required materials will commence. Ordering is dependent on the date the materials are required for performing the site work and the lead time for each item.

7.4.1.2 Process Facilitators

- SAP R/3 Integrated Work Management (IWM)
- SAP R/3 Materials Management Information System (MMIS)

The stock ordering process is largely automatic. IWM issues requisitions for each item on a given date, where that date is equal to the work start date minus lead time. Requisitions are processed through MMIS and stock is routed to the closest depot to the work site shortly before that is due to begin. Some stock will be routed through one of EnerCo Network's main depots, typically in Dublin.

7.4.1.3 Process Outputs

- SAP R/3 Integrated Work Management (IWM)

The output of this process is an update IWM Work order, indicating that all stock is in hand. This signals the handover to the Site Work process.

7.4.2 Site Work

IWM work orders originate from the Programme Management and Planning activities earlier in the asset lifecycle, as well as connection requests from individual customers. The build process incorporates ordering and staging of raw materials, allocation of personnel, building and commissioning of infrastructure and documentation of the completed work. A piece of network infrastructure does not become an asset until it is carrying load.

7.4.2.1 Process Inputs

- SAP R/3 Integrated Work Management (IWM)

The Site work process starts with an IWM work order with all stock available at the relevant depot to commence work. The Construction Supervisor will print a paper copy of the work order for travel to site.

7.4.2.2 Process Facilitators

- Paper work order, printed from IWM

The main Process Facilitator here is a paper work order, which is printed from IWM. The Network Technician takes this to site and makes any annotations on the work order during and on completion of site work.

7.4.2.3 Process Outputs

- SAP R/3 Integrated Work Management (IWM)

On completion of site work, the Construction Supervisor updates IWM with any notes from the paper work order. The end of the process is a work order marked completed in IWM.

7.4.3 Integration, Learning, Reconfiguration and Transformation Processes

Process Integration is focused on the tighter coupling of stock ordering processes to the site work process. Prior to this integration work, stock ordering was somewhat independent of actual site work. Stock would be ordered as a contingency, resulting in considerable accumulation in some depots in EnerDist.

IWM acts as a bridge between the stock ordering and site work processes, by means of the Compatible Unit, which not only identifies the part required but also specifies its order cost and order lead time. As a result, when a work order is created, the site work is correctly scheduled and the required stock is ordered.

The restructuring of the depot network and the introduction of IWM has resulted in a drop in stock levels for no more than four weeks' worth for most common items. This is seen as a significant change by EnerDist with a consequent drop in working capital. Four weeks is regarded as the minimum so it is unlikely that further inventory reduction will occur.

The changes to the stock ordering process have led to a restructuring and rationalisation of EnerDist's depots. There is a single large depot in Dublin with smaller depots situated at regional offices. Goods only arrive at depots when needed; the stockpiles of goods that used to be held in anticipation of work no longer exist.

The Site Work process has undergone some transformation as a result of the introduction of SAP IS-U. While the site work itself has not changed, IS-U permits the Network Technician to have more control over their own schedule on a daily bases. The apparent paradox is that, while IWM and IS-U have imposed some rigidities in how work is to be performed, IS-U now permits more flexibility in site work scheduling:

This has resulted in a transfer of responsibility for site work scheduling and completion from the Construction Supervisor to the Network Technician.

7.4.3.1 Process Inputs

- SAP R/3 IS-U

With respect to the Site Work process, some flexibility has been introduced by SAP IS-U. However, once work orders are issued, little by way of transformation or learning is evident in on-site work processes. It is possible this may change in the future once Network Technicians have access to handheld devices.

7.4.3.2 Process Facilitators and Outputs

- SAP R/3 IWM Compatible Unit (CU)

The IWM Compatible Unit is the main process integrator in *Building New Assets*. This integrates the stock ordering process with the site work process. Most of the transformation and reconfiguration has happened in the Stock Ordering process, where working capital has been reduced and the whole process has been streamlined. This is all contingent on IWM and CU.

7.4.4 Analysis

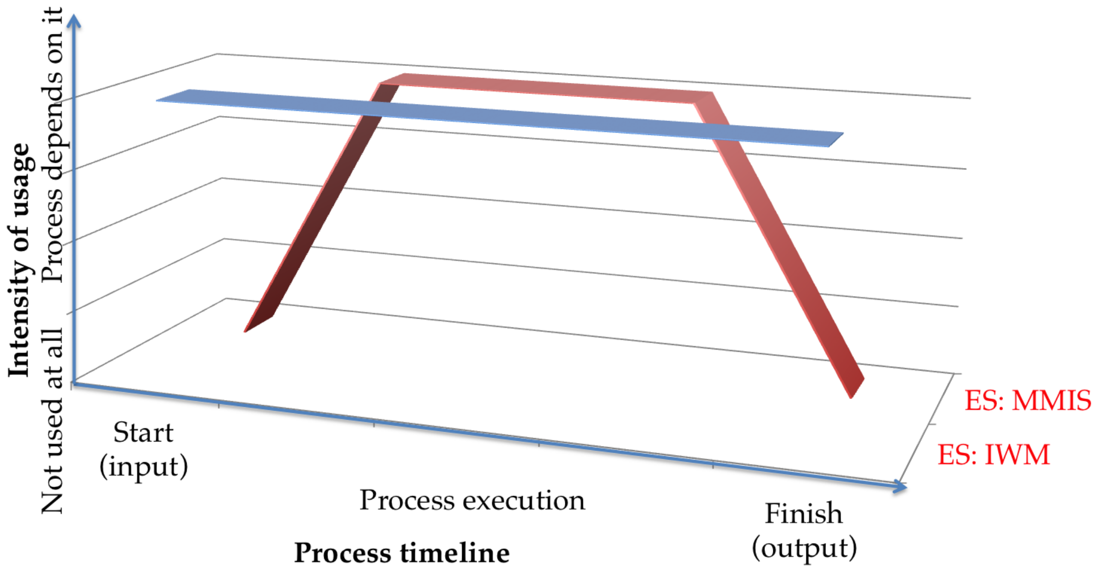

Figure 7.7: IS footprint for the Stock Ordering process in *Building New Assets.*

Figures 7.7 and 7.8 illustrate the footprint of IS-U, IWM and the Compatible Unit on the Stock Ordering and Site Work processes. IWM, when applied, is used intensely but its usage is still limited by the dependence on paper forms on site. However, the Stock Ordering process is critically dependent on MMIS and IWM, as well as the Compatible Unit. The stock ordering processes have become embodied in the underlying Enterprise System.

The start and finish of the Site Work process are very dependent on IWM but there is no IWM dependency on the process is running. The disadvantage of this is that the construction supervisor has no visibility of the progress of site work until the end of the day when the Network Technician returns to the depot. Also, paperwork can take a day or two to update.

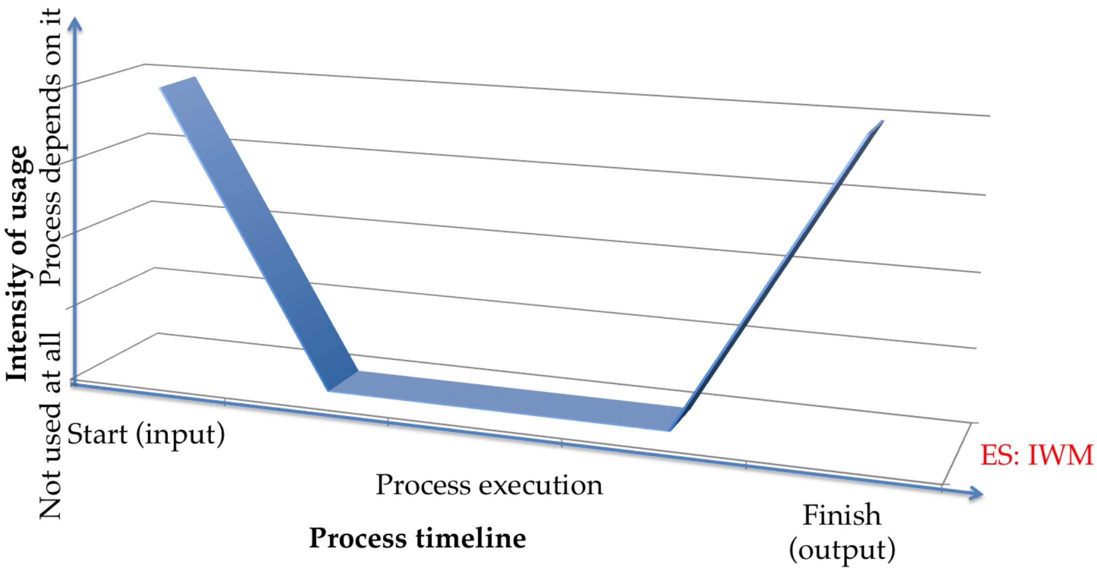

Figure 7.8: IS footprint for the Site work process in *Building New Assets*.

As illustrated in Figure 7.9, integration processes are very dependent on the Compatible unit and the new-found flexibility in site work originated by new connections is dependent on IS-U.

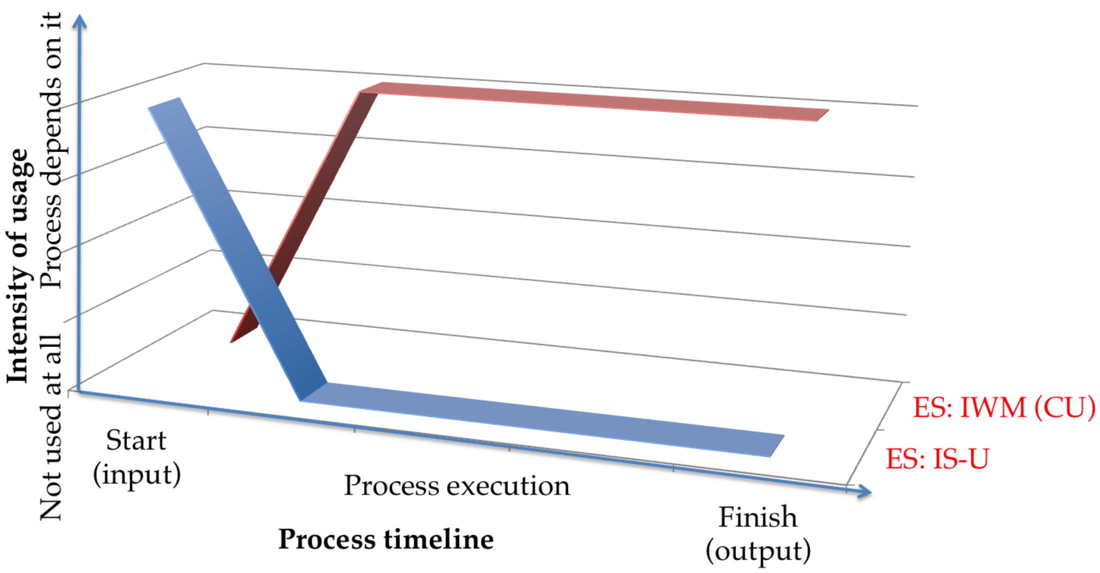

Figure 7.9: IS footprint for the Integration, Learning, Reconfiguration and Transformation processes in *Building New Assets*.

Building New Assets is intensely dependent on a small number of ES modules. The extent of that dependence is limited by the use of paper forms on site but, where ES modules are used, they are used intensely.

7.5 Determining Asset Policies

7.5.1 pricing round Negotiation

The periodic pricing round submission by EnerDist to the CER includes a proposal for maintaining all the network assets for the upcoming five years. While in principle EnerDist prefers to continuously maintain all its assets, in practice such maintenance must be prioritised. The pricing round proposal includes a list of assets to be maintained and the estimated operational and capital cost of same. The initial proposal is based on researching the existing asset register. The regulator may challenge this proposal, based on information gathered on comparable asset maintenance intervals, from the UK or other markets. The amount allowed by the regulator for asset maintenance is frequently not that proposed by EnerDist. Consequently the final schedule of assets to be maintained and the expenditure allowed is a compromise.

7.5.1.1 Process Inputs

- SAP R/3 Asset Register (ARM)
- SAP R/3 Resource Project Manager (xRPM)
- SAP R/3 Business Warehouse (BW)

The Asset Register is used to determine the current state of the asset base and the policies currently in force. It can also be used to determine the capital cost of those assets and the applicable depreciation curve. In addition xRPM and BW may be referred to for current programme status. From this EnerDist can determine the cost of a a suitable maintenance policy for each asset type as part of its initial submission to the regulator.

7.5.1.2 Process Facilitators

The negotiation process is not dependent on any ES module.

7.5.1.3 Process Outputs

One of the outputs of the negotiation process is an agreed set of maintenance policies, which then must be implemented in ARM. This is part of the Maintenance Policy Determination process.

7.5.2 Maintenance Policy Determination

The typical economic lifetime of a network asset is now forty years; all assets require maintenance to ensure reliable and safe operation and continuity of service. Any new asset that is acquired will either need to have an existing policy applied to it or have a new maintenance policy devised for it if the asset is of a type not previously installed in the network.

The job of determining new maintenance policies and revising existing maintenance policies falls to the Asset Manager. While safety, reliability and continuity are all issues, cost and regulatory requirements must also be taken into consideration. Any new maintenance policy must be drafted to ensure safe, reliable operation at minimal cost. The asset manager refers to the PAS55 standard, a framework for the optimised management of physical assets, as published by the British Standards Institute and developed by the Institute for Asset Management.

Devising a maintenance policy is done with reference to the PAS55 specification, manufacturer's recommendations, regulatory requirements and health, safety and risk reduction imperatives. Certain aspects such as the economic life of the network asset may be negotiated with the regulator. Existing maintenance policies are also subject to review and, in some cases, challenge as older policies are found to be either uneconomic or inappropriate. An example is the move from time-based to condition-based servicing.

A finished maintenance policy dictates how often assets are to inspected to ensure public safety and to minimise risk, how frequently assets must be inspected for deterioration and what actions are to be taken when a fault is found. New and updated policies are entered into the Asset Register (ARM) and applied to all the relevant assets. Thus the Asset Register contains up to date details on the maintenance and inspection requirements for every single asset, per the relevant maintenance policy. The sum total of all maintenance policies dictates the annual maintenance workload that must be planned for at the start of each calendar year.

7.5.2.1 Process Inputs

- Agreed set of policies with the regulator

The starting point of this process is a set of maintenance policies, as agreed with the regulator, as part of the current pricing round negotiation.

7.5.2.2 Process Facilitators

- SAP R/3 Asset Register (ARM)

Maintenance policies for particular groups of assets are derived by the asset manager from the policies agreed with the regulator as well as any additional maintenance needs as established by EnerDist. These policies are implemented in the Asset Register (ARM).

7.5.2.3 Process Outputs

- SAP R/3 Asset Register (ARM)

The output of this process is the completed set of policies in the Asset Register.

7.5.3 Integration, Learning, Reconfiguration and Transformation Processes

The pricing round negotiation and maintenance policy determination processes are necessarily interdependent. Maintenance policies are set within the parameters of allowed maintenance spending within the current pricing round and negotiation on future pricing rounds is contingent on observed performance of prior pricing rounds. Both processes are dependent on ARM and the Asset Register forms the common data source that integrates those processes. However the processes are also integrated at the level of complementary assets, as Asset Managers will sit with those negotiating with the regulator to discuss what constitutes an effective maintenance policy that is also acceptable to the regulator.

Reduction of controllable operating costs is a requirement of the regulator and EnerDist has demonstrated a drop in costs from one cent per kilowatt-hour distributed in 2001, to 0.89 cent in 2011. Controllable operating costs include planned maintenance, which is dictated by asset maintenance policy. As a more detailed view of the asset base has emerged, more astute maintenance policies can be applied, lowering controllable operating costs even further.

Asset maintenance policies have started to move from time-based maintenance to condition-based maintenance. This is with the stated aim of reducing controllable operating costs, by reducing unnecessary maintenance visits and combining maintenance visits with other site work. The implications for site work are dealt with under Work Management, but the transformation in site work scheduling is a direct consequence of revised maintenance policies.

Two reconfiguration and transformation themes emerge from the implementation of ARM: The increase in flexibility and the ability to introduce condition-based maintenance. The ability to replan during the year as a result of an enhanced Asset Register is already demonstrated and represents an opportunity to further reduce controlled operational expenditure. As such ARM enhances the flexibility of this dynamic capability.

7.5.3.1 Process Inputs, Facilitators and Outputs

- SAP R/3 Asset Register (ARM)

The Asset Register is the main facilitator for all Integration, Learning, Reconfiguration and Transformation processes. It supports learning processes by providing accurate and precise feedback on the application of time-based and condition-based maintenance policies. Integration processes are supported by the extent of ARM: Almost every dynamic capability discussed here uses it to some degree. Reconfiguration and Transformation processes, as evidenced by the establishment of the Asset Management Forum and the growth of Asset Register Administration, are informed in detail by the data that are stored and maintained in ARM.

7.5.4 Analysis

Determining Asset Policies is heavily dependent on the SAP R/3 Asset Register at the start of all processes. While pricing round Negotiation is a rather amorphous and very tacit process, it is still dependent on ARM and also xRPM and BW at the beginning to provide accurate and precise data concerning the current status of the regulated asset base. See Figure 7.10. Maintenance Policy Determination is intrinsically dependent on ARM; in fact, ARM embodies this process almost completely. Figure 7.11 illustrates this dependency, which is limited to the body and the finish stage of the process.

As illustrated in Figure 7.12 ARM has also been a major driver of Integration, Reconfiguration and Transformation processes and a facilitator of Learning processes. It is unlikely the Asset Register Administration would have evolved in the way it did without ARM. The integration imposed by ARM has lead to integration and transformation at the organisational level, especially with the Asset Management Forum.

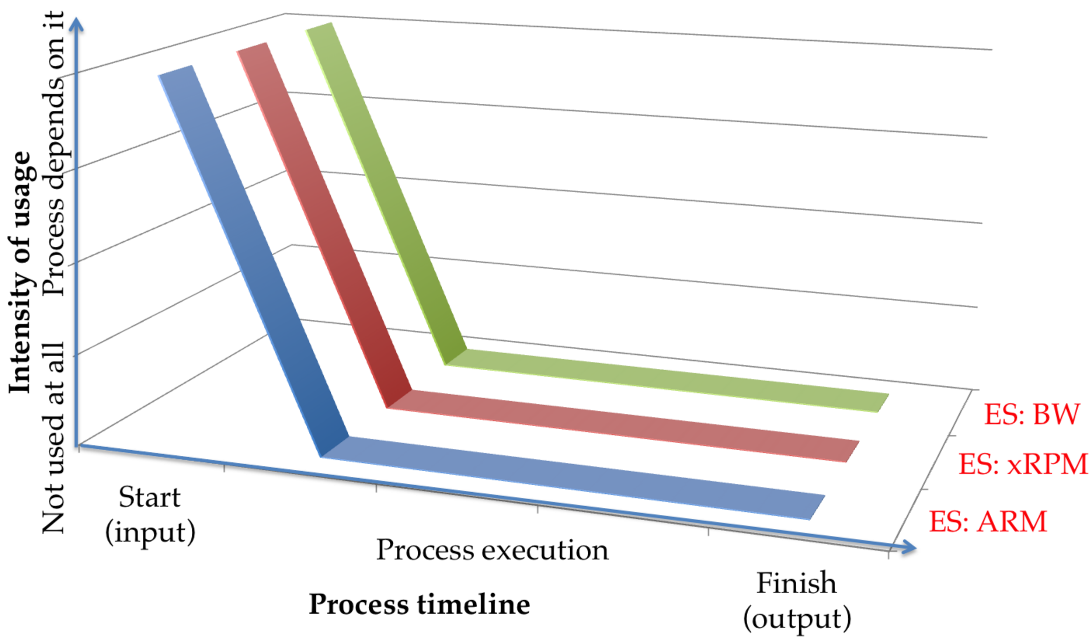

Figure 7.10: IS footprint for the pricing round Negotiation process in *Determining Asset Policies*.

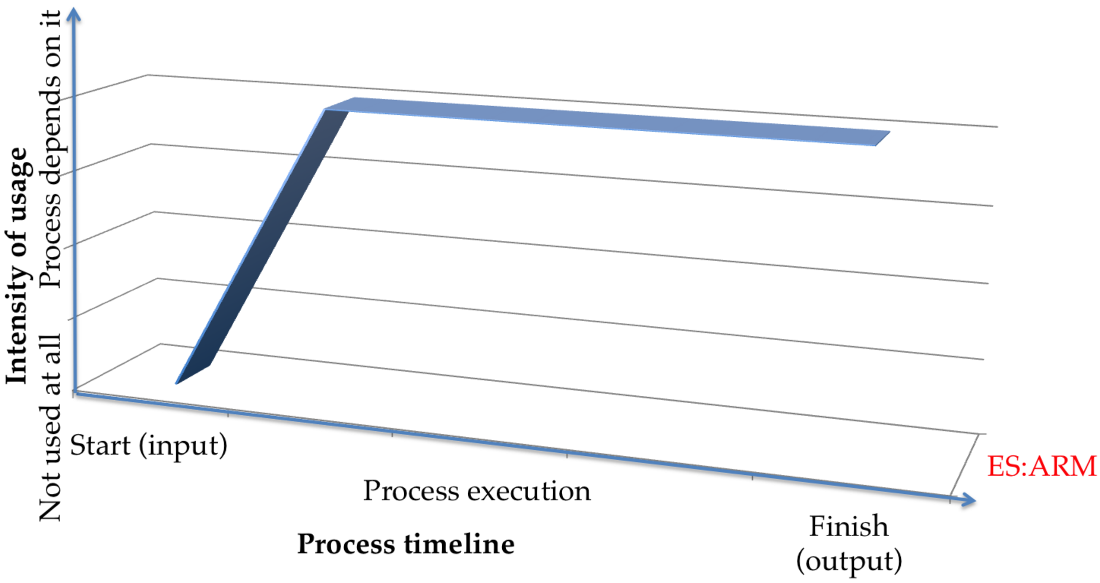

Figure 7.11: IS footprint for the Maintenance Policy Determination process in *Determining Asset Policies.*

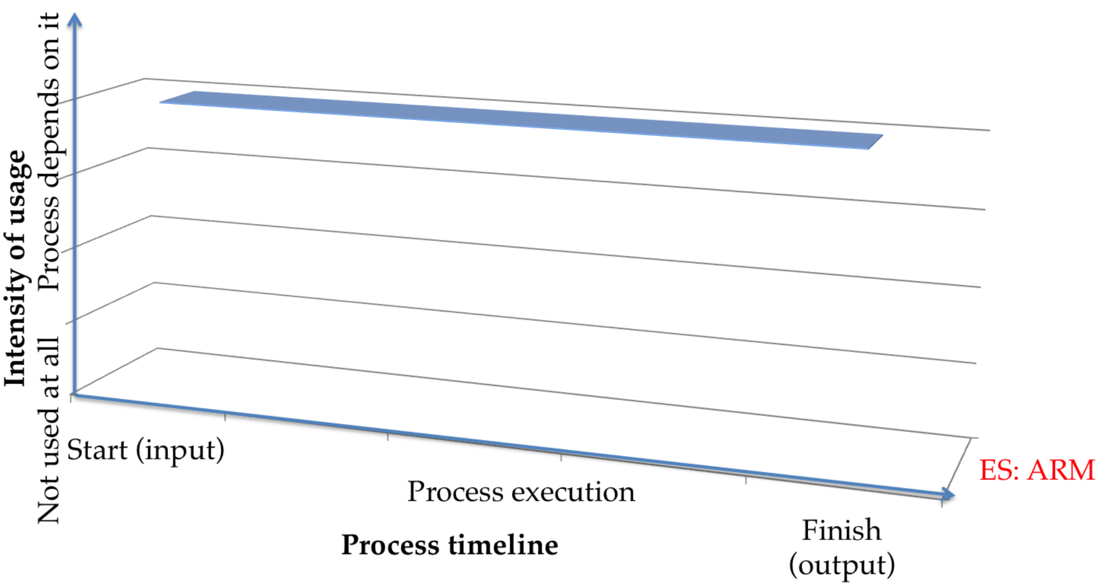

Figure 7.12: IS footprint for the Integration, Learning, Reconfiguration and Transformation processes in *Determining Asset Policies.*

7.6 Servicing Existing Assets

7.6.1 Annual Maintenance Planning

Planning of annual maintenance takes place at the end of each year and is effective for twelve months of the following year. The starting point for the maintenance planning process is the suite of existing maintenance policies, the outcomes of maintenance programmes from the previous year and maintenance programmes agreed with the regulator as part of the current pricing round. Maintenance programmers tend to be organised around a specific asset type. For example, a specific programme may involve tree and branch cutting to prevent interference with transmission and distribution lines.

The planning process starts immediately upon completion of budgeting for the upcoming year. A number of reports are run from ARM to show which assets require maintenance or inspection for the upcoming year. The Asset Register applies the appropriate maintenance policy to each asset, as well as inspecting that asset's maintenance history, to complete the report. As there is an operational cost associated with maintaining each asset, the stated maintenance requirements must be aligned with the constraints set down by the completed budget. In addition any work not completed by the end of the current year must also be taken into account for the upcoming year.

The final part of the Annual Maintenance Planning process takes place in early January, where the agreed work packages are compiled and distributed for execution. This set of work packages is designed to facilitate the execution of all the required maintenance, within the constraints of the operational budget for the year. These work packages are then entered into SAP R/3 IWM.

Some of the Annual Maintenance Planning process is influenced by xRPM in that large maintenance programmes are agreed with the regulator, or dictated by safety concerns and managed by Programme Management.

7.6.1.1 Process Inputs and Facilitators

- SAP R/3 Asset Register (ARM)
- SAP R/3 Resource Project Manager (xRPM)
- SAP R/3 Business Warehouse (BW)

As reporting is required on all activities impacting on the regulated asset base, ARM, xRPM and BW provide the status of assets undergoing periodic maintenance and also those being refurbished or replaced as part of a major programme. This information forms the basis for starting the Annual Maintenance Planning processes. Once the process is underway, changes may be made in both ARM and xRPM to reflect changes in maintenance priorities. Use of BW is restricted to reporting only.

7.6.1.2 Process Outputs

- SAP R/3 Asset Register (ARM)
- SAP R/3 Resource Project Manager (xRPM)
- SAP R/3 Integrated Work Management (IWM)

The output of the planning process is captured as work orders in IWM. Any updates to large scale programmes and maintenance policies (if needed) are captured in ARM and xRPM.

7.6.2 Maintenance Execution

This process starts at the point that work orders are entered into SAP R/3 Integrated Work Management. The work order details all the materials that must be ordered - the ordering process is automated and lead times are allowed for. Some inspection procedures are very simple. For mini-pillars, which are street cabinets which distribute electricity, the typical hazard inspection is a simple walk-past where any defects that might expose the public to electric shock are noted. Any defective units are then scheduled for full maintenance and repair. Other maintenance and inspection procedures are more complex, depending on the type of asset being serviced.

If the Annual Maintenance Plans dictate large-scale maintenance of a a significant number of similar assets, then the execution of this maintenance is likely to be treated as a project in itself. Economies of scale may apply, where some of the work can be subcontracted at lower cost.

For each individual maintenance job, a work order is issued from IWM. This is printed on paper by the construction supervisor at a specific EnerDist site, and then issued to a network technician for completion. The network technician then travels to the maintenance site and performs the work. If additional issues arise, the network technician notes these and returns with the completed work order. IWM is updated from the paper copy by the construction supervisor.

This process completes the maintenance work for a particular asset. If mandated maintenance of a particular asset has not been carried out, this is reflected in the Asset Register and is picked up for the next Maintenance Planning session.

7.6.2.1 Process Inputs and Facilitators

- SAP R/3 Integrated Work Management (IWM)

All of the work here is driven through IWM and the actual Stock Ordering and Site Work are part of the *Building New Assets* capability.

7.6.2.2 Process Outputs

- SAP R/3 Asset Register (ARM)
- SAP R/3 Asset Register (IWM)

At the end of the Maintenance Execution process, IWM is updated to reflect the completed work orders and ARM is consequently updated automatically to reflect the changed asset status.

7.6.3 Integration, Learning, Reconfiguration and Transformation Processes

Integration processes are evident both at the design phase prior to on-site work being carried out, during the execution of the site work itself and also across different organisational units.

At a higher level in the organisation, the Asset Management Forum integrates the design processes associated with building new assets and maintaining existing assets. This simplifies the design process as all on-site building requirements, regardless of source, are discussed in a single forum before the design is finalised.

The process of asset servicing and maintenance has been integrated with other on-site processes, such as building new assets, as a result of the activities of the asset register administration group and facilitated by the Asset Register. This integration works in two ways: First, by identifying what assets are serviced in the normal course of other repairs and thus reducing the number of assets that need to be serviced independently. Second, by identifying co-located assets present at the site of other work, which can be serviced separately without a second trip to site. Integration of on-site work is effected by combining the required work into a single work order in IWM.

A third type of integration is integrating all the financial, supply chain and manufacturing processes into a single end to end process that runs from project proposal all the way to on-site execution.

Integration at all levels is enabled by the Asset Register (ARM) and Integrated Work Management (IWM).

Maintaining the asset base at minimal cost requires understanding the location and condition of every asset in the network. The emergence of increased levels of detail about the status of the asset base has driven improvements in the way assets are serviced. The move to condition - based servicing and the integrated approach to design and asset servicing on-site, detailed above, have driven down operational costs associated with asset servicing.

An underlying driver behind improvements to Asset Maintenance in EnerDist has been the increasingly detailed picture of its network asset base provided by the SAP R/3 ARM Asset Register. Not only has this had a significant influence on asset maintenance processes, it has enabled EnerDist to restructure its Asset Management organisational structures to maintain its asset base in a more effective and efficient manner. The Asset Register has driven process transformation and organisational reconfiguration.

As the Asset Register is vital to most, if not all, asset lifecycle processes, an Asset Register Administration organisation has grown up around ARM itself.

Asset maintenance processes have been transformed as a result of a more detailed and consistent view of what is happening with the asset base. The integrated approach has emerged from this understanding, as well as recognition that some assets need not be checked as frequently. While asset servicing is very much part of the maintenance part of the asset lifecycle, the asset servicing processes, in their transformed state, have also become important to programme management activities where large scale asset replacement or maintenance activities are coordinated.

Another emergent structure is the Enterprise Asset Management Forum. This Forum was set up to oversee and coordinate multiple proposed changes to a single asset site. The Forum is designed to eliminate loops in existing design processes where multiple redesigns are required to resolve a range of divergent and even conflicting requirements. The EAM Forum permits all interested parties to discuss their requirements for changes to or additions to network assets, so that a single solution can be identified.

7.6.3.1 Process Inputs, Facilitators and Outputs

- SAP R/3 Asset Register (ARM)
- SAP R/3 Integrated Work Management (IWM)

IWM serves as an integrator of several processes as it provides a single point for combining several different operations on a single site into a single work order. It is possible that work originating from xRPM, ARM and IS-U may be combine into a single work order on IWM.

ARM has provided hitherto unavailable data on EnerDist's regulated asset base, in unprecedented scope and depth of detail. As a result ARM has been a major facilitator (and even driver) of the development of Asset Register Administration and subsequently the Asset Management Forum.

7.6.4 Analysis

Servicing Existing Assets is a dynamic capability that is at the core of EnerDist's ability to realise value from its regulated asset base. As such the Asset Register provides critical data to facilitate the Maintenance Planning and Maintenance Execution processes. Integrated Work Management is also central to the Maintenance Execution process. This is illustrated in Figures 7.13 and 7.14.

Figure 7.15 shows that ARM and IWM are also central to the integration and transformation of *Servicing Existing Assets*. IWM provides a single point of reference for all site work, regardless of the origin of that work. The organisational transformation that EnerDist has undergone would not have happened without ARM being available to organise the data around the regulated asset base. Using ARM, EnerDist has been able to identify where more value could be generated and to optimise its organisation to fully realise that value and better meet the demands of the regulator.

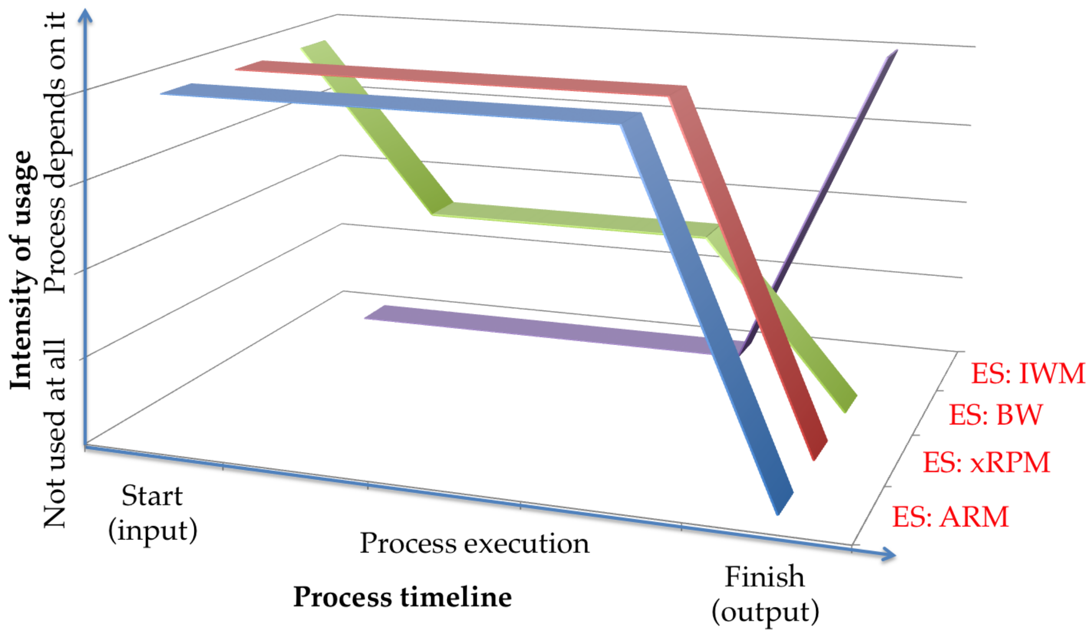

Figure 7.13: IS footprint for the Annual Maintenance Planning process in *Servicing Existing Assets.*

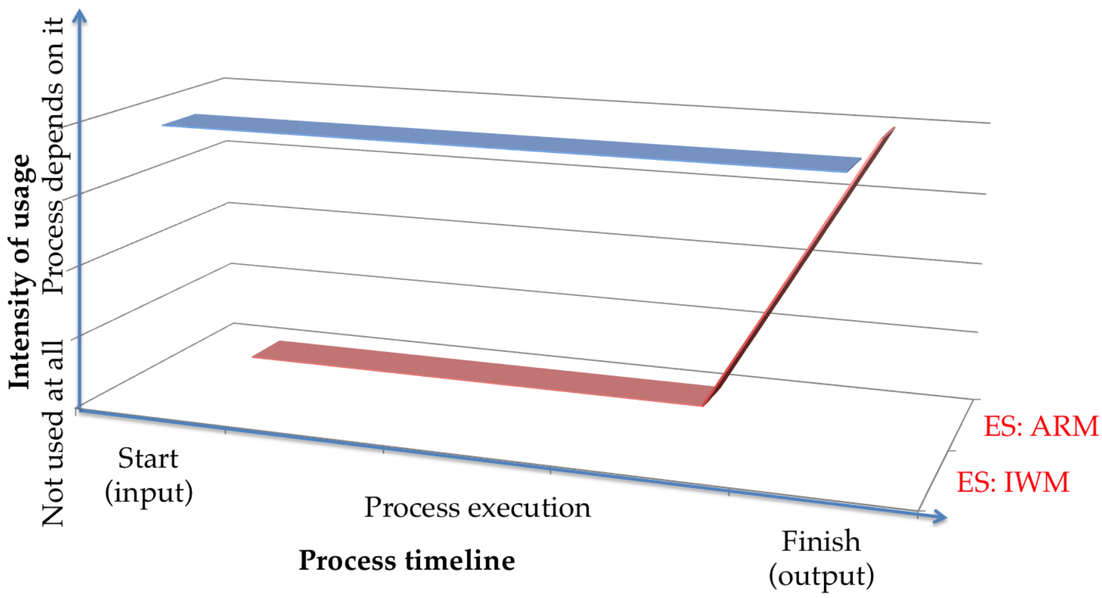

Figure 7.14: IS footprint for the Maintenance Execution process in *Servicing Existing Assets.*

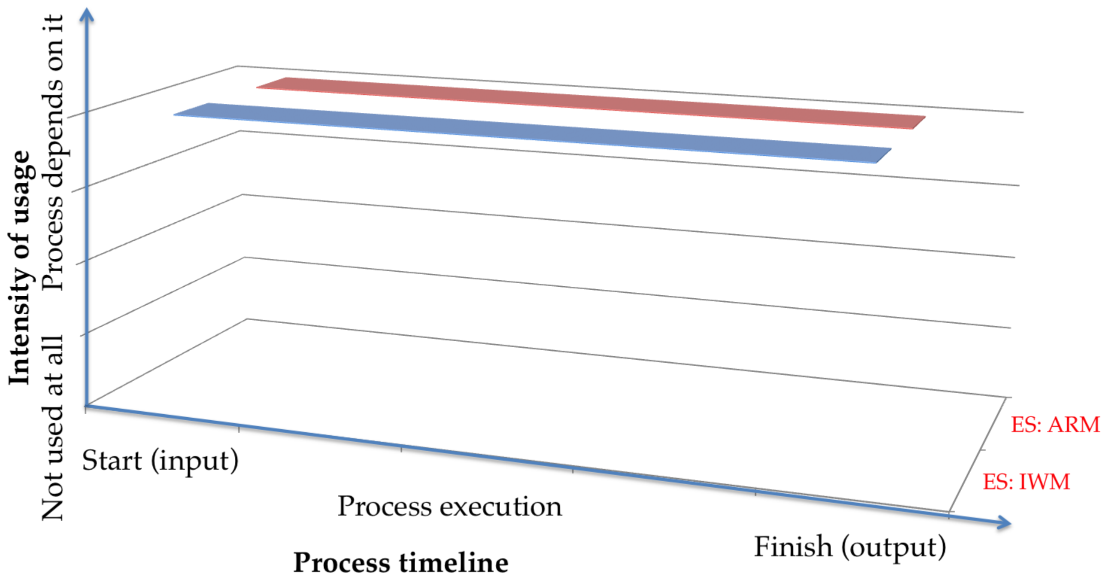

Figure 7.15: IS footprint for the Integration, Learning, Reconfiguration and Transformation processes in *Servicing Existing Assets*.

7.7 Summary

This section summarises the findings from Research Question 3. It presents a summary of the footprint of ES on both business processes in SubSection 7.7.1 and also on integration, learning, reconfiguration and transformation processes in SubSection 7.7.2. These summaries are presented separately: While the Enterprise System is expected to have some footprint on business processes by default, the extent of its footprint on those processes that make a capability dynamic will have some bearing on what makes that capability core over extended periods of time. The section ends with a conclusion to this chapter.

Table 7.1 summarises the findings of Research Question 3. A notable feature is that the Asset Register (ARM) serves as a data source for four Dynamic Capabilities and Integrated Work Management (IWM) serves as a sink, or output, for a different set of four Dynamic Capabilities. It is perhaps unsurprising that the Asset Register plays such a vital part in what ultimately is an Asset Management organisation. The significance of IWM is due to its emboying all work that is required to be carried out on the electricity distribution network, which comprises the Regulated Asset Base.

Table 7.1: Findings of Research Question 3

Life Cycle Stage	Dynamic Capability	Technology (Technological Assets / Positions) Inputs From	Uses	Outputs To
Plan, Design	Identifying New Assets	GIS, OMS, SCADA, IS-U, ARM	MS Word for drafting solutions, Stoner Synergy and CBAT for modelling solutions	IWM as new work order
All	Coordinating Asset Programmes	ARM	BW for reporting and coordination	IWM as new work orders, xRPM as plans
Build	Building New Assets	IWM for new work orders which in turn drive requisitions into MMIS.	Paper for site work. MMIS for stock order fulfilment	IWM for work order completions and then ARM for asset status updates
Maintain, End Of Life	Determining Asset Policies	ARM for asset history	ARM and occasionally Excel	ARM as new asset policies
	Servicing Existing Assets	ARM for applicable policies and plans	ARM for plan revision and refinement	IWM as new work orders

7.7.1 The Footprint of ES on Business Processes

Table 7.2 illustrates the extent and intensity of the ES and IS footprints on the five Dynamic Capabilities and their business processes. In addition, the table illustrates the relative extent and intensity with which SAP modules are used. Finally, the table summarises the intensity of process dependence on ES modules and other IS applications overall. This table is effectively a summary presentation of Figures 7.1 through 7.15, where ES and IT footprint intensity was mapped for the start, middle and end of each process. In Table 7.2 footprint intensity is totalled for every process and ES module or IT software package.

The SAP R/3 ARM, IWM and xRPM modules have the most intense footprints on Asset Lifecycle Management Dynamic Capabilities and processes. Of the other SAP modules, BW comes a distant fourth. Of the Information Systems outside SAP, only GIS has a significant footprint.

That ARM has such a large footprint on all identified Asset Lifecycle Dynamic Capabilities is perhaps unsurprising. The Asset Register maintains detailed in-depth information about every piece of load-carrying equipment in EnerDist's Regulated Asset Base. The regulatory requirement to maintain an ever more detailed and granular picture of that base requires continuous and intensive usage of ARM. ARM is essential for the effective execution of all business processes in the five identified Dynamic Capabilities, with the exception of *Building New Assets*, which is instead dependent on IWM.

IWM usage is almost as intense. Over the study period, IWM went from just-introduced to constantly used. Despite some misgivings about IWM's fit with existing work processes, it has established itself across four Dynamic Capabilities, excluding Determining Asset Policies. Any site work to be performed, regardless of whether it originates from a major maintenance programme or an individual subscriber connection, is planned, scheduled and executed via IWM.

xRPM and BW are used extensively for planning, negotiation and monitoring processes. BW provides detailed reports on all aspects of Asset Management and other Network Projects and Operations. xRPM provides project management tools, especially for the early stages of projects before work orders are created in IWM. Programme Management in particular is dependent on xRPM. Any negotiation and annual planning processes are contingent on having a high level view of all projects, hence the dependency on xRPM and BW.

Of the Dynamic Capabilities, *Coordinating Asset Programmes* is most dependent on Enterprise System Modules, followed by *Servicing Existing Assets*. This is a consequence of regulatory imperatives requiring management of the asset base to be done in considerable detail, and tight control of the costs and execution of large programmes.

In conclusion, ARM, IWM, xRPM and BW impose a significant footprint on *Coordinating Asset Programmes* and *Servicing Existing Assets*, as the regulatory environment requires detailed and extensive reporting on asset management activities that feature in the 5-yearly pricing rounds.

Table 7.2: Intensity and Extent of ES Footprint on Business Processes and Dynamic Capabilities

Dynamic Capability	Process	ARM	IWM	xRPM	IS-U	BW	CU	MMIS	ES Intensity	GIS	OMS	SCADA	MSWord	LFAT	CBAT	Other IT Intensity
Identifying New Assets	Solution Identification	H__	__H	H__	H__				4	H__	H__	H__	_H_	_H_	_m_	5
Coordinating Asset Programmes	Programme Negotiation	Hm_		__H		Hm_			3	Hm_						1
	Programme Execution	HH_	__H	HH_					5	_HH						2
	Programme Monitoring	HHH		HHH		HH_			8							0
Building New Assets	Stock Ordering		HHH					_H_	4							0
	Site Work		H_H						2							0
Determining Asset Policies	pricing round Negotiation	H__		H__		H__			3							0
	Maint. Policy Determ.	_HH							2							0
Servicing Existing Assets	Annual Maintenance Planning	HH_	__H	HH_		Hm_			6							0
	Maintenance Execution	__H	HHH						4							0
Module Intensity Of Usage		13	11	10	1	5	0	1		4	1	1	1	1	0	

Footprint intensity (H = High, m = medium, _ = low or none) was mapped for the ***start, middle*** *and* ***end*** *of each process in Figures 7.1 through 7.15 and is totalled for every process and module here. (For example HHH indicates high footprint intensity at the start, middle and end of a particular process.) Grand totals for high (H) intensity usage are highlighted in yellow. Information Systems outside SAP R/3 and SAP IS-U are under-reported in this table as customer service and network operations were excluded from the study.*

Intensity of ES usage across both processes and modules is highlighted in yellow. From this it can be seen that ARM, IWM and xRPM are most intensively used and the Solution Identification Process uniquely depends primarily on IT outside the ES. The Programme Monitoring, Programme Execution and Annual Maintenance Execution processes make most intense use of the SAP R/3 Enterprise System.

7.7.2 The Footprint of ES on Integration, Learning, Reconfiguration and Transformation Processes

Table 7.3 illustrates the extent and intensity of the ES and IS footprints on the five Dynamic Capabilities and their Integration, Learning, Reconfiguration and Transformation (ILRT) processes. Similarly to Table 7.2, Table 7.3 is effectively a summary presentation of Figures 7.1 through 7.15, where ES and IT footprint intensity was mapped for the start, middle and end of each process. In Table 7.3 footprint intensity is totalled for every process and ES module or IT software package.

In addition, Table 7.3 illustrates the relative extent and intensity with which SAP modules are used. Finally, the table summarises the intensity of Dynamic Capability dependence on ES modules and other IS applications overall.

The SAP R/3 ARM and IWM modules have the most intense footprints on Asset Lifecycle Dynamic Capabilities, followed by BW and the SAP Compatible Unit (CU). The CU is not a module in its own right, but a data entity that provides a multidimensional view of a given asset.

Again, ARM's footprint is large, as is IWM's, for similar reasons that its footprint on business processes is large: The Asset Register maintains detailed in-depth information about every piece of load-carrying equipment in EnerDist's Regulated Asset Base. The regulatory requirement to maintain an ever more detailed and granular picture of that base requires continuous and intensive usage of ARM. Additionally, ARM has revealed considerable detail on how certain asset management processes work and this has driven organisational and process changes.

ARM's footprint is large here as the data in the Asset Register are recognised as essential to optimising processes, organisational structures and capabilities to match regulatory requirements. Additionally, BW's footprint can be explained as BW facilitates the dissemination of these data at higher levels in the organisation. Thus ARM, IWM and BW provide the impetus for the transformation of all five Asset Management Dynamic Capabilities.

The Compatible Unit (CU) has had a transformative effect on some processes and capabilities: The CU is an entity that permits an asset to be described in terms of its operational nature, its capital and operational costs, its depreciation curve and its ordering information. Thus the CU permits the same asset to be seen in different ways by different processes. This turns the traditional idea of an ES providing a single viewpoint on its head: While there is still a singular data source, different views of a single asset can be facilitated as needed by the relevant processes and capabilities. The impact of this is noticed at programme level, when preparation of new projects automatically drives all the required ordering as soon as work orders are created in IWM.

The footprint of the ES on the transformative elements of the five Dynamic Capabilities is observable everywhere, with the exception of *Identifying New Assets*. Thus SAP R/3 influences those processes that make Asset Management Capabilities dynamic: The data made available by the Enterprise System allows those capabilities to be reshaped to meet future regulatory demands.

7.7.3 The Strategic Importance of the ES Footprint

The footprint of the Enterprise system can be evaluated in strategic terms by examining Figures 7.16 and 7.17. These two Figures overlay ES footprint data on Asset Lifecycle Dynamic Capabilities as documented in Research Question 1. Combining data from RQ1 and RQ2 reveals what role the Enterprise System plays in strategically important activities in the organisation.

Figure 7.16 reveals the role that the Enterprise System plays in facilitating or embodying strategically important business processes and Dynamic Capabilities. *Coordinating Asset Programmes* and its component processes is notable for the large ES footprint there. Thus the SAP R/3 Enterprise System plays a significant role in an activity that is both value generating and strategically important. How well this role is played will dictate the exploitability of this and other Asset Management Dynamic Capabilities; this is discussed in Research Question 4.

Figure 7.17 reveals the role that the Enterprise System plays in facilitating the integration, learning, reconfiguration and transformation processes in strategically important Dynamic Capabilities. Again, *Coordinating Asset Programmes* is notable for its ES footprint. In this case, SAP R/3 plays a significant role in the organisational routines that permit a Dynamic Capability to remain dynamic and renew itself. The larger the role of the ES in these processes, then the more dependent the continuing value and flexibility of that Dynamic Capability is on the Enterprise System. EnerCo Network's ongoing ability to adapt itself is thus directly dependent on SAP R/3 in these cases.

Table 7.3: Intensity and Extent of ES Footprint on ILRT Processes and Dynamic Capabilities

Dynamic Capability	ARM	IWM	xRPM	IS-U	BW	CU	MMIS	ES Intensity	GIS	OMS	SCADA	MSWord	LFAT	CBAT	Other IT Intensity
Identifying New Assets	Hmm							1	H__	H__	H__				3
Coordinating Asset Programmes		HHH	HHH			HHH		9							0
Building New Assets		_HH		H__				3							0
Determining Asset Policies	HHH							3							0
Servicing Existing Assets	HHH	HHH						6							0
Module Intensity Of Usage	7	8	3	1	0	3	0		1	1	1	0	0	0	

Footprint intensity (H = High, m = medium, _ = low or none) was mapped for the ***start, middle*** *and* ***end*** *of each process in Figures 7.1 through 7.15 and is totalled for every process and module here. (For example HHH indicates high footprint intensity at the start, middle and end of a particular process.) Grand totals for high (H) intensity usage are highlighted in yellow. Information Systems outside SAP R/3 and SAP IS-U are under-reported in this table as customer service and network operations were excluded from the study.*

Intensity of ES usage across both dynamic capabilities and modules is highlighted in yellow. From this it can be seen that IWM and xRPM are most intensively used across all ILRT processes in most Dynamic Capabilities. Coordinating Asset Programmes and Servicing Existing Assets make the most intense use of ES modules, whereas Identifying New Assets is uniquely more dependent on IT outside SAP R/3.

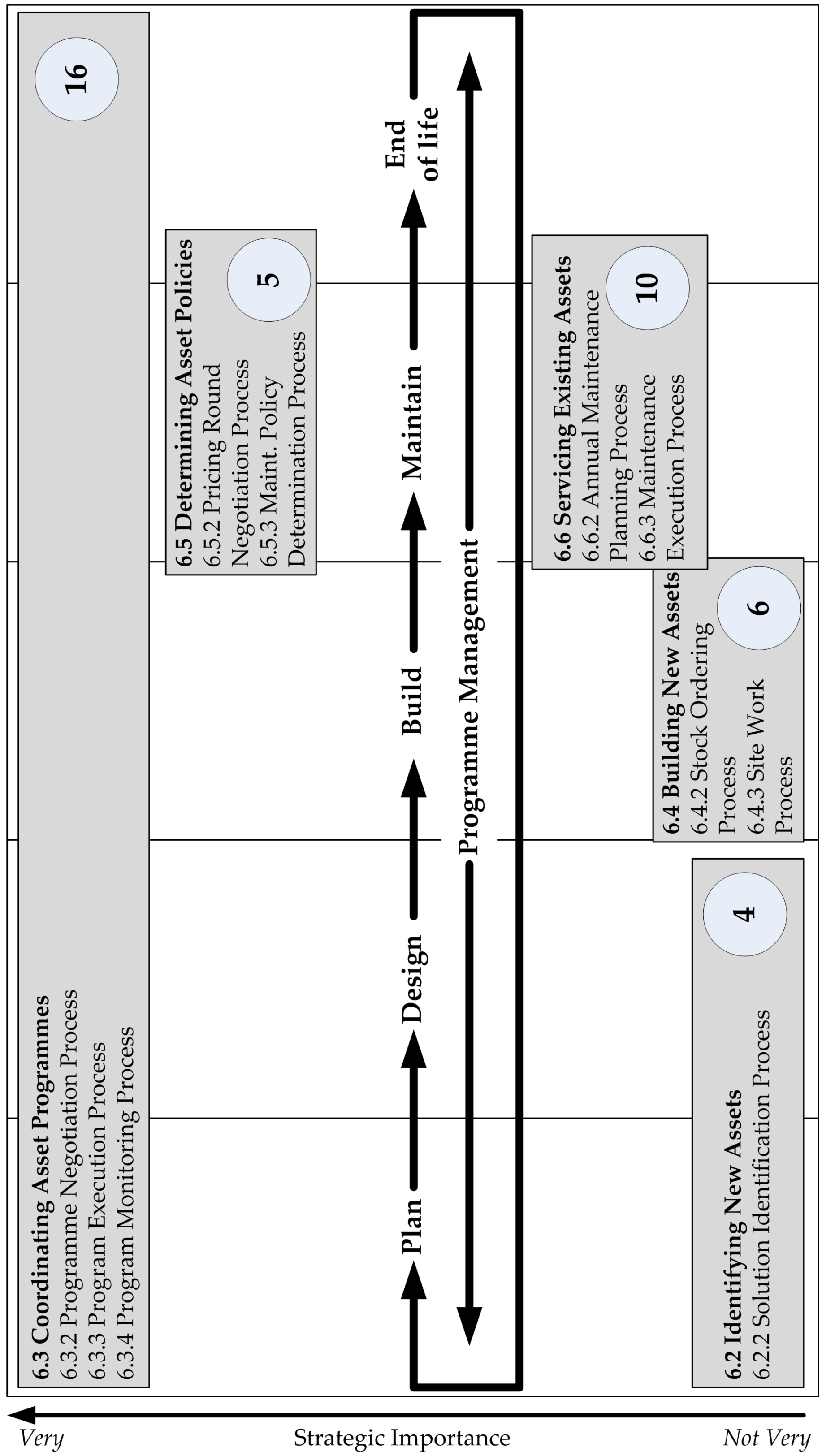

Figure 7.16: ES footprint on Asset Lifecycle Dynamic Capabilities, Business Processes

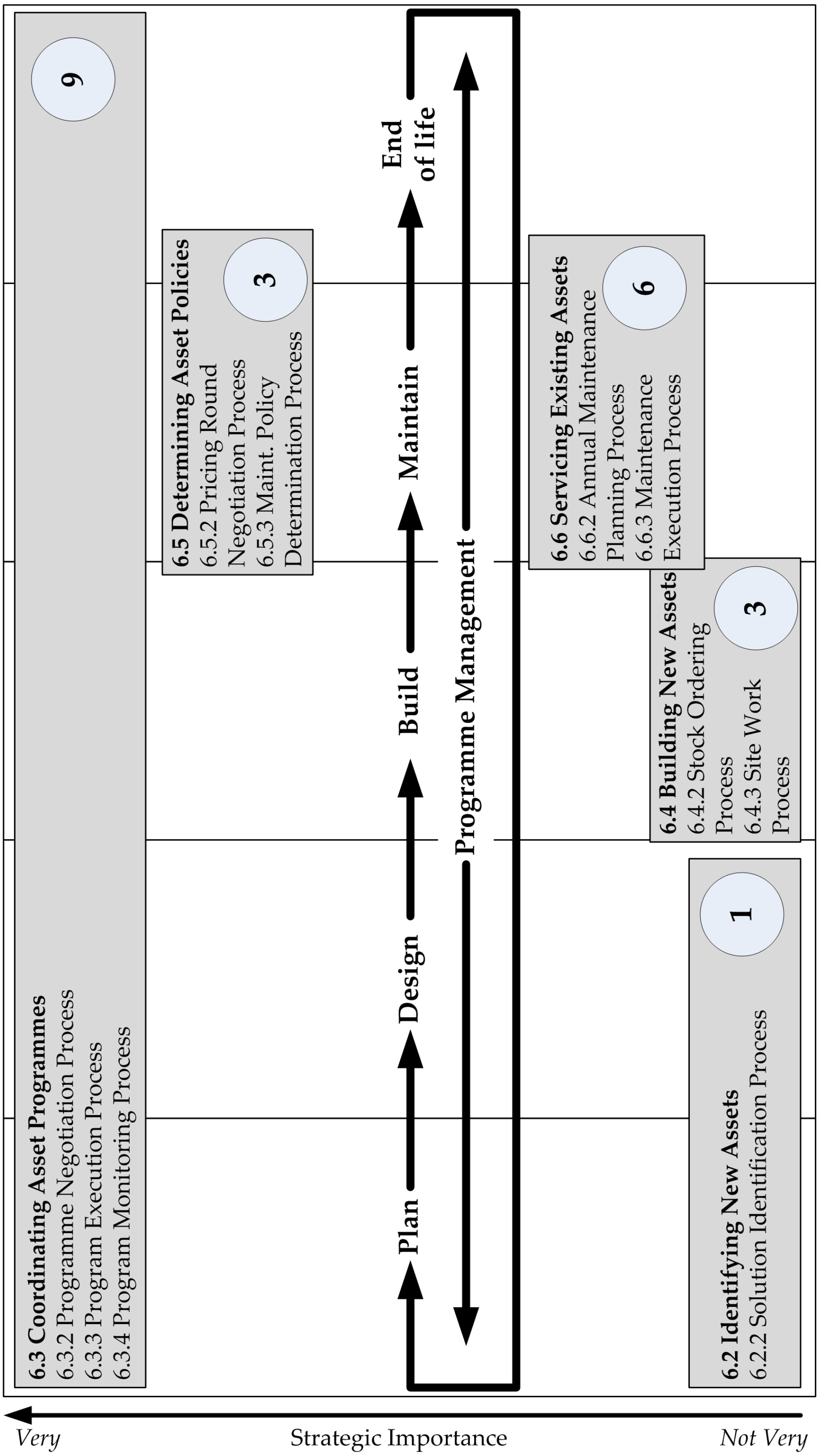

Figure 7.17: ES footprint on Asset Lifecycle Dynamic Capabilities, Integration, Learning, Reconfiguration and Transformation Processes

Chapter 8

Research Question 4: The Effect of ES on Exploitability and Renewability

8.1 Introduction

This chapter addresses **Research Question 4** by describing the effect of the Enterprise System (ES) on the exploitability of the Asset Management Dynamic Capabilities. The extent to which the ES facilitates the Dynamic Capabilities is explored, as well as identifying how the ES contributes to the future development of a Dynamic Capability, compared to what has happened in the past. Research Question 4 is restated below:

Research Question 4: What effect do ES have on Exploitability and Renewability?

The *Exploitability* of a Dynamic Capability is a measure of how well an organisation can utilise that Dynamic Capability to generate rents. If the Dynamic Capability has an ES as part of its component processes and resources, then the Exploitability of that Dynamic Capability is to some degree contingent on that ES. This is investigated in Research Question 4. In addition, *how* Exploitability is affected by the ES is explained.

Renewability is similar to Exploitability. It is the degree to which the organisation is positioned to exploit the integration, learning, reconfiguration and transformation processes inherent within a Dynamic Capability. The Renewability of a Dynamic Capability is contingent on how well any Enterprise system elements facilitate those processes. Table 8.4 summarises some of the mechanisms by which Exploitability and Renewability are enhanced.

The findings of Research Question 4 are summarised in the Chapter Summary in Section 8.7 and particularly in Table 8.1. Further analysis of the findings is summarised in Section 8.7 in Tables 8.2, 8.3 and 8.4.

The chapter is laid out in sections, each addressing the effect of the ES and any other Information Technology on the exploitability of a different Dynamic Capability. These are presented in approximate lifecycle order from the planning through to the end of life phases. The final section of the chapter summarises the overall effect of the ES on the exploitability of all the Dynamic Capabilities in the Asset Management Lifecycle.

Section 8.2: ***Identifying New Assets*** covers the Plan and Design phases of the Asset Lifecycle.

Section 8.3: ***Coordinating Asset Programmes*** covers the coordination of the maintenance and building of Network Assets on a large scale. It primarily covers the Maintain and Build phases of the Asset Lifecycle, with influence on all other phases.

Section 8.4: ***Building New Assets*** covers the Build phase of the Asset Lifecycle.

Section 8.5: ***Determining Asset Policies*** covers the Maintain and End of Life phases of the Asset Lifecycle.

Section 8.6: ***Servicing Existing Assets*** covers the Maintain phase of the Asset Lifecycle.

Section 8.7 provides a summary of the effect of the ES on the Exploitability and Renewability of all the Dynamic Capabilities.

Each section is laid out as follows: The history and Path Dependencies for the Dynamic Capability are summarised. Then the Current Exploitability of that Dynamic Capability is evaluated. This summary includes an identification of the Information Technologies used. The footprint of IT on the process inputs and outputs is clearly summarised as well as the footprint on the main body of the process. The relative intensity of the footprint at process start, middle and end is also mapped. Finally, each section ends with an analysis which summarises the overall effect of the Enterprise system on the exploitability of that Dynamic Capability.

8.2 Identifying New Assets

8.2.1 Path Dependencies

The planning process predates market opening and EnerDist's transition to an Asset Management organisation. As such, while asset identification and optimum solution selection processes predate market opening in 2000, the *Identifying New Assets* capability is very much driven by regulatory imperatives that postdate market opening. The starting point for the planning process and thus identification of new assets is dictated both by economic activity in the state and also by ever-tightening regulatory requirements. For example, most of the solution design activity at the height of the Celtic Tiger boom in 2002-2007 was in response to new load requirements from residential and commercial customers. However, given the economic decline since 2008, most planning activity has shifted to network improvements. In general load requests take priority and network improvements are grouped into programmes such as, for example, the current programme to upgrade the Medium Voltage (MV) network from 10kV to 20kV.

Selecting the least cost technically acceptable solution has not been without problems in the past. Completed proposals have been found to be in conflict with network development activities elsewhere in the organisation, leading to potentially costly but necessary redesign work. The introduction of the Asset Register (discussed elsewhere) serves to alleviate some of these problems, as any new asset must be notified to both Project and Asset Accounting and also Asset Register Administration. This ensures that any new or changed assets are up to date in the Asset Register before the asset carries load.

Finally, as this Dynamic Capability is composed of largely production line processes, the previous and current state of the network and Regulated Asset Base directly form part of the immediate history of *Identifying New Assets*.

8.2.2 Current Exploitability and Renewability

EnerDist is well positioned to exploit this capability, as the systems used - the Stoner Synergy Load Balancing Analysis Tool, The Cost Benefit Analysis Tool, GIS and Microsoft Word - are reasonably well suited to the task. In addition this Capability is largely contingent on the skill, training and experience of the planner.

However, none of the Information Technology used is directly coupled to SAP R/3. At the start of the process data are drawn from OMS, GIS, SCADA and ARM. At the end of the process a proposal is keyed into IWM. However, the bulk of the process is contingent on applications that sit outside SAP and are not well integrated. The integration of OMS, SCADA, ARM, GIS and IWM at least means that a consistent set of up-to-date data are available at the start of the solution selection process. However, tighter coupling between the solution selection process and IWM might be advantageous in maintaining data integrity.

8.2.3 Technological Opportunities

The *Identifying New Assets* capability includes modelling and planning processes that are designed to minimise the occurrence and duration of future outages while also providing the best option for extending the network to accommodate extra load. The technological opportunities offered by this capability are "production line" in nature in that they operate directly on the regulated asset base; there is little evidence that Identifying New Assets provides an opportunity for change at higher levels elsewhere in the organisation.

The GIS system is due to be replaced as part of Pricing Round 3 and so in the 2011-2016 timeframe. It is possible that the new GIS will provide more scope for integrating the modelling tools required for solution selection into the wider IT infrastructure.

8.2.4 Analysis

Identifying New Assets is singular as it is the only Dynamic Capability in this Study that is largely independent of the ES. Consequently the Exploitability and Renewability mechanisms visible elsewhere are not so prominent here.

Nevertheless the Capability is still Dynamic as there is strong evidence of acquisition of new tool and modification of processes to accommodate new technologies for the Regulated Asset Base.

The process of identifying an optimum solution to a load request or network deficiency was modified to accommodate new network technologies. This modification consisted of the development and application of a cost benefit analysis tool to apply those technologies to maximum effect.

The Path Dependencies, namely the current and previous network states and the training and experience of the planner, shape both the technological and complementary assets available at any point in time. The planner commencing a process of solution selection has at her disposal the network in its current state, the history of any relevant outages, any relevant load requests and her training and experience as a planner. With these technological and complementary assets at her disposal, she executes the required processes to arrive at a suitable solution. Finally, the technological assets of SAP, GIS, the Load Flow Analysis Tool, the Cost Benefit Analysis Tool and Microsoft Word are enablers of the solution selection process.

The optimal solution selection process, as the main production process of Identifying New Assets, modifies technological assets in that its intended result is to make changes to the regulated asset base. That modified asset base in turn generates new technological opportunities in that an astute solution will provide for future expansion of the distribution network.

8.3 Coordinating Asset Programmes

8.3.1 Path Dependencies

Programme Management in EnerDist predates market opening. It was a decentralised organisational function with no clear priorities. As such it suffered from a lack of focus on what network improvements needed to be completed first; difficult or expensive projects tended to get delayed while the "easy wins" were dealt with first. Work was prioritised on the ground on the basis that problems immediately facing network technicians were fixed with little thought given to prioritisation. Additionally, little thought was given to the long term impacts of certain changes.

Problems with the network due to a lack of coordination over improvements were exacerbated by Ireland's rapid Celtic Tiger Growth, as efforts were focused on connecting new load rather than reinforcing the existing network. The problems were further compounded as no capacity existed to transfer load from faulty links in the network to facilitate essential repairs. As a result the consequences of outages on parts of the network were much more serious than they needed to be, as no spare capacity was available to route supply around the damaged part of the network.

In addition, prior to the implementation of SAP R/3, specifically IWM, ARM and xRPM, no structured Information System existed to support programme management. Paperwork was generated by the staff concerned on an ad hoc basis. Disparate systems existed on Microsoft Excel spreadsheets; these were neither connected nor coordinated. As a result, there was no standardisation across EnerDist nationally, especially as its regionalised management structure effectively led to isolation of some parts of the organisation from others:

> *"It was just an Excel spreadsheet. There was no feeding back into a system. We created our own paperwork and managed it that way. I had one system. The crowd that were looking after Cork City and West Cork had another system. And I'm sure up the country there was any number of systems."*
>
> Network Projects Supervisor

This lack of structure or integration impeded the recording of programme work completion, which led to problems with programme planning for subsequent years. An example is where paperwork for hazard patrols would not be completed one year, a result of which hazard patrol planning for the following year was not able to take into account those patrols already completed:

> *"I suppose the basic problem with that is that there wasn't sufficient interaction necessarily between ourselves and those processing the data so that what we got the following year reflected all the hard work and graft."*
>
> Network Projects Supervisor

The landscape against which Programme Management was carried out has changed. The distribution network has undergone significant improvements since market opening and, as Ireland transitioned from economic growth to stagnation and recession, the nature of the work changed. While the network has improved in reliability, the focus has moved from new connections to reinforcement, with the introduction of the Network Renewal Programme. A consequence is that the number of unplanned outages in the network has decreased substantially:

> *"What has happened really in the EnerCo in the last twelve months is that, there's been a switch from services work to projects work, because what we class as services now is new supplies. So, obviously there's been a fierce drive in the last five, six years with the Celtic Tiger ... and all the new connections in all, the new houses. There's been a fierce drive, fierce, demand for new connections. So that was all, that was, ah, the focus was on services rather. Now, it's gone from sort of a hundred thousand connections, new connections a year down to probably ten thousand now."*
>
> Materials Supervisor

At the same time, subcontracting was introduced to manage the high workload imposed by the Regulator. This was a new experience for EnerDist, which up until then had employed directly all the people necessary to maintain the network. The introduction of subcontracting was necessary to complete Network Renewal work in the very tight timeframe prescribed by the regulator:

> *"The Regulator had given us a very short period to finish a piece of renewal work that we had started ourselves in the mid 90's and just weren't able to complete ... and the big challenge there was that it was, contracting, was so new you know."*
>
> Network Projects Manager

Prior to the introduction of SAP R/3, Programme Management was reactive at best and chaotic at worst. The need for EnerDist to move to an asset management business model and the need to comply with the regulator brought discipline to its Programme Management activities. SAP R/3 was rolled out as the business transitioned to asset management and as the type of work transitioned between network expansion and network reinforcement. The next subsection discusses the current situation post introduction of SAP R/3.

8.3.2 Current Exploitability and Renewability

As elucidated in Chapter 6, Programme Management is dependent on the SAP R/3 xRPM, ARM, BW and IWM modules. EnerDist's ability to exploit its *Co-ordinating Asset Programmes* dynamic capability is contingent on how well the related ES components facilitate the relevant processes.

The centralisation and prioritisation brought about by implementing a single SAP R/3 ES is seen as an advantage as it eliminated the diverse and disconnected systems that existed previously. The SAP R/3 system was seen as a means of unifying previously disconnected regional operations areas, and as a way of properly prioritising work and ensuring that those priorities were adhered to. The ability to impose consistency and control is also important to EnerDist:

> *"So that's, at least now there will be better planning around that as well and them dates are more critical now that people are made, more, they're answerable for them now, more so than they were in the past."*
>
> Network Projects Manager

This permits EnerDist to respond better to the requirements laid down by the regulator. The regulator expects the DSO to execute asset replacement and refurbishment programmes in a consistent manner. Regional variations in priorities and work practices would impair EnerDist from meeting regulatory targets, increasing costs and the likelihood of incurring performance penalties. Furthermore, the operational and capital cost of carrying out any such programmes is capped under the current pricing round. xRPM provides control of the related projects, as do ARM and IWM.

As well as xRPM, IWM and ARM providing the functionality required to conduct programmes in an economical and consistent manner, BW and IWM(CU) provide the means to integrate the component processes. As the Business Warehouse (BW) is predominantly a reporting tool, it can be used by users who do not need (or want) access to IWM or other parts of the SAP system. BW effectively provides the process integration that these users require as it draws from multiple sources to provide reporting:

> *"It depends on the extent to which it takes our existing systems and takes the information from them. I think it's as best as could be done because it was a*

> *major, major project and given the, the variation and the complexity in terms of what we do, depends on how well it sucks up the information, particularly the Business Warehouse end of it. Because that's the bit that we are depending on to interconnect all the systems."*
>
> Network Projects Supervisor

In particular, the SAP R/3 Compatible Unit provides both a powerful point of data and process integration for many asset-related processes and also provides the means to view a single asset either as a financial entity, a piece of work to be done, a bill of materials, a component of a project, or something to be maintained. The Compatible Unit turns the concept of a single point of reference in an ES on its head and provides a multidimensional view of the same entity.

While also providing consistency across the organisation, IWM, xRPM, BW and ARM provide enhancements to flexibility and adaptability. In addition, the Compatible Unit has rendered some activities scalable. Programme Managers can now implement generic designs as Compatible Units that can be used for large programmes where the work is largely repetitive. This represents a considerable acceleration in the required design and procurement processes for repetitive work. For projects where cabling and poling is being replaced, and all the materials are the same from site to site, this is distinct advantage:

> *"Well an example of one, we have a contractor now in low voltage, he's gone into every low voltage group in the country and maintaining it to a specific standard that we have agreed with the Regulator. So we've done a generic CU we've put it in there to cover that group. When he goes in, all he has to do is pick that, well, and do an execution factor and things if he's doing a hundred groups in an area. Execute that by a hundred and there's his hundred designs done and it will spit out his costs, his materials."*
>
> Network Projects Manager

However, there are some limitations to flexibility and adaptability. Introducing subcontractors to the workforce required modifications to the SAP R/3 system that had not been anticipated. The high level of integration of processes introduced by SAP R/3 has meant that previously simple work routines, such as completing time sheets, has become more complex because activities as well as hours worked must now be recorded. There is a tradeoff between increased flexibility in the main asset management processes and increased workload on those lower level processes that must return accurate and timely data.

Not all projects had been transitioned into IWM at the time of writing. Any jobs initiated before the introduction of IWM in 2009 remained in the old DWMS system. The workload for projects containing these jobs is consequently higher, but is expected to drop once all projects have completed the transition. In addition, some work is still needed on BW so that it provides comprehensive reports on all activities.

Finally, there is some resistance to the complexity of ARM. This is perhaps unsurprising given the observed tradeoff between increased flexibility in one area and more workload with previously simple processes in another:

> *"There needs to be an Asset Register. There [needs] to be some way of creating work orders so the system is followed. But, for me to use it is way up and above and beyond what I need. I don't need this. I don't need to know whether the job numbers are there or not."*
>
> Network Projects Supervisor

Notwithstanding some dissatisfaction about the amount of data that needs to be maintained, however, the overall impression of respondents was that a centralised consistent programme management system was an improvement. Some teething problems were expected, according to some of the interview participants. Also, the introduction of xRPM, ARM, BW and IWM has increased the exploitability of *Coordinating Asset Programmes*. Programmes are now scaleable, centrally manageable and consistently applicable. The ability to replan now exists. Reporting is coordinated and standardised across the organisation. As a result *Coordinating Asset Programmes* is Exploitable due to the improvements brought about by the introduction of SAP R/3.

8.3.3 Technological Opportunities

Integrated Work Management and the Compatible Unit provide opportunities for further enhancing the integration of processes in *Coordinating Asset Programmes*. It allows work packages to be reported on in a consistent manner. Initial concept work is completed on IWM, which permits other actors in Asset Management to provide input on what the design needs. The draft work package is then discussed and approved at an Asset Management meeting and passed onwards to the designers for the final design. This eliminate mis-steps and loops in the process, and ensures that a single work package and design for a particular site or group of sites can meet the technical requirements of several distinct groups in Asset Management and also the wider EnerDist organisation.

Further improvements with IWM are expected by using the enhanced management and reporting facilities now available to optimise processes. This is seen as a learning process where opportunities to customise IWM and other SAP R/3 modules will occur once it is understood by EnerDist which modifications will be beneficial:

> *"I'd hope that with IWM in the next year we would be fine tuning that, and making sure that everyone was working through the exact same programmes ... there's a lot more that we do need to kind of customise a lot more, to get what we need out of it, so we only learning that as we go along, as we say you know."*
>
> Programme Manager

Improvements to planning and control of future programmes are expected, especially in the area of resource planning. Detailed report on person years required for a project are now available. In effect an explicit process within SAP R/3 supplants an earlier tacit process where workloads were estimated based on the experience of the individual doing the estimating. This was recognised by one respondent as being a distinct improvement over the older system:

> *"It all feeds into good planning now that gives us a far more refined plan."*
>
> Network Projects Manager

Because IWM now links stock ordering to site work, further work is needed on Programme Management and related planning activities to ensure that IWM's ordering triggering processes do not compress other parts of the process unduly. Initially SAP R/3 did not affect project work. However, the introduction of IWM in 2009 has tightly coupled programme management and project work processes that were previously somewhat disconnected from each other. The natural buffering that this provides has now gone. Consequently, processes have to be fine tuned to take account of the automated procurement processes and lead times tied to IWM. This is not perceived as a process change but rather a refinement to processes that have worked in the past.

8.3.4 Analysis

IWM, BW, xRPM and ARM clearly enhance the exploitability of *Coordinating Asset Programmes* by making more of the process visible and reportable, integrating other processes and imposing much-needed uniformity on how Programme Management is carried out nationwide. Before SAP R/3 was introduced, there was a large amount of chaos and inconsistency in Programme management activities. This situation became untenable when the Irish energy market was opened, restructured and regulated. Once EnerDist was expected to perform to certain levels, it became very desirable to reduce costs by streamlining processes. Hence the introduction of SAP R/3 is welcome.

The Technological Opportunities that a Dynamic Capability can create can be of the source that allows the organisation to move into different market areas by transforming its existing processes and asset base, or to become significantly better at what it does already through the same transformation. The Technological Opportunities presented by *Coordinating Asset Programmes* fall into this second category. This suggests that there may be a limit to such improvements in the future, however, this point has not been reached yet.

8.4 Building New Assets

8.4.1 Path Dependencies

The history of *Building New Assets*, like *Coordinating Asset Programmes*, is characterised by the replacement of old, disconnected IT systems with SAP R/3, as well as shifts in the nature of the work done depending on the external economic environment. More significantly, *Building New Assets* saw a structural shift in the way stock is ordered and inventory is managed. In past, stock levels were managed with automatic reorder points where stock was replenished if it dropped below a certain safety level. A side-effect of this was the unnecessary accumulation of large amounts of expensive stock.

While stock levels were of little concern in the past, as long as stock was not short, efforts are now being made to reduce stock to the minimum required.

This is simply to reduce working capital and the costs associated with maintaining unnecessarily large amounts of inventory. At the same time the warehouses and yards where stock was held were consolidated and streamlined to further reduce running costs. With the introduction of IWM, the stock system transitioned from automatic replenishment to demand-driven stocking, with appropriate lead times built in. Additionally, pressure was exerted from EnerDist's Finance department to reduce the amount of capital held in stock. At the time of writing. €15m had been saved in the year to date with a further €10m to follow the next year.

Prior to the introduction of IWM, all site work was managed through an older system called Distribution Works Management System (DWMS). In addition an in-house system based on Microsoft Access called Pendulum was developed to deal with subcontractor work. The major limitation of DWMS was that is was very user unfriendly and punished users who did not follow procedure correctly. In addition, EnerDist ceased maintaing it and, over time, new elements that were essential to projects were not made available. As a result DWMS did not reflect the reality of what was being done on site and the system was open to a certain amount of abuse:

> *"So you were getting out very limited information and as a result of that people weren't placing much value on it, they were getting out man days and costs that didn't really reflect what was happening so it was defeating."*
>
> Network Projects Manager

The concerns expressed by Network Projects about DWMS were expressed elsewhere in EnerDist. As well as being outdated, DWMS was completely unable to cope with cost reporting in detail. The result was that it was impossible to work out in detail what each job cost.

As with *Coordinating Asset Programmes*, the nature of site work has shifted with Ireland's changing economic fortunes over the last number of year. The number of new connections per year is the most evident measure of what sort of work is being done:

> *"We discovered that because we're running at a fifth of what we were doing we have to reallocate and retrain staff to do project type work. The good thing about EnerCo, is that we have loads of project work to do, and because we have so many new connections and everybody was rushing around like mad, for the last four*

> *years, we are behind on our planned work, so there's at the moment, plenty of planned work to be done so we are retraining."*
>
> Customer Services Manager

A huge drop in the number of connections from 105,000 per annum to 34,000 per annum meant that Network Technicians had to be redeployed to other work. This means that Network Technicians were being moved from fairly repetitive new connections work (which is highly automated and supported with a mobile device) to other site work related to asset refurbishment or replacement, which is still supported by paper forms only.

8.4.2 Current Exploitability and Renewability

Following the introduction of SAP R/3, a lot of processes were centralised. An example is the new subscriber connection process, which used to be handled at area office level. These are all now concentrated in Athlone. Similarly to other processes, EnerDist has replaced a number of regionally separated diverse processes with a single process managed from a single location. A consequence is that new connections that previously took up to six weeks to process can now be dealt with and scheduled in a matter of days.

In addition, when IWM was introduced in 2009, all the work was migrated from DWMS and Pendulum. This did not happen overnight but subcontractor work in particular was transitioned over several months. IWM is the backbone of all work from completion of designs to completion of site work, regardless of the origin of that work. Some customisation was required to support the new demand-driven materials planning and ordering processes that EnerDist required. Nevertheless, IWM has brought significant benefits through process integration and also through the introduction of the Compatible Unit. The most significant enhancement has been to the Stock Ordering process, where the IWM system is capable of managing large variations in lead times for different stock, with some lead times being a year or more.

There are factors that may limit the exploitability of *Building New Assets*. There is some misfit between IWM and business processes around executing projects and site work. In particular, it is currently not possible to subdivide a large project into smaller projects or amongst several subcontractors. Also, the lead time to bring a new supplier online is very long, in the order of six months.

This is expected to be mitigated by more astute management of materials with long lead times.

IWM's full abilities are not being exploited. It is possible to set up templates for certain types of jobs. This would save a considerable amount of time working out which Compatible Units belong to which job type and would make work order setup much faster. In addition IWM's imposition of lead time for projects is still not fully understood. The necessity to plan long-lead time projects well in advance, with sufficient time left for those long leads to run before the project is due to start, is still something that needs to be assimilated by EnerDist staff as they become familiar with the IWM system.

Also, while stock visibility has improved, there are still issues with understanding the stock ordering process when creating a new work order in IWM. If the correct date for the work to be done is not used, today's date is used as a default and stock is immediately ordered for the job. The consequence is stock being held for a job far longer than is actually necessary. Eliminating the problem involves educating staff on the implications of entering work dates into IWM. Again, processes that were previously buffered from each other are now connected.

Some integration work still needs to be done, mainly by making sure that all required materials are available on IWM. This means that certain designs can not be completed on IWM as the required materials are not yet in the system. Circumventing this problem requires a certain amount of bricolage by directly requesting the materials from stores. Effectively this falls back into the old procurement model and results in over-ordering and the necessity to return unused stock to inventory. This problem is expected to disappear as the entire inventory database is migrated to IWM.

Initially there was some difficulty adapting to the SAP IS-U module which is used to manage new customer connections. Under market opening, domestic and commercial customers may procure electricity from any of a number of suppliers, but the responsibility for connecting that customer with the grid rests with EnerDist. Thus IS-U is used intensively by EnerDist's Customer Services staff. Many of the problems encountered were to do with changes in terminology from the older legacy IT systems to SAP R/3. Overcoming these changes required user adaptation and, to some extent, unlearning older terms and work practices:

> *" I remember one guy had a screen with a whole series of questions on it, and the only thing he recognised was division and he was putting down mid west division because he knew that's where he was, but it would take it would only take a number, from 1 to 3 and it turned out division stood for either water, electricity, so the naming was all wrong so we were at a complete loss with ISU."*
>
> Customer Services Manager

By the time IWM was deployed, user adaptation to the system took much less time. This is attributed by EnerDist staff to much more user awareness of the likely changes the new module was likely to impose. Consequently any changes in terminology were expected, users were much better prepared and less confused and adaptation to the new system took much less time:

> *" ... we were aware of that for IWM, so we were able to use it and we surprised ourselves how quickly we adapted."*
>
> Customer Services Manager

IWM has significantly improved the exploitability of *Building New Assets* by transforming stock control from an automated recording system to a demand driven system. In effect EnerDist's internal supply chain has been transformed completely in terms of operation, processes and supply infrastructure. Consequently EnerDist has been able to achieve significant cost savings by reducing working capital.

The Compatible Unit has permitted much tighter coupling of previously disparate processes within EnerCo networks. The Compatible Unit permits the different divisions of EnerDist to view the same asset, or project, or work order from the financial, planning, asset management and work scheduling perspectives. A notable side effect of this tighter coupling has been the need for the organisation to adapt its work practices to allow for the lack of buffering between processes. As is clear from the account given here, these adaptations are still ongoing.

There is one notable exception where IWM has not (yet) had the desired effect of process integration: The site work itself. This is simply because, at the time of writing, there is no access to IWM from site. All site work is tracked through paper forms which must be transcribed to IWM by a Construction Supervisor when the Network Technicians return from site. This is discussed further in the next Subsection 8.4.3.

8.4.3 Technological Opportunities

Building New Assets allows for two possible technological opportunities. The first is to move further towards a Just-In-Time supply chain approach to making changes and additions to the distribution network. In particular, the Network Renewal Programme has to date focused on getting the required work done without addressing inventory costs. As the overall volume of work has slowed down due to the drop off in new connections, the focus has moved to getting the supply chain and inventory elements of the Network Renewal Programme operating optimally:

> *"Now there's, now that the work has slowed down and there's a kind of different focus. The focus is we get the materials right, so, trying to implement [a] just-in-time system."*
>
> Materials Supervisor

This is a process that has already started and will continue until inventory and working capital has been minimised as far as possible. The second opportunity is to completely integrate site work with other processes by giving Network Technicians handheld devices. The expected benefits of providing on-site access to SAP R/3 and IWM in particular are eliminating a cumbersome step in manually typing in paper data and also improving the timeliness of asset data.

In fact, at the time of writing ,a pilot of handheld devices for substation work had already taken place:

> *"[A project manager] was involved very heavily in a pilot using handhelds, I think around Dublin North, Finglas, to do with substations, so basically the substation guys who were going out and doing the motions were using the handhelds, and the pilot went quite well, but as soon as we went to extend the pilot, there was actually an IT issue in that, the system couldn't cope with higher numbers, we weren't, it wasn't able to cope with transmitting the data forward and back."*
>
> Asset Manager

Notwithstanding early teething problems, as part of EnerDist's Pricing Round 3 agreement with the CER, €16.5 million has been agreed for a Mobile Workforce Management system, which will support handheld access to SAP R/3

(CER, 2010)[p94]. Some of the justification for this is illustrated by the following comment, which encapsulates some of the frustration of having to deal with manually keying finished work into IWM:

> *"I have a funny feeling that because of the age profile probably of the auditors and what have you they're probably more comfortable seeing paper because that's something they understand. We have to file all of this and have it in some semblance of order. And, um, d'you know it's hugely cumbersome. There's a huge clerical side to all of this that, um, doesn't need to be there. So, we have a huge, cumbersome ... you have a wonderful system for the amount of information you can process and handle. You can generate screens and, all, masses of information. We have, we have the whole thing here on the desk in front of us the, the financial management of it, the asset management part of it and all of that don't need to see it. Do I need to care? No, no. All I need is to get work out to these lads, get it back and input it in something that's quick, simple and easy and efficient. And, whatever systems have to be put in place so that I can create stuff in the background or someone works away in the background with other stuff to feed other than, d'you know, very basic information would be nice."*
>
> Construction Supervisor

This comment is another indicator of the tradeoff between process flexibility elsewhere and extra work required to make the extra data available to those processes. In this case the Construction Supervisor feels the burden particularly keenly, as the paper work orders printed from IWM and taken to site must be rekeyed into IWM under the Construction Supervisor's supervision, once the site work is completed. Consequently, the Construction Supervisor bears the burden of updating all the relevant asset data in a timely manner.

Introducing a mobile workforce management system, while likely to produce technical teething problems, immediately eliminates this burden from the Construction Supervisor. It is reasonable to speculate the the Supervisor can then take a higher level view of site operations, with a view to identifying further means of optimising site work schedules.

8.4.4 Analysis

The exploitability of *Building New Assets* has clearly been enhanced with the introduction of IWM. IWM is a distinct improvement on DWMS-it is more integrated and generates improved reporting. It also facilitated the introduction of the Compatible Unit, which allows multiple views of assets.

Current exploitability is clearly limited by the failure to integrate IWM into the on-site work environment. However, this limitation also presents a future technological opportunity as preliminary tests on integrated handheld devices have already been completed with a more extensive rollout planned for the third pricing round (PR3) from 2011 to 2016. Integrating on-site work and asset tracking directly into IWM is likely to yield improvements in timeliness of asset register data and work order status. The risk of error is also reduced.

In the short term the introduction of IWM has imposed an extra burden on parts of EnerDist's workforce. This is due to tighter process coupling requiring much more vigilance in some parts of the affected processes. In other parts, workload is increased because the site work part of *Building New Assets* has yet to be electronically integrated with other processes. As a result a considerable amount of time is spent in bricolage efforts to make up for the discontinuity. This is prone to error and consumes resources that might be more gainfully employed elsewhere.

These are two clear impediments to Exploitability. However, there is also evidence of remedies emerging to these problems. The first remedy is an adaptation process on the part of the workforce, learnt initially through slow adaptation to IS-U and applied much more rapidly and effectively to IWM. The second remedy is in fact a Technological Opportunity, where capital is invested in a Mobile Workforce Management System to eliminate the paper forms required for site work. Completion of this system will fully integrate all the processes involved in *Building New Assets* and will, to a certain degree at least, sidestep the observed tradeoff between flexibility in Asset Management and increased data entry workload elsewhere.

8.5 Determining Asset Policies

8.5.1 Path Dependencies

Existing asset maintenance policies were quite restrictive, and more stringent than comparable DSOs in the UK. At the same time the asset register was maintained on a Microsoft Access database. The asset database accumulated over time. However, detail was lacking until after the transition to ARM, which drove an effort to acquire more comprehensive data. The policy determination process has progressed from asset replacement programmes to asset maintenance programmes. The whole process of policy negotiation did not exist prior to Market Opening as EnerDist was the sole arbiter of its own asset maintenance polices. These were determined in line with what was understood to be best practice at the time.

Asset maintenance policies, prior to market opening and independent regulation, were focused on maintaining network safety and reliability with cost a lower priority. In addition, a certain amount of asset maintenance was not policy driven at all, instead being opportunistic and driven by observed conditions when on site. This was illustrated by one respondent who explained that maintenance work might be performed as a follow on to scheduled site work. Unlike the site work, the maintenance work would be performed as a consequence of observing unacceptable conditions at site. The problem with this approach was that the work was not clearly costed or documented. A consequence was that future maintenance visits to the same site might be scheduled, with no awareness that the required work was already done.

Since market opening, however, EnerDist has been required to negotiate and execute maintenance policies that both maintain and improve safety and reliability, while also reducing costs. Effectively the regulator has imposed limits on capital and operational spending, while at the same time imposing penalties for outages and safety violations. EnerDist has been asked to do more at less cost. This mandated changes in approach to determining asset policies. The SAP R/3 Asset Register (ARM) was not implemented until six years after Market Opening; prior to its introduction, negotiation of asset policies was based on asset data that were either incomplete, insufficiently granular or difficult to access.

8.5.2 Current Exploitability and Renewability

The Asset Register gives Asset Managers a new ability to fine tune asset maintenance policies over the course of a year. This is sometimes necessary if deficiencies are revealed with existing programmes or if an opportunity presents itself to combine the required work with other site activities. Prior to the introduction of ARM, it was very difficult, if not impossible, to adjust maintenance policies halfway through a year. This flexibility now exists:

> *"... if anything needs to be changed over the course of the year, it can be changed very easily in ARM because orders can just be added or removed."*
>
> Asset Manager

In addition, maintenance policies can now be designed to take account of recent renewal programmes, which presents a cost saving opportunity. Newly installed assets may not need maintenance for the next number of years and can thus be excluded from maintenance policies negotiated with the regulator. This in turn frees up capacity to focus attention on maintenance where it is needed. A specific example was illustrated by a respondent as follows:

> *"They've cut us back a lot on [operational expenditure]; what we've been able to do, is we've been able to say, we have pretty much got approval that we were going to be allowed to replace X number of particular types of switch gear, over the next two years, because of their nature, so what we have said as well, if we know that these particular units are now on a list for replacement, well there's no point in actually doing a proper full maintenance programme on them this year or next year."*
>
> Senior Asset Manager

More significantly, the Asset Register is a significant weapon in Pricing Round negotiations with the Commissioner for Energy Regulation. A feature of Pricing Round negotiations is that any assertions made by EnerDist concerning the cost or extent of proposed programmes, or the operational and capital costs of completed work, are subject to challenge either by the regulator or by consultants and auditors acting on its behalf. Prior to the introduction of the Asset Register (ARM) in 2006, these challenges would have been difficult to defend. Six years after the inception of ARM, EnerDist is now able to avail of a comprehensive and detailed database of its own Regulated Asset Base. The detail in the register increases year on year as more detail is added.

Thus the Asset Register provides detailed and extensive data to back up EnerDist's assertions and defend any challenges by the Regulator and its auditors. ARM assists future Pricing Round negotiations by providing incontestable data on the performance of previous asset maintenance policies and on the expected performance of future asset policies:

> *"They will challenge things ... I have no doubt, if they do send in consultants, they will look for background information to back it up."*
>
> Asset Manager

The enhanced detail works both ways, however: As the Asset Register becomes more comprehensive, the Regulator is empowered to demand that future asset maintenance policies are more detailed. It will also look for more targeted savings which in turn demand yet more detail in the Asset Register.

8.5.3 Technological Opportunities

It is recognised that ARM could be exploited further to yield a more comprehensive understanding of how maintenance is being performed now and how it could be improved in the future. There are further opportunities to use ARM to more artfully design future maintenance policies:

> *"We're primarily using ARM to create maintenance work orders ... we're not capturing qualitative data, that we can capture on a system ... and get more focused maintenance."*
>
> Asset Manager

This perhaps understates importance of ARM in providing *quantitative* data on asset status: Not only are data on more assets now available, but considerably more depth and detail is available as well. The Asset Manager's frustration that qualitative data are not being captured is premature; it is likely that a more detailed capture capability will be contingent on providing on site access to IWM and ARM, as well as more accumulation of data.

Further opportunities are likely to present themselves as the tighter coupling of processes brought about by the implementation of IWM make themselves felt. It is likely that, as qualitative asset data become available, and the Mobile Work Management System comes on line, that future asset maintenance policies can be very finely tuned to achieve the desired results at minimum cost. Real-time updating of asset status from site may allow precise prioritisation of work where there is a serious safety issue or an increased risk of a network outage. The turnaround in scheduling follow-up work at a site will become much shorter.

8.5.4 Analysis

ARM enhances the exploitability of *Determining Asset Policies* by placing EnerDist in a much better position to review its own policies and plan new policies. As the level of detail and breadth of data captured within ARM continues to grow, ARM is likely to make this Dynamic Capability even more exploitable. At some point in the future, further improvements in exploitability will be contingent on moving from quantitative analysis of numeric data to a more qualitative approach. The Regulator may demand levels of analysis and response that cannot be served by a simple analysis of aggregate data.

The current Exploitability of *Determining Asset Policies* is entirely contingent on the Asset Register, and the Exploitability of this Dynamic Capability improves as the data in the Asset Register improve and become more extensive. The integration of processes and technological improvements outside this Dynamic Capability will allow far more frequent updates to asset status and thus better planning of future policies.

The Dynamic Capability *Determining Asset Policies* is heavily dependent on the Asset Register and other elements of the SAP R/3 ES. However, its current Exploitability and future Technological Opportunities have been achieved primarily because of its significant Path Dependencies. This Dynamic Capability depends on the accumulation and refinement of data on the Regulated Asset Base over time. In future it will depend on process integration and adaptation with resulting improvements in depth of data.

8.6 Servicing Existing Assets

8.6.1 Path Dependencies

The existing Asset Register was preceded by an application called Main Saver. The application had two functions, first, to track the status of every asset over its lifetime, and second, to schedule the maintenance of those assets. This application suffered from incomplete and missing data from significant sections of the Regulated Asset Base. Asset maintenance was time-based rather than condition based. This caused two problems: First, there was always the risk of assets not being maintained at the predetermined intervals, or of the asset deteriorating significantly in condition between two intervals. Second, costs were increased as some assets incurred unnecessary maintenance visits.

Additionally, maintenance was done on an opportunistic basis in conjunction with other site work. This approach was problematic as, while it ensured safety by erring on the side of caution, it tended to be expensive. Furthermore, the work was not tracked so it was hard to see what money was being spent on maintenance

The SAP R/3 Asset Register was introduced in 2006 and much early work was dome on transferring data from various Microsoft Excel Spreadsheets and Microsoft Access databases to the new system. This accumulation of data is continuous and ongoing, as renewal programmes permitted large groups of asset data to be updated as those programmes completed.

The current abilities of the Asset Register Administration group to effectively service assets is based on a number of years' work in populating the SAP ARM with increasingly extensive, detailed and accurate asset data. Where *Servicing Existing Assets* is now is a direct result of this effort, driven by the regulatory requirement to reduce the cost of maintenance per asset.

8.6.2 Current Exploitability and Renewability

Driven by ARM and enabled by IWM, EnerDist is well positioned to exploit this Dynamic Capability, a situation that improves all the time as the Asset Register is populated with more and more accurate asset data. The Exploitability of this Dynamic Capability has several different dimensions:

First, more accurate asset data permits EnerDist to focus asset servicing on only the assets that need servicing. Also, the asset database is constantly updated with the current asset status. Not only are these updates a direct result of maintenance or renewal activity, but the OMS and SCADA systems feed live network data into the Asset Register via overnight data transfer. Since the introduction of IWM, any asset status changes as a result of scheduled site work are also fed directly into ARM, with the proviso that these data are sometimes delayed by the need to key paper work orders into IWM. Thus the data in the Asset Register are as timely as possible.

The second dimension is that of process integration. This is more than simply retaining all the data pertaining to an assert in one places. As numerous different processes are dependent on and supply the same data, an opportunity presented itself to coordinate site work so that modifications to an asset or set of assets could be coordinated across scheduled maintenance, renewal programmes and other site work. As a result, the work order sent to site contains the minimal set of tasks required to meet the requirements of several different divisions within EnerDist.

The third dimension is condition based maintenance. Condition based maintenance works better than time based maintenance for certain assets, where maintaing the asset in an operational state is dependent on the use that asset sees over a period of twelve months. In particular, EnerDist has several thousand switches in its network. Some of these are oil filled and some are gas filled, and both have different maintenance criteria. The basic maintenance criterion is that each switch must be cycled between the closed an open positions a number of times a year.

In the old Main Saver system, no distinction was made between oil and gas switches. As a result, switches were cycled more than necessary. Since the introduction of ARM, the necessary detail to distinguish the switch types has been loaded into the Asset Register. Additionally, ARM data was supplemented by data from IWM, OMS and SCADA, so the number of switch cycles as a result of outages or other site work were recorded for each switch.

The consequence of this is that the actual number of maintenance visits per annum for each switch is now determined by the switch type and the number of times it has been cycled as a result of non-maintenance activities in the previous twelve months. As the required servicing is now based on the switch's actual type and condition, the number of maintenance visits for a large number of oil- and gas-filled switches, and thus the cost, has been reduced.

8.6.3 Technological Opportunities

Considerable progress has already been made by integrating ARM and IWM with OMS and SCADA and then integrating some of the work processes and organisational functions dependent on those systems. However, even more progress will be made once the Mobile Work Management System is deployed. In effect, this will mean that IWM updates will be very close to real-time. This brings IWM data in line with OMS and SCADA data, which is also nearly real time. The maximum age of any asset data should be no more than 24 hours.

This is illustrated by the following observation by a respondent:

> *"They want something that is capable of on-site asset updates so in other words hand held tools that will allow the Network Technician or computers or whatever to update the Asset Register while they are there. So in other words they will say well I am on-site, this is a job ID it's been done now and it's you know whatever and the Asset Register's automatically updated or even it just allows them to fill in the information there based on I don't think bar codes because they are gone now but maybe some chip that can be identified something like that."*
>
> Asset Register Administration Manager

Continued work on improving the asset register will enable EnerDist to continue to meet or exceed its regulatory targets in the future. However, a characteristic of the targets set is that those targets have moved in ever smaller increments with ever more detail put into the regulatory requirements. It is possible that a lot of the easy gains have been made and that efforts to improve the asset register in the future will yield smaller returns as future gains become more difficult to achieve. This may not matter if regulatory incentives are structured appropriately to make those gains continue to be cost effective.

Another possibility is that more significant reconfigurations and transformations in asset servicing, the technological assets involved and the regulated asset base itself will occur to achieve significant gains against regulatory targets. An example of such structural and process changes is the Asset Register Administration Group itself, which severs as an integration point for much of the asset data. In addition, an Asset Management Forum now exists to provide additional coordination of processes that affect the asset base. Ultimately, EnerDist is moving towards an Enterprise Asset Management model.

8.6.4 Analysis

The accumulation of a detailed and comprehensive Asset Register since the implementation of ARM in 2006 forms the major part of the history of *Servicing Existing Assets*. The Asset Register represents a major Path Dependency, simply because of its accumulation over time, its role as a data source and also as a process integration point. The Asset Register in turn has spawned structural changes such as Asset Register Administration, the Asset Management Forum and, in the future, Enterprise Asset Management, The Exploitability of *Servicing Existing Assets* is directly contingent on the Asset Register as data source and data store and also on the process and data links with IWM, OMS and SCADA. All serve to keep asset data as timely as possible. Explitability is indirectly contingent on the resultant adaptations and structural changes that have taken place because of this process integration and data availability. EnerDist as an organisation has worked to adapt itself to processes that are now much more immediate and has introduced new organisational functions to fully exploit the advantages offered by the Asset Register.

Future Technological Opportunities are in part contingent on the rollout of the Mobile Work Management System, which will permit further process and data integration. Exploiting these technological opportunities is likely to take the form of further cost reductions, faster turnaround times and further structural changes to those divisions responsible for any work that affects the Regulated Asset Base.

The next Section 8.7, in summarising this chapter, draw together some of the common themes emergent from discussing the effect of the ES on the Exploitability of Asset Management Dynamic Capabilities.

8.7 Summary

This section analyses and summarises the effect of the ES on Exploitability and Renewability across all five Asset Lifecycle Management Dynamic Capabilities.

Table 8.1 summarises the findings of Research Question 4. Limits to exploitability and Renewability are mainly due to poor process fit, in the case of *Identifying New Assets* and *Building New Assets* and greater workload imposed on certain staff due to the necessity for increased data in some processes so that other processes can function with greater flexibility. Exploitability across all Dynamic Capabilities is discussed in Subsection 8.7.1. Renewability is similarly discussed in Subsection 8.7.2. Enablers of Exploitability and Renewability are discussed in greater detail later in this section, specifically in Subsection 8.7.3 with respect to Table 8.4. Subsection 8.7.3 also concludes this chapter.

Table 8.1: Findings of Research Question 4

Life Cycle Stage	Dynamic Capability	Paths (Past, Present, Future) History	Exploitability, Renewability	Technological Opportunities
Plan, Design	Identifying New Assets	History of network. Regulatory targets for CI and CML.	Limited by poor fit with IWM. Relies on ARM for data	Application of new network technologies. Future upgrade to GIS
All	Coordinating Asset Programmes	Decentralised with no clear priorities. Dramatic changes in economic environment	Resistance to complexity of ARM. Increased adaptability of people. Increased flexibility of system	Enhanced reporting, tighter integration of processes facilitated by IWM, CU, xRPM, BW and ARM
Build	Building New Assets	Previous work on site. Poor work management. Large inventory and working capital	Centralisation and standardisation of some processes. Some constraints on ability to subcontract. Stock management greatly enhanced	Move towards JIT Supply Chain. Mobile Work Management System will eliminate paper
Maintain, End Of Life	Determining Asset Policies	Prior pricing round. Stringent policies. Poor documentation	Greater flexibility. Much more detail on asset base. Better negotiating position with CER	Cheaper policies can be constructed. Increase in visibility of asset base. Condition based maintenance
	Servicing Existing Assets	Poor data, opportunistic asset maintenance, high costs	More asset detail, integration of site work processes with maintenance planning	Enhanced ability to replan to meet changing financial needs

*For **Renewability**, Integration processes are driven across all Dynamic Capabilities (except* Identifying New Assets *) by IWM, ARM, BW and xRPM. Learning, Reconfiguration, Transformation processes are driven across all Dynamic Capabilities by observing and acting on more extensive and more detailed data seen from ARM and, to a lesser extent, from IWM, xRPM, BW.*

8.7.1 Exploitability

As shown in Table 8.2, the Asset Register (ARM) acts as a data *source* for all Dynamic Capabilities; in all cases ARM enhances the Exploitability of those Dynamic Capabilities by increasing the availability of detailed and extensive data on the Regulated Asset Base of EnerDist. It also acts as a data *sink* for *Building New Assets* and *Servicing Existing Assets*, by virtue of the fact that asset data are automatically updated in ARM once the relevant IWM work orders are complete.

In the case of these two Dynamic Capabilities, this data update does not increase their Exploitability; however, it does contribute to the Exploitability of the other three Dynamic Capabilities.

The effect of IWM on Exploitability is somewhat different: It acts as both data *source* (what is the progress on existing Work Orders?) and data *sink* (creation of new Work Orders, completion of Work Orders) for three Asset Management Dynamic Capabilities: *Coordinating Asset Programmes*, *Building New Assets* and *Servicing Existing Assets.* In all three cases IWM imposes a specific workflow from the time a project completes the design phase and a work order is created to completion of construction. As well as the actual site work to be done, IWM also affects materials ordering. Through the Compatible Unit, IWM also influences the financial aspects of asset construction and servicing, along with imitation of the appropriate maintenance policies.

IWM was introduced by EnerDist just before the researcher commenced data gathering. It was evident during the data gathering phase that imposition of IWM's workflow was keenly felt by some of the actors involved in that workflow. Nevertheless IWM has driven a change in stock management processes and an introduction of near just-in-time inventory management principles. IWM has a direct effect on Exploitability as usage of IWM guarantees that ARM data is as timely as it can be. Work Orders are updated shortly after work on site is completed. The Asset Register is directly updated by ARM as soon as the Work Order is complete. Thus IWM informs some processes while driving others.

Table 8.2: Effect of ES modules on Exploitability of Dynamic Capabilities

Dynamic Capability	ARM	IWM	xRPM	IS-U	BW	CU	MMIS	GIS	OMS	SCADA	MSWord	LFAT	CBAT
Identifying New Assets	Source							Both	Source	Source	Sink	Source	Source
Coordinating Asset Programmes	Source	Both	Source			Source							
Building New Assets	Sink	Both		Source									
Determining Asset Policies	Source												
Servicing Existing Assets	Sink	Both											

This table focuses on the effect of the ES on the Exploitability of Asset Management Dynamic capabilities, with respect to their Business Processes.

Source *indicates that the module concerned enhances the Exploitability of the capability by providing necessary data.* ***Sink*** *indicates that the module enhances Exploitability by facilitating data entry.* ***Both*** *indicates that module facilitates two way data flow.*

8.7.2 Renewability

Renewability is the degree to which the organisation is positioned to exploit the integration, learning, reconfiguration and transformation processes inherent within a Dynamic Capability. The effect of the ES on Renewability is thus the degree to which the ES facilitates these processes. The intensity of the ES footprint on this processes is shown in Research Question 3.

Here, Table 8.3 illustrates that the renewability of Asset Management Dynamic Capabilities is dependent primarily on IWM and ARM, with some dependence also on xRPM, IS-U and CU. IWM serves as a facilitator of integrating processes by drawing together process outputs from *Coordinating Asset Programmes, Building New Assets* and new subscriber connection processes. ARM serves as an integrator for *Servicing Existing Assets, Identifying New Assets and Determining Asset Policies*.

In addition continuous fine tuning of asset policies, and refinements to that fine tuning process are both informed by ARM and reflected by changes in the data held within ARM.

Finally, data gleaned from ARM concerning service events on specific assets has led to specific process and structure changes within EnerDist's Asset Management organisation. In particular the servicing of certain asset types has been optimised to take into account other activities that effect those assets, thus reducing the amount of site visits required. Additionally, ARM and xRPM have driven the removal of loops in the early stages of the planning processes by the institution of inter-departmental reviews of planned work. This eliminates duplication of effort and also eliminates the possibility of conflicting requirements for site work.

Table 8.3: Effect of ES modules on Renewal of Dynamic Capabilities

Dynamic Capability	ARM	IWM	xRPM	IS-U	BW	CU	MMIS	GIS	OMS	SCADA	MSWord	LFAT	CBAT
Identifying New Assets	Source							Source	Source	Source			
Coordinating Asset Programmes		Both	Both			Both							
Building New Assets		Sink		Source									
Determining Asset Policies	Both												
Servicing Existing Assets	Both	Both											

*This table focuses on the effect of the ES on the Exploitability of Asset Management Dynamic capabilities, with respect to their Integration, Learning, Reconfiguration and Transformation Processes. In this case such Exploitability may be termed **Renewability** as the table thus maps the effect of the ES on those organisational routines that allow those Dynamic Capabilities to remain Core in a changing regulatory environment.*

***Source** indicates that the module concerned enhances the Exploitability of the capability by providing necessary data. **Sink** indicates that the module enhances Exploitability by facilitating data entry. **Both** indicates that module facilitates two way data flow.*

8.7.3 Conclusion

Table 8.4 summarises some of the Exploitation and Renewability mechanisms observed to be at work across all five Dynamic Capabilities. Much of the Exploitability and Renewability of Asset Lifecycle Management Dynamic Capabilities can be attributed to three factors: Embodiment of improved processes, integration of previously loosely couple processes and exposure of detailed data in much greater volume than before.

Table 8.4: Mechanisms by which ES enhance Exploitability and Renewability

Dynamic Capability	Direct Mechanism	Indirect Mechanism
Identifying New Assets	Enhanced data availability (minimal influence)	None observed
Coordinating Asset Programmes	ARM, xRPM and BW as data exposers	Datasets used to integrate processes
Building New Assets	IWM as embodiment of process (limited by paper entry on site), IWM as process integrator	Adaptation as a result of integration.
Determining Asset Policies	ARM, xRPM and BW as data exposers	Policy refinement
Servicing Existing Assets	IWM as process coordinator, ARM as data exposer	Optimisation of asset servicing

This chapter demonstrates the effect of ES on the Exploitability of Asset Management Dynamic Capabilities. The Exploitability of these Dynamic Capabilities is enhanced as the ES facilitates the relevant business processes. However, for a Dynamic Capability to remain Core under changing regulatory or market conditions, it must be renewable. In other words, the Dynamic Capability must possess learning, integration, transformation and reconfiguration routines that permit the organisation to rearrange assets to meet the changed conditions.

The effect of ES on Renewability, therefore, is a key influencer on keeping Dynamic Capabilities dynamic and a key preventer of Core Capabilities transforming into Core Rigidities through increasing irrelevance. This chapter demonstrates that two mechanisms are manifested in ES enhancing Renewability.

First, ES modules make process and asset data available that permit the relevant actors to modify those processes to achieve greater performance within the criteria laid down by the regulator. In essence, these renewal mechanisms provide new opportunities to increase rents. Second, the ES serves as an integrator for previously disjoint processes. This integration process has a transformative effect in that it provides a coherent view of the asset lifecycle from design to end of life.

Specifically, through the planning, design and build phases, IWM and the Compatible Unit provide a unified yet multidimensional view of the assets and materials concerned that permits more precise project budgeting. This in turn allows EnerDist to ensure that regulatory demands are or exceeded, in effect allowing the organisation to generate rents by reducing costs and targeting expenditure. A major cost reducer is the resultant transformation of inventory control, reducing working capital and moving to something much closer to a Just In Time model.

Chapter 9

Dynamic Capabilities Theory as a Lens for examining the Role of Enterprise Systems

9.1 Introduction

This chapter draws on earlier chapters to discuss the findings of the study, to reflect on the contributions of this study to theory and practice and to present the conclusions of the study. It concludes the study by reflecting on the findings of Research Questions 1 through 4 and drawing some overall conclusions from those findings. In particular the chapter assesses whether the research objective has been met.

In addition this chapter assesses the suitability of Dynamic Capabilities Theory (DCT) - a theory that has suffered from some criticisms of its empirical usefulness (Newbert, 2007) - as a theoretical lens and evaluates any resultant practical applications of that theory, namely the proposed frameworks ESCF and VINER. The chapter generalises from the specific case of EnerDist and ESAMC to comment on an applied DCT framework for use in situations where Enterprise Systems (ES) are present. The chapter also assesses the implications for IS research, Strategic research and finally for IT practitioners.

An initial analysis of the findings of Research Questions 1 to 4 reveals that the Tentative Capabilities posited in Research Question 1 stand up as Dynamic Capabilities through the results revealed in Research Question 2, 3 and 4. Furthermore, the SAP R/3 ES has a distinct and identifiable role in making those capabilities Dynamic.

Further analysis identifies what makes these Dynamic Capabilities Core. As the VINER framework is being applied, the capabilities must be Valuable, Inimitable, Non-substitutable, Exploitable and Renewable. Evidence for all five of these characteristics is presented here, with the proviso that issues of Inimitability and Non-substitutability have not been separated. While no *direct* effect of the ES on Inimitability and Non-substitutability has been observed, some *indirect* effects have been discovered. Crucially, the ES has a direct effect on Exploitability and Renewability.

The chapter states that the Study has demonstrated that five Core Dynamic Capabilities have been identified, with *Identifying New Assets* perhaps exhibiting more of the characteristics of an Operational Capability, per Helfat and Peteraf (2003, p.999). Thus, by the end of Section 9.3, the Chapter has established that the Research Objective has been met.

This Study, however, relies heavily on a theoretical component and the Study is intended also to demonstrate the practicality of deriving an applied version of DCT from the molar theory as expressed in essence by Barney (1997) and Teece and Pisano (1998), and using this theory to inform the findings as stated in Section 9.3. While EnerDist is a singular case with sufficient depth and an interesting history to make it a useful case to study, it is not a *talking pig*, per Siggelkow (2007). Therefore the research is obliged to justify this post-positivist, single case study by generalising the applied DCT from the singular case of ESAMC and EnerDist.

Section 9.4, in discussing implications for theory and practice, addresses this generalisation of ESAMC, titled Enterprise System Capability Framework (ESCF). It is asserted that ESCF, with the assistance of VINER (which is a synthesis of prior frameworks from Mata et al. (1995), Barney (1997), Leonard-Barton (1995) and Teece and Pisano (1998)), is a useful applied theory for examining the role of ES in continuously returning value to an organisation. This generalisation speaks directly to concerns articulated in Chapter 2 concerning ES and Sustainable Competitive Advantage. ESCF and VINER provide useful frameworks to explore the concerns, with the proviso that there are certain limitations concerning differentiating between supplemental and enabling capabilities and inimitability and non-substitutability.

Penultimately, the chapter reflects on both the implications for IS Research and for IT professionals. Because ESCF and VINER trade some precision for practicality, it is possible to propose some guidelines for practitioners. While this is a single case study, the logical replicability of ESCF and VINER implies that these frameworks can be used in other areas of IS research.

The chapter concludes with a few comments on the limitations of the study, the issue of generalisability and suggestions for future research.

9.2 Review of the Research Objective and Research Questions

The Research Objective is **To examine whether and how an ES transforms an organisation's Asset Management Core Dynamic Capabilities.**

The Research Questions are restated below:

Research Question 1: What Asset Management activities are evident in the organisation?

Research Question 2: What Dynamic Capabilities are evident in the Asset Management Lifecycle?

Research Question 3: What is the footprint of the ES on Asset Lifecycle Management Dynamic Capabilities?

Research Question 4: What effect do ES have on Exploitability and Renewability?

Research Question 1, in describing the history of EnerDist, the SAP R/3 ES as implemented by EnerDist and the wider IT landscape within the organisation, reveals five **Tentative** Dynamic Capabilities as emergent from the Asset Management Lifecycle. These are *Identifying New Assets, Coordinating Asset Programmes, Building New Assets, Determining Asset Policies and Servicing Existing Assets.* Research Questions 2, 3 and 4 are structured around these five Tentative Capabilities.

Research Question 2 describes the five Tentative Capabilities introduced in Research Question 1, and frames them as Dynamic Capabilities. Their constituent business processes are described, as are the Integration, Learning, Reconfiguration and Transformation processes that make them Dynamic. Complementary Assets (People) are discussed, usually in terms of the skills, training and experience of the people executing the business processes. Value generating mechanisms are discovered to be penalty reducing mechanisms as well as cost reductions due to increases in efficiency. Finally the qualities that make these Dynamic Capabilities Inimitable and Non-substitutable are discussed; In most cases these are found to be attributable to the accumulation of knowledge of the people involved, or in the build up of organisational structures and routines, in a manner that is costly to imitate, over time.

Research Question 3 describes the footprint of the ES on the five Dynamic Capabilities. The SAP R/3 ARM, IWM and xRPM modules have the most intense footprints on the business processes of the Asset Lifecycle Management Dynamic Capabilities. Of the other SAP modules, BW comes a distant fourth. Of the Information Systems outside SAP, only GIS has a significant footprint. ARM in particular has a large footprint on all identified Asset Lifecycle Dynamic Capabilities. Additionally, the footprint of the ES is observable on the transformative elements of four of the five Dynamic Capabilities, with the exception of *Identifying New Assets*. Thus SAP R/3 influences those processes that make Asset Management Capabilities dynamic: The data made available by the ES allows those capabilities to be reshaped to meet future regulatory demands.

Research Question 4 describes the effect of the ES on Exploitability and Renewability. The Chapter concludes that the Exploitability of these Dynamic Capabilities is enhanced as the ES facilitates the relevant business processes. However for a Dynamic Capability to remain Core under changing regulatory or market conditions, it must be Renewable through its integration, learning, reconfiguration and transformation processes. The effect of ES on Renewability, therefore, is a key influencer on Dynamic Capabilities. The ES makes process and asset data available that permit the relevant actors to modify those processes to achieve greater performance within the criteria laid down by the regulator. In essence, these renewal mechanisms provide new opportunities to increase rents. Also, the ES serves as an integrator for previously disjointed processes.

9.3 Discussion of the Findings

This Section discusses the findings with respect to the ESAMC framework introduced in Chapter 4. The Section starts by presenting the findings organised using the ESAMC framework and moves on to discuss those findings in more detail.

9.3.1 A presentation of the findings using ESAMC

Table 9.1 presents the findings of Research Questions 1-4 as organised using the ESAMC applied DCT framework proposed in Table 4.5 in Chapter 4. Research Question 1 defines the Capabilities under which the findings for Research Questions 2-3 are organised. As RQ1 identifies 5 Tentative Capabilities (later confirmed as Dynamic and Core) in its findings, the findings of RQ1 are evident in the organisation of columns 5-9 under those 5 capabilities.

The findings of RQ2, RQ3 and RQ4 are organised as rows in this table under the relevant ESAMC headings. The sequence of presentation of Value, Inimitability, Non-substitutability, etc., is different from that used in the presentation of the findings in the Research Questions themselves and is instead informed by Mata et al. (1995), Barney (1997) and Teece and Pisano (1998). Thus Table 9.1 shows how Research Questions 1-4 cover the key characteristics of Core Capabilities and Dynamic Capabilities, as well as illustrating the role of ES.

The ESAMC framework is contingent on two concepts: First, a Core Capability must be Valuable, Inimitable, Non-substitutable, Exploitable and Renewable. Second, a Dynamic Capability must consist of organisational routines which permit the orchestration of resources to meet ever changing conditions. The role of the ES can therefore be examined in terms of whether and how it helps to make a capability **Core** and whether and how it helps to make a capability **Dynamic**.

While the concept of Core Capabilities is informed by works such as Mata et al. (1995) and Barney (1997) and the concept of Dynamic Capabilities arises from Teece et al. (1997) and Teece and Pisano (1998), the ESAMC framework permits a synthesis of these two strands to present a unified view of the role of ES in Dynamic Core Capabilities.

Table 9.1: Findings of Research Questions 1, 2, 3 and 4, organised using ESAMC framework

ESAMC Element			<—— Dynamic Capability (Determined from RQ1) ——>				
Component	**Observable**	**RQ**	**Identifying New Assets**	**Coordinating Asset Programmes**	**Building New Assets**	**Determining Asset Policies**	**Servicing Existing Assets**
Business Processes	Production / Service Processes directly related to day to day operations.	2	Solution identification	Programme planning. Work packaging. Asset upgrades	Materials ordering. Job design. Job execution.	Pricing round negotiation. Maintenance policy determination	Annual maintenance planning. Maintenance execution
Integration Processes	Combining of disparate organisational functions directly impacting Regulated Asset Base, tighter coupling of business processes across functions, data sharing.	2	Assimilation and application of new network technologies.	SAP R/3 BW, ARM and CU all serve as integrators of data and thus processes	Imposition of consistency across network. Coupling of stock and work processes	Data integration via ARM. Asset Mgrs and Negotiators work jointly with CER.	Integrated site design reflecting needs of different groups. Maintenance combined with construction.
Learning Processes	Changes to processes as a result of prior events, evidenced by improvements in performance indicators, as documented by regulator	2	Reduction in Customer Interruptions and Customer Minutes Lost	Reduction in outages due to refurbishments and capital programmes	Drop in working capital of €23m	Refinements of policies as more asset data become available. Reduced costs.	Reduction in OPEX associated with asset servicing.
Reconfiguration Processes	Any process change or reorganisation of assets, especially as an adaptation to regulatory or market pressures	2	Introduction of CBAT, changes to exploit new tech.	New: Asset Register Administration, Asset Management Forum, Enterprise Asset Management	Changes to work orders: Additional work performed as new work order.	Move to condition based maintenance.	New Asset Management organisation structures
Transformation Processes	Replacement of older processes, structures, assets and IT artefacts with newer ones.	2	SAP R/3 and its modules and applications as replacement for older legacy systems such as DWMS, Main Saver, MS Access, MS Excel and paper systems. Replacement of regional EnerDist structure with centralised organisational structure.				

Findings of Research Questions 2-3 are presented as table rows and Research Question 1 as columns 5-9 *Continued on next page*

Table 9.1 – *Continued from previous page*

ESAMC Element			<—— Dynamic Capability (Determined from RQ1) ——>				
Component	**Observable**	**RQ**	**Identifying New Assets**	**Coordinating Asset Programmes**	**Building New Assets**	**Determining Asset Policies**	**Servicing Existing Assets**
Technologies (Process Inputs)	ES applications used. Other Information Systems and Information Technology	3	GIS, OMS, SCADA, IS-U, ARM	ARM	IWM, MMIS.	ARM for asset history	ARM for applicable policies and plans
Technologies (Process Facilitators)		3	MS Word, LFAT and CBAT	BW for reporting and coordination	Paper for site work. MMIS for inventory	ARM, MS Excel	ARM for plan revision and refinement
Technologies (Process Outputs)		3	IWM as new work order	IWM as new work orders, xRPM as plans	IWM for work orders, ARM for asset updates	ARM as new asset policies	IWM as new work orders
People	Training undertaken by people executing processes. Their knowledge, skills and experience.	2	Planner, who has acquired skills over 6-18 months.	Programme Manager, Asset Manager, Asset Register Admin	Construction Supervisor, Engineering Officer, Network Technician	Regulatory Staff, Asset Manager, Asset Register Admin	Asset Manager, Asset Register Admin
Path Dependencies	History of organisation, processes, people and technologies to this point.	4	History of network. Regulatory targets for CI and CML.	Decentralised with no clear priorities. Dramatic changes in economic environment	Previous work on site. Poor work management. Large inventory	Prior pricing round. Stringent policies. Poor documentation	Poor data, opportunistic asset maintenance, high costs
Future Opportunities	New technologies, both for network and also IT. Process, organisational change. Expanded range of future choices.	4	Application of new network technologies. Upgrades to GIS	Enhanced reporting, tighter integration of processes facilitated by SAP R/3	Move towards JIT Supply Chain. Mobile Work Management System will eliminate paper	Cheaper policies can be constructed. Increase in visibility of asset base. Condition based maintenance	Enhanced ability to replan to meet changing financial needs

Findings of Research Questions 2-3 are presented as table rows and Research Question 1 as columns 5-9 *Continued on next page*

Table 9.1 – *Continued from previous page*

ESAMC Element			<—— Dynamic Capability (Determined from RQ1) ——>				
Component	**Observable**	**RQ**	**Identifying New Assets**	**Coordinating Asset Programmes**	**Building New Assets**	**Determining Asset Policies**	**Servicing Existing Assets**
Value	Reductions in CAPEX, OPEX and penalties. Increases in safety and reliability of network. DSO meets or exceed regulatory targets. ES also drives reconfigurations.	2	Reduction in penalties from regulator.	Outage penalty reduction, increase in value of regulated asset base	Optimised stock ordering, reductions in inventory and working capital	Reduction in maintenance cost and optimisation of asset lifetime.	Reduction in maintenance cost
Inimitability Non-substitutability.	Contingent on history of DSO and staff, also on level of customisation of ES or else on specific adaptations by organisation to ES. Highly specialised capabilities will have no direct substitutes.	2	Embodied in knowledge and training of planner	Embodied in organisational structures that have built up over time	Initially embodied in knowledge of staff. However site work can be subcontracted. Locus moving to supply chain experience.	Embodied in organisational structures that have built up over time	Buildup of ARA organisational structure over time is barrier to entry. Also difficult to imitate due to social complexity.
Exploitability	Organisation reengineers its processes to reconfigure its positions and to exploit new opportunities. ES may hinder, support or drive this	4	Limited by poor fit with IWM. Relies on ARM for data	Resistance to complexity of ARM. Increased adaptability of people. Increased flexibility of system	Standardisation. Some constraints on subcontracting. Stock management enhanced	Greater flexibility. Much more detail on asset base. Better negotiating position with CER	More asset detail, integration of site work processes with maintenance planning
Renewability	A process of continuous reengineering, facilitated or inhibited by ES.	4	Integration processes driven directly by IWM, ARM, BW and xRPM. Learning, Reconfiguration, Transformation processes driven by observing and acting on more extensive and more detailed data seen from ARM and, to a lesser extent, from IWM, xRPM, BW.				

This table summarises the findings of RQ1, RQ2, RQ3 and RQ4 and is organised according to the ESAMC applied DCT framework proposed in Table 4.5 in Chapter 4. As RQ1 identifies 5 tentative capabilities, later confirmed as dynamic and core, the findings of RQ1 are evident in the organisation of columns 5-9 under those 5 capabilities. The findings of RQ2, RQ3 and RQ4 are organised as rows in this table under the relevant ESAMC headings.

This unified view can be established by considering the direct and indirect contributions of ES to Value, Inimitability, Non-substitutability, Exploitability and Renewability. In particular Exploitability and Renewability may be discussed with reference to those characteristics which make Capabilities Dynamic.

The five key characteristics of Capabilities that are both Core and Dynamic are discussed in Subsections 9.3.2 through 9.3.5 under the headings of Value, Inimitability and Non-substitutability, Exploitability and Renewability. These discussions are informed by extracting the findings from Table 9.1 under the relevant row heading. Relevant Dynamic Capabilities are extracted from the applicable columns of Table 9.1 under that row heading. In the case of Renewability in Subsection 9.3.5, reference is also made to the rows of Table 9.1 which refer to reconfiguration and transformation.

9.3.2 Value

Table 9.1, under the row heading *Value*, notes value generating mechanisms as follows:

- Reduction in inventory and thus costly working capital;
- Reduction in penalties and thus costs;
- Reduction of operational expenditure and costs;
- Maximisation of asset value and return on assets.

The first three items amount to cost reductions while the fourth may be argued as a maximisation of value. However no value is directly created within Asset Lifecycle Management by selling more of an existing product or devising new products to sell. In this case **ES directly contribute to value generation only by reducing costs.**

The role of ES in enhancing Value is summarised in Table 9.2.

Table 9.2: ES as an Enhancer of Value in Dynamic Capabilities

Dynamic Capability	Value Enhancer	Mode
Determining Asset Policies	Exposes asset data and history for Pricing Round Negotiation and Maintenance Policy Determination processes	Indirect

Continued on next page

Table 9.2 – *Continued from previous page*

Dynamic Capability	Value Enhancer	Mode
Servicing Existing Assets, Building New Assets	Integrates stock control and site work processes	Direct

The direct impact of ES on business processes is effected by more tightly integrating business processes across different organisational
functions and streamlining certain functions, in the Dynamic Capabilities *Determining Asset Policies*, *Servicing Existing Assets* and *Building New Assets*. This streamlining is constrained in some cases because not all the relevant workflows are fully automated, for example the management of site work using paper work orders. This limitation affects *Servicing Existing Assets* and *Building New Assets* in particular as both Dynamic Capabilities contain work processes directly related to site work.

Identifying New Assets demonstrates measurable effects on value, but does not rely on ES to achieve this (for this reason it is not listed in Table 9.2). Nevertheless this Dynamic Capability affects the asset base on which other capabilities depend. *Identifying New Assets* has applied new network distribution and switching technologies to reduce the recovery time from a network outage. In particular, the processes and tools that form part of this capability have been modified to accommodate automatic switchgear which can return the network to an operational state without on-site intervention. This has resulted in a reduction in Customer Minutes Lost, with a consequent reduction in regulator penalties and thus generation of value for EnerDist. Of the dynamic capabilities discussed in this section, this one is unique in that information systems other than SAP R/3 enhance value. In this case those systems are Microsoft Word, the Stoner Synergy modelling tool and the Cost Benefit Analysis tool.

The Asset Register plays a key role in enhancing value for *Determining Asset Policies* and *Servicing Assets*. In the case of *Determining Asset Policies*, the Asset Register provides a detailed and comprehensive history of all the network assets to date, including the vast majority of assets that were commissioned prior to the implementation of SAP R/3. The Asset Register influences two significant processes in *Determining Asset Policies*: Pricing Round Negotiation and Maintenance Policy Determination.

As Pricing Round Negotiation depends on a detailed knowledge of EnerDist's regulated asset base, the Asset Register provides all the necessary data for these negotiations to be conducted effectively. In particular a detailed knowledge of the asset base has allowed EnerDist to successfully make the case for altering asset lifetimes, for agreeing maintenance intervals and for deciding which asset maintenance programmes must be carried out over the next pricing round. Not to have this detailed information to hand would place EnerDist at a distinct, and costly, disadvantage.

Since Maintenance Policies dictate how frequently an asset is to be serviced and thus how costly its maintenance will be, the history of the asset is crucial in determining the best and most cost-effective policy for maintenance. The introduction of the Asset Register meant that condition-based policies, which are inherently cheaper, could be introduced.

The value enhancement mechanism for *Servicing Existing Assets* is more direct: The introduction of ARM has permitted a process change to condition-based asset maintenance which has reduced the cost of maintaining certain assets. ARM has allowed approaches to maintenance which did not exist before. Condition-based maintenance is inherently cheaper as unnecessary site visits to inspect assets are eliminated and reporting from the OMS and SCADA systems is relied on in part to verify the current state of the asset. While ARM facilitated the concept of condition-based maintenance by introducing new processes, it also optimises the execution of these processes by providing a repository for all the operational data concerning every asset. Thus the maintenance requirements of certain assets can be met in the course of other site activity, even resolving outage problems.

This is illustrated by the example of oil- and gas-filled circuit breakers. Prior to the implementation of ARM, no means existed to distinguish these two breaker types without actually making site visits. After the implementation of ARM, significant efforts were made to correctly identify and record all breaker types. Once this was completed, it became possible to devise maintenance strategies tailored to each breaker type. In addition it is now possible to determine how many times each breaker has been opened and closed in the course of non-maintenance and outage resolution work. Consequently maintenance is only performed on those oil- and gas-filled breakers that have not me the required minimum of open/close cycles for any given year.

For *Building New Assets*, the main area of value generation lies not in the construction of the assets but in optimisation of the processes required to process stock prior to construction. Prior to the introduction of Integrated Work Management (IWM), a characteristic of the stock ordering process was the tendency to order all required stock at the same time, considerably in advance of the date for the required site work. As a result, stock would accumulate in EnerDist's depots around the country and working capital would be unnecessarily be tied up. After the introduction of IWM, stock ordering became automated and each item is ordered individually according to its lead time. Therefore, items with the longest lead times are ordered first. This has resulted in a significant reduction in the overall amount of stock held, and thus a reduction in working capital. Costs are reduced (and value increased) as that working capital no longer has to be maintained.

9.3.3 Inimitability and Non-substitutability

Under the row headings *Inimitability, Non-substitutability*, Table 9.1 illustrates that these aspects of EnerDist's Core Capabilities are grounded in the training, skill and experience of its staff, as well as in the organisational structures that have built up over time. These Core Capabilities are either hard to apprehend or too expensive to copy. ES are regarded in some quarters as commodity mechanisms that eliminate the distinctiveness that makes Capabilities Inimitable and Non-substitutable (for example Carr (2004)). The reality is more complex, as shown in this subsection.

The role of ES in enhancing Inimitability and Non-substitutability is summarised in Table 9.3

Table 9.3: ES as an Enhancer of Inimitability and Non-substitutability in Dynamic Capabilities

Dynamic Capability	Inimitability / Non-substitutability Enhancer	Mode
Servicing Existing Assets	Data from ES used to change organisational structures to optimise existing processes	Indirect
Dynamic Capability	**Inimitability / Non-substitutability Inhibitor**	**Mode**
All	Propagation of customisations into ES base code	Direct
Building New Assets, Servicing Existing Assets	Facilitation of subcontracting through standardised site work processes	Indirect

From Table 9.3, it can be seen that, while ES indirectly enhance Inimitability and Non-substitutability, they also directly and indirectly inhibit some qualities that make Core Capabilities hard to copy. Both the Enhancers and Inhibitors are discussed below.

9.3.3.1 Trading away Inimitability and Non-substitutability

The traditional argument against ES and distinctiveness is that an ES represents a set of prepackaged business processes which correspond to best practices as perceived by the vendor. While customisation of the ES is possible, it is frequently expensive both at the time of implementation and following every software upgrade as the customisations have to be reapplied separately.

In the case of EnerDist, some customisations were implemented, but the cost of these was partially defrayed by moving the changes back into SAP base code, in cooperation with the vendor. Therefore any customisations made by EnerDist were and are available to other customers of SAP.

While the inimitability and non-substitutability of *Identifying New Assets* and *Building New Assets* is contingent on the considerable training and experience of Planners, Network Technicians, Engineering Officers and Supervisors, to some degree some of the work associated with *Building New Assets* can be, and has been, subcontracted. The distinctiveness associated with site work has at least, in part, been traded away. In fact this happened prior to the relevant module of SAP R/3 - IWM - being implemented, when the Irish Celtic Tiger property boom drove an unprecedented number of new subscriber connections. Indirectly, at least, the ES erodes inimitability and non-substitutability. Where, then, does SAP's contribution to inimitability and non substitutability lie, in the case of EnerDist?

9.3.3.2 The accumulation of Inimitability and Non-substitutability through the evolution of organisational structures

The implementation of SAP, in particular the Asset Register, has revealed previously unavailable detail about EnerDist's processes. The advent of IWM serves to feed ARM with even more detail. The combination of this revealed detail and the imperatives imposed by the regulator have led EnerDist to optimise its Asset Management structures and processes.

Asset Register Administration (ARA) is a group within EnerDist which has grown around the need to maintain an Asset Register that is at all times up-to-date. The Asset Register is updated each time a new asset on the network becomes live; it is updated with information from OMS and SCADA about the current operational state of the network; IWM provides updates when site work has been completed. In turn Asset Register Administration feeds aggregate and volume asset data to the Asset Managers to facilitate annual maintenance plans and also the formulation of asset maintenance policies in negotiation with the Regulator. It also feeds similar data to Programme Managers when large scale asset replacement or upgrade programmes are being designed, again with agreement with the regulator.

ARA has grown over time and is a reflection of the specific needs of EnerDist in meeting its obligations as a semi-state organisation. ARA is the heart of EnerDist as an asset management company and facilitates capabilities at all stages of the asset management lifecycle. As such it is both difficult to imitate or substitute, not without an enormous investment in time and cost. This growth is facilitated by the SAP R/3 Asset Register, which superseded inadequate and disjointed systems based on Microsoft Access and Microsoft Excel. A single coherent Asset Register itself provides the means by which ARA can achieve its goals. In this case an ES contributes to Inimitability and Non-substitutability by facilitating the growth of a group unique to EnerDist.

However ARA is not the only example of a group to grow out of the implementation of an ES implementation. While it might be argued that ARA's growth was as a result of a regulatory and business change imperative, the next example clearly illustrates the organisational change that can directly result from data obtained from an ES itself.

The Asset Management Forum was created out of the need to coordinate onsite work across several projects and work orders, some capital works and others as a result of operational issues. Prior to the establishment of the Forum, several different projects could be vying for access to the same network distribution site, sometimes with conflicting design requirements. This resulted in process loops where multiple and time-consuming stages of review were required to resolve any design conflicts. The advent of ARM, IWM, xRPM and BW made all these conflicts very visible to the organisation. Thus the Asset Management Forum was established so that all the projects that were reported by SAP R/3 as being in possible conflict could be resolved in a single meeting without incurring further process loops.

Again, The Asset Management Forum is a product of history in EnerDist and also would prove hard to imitate quickly. The role of history and the amount of time taken to put the Forum in place serve as barriers to imitation. Thus the Asset Management Forum is both inimitable and non-substitutable. As the Forum was created as a direct response to project conflicts made visible by SAP R/3, this is a clear case of an ES having an indirect but certain effect on Inimitability ands Non-substitutability.

9.3.4 Exploitability

Under the row heading *Exploitability*, Table 9.1 illustrates some of the advantages that implementing both ARM and IWM have brought. IWM in particular has permitted better stock management processes, as well as integrating and standardising other processes. The influence of ARM is more widespread, however: Increased flexibility and detail are observed, across three Dynamic Capabilities, with the proviso that the added complexity in providing this detail has been met with a little resistance by some ARM and IWM users. Nevertheless the overall effect is positive, as EnerDist has an ability to replan large and complex maintenance schedules that it hitherto did not have.

The role of ES in enhancing or inhibiting Exploitability is summarised in Table 9.4

Table 9.4: ES as an Enhancer / Inhibitor of Exploitability in Dynamic Capabilities

Dynamic Capability	Exploitability Enhancer	Mode
Servicing Existing Assets	ES enables mid-year replanning of maintenance programmes	Direct
Determining Asset Policies, Servicing Existing Assets	Consistency imposed by ES enables fine-tuned application of maintenance policies and thus maximises opportunities to respond to regulatory pressures	Direct
Dynamic Capability	**Exploitability Inhibitor**	**Mode**
Identifying New Assets	Processes use systems not integrated with ES; data must be copied by hand	Direct
Building New Assets	All work orders still handled using paper; data must be copied to and from ES by hand	Direct

While Table 9.4 illustrates that ES directly enhance Exploitability, Inhibitors are also evident. In this case both Inhibitors exhibit the characteristic of an incompletely integrated system, where hand copying of data or paper forms are required to bridge the gap. Both Enhancers and Inhibitors are discussed below.

9.3.4.1 Inhibitors of Exploitability

The ES has a direct effect on Exploitability because EnerDist's ability to make effective use of the relevant dynamic capabilities is dependent on how well SAP R/3 facilitates or impedes the organisation's application of those capabilities. In two cases the ES's influence is slightly inhibitory: In the case of *Identifying New Assets*, the ES plays no part until the completed plans are coded as work orders into SAP R/3 IWM. This is a manual operation and possibly prone to error. While the solution selection process naturally occurs outside the ES, it would make more sense to automatically transfer the output of this process to IWM.

A more serious limitation on the Exploitability of *Building New Assets* is that all field and site work is still managed through paper work orders. The footprint of IWM extends no further than the Construction Supervisor's office, where work orders are printed as paper forms and taken to site. On-site, the Network Technician carries out the work mandated by the work order and then marks that work as complete on the paper form. Additional comments are noted by the Network Technician, also on the form. On return to the depot the form must be handed to the Construction Supervisor; the data on the form must then be hand-entered into IWM. As current asset status in ARM is partially dependent on these data in IWM, any delay in getting the forms keyed in will impair EnerDist's ability to maintain a complete current picture of its assets.

However EnerDist recognises the constraints imposed by the current system: At the time of writing, the DSO had proposed and secured funding approvals from the regulator for the development and deployment of a handheld device to carry electronic work orders to site. This will permit realtime updating of IWM and consequently the Asset Register, ARM. In the meantime, unsatisfactory sticking-plaster solutions such as preprinted removable tags on assets such as substation transformers are still in use.

9.3.4.2 Increases in Flexibility

While the previous subsection presents a negative view of the effect of SAP R/3 on the exploitability of EnerCo Network's dynamic capabilities, it is by no means the full story. The following two examples illustrate how both the constraints and flexibilities furnished by an ES can enhance the exploitability of core capabilities:

Increases in Flexibility, and therefore Exploitability are evidence by EnerCo Network's new-found ability to replan asset maintenance programmes in the middle of the financial year. Prior to the introduction of ARM, this was impossible as annual planning was effected using Microsoft Access and numerous Excel spreadsheets. This system was cumbersome and any changes were in practice very difficult and costly to make. The transition to ARM meant that a proper asset management infrastructure was made available and alterations to existing plans required far less work. Replans are sometimes necessary to rebalance operational expenditure during the year and so this increase in flexibility is essential. In essence ARM as part of the ES is a far better fit to asset management activities and processes than the older disjointed system. By being much more congruent and flexible, ARM enhances the Exploitability of the *Servicing Asset* dynamic capability.

9.3.4.3 Imposition of Consistency

The history of EnerDist and the application of network equipment maintenance processes has been characterised by significant inconsistencies across Ireland. An example is variation in frequency and intensity of hazard patrols between Donegal, Dublin and Cork. These variations can be attributed to lack of an integrated information systems, a relatively dispersed and autonomous management structure and geographical distances that were more significant before the recent development of the national motorway network. Consequently comparisons were rarely made between the standards applied in different parts of the country and, when differences were noted, few attempts were made to impose a standard.

However, EnerDist staff repeatedly asseverated that consistency was and is essential in the new Asset Management infrastructure and that variations in work practices could not be tolerated. The need for consistency and control is governed by the requirement to respond optimally to the constraints imposed by the regulator on network performance, reliability, safety and capital and operational expenditure. This has become increasingly important as the regulator has become more and more specific in its demands in successive pricing rounds and performance improvements have been specified in fractions of a percentage point.

Therefore the imposition of consistency and control in some areas enhances EnerDist's ability to respond to regulatory pressures. As consistency can be guaranteed, operational and capital costs can be very tightly controlled and surprises late in the financial year are unlikely. This increases EnerDist's ability to exploit its *Determining Asset Policies* Dynamic Capability as consistency of policy application is guaranteed. In addition, the ability to exploit its *Servicing Existing Assets* capability is enhanced as annual maintenance plans can be devised and modified consistently. Ultimately, the constraints imposed by the SAP R/3 Asset Register (ARM) permit the imposition of control in order to better meet regulatory requirements.

9.3.5 Renewability

The row heading *Renewability* reveals the influence of the ES on integration, learning, reconfiguration and transformation processes. These processes specifically relate to what keeps a Capability Dynamic. The influence of the ES is significant, mainly be exposing data that actors within EnerDist need to determine what structural changes are needed to adapt to increasing regulatory pressure.

The role of ES in enhancing Renewability is summarised in Table 9.5. Two modes of Renewability are observed in this Table: The first is where the ES facilitates optimisation of business processes inherent in a Dynamic Capability; the second is where a transformation from one Dynamic Capability to another is observed. These are discussed below.

Table 9.5: ES as an Enhancer of Renewability in Dynamic Capabilities

Dynamic Capability	Renewability Enhancer	Mode
Servicing Existing Assets, Coordinating Asset Programmes, Determining Asset Policies	Integration of processes across organisational boundaries increases efficiency of processes and data integration a gross and within processes eliminates loops from design, planning and construction processes.	Direct
	Reconfiguration and transformation of organisational structures driven by increase in amount and quality of data exposed by Asset Register.	Indirect

Continued on next page

Table 9.5 – *Continued from previous page*

Dynamic Capability	Renewability Enhancer	Mode
	Learning processes evident through increases in performance against regulatory requirements	Direct
Building New Assets	ES drives shift in emphasis from asset construction to optimal stock ordering and astute inventory management. *Building New Assets* will transform into new Capability, *Optimise Stock Levels* in time	Direct

9.3.5.1 ES as Renewability drivers

In the case of EnerDist, SAP R/3 serves as a driver of Renewability by facilitating the integration processes of some dynamic capabilities drawing some business process outputs in direct contact with the inputs of other business processes. In particular The Asset Register has also served to drive the removal of loops in the planning processes by facilitating integrated reviews of projects across departments. This is most visible with the Asset Register which provides a single viewpoint of every asset in EnerDist's Regulated Asset Base. In addition, reconfiguration, transformation and learning processes are facilitated by making data on current asset state available and, as the organisation processes these data on asset changes and adapts its organisational routines and structures to match (a process described by Shanks and Bekmamedova (2012)[p.165] as *asset orchestration*), reflecting any changes to processes (especially maintenance procedures) in its databases. A case in point is modification of the Asset Register to reflect optimisations in service routines and annual planning processes.

Thus the ES facilitates renewability by integrating processes making the data available to drive changes and improvements and then reflecting those changes in the data. Renewability is essential if a Dynamic Capability is to remain Dynamic and if a Core Capability is not to become a Core Rigidity.

9.3.5.2 More accurate and extensive asset data

The SAP ARM and IWM systems now allow asset data to be aggregated and analysed in a holistic manner not previously possible. In fact the richer data exposed by the system and the Asset Register (ARM) in particular, drives two improvements. The first is maintenance policies and schedules more precisely targeted to asset types no previously distinguishable. The second is allowing maintenance schedules to take into account the servicing of assets carried out as part of non-maintenance construction or renewal work. Both of these allow for more astute planning of field work, thus saving costs. The SAP ARM and IWM systems permit correlation of Asset data from different sources; the emergence of this holistic viewpoint has led to the emergence of the concept of Enterprise Asset Management and the establishment of higher-level planning structures in the organisation which permits a more cohesive approach to network expansion and maintenance.

9.3.5.3 The Compatible Unit

One of the key tenets of the ES is the idea of a single unified view of all of an organisations assets and processes. The SAP Compatible Unit (or CU) concept turns this view on its head. A SAP CU is a highly integrated view of a network asset, but one which contains considerable richness and depth on not only the physical characteristics of that asset, but also its capital costs, its maintenance cost, its maintenance requirements and also how it is to be depreciated. While the CU is constant, different parts of the organisation can view it from different angles, so to speak, to obtain an asset maintenance view, a financial view, a risk based view and so on.

9.3.5.4 ES as a moderator of capability transition

Apart from the introduction of new paper forms and a rather cumbersome manual interface of these worksheets to IWM, the work of the Network Technician has a been minimally affected by the introduction of SAP R/3. In fact, from the Network Technician's point of view, the impact may be viewed as negative. Constraints have been imposed on work practices in the name of consistency, and the Network Technician is now required to return data not necessarily essential to the completion of the job at hand.

While the inimitability and non-substitutability of *Building New Assets* is contingent on the considerable training and experience of the Network Technician, Engineering Officers and Supervisors, to some degree some of this work can be, and has been, subcontracted. Therefore if any value is to be extracted from construction work as par of Building New Assets, such value generating activity is unlikely to be remain distinctively ahead of any benchmarks for an extended period of time.

However, the introduction of Integrated Work Management (IWM) and the Compatible Unit (CU) - a multidimensional entity that incorporates not just a physical asset but its financial aspects, manpower requirements and order lead times - has led to significant process and structural changes elsewhere in *Building New Assets*. Stock ordering prior to IWM was focused on building up sufficient stock so that no site work ever ran short of materials. As the lead times on some stock are very long, stockpiling of expensive pieces of network switching and distribution equipment over long periods of time was not uncommon. Regulatory pressures on OPEX and CAPEX meant that tying up such large amounts of working capital was no longer sustainable.

The effect of IWM and CU on the stock situation was seismic. Raising a Work Order in IWM also raises dependent CU orders, which in turn initiate an automated ordering process where requisitions for stock are raised only when they are required. The stock ordering process is associated with the lead times specified in each CU. In practice this means that a project six months in the future and with stock lead times of one month and three months will have stock ordered for it five months and three months into the future. In effect, this implements Just-In-Time stock ordering, where the required materials for a given piece of site work arriving at the relevant depot very shortly before the work is due to commence.

With the skill and experience of Network Technicians becoming partially substitutable by contractors, the locus of value generation moves further towards the start of the processes associated with Building New Assets and becomes focused on the need to intelligently manage the stock ordering processes. Some finesse is required to manage IWM's stock ordering processes: Once an IWM work order has been committed to the system with a start date, stock ordering will commence automatically. Consequently work order dates have to be carefully planned otherwise stock will arrive sooner than required.

Building New Assets, therefore, is a dynamic capability in transition. It will eventually be replaced by a new dynamic capability called, *Optimise Stock Levels*. This is perhaps not surprising as regulatory pressures have placed much tighter constraints on capital and operational expenditure and the need to standardise work practices has led to some commoditisation of the site work performed by Network Technicians.

The next Subsection 9.3.6 synthesises the discussion in Subsections 9.3.2 to 9.3.5 to arrive at some conclusions concerning how ES influence Core Capabilities.

9.3.6 The mechanisms by which ES influence Core Capabilities

The previous subsections established that ES directly enhance Value, Exploitability and Renewability and indirectly enhance Inimitability and Non-substitutability. In addition there are direct and indirect inhibitory effects on Inimitability, Non-substitutability and Exploitability. These Inhibitory effects are detailed in Table 9.6.

The Inhibitory effect on Exploitability is due to what may be regarded as an incompletely integrated implementation of IWM, where site work orders are still dealt with on paper. This inhibitory effect is expected to be removed once field trials and implementation of mobile handheld devices for processing work orders on site are complete.

The Inhibitory effect of ES on Inimitability and Non-substitutability takes two forms. First, customisations to some of the SAP R/3 modules (particularly in relation to ARM and the Compatible Unit) were incorporated into the SAP R/3 base code. Thus those customisations can be appropriated by EnerCo Network's competitors. However the modifications were necessary for the Enterprise system to be useful and the cost of maintaining such customisations independently must be weighed against the opportunity cost of the distinctive nature of the software being imitable. As EnerDist's implementation of SAP R/3 may be regarded as an Information System, distinctiveness is contingent on the processes and people involved as well as the technology.

Second, the introduction of the SAP R/3 system facilitates subcontracting site work (though this encountered inflexibilities in the system). However, it has already been highlighted in Subsection 9.3.5 that *Building New Assets* is a Dynamic Capability that is likely to be superseded by *Optimise Stock Levels*. Thus concerns about erosion of the distinctiveness of *Building New Assets* are likely to become moot over time as the core value-generating activities move from site work towards stock control.

Table 9.6: The Inhibiting effect of ES on Dynamic Capabilities

Dynamic Capability	Attribute	Inhibitor
All	Inimitability / Non-substitutability	Propagation of customisations into ES base code
Identifying New Assets	Exploitability	Processes use systems not integrated with ES; data must be copied by hand
Building New Assets	Exploitability	All work orders still handled using paper; data must be copied to and from ES by hand
Building New Assets, Servicing Existing Assets	Inimitability / Non-substitutability	Facilitation of subcontracting through standardised site work processes

Table 9.7 summarises the direct effects of ES on Dynamic Capabilities. From this Table it can be seen that the ES directly enhances Value, Exploitability and Renewability. Thus an ES not only directly affects what makes Core Capabilities valuable, it also directly affects what makes them Dynamic. It is also noted that all the direct effects are centred around process changes as well as the integration of existing processes and the application of learning processes to increase performance in response to regulatory inputs.

Table 9.7: The Direct influence of ES on Dynamic Capabilities

Dynamic Capability	Attribute	Enhancer
Servicing Existing Assets, Building New Assets	Value	Integrates stock control and site work processes
Servicing Existing Assets	Exploitability	ES enables mid-year replanning of maintenance programmes
Determining Asset Policies, Servicing Existing Assets	Exploitability	Consistency imposed by ES enables fine-tuned application of maintenance policies and thus maximises opportunities to respond to regulatory pressures
Servicing Existing Assets, Coordinating Asset Programmes, Determining Asset Policies	Renewability	Integration of processes across organisational boundaries increases efficiency of processes and data integration across and within processes eliminates loops from design, planning and construction processes
	Renewability	Learning processes evident through increases in performance against regulatory requirements

Table 9.8 summarises the indirect effects of ES on Dynamic Capabilities. These are effects where, while a process change may not be directly imposed by the ES, process and other changes may have arisen due to the data revealed by the ES when in use.

Value is indirectly enhanced as asset data, previously difficult to access, is now made available to facilitate negotiation of pricing rounds with the regulator. These data are essential and are more useful if the greatest possible granularity can be achieved.

Renewability is also enhanced as the same asset data can be used to identify weaknesses in both existing processes and the related organisational structures. In the case of this study there has been at least one organisational transformation, organised around asset data that highlighted inefficiencies in planning, design and construction processes.

Finally, there is also an indirect effect on Inimitability and Nonsubstitutability, While no direct effect on these attributes was observed, the data revealed by the ES drives organisational changes over time, which are not easy or cheap to replicate.

Table 9.8: The Indirect influence of ES on Dynamic Capabilities

Dynamic Capability	Attribute	Enhancer
Servicing Existing Assets, Coordinating Asset Programmes, Determining Asset Policies	Renewability	Reconfiguration and transformation of organisational structures driven by increase in amount and quality of data exposed by Asset Register
Determining Asset Policies	Value	Exposes asset data and history for Pricing Round Negotiation and Maintenance Policy Determination processes
Servicing Existing Assets	Inimitability / Nonsubstitutability	Data from ES used to change organisational structures to optimise existing processes

9.3.7 Discussion

Two mechanisms by which ES enhance Core Dynamic Capabilities are revealed from the findings: The first is *reshaping processes*, as evidenced in Table 9.7 and the second is *revealing data*, as articulated in Table 9.8. These are discussed below.

Reshaping processes is the mechanism by which the ES imposes changes on existing business processes, integrates formerly disjointed processes or introduces new processes. The literature on Business Process Reengineering is extensive and it is normal during an ES implementation to conduct a BPR exercise by examining existing business processes, identifying the deficiencies and implementing improved processes, embodied in the new ES. Whether the organisation implements best practices embodied in the system or the system reflects the ideal processes the organisation would like to have, is a question of configuration, customisation and cost.

Table 9.7 highlights several cases of the ES directly enhancing process integration and consistency. However, only one case of substantial and extensive process reengineering was observed: The introduction of Integrated Work Management forced extensive changes to procurement, inventory and internal supply chain processes. In addition IWM's automated parts ordering process had implications for how projects were budgeted for.

Ultimately IWM imposed a Just-In-Time supply chain methodology and brought consistency to site work processes. This is shown in Table 9.1, in the rows titled *Integration Processes* and *Future Opportunities*. This is also highlighted in Table 9.7 as the sole case where ES directly affect Value.

Revealing data, in contrast, as shown in Table 9.8 illustrates several observed instances of the ES revealing previously unavailable data about the Regulated Asset Base and the Asset Management processes that affect it. These data were entered into the Asset Register as part of the SAP R/3 implementation. However, once the Asset Register was populated with data, it became clear that the increased level of detail on asset types permitted optimisation of certain maintenance policies. In addition, the xRPM, ARM, IWM and BW modules permitted integration and optimisation of project planning and annual maintenance planning processes. The modules used are shown in Table 9.1, in the rows titled *Technologies*.

However, the affected processes were not transformed by imposed changes from any SAP module. Rather, the data as presented by the ES drove a renewal process where those processes and assets were examined and then those processes found to be deficient were improved or replaced. Furthermore, the organisation modified its own structure to take advantage of the improved data availability to better meet or exceed regulatory requirements. There are two examples of this: The Asset Register Administration group was set up to maintain and improve the data in the Asset Register and to exploit additional layers of detail that became available. Also, the Asset Management Forum was formed to remove repeated redesigns of projects by integrating the various sources of project data in SAP R/3. As a consequence all pending changes for an asset, regardless of source, are presented in a single forum before final site design is approved.

In conclusion, while *reshaping processes* has a direct and tangible effect on business processes, *revealing data*, while indirect in influence, has a more far reaching effect on business processes. This is at odds with the traditional view of ES primarily being engines of directly reengineering processes. The implications of this conclusion are that perhaps more attention needs to be paid to what new data an ES installation reveals and also that further changes may be needed to processes after an ES is implemented. The resulting implications for theory and practice discussed in Section 9.4

9.4 Implications for DCT and IS Research Theory and Practice

9.4.1 Introduction

This section discusses the implications of the inclusions arrived at in Section 9.3 It starts by summarising the conclusions arrived on and then goes on to discuss the generalisability of those conclusions from the case. The implications for theory and practice are then discussed.

Section 9.3 reveals the following conclusions:

1: ES *directly* influence the Value, Exploitability and Renewability of Core Capabilities;

2: ES *indirectly* influence the Non-substitutability and Inimitability of Core Capabilities;

3: The chief mechanism through which ES *directly* influence Core Capabilities is through *revealing data* rather than *reshaping processes*;

4: The primary IT artefact for influencing tacit learning, integration, reconfiguration and transformation processes in an organisation is the ES, through *revealing data*.

To facilitate the discussions of the implication of these conclusions, this Section is divided into three subsections: Subsection 9.4.2 discusses the implications for DCT and proposes the VINER framework; Subsection 9.4.3 discusses the implications for IS research and proposes the ESCF framework. Finally, Subsection 9.4.4 discusses the implications of the conclusions for IT practitioners and managers.

9.4.2 The implications for DCT

DCT is a molar theory that requires adaptation before application to a subject of study. In the case of this study, DCT underwent a series of modifications and extensions. Criticism have been levelled at DCT for the its tendency to be applied in post hoc arguments about core capabilities and sustainable advantage. While the main objective of this study was to explicate the role of ES in Core Capabilities, it was also apparent that discussion of the nature of Core Capabilities needs to be disconnected from arguments about the origins of sustainable Competitive Advantage. While Sustainable Competitive Advantage is of obvious interest, being able to identify Core Dynamic Capabilities by their structure and nature, rather than by outcomes, adds an element of predictive power to this application of DCT.

In addition, the concept of Rarity poses problems for the study of a single case. A true assessment of Rarity requires assessment of all competitors in a single market, an impractical proposition when attempting to assess whether the Dynamic Capabilities of a particular organisation are Core. In addition, the Rarity of a Capability is a function of Inimitability, Non-substitutability and Time. Assuming that Capability is not renewed, its rarity may well go down over time.

This study investigated the Value, Inimitability, Non-substitutability, Exploitability and Renewability of Asset LifeCycle Management Capabilities. Evaluating these five criteria permits a conclusion to be reached on whether that capability is Core or Dynamic, or both. Redrawing Mata et al. (1995)'s framework yields the revised framework, titled VINER, shown in Figure 9.1.

The VINER framework merges some of Teece and Pisano (1998)'s theoretical contributions to DCT with Mata et al. (1995)'s framework for Core, Enabling and Supplemental capabilities., as well as incorporating the concept of Competitive Necessity from Clemons and Row (1991, p.275) and Causal Ambiguity, the Role of History and Social Complexity from Leonard-Barton (1995). In addition the framework is informed by Shanks and Bekmamedova (2012) and, importantly, by the case study presented here.

While VINER is limited through the exclusion of Rarity from distinguishing clearly between Enabling and Supplemental Capabilities, it provides a useful diagnostic for detecting Core Capabilities that avoids the circular dependency on Sustainable Competitive Advantage and thus the need for post hoc analysis. It trades a little certainty for some practical predictive power, a choice and simplification made so that the framework can rise above the idiosyncratic case (Siggelkow, 2007, p.21). A Capability that is Valuable, Inimitable, Non-substitutable, Exploitable and Renewable is both a Core Capability and a Dynamic Capability. Its Rarity is contingent on its current Inimitability and Non-substitutability, the Path Dependencies that influence its current state and time. It is an Enduring Capability in that it is well positioned to allow the organisation concerned to exploit and reconfigure its resources and assets to potentially yield a Sustainable Competitive Advantage into the future.

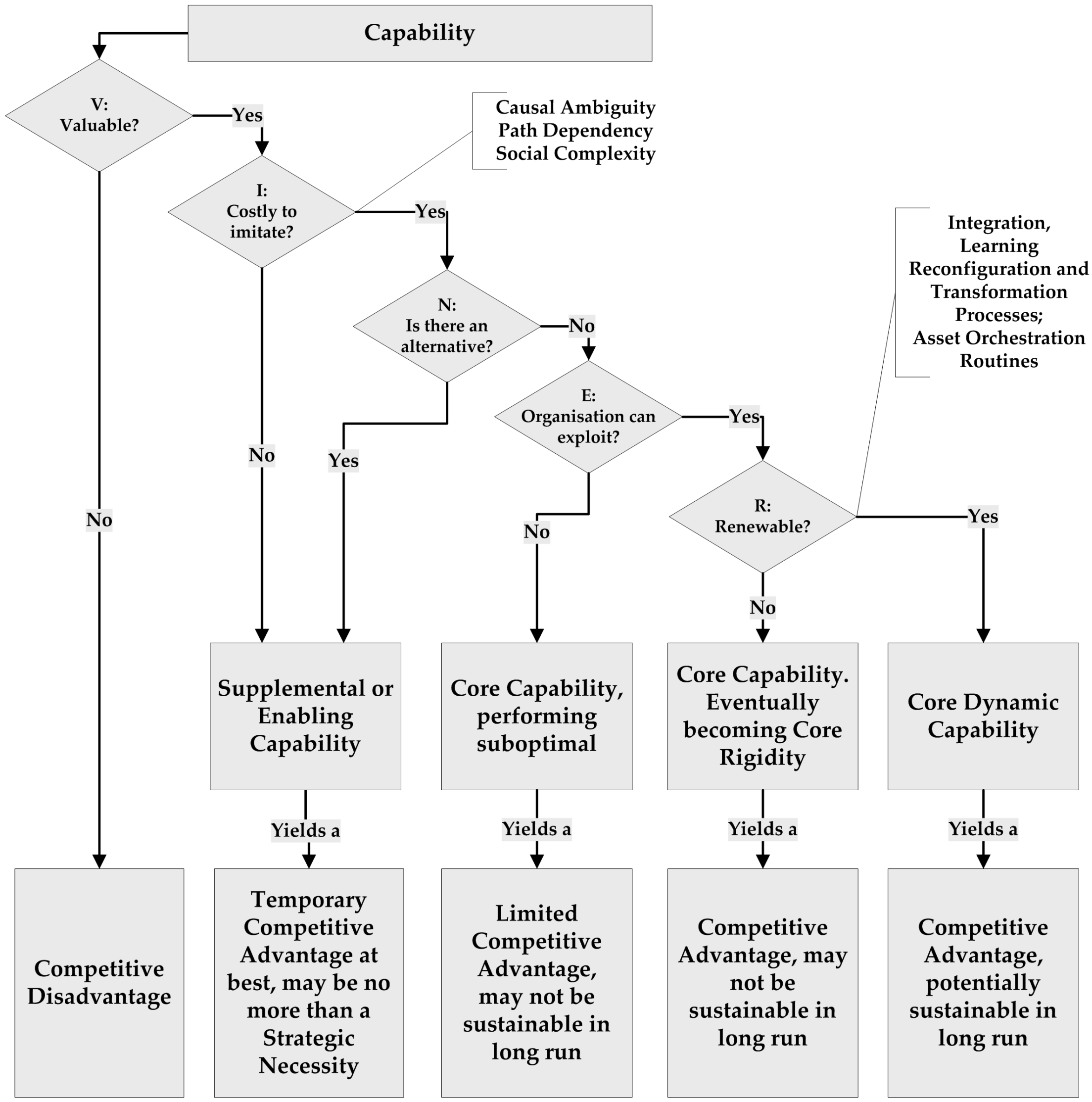

Figure 9.1: The VINER framework for evaluating capabilities

A criticism levelled at other models of competitive advantage is that they assume that markets are homogeneous and relatively unchanging. DCT assumes that markets are quite dynamic and in fact distinguishes between rapidly moving and slowly moving markets. In this case markets can be seen as slowly moving, but not unchanging. The regulatory structure guarantees that the market changes at least once every five years, if not more frequently.

Applying DCT (and in particular the VINER framework) to a regulated public utility (in this case a Distribution Service Operator) to determine whether its ES implementation had allowed it to "get ahead" of the regulator allows the researcher to explore the possibility that the DSO had undertaken steps to reconfigure its processes and structures to better meet the demands of the regulated market. If Information Systems (and by extension ES) are merely commodities with prepackaged processes, then this would not be happening and a simpler analysis would have sufficed. The perspective of DCT exposes the complexity of interaction and interdependencies between the processes, positions and paths that form the Dynamic Capabilities that permit an organisation to reconfigure its resources in the face of changing market conditions. Critically, DCT, allows the researcher to explore the influence of an ES on the tacit Renewal processes of Integration, Learning, Reconfiguration and Transformation. Thus, the ES, as a distinctly Integrative IS, facilitates some level of Organisational Transformation

As the Conclusions demonstrate that Core Capabilities are enhanced and reveal some of the mechanisms by which those Core Capabilities are enhanced, then DCT allows the researcher to demonstrate that ES contribute to an organisation's value-generating activities in a sustainable fashion. Thus, in conclusion, all other variables being equal, DCT makes it possible to propose that **ES can, and do, contribute to Sustainable Competitive Advantage.** The next Subsection 9.4.3 discusses the implications of this for IS research in general and ES research in particular.

9.4.3 Implications for Information Systems Research

There are areas of overlap overlap between Teece and Pisano (1998)'s view of Dynamic Capabilities as being composed of Processes, Positions and Paths, Alter (1992)'s view of Information Systems decomposing into Processes, People and Technology and the view of ES as a subset of Information Systems that are packages of configurable and customisable modules, embodying best practices, that integrate data, processes, resources and functions across the organisation (per Chapter 2). These overlaps are evident if Teece and Pisano (1998)'s concept of Positions is decomposed into Technological Positions and Complementary (People, Knowledge) Positions.

A synthesis of these various sources and consideration of the completed case study yields the ESCF framework in Table 9.9, which is a framework for representing and understanding Dynamic Capabilities with a significant ES element. The first page of Table 9.9 may be understood to correspond to the traditional decomposition of Information Systems into Processes, Technologies and People. Thus the correspondence of concepts between Alter (1992) and Teece and Pisano (1998) is demonstrated.

The second page of Table 9.9 corresponds to the VINER model presented in the previous subsection, as well as addressing both the history to date and future opportunities. There is some overlap between Inimitability, Non-substitutability and Path Dependencies, in that Inimitability and Non-substitutability are in part dependent on history. Similarly, Exploitability and in particular Renewability are dependent on Technological Positions and how those technologies contribute to Integration, Learning, Reconfiguration and Transformation processes.

The ESCF framework can be used, first, as a means for evaluating ES as both Information Systems and also as a part of a Dynamic Capability and, second, as a diagnostic for determining the role that ES plays in that Dynamic Capability.

This framework provides an internally focused analytical tool for examining the role of ES in value generating activities in an organisation over time. With respect to private organisation, this permits an analysis of the contribution to Sustainable Competitive Advantage; for public service sector organisation it allows the ability of ES to enable those organisations to meet stakeholder expectations to be examined.

Finally, VINER and ESCF provide a useful analytical tools for evaluating Dynamic Capabilities and the contribution of ES in low turbulence settings, where market or regulatory influences are well understood. While the *"Third Hand"* characterised by Pavlou and El Sawy (2010) is observable in turbulent environments, here ESCF and VINER allow similar effects to be observed where Dynamic Capabilities transform Operational Capabilities.

Subsection 9.4.4 discusses some of the implications of the ESCF and VINER frameworks for IT Practitioners and IT Managers.

Table 9.9: Enterprise Systems Capabilities Framework mechanisms, as inferred from the Study

Component	Observable	Mechanism	Findings Reference
Business Processes	"Factory Floor" / Production / Service Processes directly related to the day to day operations of the organisation.	ES embodies process	Table 9.1, *Business Processes*, *Technologies* row
Integration Processes	Combining organisational functions, tighter coupling of business processes across functions, enhanced data sharing.	Data integration, imposition of consistency, close process coupling, integration of different processes	Table 9.1, *Integration Processes* row
Learning Processes	Changes to processes as a result of prior events, evidenced by improvements in performance indicators, outputs, value, etc.	Measurable progress in increasing value with respect to market demands or regulatory imperatives	Table 9.1, *Learning Processes* row
Reconfiguration Processes	Any process change or reorganisation of assets, especially as an adaptation to external pressures	Process changes. Organisational changes emergent from data revealed by ES (Reshaping processes, revealing data)	Table 9.1, *Reconfiguration Processes* row. Subsection 9.3.6
Transformation Processes	Replacement of older processes, structures, assets and IT artefacts with newer ones.	Replacement of IT systems and restructuring of organisation	Table 9.1, *Transformation Processes* row
Technologies	ES applications used. Other Information Systems and Information Technology.	As stated under Observable.	Table 9.1, *Technologies* row
People	Training undertaken by people executing processes. Their knowledge, skills and experience.	As stated under Observable.	Table 9.1, *People* row

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Table 9.9 – *Continued from previous page*

Component	Observable	Mechanism	Findings Reference
Path Dependencies	History of organisation, processes, people and technologies to this point.	Constraints imposed by history	Table 9.1, *Path Dependencies* row
Future Opportunities	Future plans. Anticipated new technologies. Process and organisational changes. Expanded range of future choices due to changes made in the present.	ES as enabler for processes changes and improvements, with a view to creating value in the future	Table 9.1, *Future Opportunities* row
Value	Increased rents. Reduced costs. ES may also permit or drive valuable reconfigurations.	Improvements in efficiency. Data from ES informs reconfigurations	Table 9.1, *Value, Future Opportunities, Reconfiguration Processes* rows
Inimitability	Contingent on history of organisation and knowledge of its staff. May be contingent of level of customisation of ES or else on specific adaptations to ES.	Evolution of organisational structures driven by revealed data about operations and changes to processes	Subsection 9.3.3, Section 9.3.6
Non-substitutability	Highly specialised capabilities will have no direct substitutes.		
Exploitability	Dependent on the organisation being in a position to effectively reengineer its processes as needed, to reconfigure its positions and to exploit new opportunities. Enterprise system may either hinder this through expense of reconfiguration or drive it by providing essential data.	Increases in standardisation, centralisation, more detail in data, increased flexibility. Possibly extra data entry burden imposed in some processes	Table 9.1, *Exploitability* row
Renewability	A process of continuous reengineering, either facilitated or inhibited by the ES.	Changes to business processes and structures driven by data revealed by ES	Table 9.1, *Renewability* row

9.4.4 Implications for IT Practitioners and Managers

Chapter 2 highlights some of the concerns about the high cost and poor return on investment for ES. The chapter concluded by highlighting that it is unclear whether the benefits of ES are brought about by the technology itself or the implementation process. For example, Alvarez (2002) asserts that, in the case of an organisation's values, the implementation process itself is far more influential than the actual technology implemented. In addition, Henderson and Venkatraman (1993) assert that it is the application of business and IT capabilities to develop and leverage a firm's IT resources for organisational transformation, rather than the acquired technological functionality, that secures competitive advantage for firms.

Citing Melville et al. (2004) and Bharadwaj (2000), who offer the *Resource Based View (RBV) of the firm* as a *"robust framework for analysing whether and how IT may be associated with competitive advantage."*, this study applied DCT, a development of the RBV, to addressing the role of ES in securing competitive advantage. The study focused on the *use* of ES, rather than their *implementation*. Nevertheless, the transformation of certain processes as a direct consequence of ES implementation was evident.

This study suggests that, contrary to Henderson and Venkatraman (1993) and Alvarez (2002), the technology itself is significant. The SAP Asset Register (ARM) plays a crucial role in several business processes as well as transformation processes. Integrated Work Management (IWM) and the SAP Compatible Unit, as well as ARM, provide numerous points of integration as well as ensuring consistency across the organisation. Quite apart from the implementation process, the data organised and revealed by the ES has driven further process and organisational changes, long after the initial implementation was completed. In particular the history of the Asset Register and Asset Register Management has been one of increasingly detailed asset data driving process and organisational changes.

The practical implications of this are that, while the process of implementing an ES is important, consideration must also be given to post-implementation use. While implementation options are numerous, one in particular is a choice between the generic "best practice" processes packaged off-the shelf with the ES, and a "best fit" approach where the ES is customised as necessary to fit existing processes or revised versions of existing processes, which are unique to the organisation. As customisation is inevitably expensive, the result is usually a compromise.

Regardless of whether the implemented processes are generic or customised, consideration must be given by the IS manager to the possibility that the new ES will reveal information about business performance that was previously unavailable. Mindful interpretation of those performance data is likely to mandate that further changes and enhancements to the ES may be needed, along with more processes changes and even changes to the organisation structure. No ES implementation should be considered as cast in stone and and ES, far from being a commodity, must be considered as a potential engine of continuous renewal of an organisation's value generating activities.

The VINER and ESCF frameworks presented in Subsections 9.4.2 and 9.4.3 provide some practical tools for examining how an ES performs in a real life setting. The ESCF framework presented in Table 9.9 in particular allows the IT practitioner to asses whether an ES contributes to value in a meaningful, exploitable and renewable fashion. An ES that fails to figure significantly in this table is unlikely to be contributing to value and thus is not making an adequate return on investment.

9.5 Conclusions: Limitations and Avenues for Future Research

9.5.1 Limitations of the Study

This section addresses some of the limitations of the study and also comments on the validity and generalizability of the study. Concerns typically arise with single case studies that the results in particular are applicable to other cases. In order to ensure that the research done for this case study is applicable elsewhere, the Limitations and the Generalizability of this case study are elucidated here.

This is a single case study and as such is open to criticism as to whether the case is representative and also whether the case is generalisable. In response, it is noted that the subject of the case study was selected because it presented a number of interesting characteristics. First, it presented an opportunity to study ES usage in the public sector - an area that has not received sufficient attention in the literature. Second, the case is a public utility under regulation, which means that the external environment under which the organisation operates is well understood and documented in considerable detail. Third, the public utility selected for study is a critical and unique case in that it is constrained by its own history. The public utility transitioned from being an energy generator and distributor run at cost to an asset management organisation that needed to make a profit. Other public utilities in the same field are not subject to the same constraints.

The object of the study is thus interesting because it is constrained in a way that other utilities are not. In effect it is **not** representative. However, the purpose of the study was not to seek out an average or typical case that might yield some small argument for generalisability on statistical grounds. Like all single case studies, this study is not amenable to numeric or statistical generalisability; it can be trivially stated that this study, like most case studies, has a generalisability of 1. However generalisability need not be statistical in nature: Generalisability from a theoretical standpoint is also permitted. Instead, the mode of generalisability sought is analytic per Yin (2003), as articulated in Chapter 4, Subsection 4.3.3, where the ESCF and VINER frameworks resultant from the study may be addressed in other settings. This is addressed in Subsection 9.5.2

Siggelkow (2007, p.21) notes that a case, to be compelling, must be one that provides some conceptual insight without necessarily relying on the descriptive aspects of the case itself. The case therefore motivates, illustrates or inspires the theory. This study meets these criteria: It provides refinements to DCT via the VINER framework and offer a framework for examining the interplay between ES and Dynamic Capabilities in a manner that links ES to performance. Furthermore the study provides some conceptual insight by explicating some of the mechanisms that allow ES to contribute to the Value, Exploitability and Renewability of Dynamic Capabilities.

9.5.2 Recommendations for Future Research

This study presents numerous opportunities for further research. The most obvious is a confirmatory case study on a second utility company. Alternatively, or additionally, a case study using a private sector firm as the target might be attempted. Also, a turbulent rather than relatively stable market setting could be sought. All of these suggested studies would seek to confirm the applicability of the ESCF and VINER frameworks in a slightly different setting and would further enhance the generalisability of those frameworks.

However, now that some of the relationships between ES and Dynamic Capabilities are better understood, a different research approach could be adopted. A field study with multiple cases or even a survey could be attempted. Either approach should allow the concept of resource rarity to be explored in a setting where comparisons could be made among different organisations in the same market environment.

While Dynamic Capabilities Theory (DCT) is the theoretical viewpoint applied here, other theoretical approaches are possible. The earlier discussion of the effect of ES on both explicit and tacit processes and organisation structures, after implementation is fully complete, suggests that Diffusion of Innovations Theory (DOI) may be applicable. In particular, the diffusion stages model articulated by McKenney and McFarlan (1982, p.115) should offer a useful perspective on how those changes after implementation are propagated and adapted throughout the organisation. A synthesis of DCT and DOI may yield useful insights on strategies undertaken by organisations and individuals to leverage maximum advantage from an ES post-implementation.

A DCT / DOI combined approach would in particular address the issue of how the processes embodied by ES are fixed or changed over time. Bearing in mind that certain explicit production processes are fixed at the point of implementation, attention should be turned to those tacit processes that rely on data furnished by the ES to drive local and organisational transformations. Some of these may well be be pre-existing process that have been transformed, or new processes that have emerged post-implementation. The effect of structured and consolidated ES data on relevant decision making should also be considered here.

The Resource-Based View (RBV) and DCT, notwithstanding criticisms of lack of empirical support, lend themselves to process-level analysis of those artefacts, structures and routines within organisations that contribute to competitive advantage, sustained or otherwise. It is recommended that in future applications of DCT to empirical settings, attention is paid to the applied framework used to ensure that it is amenable to practical use. In this study, it was necessary to set aside the concept of rarity to permit a single critical case to be utilised. The limitations of VINER, a variant of Barney's earlier VRIO model, have already been noted; other variations on VRIO may be suitable for investigation in different research settings or where different research approaches are used.

Finally, while Enterprise Systems both as a concept and as a technology may be superseded over time, consideration could be given to investigating how a competitive return is to be achieved on future investment in large software platforms with the distinctive characteristic of integrating different organisational processes and functions. This includes consideration being given to the reconfiguration, learning, integration and transformation processes that make those organisational transformations.

Appendix A

Chain Of Evidence Tables

Table A.1: Identifying New Assets.

Characteristic	Manifested As	Evidence For
Processes:	Solution Identification	MS: *"For any load greater than 630kVA ... needs to come through the planning function do that they can do a study for it and recommend the connection methods ... We do up a ... report that takes all the results of our studies and details exactly the work that needs to be done."*
		EnerDist sample report per above comment.
		CH: *"The planners have [a] least-cost technically acceptable solution ... We want to get the best, most robust solution ... the two don't always dovetail."*
Integration	This capability integrated at higher level in organisation.	MS: *"We just recently started with an Asset Management Forum ... [which] coordinates everything from the time it leaves the Planner's desk to the time it gets Capital Approval."*
Learning	Adoption of remotely operated switchgear and application to distribution network.	CER11090, p.25: *"The reduction in fault CML [Customer Minutes Lost] since 2006 has been mainly due to the deployment of downline automatic reclosers and switches on rural MV feeders ... They have the effect of reducing the number of customers affected by faults and permit faster restoration of supply."*
Reconfiguration, Transformation	Assimilation of new technologies into network.	MS: *"[The System Performance Manager] do studies for putting automation devices on the network. Soulé switches and Arc Closers."*
	Changes to processes and tools to accommodate those technologies.	MS: *"There's a tool that was developed by the Planners ... where they can, by putting [in] different devices, they can [calculate] the cost-benefit."*
	Coordination of planning activities.	MS: *"The idea of this Asset Management Forum is that all the people involved ... have a meeting once a mono [and] a certain number of projects are put forward for each meeting. The planner has the decision made and they're putting forward their proposal ... everyone has a chance to have their comments and then it comes into the meeting."*
Positions:		
Technological	Distribution equipment, xRPM, GIS, Modelling tools, MS Word, IWM	MS: *"It's fed into IWM then and that's what triggers off ... getting the work issued to people to get it done on the ground."*
Complementary	Planner, Planner's learned skills	MS: *"There's quite a learning curve ... t's up to the planner to take results out of the planning package, formalize the conclusions and then draw up a complete package of work."*

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Table A.1 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
Paths:		
Dependencies	Predates market opening but financial landscape has changed.	JOD: "*We [had] the same planning criteria ... I would haves assumed an infinite budget. Whereas nowadays we have a fixed capital budget for a five year period.*"
	Emphasis has shifted from new load requests to remedial and improvement work as a result of economic downturn.	MS: "*We'd still be getting the odd load enquiry. But the main focus would be rolling out [improvements like] the 20KV conversion program.*"
Opportunities	Solutions optimised to reduce penalty from future network outages.	MS: "*There's a tool that was developed by the Planners ... where they can, by putting [in] different devices, they can [calculate] the cost-benefit.*"
	Used to be done in Access, now replaced by	BG: "*We would have had our planners here approving on an Access database.*"
	IWM.	MS: "*And now we have IWM ... it's catering for an awful lot more than ... the TA database.*"
Value	Minimises CAPEX and, if possible, OPEX by	CH: "*The planners have [a] least-cost technically acceptable solution.*"
	selecting most efficient solution that minimises risk of future outages and allows for future network expansion.	CER11090 showa reduction in CML form 2006 to 2010.
Inimitability	Process is dependent on interpretation of modelling package results.	MS: "*The modeling package is limited. It can give us the results but the format it comes out in, it still has to be interpreted by the Planner.*"
Non-substitutability	Acquisition of skills takes 6 months to 1 year.	MS: "*There's quite a learning curve. There'd be at least six months if not a year [before] a Planner could be confident in .. the concepts they're taking into account when they're planning and making sure they had every angle covered.*"
Exploitability	Well fitted with existing planning tools, disconnected from SAP R/3 IWM.	MS: "*Our modeling system doesn't talk to IWM in any shape or form. It's up to the planner to take results out of the planning package, formalize the conclusions and then draw up a complete package of work.*"

Table A.2: Coordinating Asset Programmes.

Characteristic	Manifested As	Evidence For
Processes:	Asset replacement and refurbishment	COC: *"Not all of the work programmes that we do on the assets are generated by the planners, which would be the new business end of it or new changes, some of it would be because of obsolescence reasons, we would be doing asset replacement, or refurbishment programmes"*
	Work packaging	BG: *"They're doing their initial concept on IWM, to package the work to see what's being called for by other parties in asset management, and then package it, put it together, agree it around the asset management table, and then approve that work package over to the designers, because its happened before, stuff has been missed and its reworked, redesigned, and its gets delayed, so from a project scoping point of view, IWM will definitely help there, but from, and also my perspective, it's from programme management, it keeps everything in a package, it tightens up everything in for the designers in EnerCoI, to design properly, and also from a deliverability point of view, I can then, once the widgets are linked to the package over here, that package is closed, I can then, then report back on programme basis quite automatically"*
	Programme planning	PD: *"What they do is that at the very outset say around October every year, the Asset Managers and the Planners would sit down with Programme Management and they would look at what's planned for the next few years and Programme Management would say well listen, we feel this is what we have the resource to do what do ye want? They, they're the ones that drive what needs to be done, so we train that, they'll decide on what's feasible to be done in any one year based on the resource and based on the need. And sometimes you may have to up the resources if you haven't because there's some work has to happen and other work you have the opportunity to push it back say. Some of the refurbs may not be as critical, especially now with the downturn in the economy, there was a lot of new stuff we were planning to do that we don't see necessary to do now at all, because the load growth is not there so there's a good bit ... once it's been shelved but, the pressure is off, it can be pushed back for a year or two."*

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Table A.2 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
		PD: *"So now with the dates you can just go in and pick this year's plan but equally you can go in and look and say now ok, I know what is on next year's, is it going to impact on in any way on any of these lines I'm doing this year? And you might make decisions based on that but at least you can see each plan or if you have a project that you know is not going to start as well this year for whatever reason rarely it's been the single biggest one that holds us up you can purposely go in and get your Coordinator, push that out until 2010, that's not going to start and I'm not going to be reporting on that this year 'cos I, I don't want delivery, it will come up every month if I leave it there, looking for a report so push it out to whenever they think, January 2011 so."*
	Programme as agreed with regulator.	BN: *"To put that into perspective you asked earlier about the financial pace of it. We have, we work on the basis of agreed work programmes with the Regulator and what that means is that every,... We have a five year work programme with the Regulator, whereby we do an analysis of the system, look at where reinforcements, refurbishment is needed, justify that on a business basis. The Regulator then looks at that and does a detailed analysis of that and says ok, I think it makes sense to do this, I am not going to allow this, because the Regulator balances that against the cost of electricity and he says with, so, if, if I go ahead with that programme, it's going to push up the price of electricity too much therefore we'll defer. So he makes, he, he, he, he as in collectively, makes those calls. Once we have the agreed programme, then it's up to us to deliver it but we don't get the next programme, our credibility for delivery of the next programme depends on our delivery of the existing [programme]."*

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Table A.2 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
		PD: *"Well I suppose...whenever...well...if...you know Projects or Coordinators would be in on it on a very regular basis now they would be in on it. I won't say every day but most days they will be doing something with it you know if they're...like it will take them probably a fortnight out of every month for them to get around to all their Supervisors to do the updating. They will do the final updating at the end of the month but there's certain information to be gathered and they'll be picking up the phone and ringing them and checking projects because we have, we have two sets of projects in, what we call WIP 'Work In Progress' These are jobs we carried over from before IWM came in and they'd be there, they could be there for another two years because they are big projects, they could be...Now some of those have to be managed, there's a certain one that has to be managed offline because they are jobs that were initiated before IWM so they are not fully fledged IWM jobs. Now, now, we can report in IWM but their WBS structure and all is outside IWM, it's the old structure so there's a certain amount of management into them offline. We do that on a spreadsheet, but hopefully by the end of this year we will have them all set up in ...We had an issue with them as well that we didn't realise, that we would have maybe five or six elements to a job, you have your lines, your stations and your cables but normally we would maybe do the lines first but if you close the line and take out and, and, and er, financial close it off, it blocks us from doing anything with the other two. So at least we found it so when people confirm those jobs, so those ones we had to manage offline until we got the opportunity to go in and unTeCo them because obviously you can't go in and just unTeCo a job because it screws up reporting for financials because if they've reported on this one, every time you unTeCo it, it brings it back as a live job."*
Integration	BW as integrator	BN: *"I'm not so sure that I, it depends on the extent to which it takes our existing systems and takes the information from them, right. I think it's as best as could be done because it was a major, major project and given the, the variation and the complexity in terms of what we do, depends on how well it sucks up the information, particularly the Business Warehouse end of it is the piece that I am interested in, not the IWM per se, or not the SAP element of it. Because that's the bit that we are depending on to interconnect all the systems that we are talking about. They were all developed independently, not communicating."*

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Table A.2 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
Learning	Now know how long a job takes.	PD: *"Because we contract them each month and quarterly and there are quarterly reviews when they look and say listen this is what we envisage we'll get done, did we or did we achieve and if we didn't, why didn't we, did we expect too much, or equally if things were moving better you can, they'd be look, saying we can add something on to the work programme at the end of the year you know. I remember one thing it gives us, it will give you a breakdown of your man years so you'll always know where you are during the year in relation to what manpower you have available to you. Whereas in the past we wouldn't have had that facility, we wouldn't have had,... we would have been based on experience saying we expect that job will take 20 man years but no one knew exactly. Whereas now that has been developed that we have it fairly accurately built into the system that it will spill us out if we put in a work programme into it, it will say you don't have the resources to do that or this is what it is taking and you only have 90% of it you know. So there's, there's an element of that end as well that it all feeds into good planning now that gives us a far more refined plan."*
Reconfiguration, Transformation	Compatible Unit	JC: *"You are using this compatible unit which isn't a set, it's a building block but it's multi-dimensional, it's got the financial side of it, it's got the asset side of it, it's got the materials you know so that whole thing of using an entity, a core component that has all of these different dimensions, that everybody uses and everyone feeds off, that's great strength in that but then when somebody wants to change something it can have knock-on, unintended consequences."*
	Multidimensionality	JC: *"I suppose probably a lot of regulatory stuff has changed that as well that the business now can no longer afford to be good at just one dimension and the business has to be multi-dimensional; really an electricity utility has got to have its finances right, its got to have its HR right, its got to have its asset base right, its got to not just be able to do the work, it's got to be able to record the work properly. In its systems it's got to have its data management right, its IT right and so on. So I think, I think that is just the progress that we have had over the last number of years has driven that so I suppose it's not just an EnerCo phenomenon I suppose all organisations now are probably a bit more flexible and a bit more, more kind of nimble and for finance people as well, there's not as many of us as there used to be and you just have to be more, I suppose, value adding, you know."*
Positions:		

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Table A.2 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
Technological	IWM	BG: *"[IWM] was purely to manage our capital work programme, so it covers from you know, the normal new domestic connection, farmer domestic schemes right up to our 110 transmission wind farm connection, so it's all capital works"*
	ARM	BG: *"Although ARM is designed for maintenance work, we use it in the absence of IWM, for the last 2 years of PR2, we used it for tracking some capital work which was, and we continue to use it although our IWM now is available since 09, we continue to use it for the last year and bit of PR 2, because we want to have it in one particular place."*
	xRPM/RPM	BG: *"So RPM basically it replaces the old TA database. And it purely is asset management, its where we put in, the planners in particular, we put in and set up jobs ... RPM is very much a kind of standalone module ... I think RPM, my understanding was that RPM was nearly custom built using SAP."*
	BW	BG: *"From a programme management point of view, that's where the BW report is really giving us that function, you can you know, suck it all up into one particular programme ... there's the reporting because BW marries the two [IWM and xRPM]."*
Complementary		
Paths:		
Dependencies	No structured system prior to IWM, ARM and xRPM.	MK: *"It was just an Excel spreadsheet. There was no feeding back into a system. We created our own paperwork and managed it that way. I had one system. The crowd that were looking after Cork City and West Cork had another system."*

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Table A.2 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
	History of Progamme Management	BG: *"It was always there yeah, now I'm there I'm two years, two and bit years, and it was, well no, it was decentralised I suppose for number of years, and I think in the last, how many years, was Carmel there, I say Carmel was there maybe six, I'd say in the last maybe 8-10 years, it was brought in centrally, so what happened in the past was, it was the network projects people decided what was, like you'd investment people deciding, OK well this operating of a 38kV line is required, because it now looping whatever towns whatever, and that you know, networks projects may not understand the importance of getting it done, they may just get the quick wins or easier jobs, they don't want to go for planning permission, or they want to, so there was, going back I'd say 8-10 years, that whole programme management was centralised."* BG: *"[It] wasn't anything to do with market opening, it's a separate thing altogether, market opening, its I think it was when asset, the asset management concept, this department just be distribution department and then asset management then came in, last say 8-10 years maybe its longer, just trying to think when we renamed asset management, but and then I suppose there's an awful lot of asset management concepts that it would have been new to distribution department, and this whole thing about having a central programme, and not letting people on the ground decide what's actually going to be done, like you can be dishing out work and they're just going to take cherry pick, whereas if there urgent ones need to be done from, and that's prioritisation, now it can work a lot better."* PD: *"Because actually it was crazy there for a few years, we were chasing our tail trying to keep ahead of ...And, and the bigger problem with that was that we couldn't get outages on existing lines because they were so overloaded we had no back feeds for them to keep when people didn't want outages. So that's, at least now there will be better planning around that as well and them dates are more critical now that people are made, more, they're answerable for them now, more so than they were in the past."*

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Table A.2 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
		PD: *"So, that's whittled down a bit now, we had a big programme of work there for 2003 - 2006 and we looked at that going forward and we said, ok, we've got that chunk of work over we don't need to maintain, we're back to about fifteen hundred now. That fifteen hundred is constant there now and that seems to be the norm and the average that we would need to keep a steady workflow and meet the targets that we have set for ourselves. But the first batch that was a challenge now because I mean we... the Regulator had given us a very short period to finish a piece of renewal work that we had started ourselves in the mid 90's and just weren't able to complete, we just, we just hadn't enough staff and then with the ...well we had planned the 20 year programme for it but so we asked but the Regulator said, no I am giving you five to do what we were planning for twenty years so that focused the thinking a fair bit and the big challenge there was that it was, contracting, was so new you know. Staff wasn't used to it, we had plenty of problems because I mean, when I came back, I was abroad at the time and I came back and well people now well I think with contractors, well listen, these are out to screw you, you need to watch them, cut them everywhere we can but you don't, the contractor has to make a living, you work with them. Obviously you have to be aware but if you screw the contractor he equally, he's better ways of going back on you. So it took about a year to get that sorted out and then to weed out some of the contractors that didn't want to, who had no great interest in staying the long haul, they were in to make a killing and then get out. Because I think we had about thirteen contractors initially and we are down to five or six now. And them five or six are doing the business for us."*
	Diversity of systems	MK: *"We created our own paperwork if you like and d'you know and managed it that way. I had to do the whole thing myself d'you know, create the paperwork and follow things through from start to finish. Say if you went out to somebody in the patrol and there was, um, d'you know a door had needed welding and stuff like that you'd do x amount but if that was all that was left in you to get someone else sent to do that you'd record that and so on support and then bring the other, uh, you know, welder back to fix up the door and stuff like that. But that was all recorded in whatever system. I had one system. The crowd that were looking after Cork City and West Cork had another system. MK And I'm sure up the country there was any number of systems."*

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Table A.2 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
		MK: *"Then, em, the hazard patrols and the detailed inspections were done on, em... what they were done actually on scanned sheets, where you had this pre-printed form that you just print and it was blank virtually and the data we went out, we filled them in and we sent them off, they were scanned and they were put, put onto a spreadsheet or whatever works. But, what we found with that is that, um, the data we recorded and it got scanned below didn't necessarily migrate onto the sheets as it should do. The following year then we were printed out, because we were printing them out the following year they were meant to be pre-printed. Or, they were meant to be filled in, they had the directions and so on, so forth. So. Again, the problem with that really, I suppose the basic problem with that is that there wasn't sufficient interaction necessarily between ourselves and those processing the data so that what we got the following year reflected all the hard work and graft."*
	Increase in network reliability	JOL: *"Like, if you go back ten years, oh, we were without supply there in January, we were without supply in March the year before. But, now people can't remember [outages]. That's how good the network is. You see that was the Network Renewal Program. The, the, the latest program, there's a few programs going on at the one time and one of the programs that's going on is LVU, that's Low Voltage Urban. So, at the moment now, you'd see a lot of, you'd see a lot of activity not in the rural areas but in the cities and that. A lot of the timber poles being replaced with steel poles and that sort of thing ... I was talking there now recently to the Operations Manager in the Call Centre and he said, for the first year ever, storms and anything like, he said it's just unbelievable how, how few outages they get because the network was so new and so improved."*

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Table A.2 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
	Shift in type of work	JOL: *"What has happened really in the EnerCo in the last twelve months is that, there's been a switch from services work to projects work, because what we class as services now is new supplies. So, obviously there's been a fierce drive in the last five, six years with the Celtic Tiger - the famous Celtic Tiger and all the new connections in all, the new houses. There's been a fierce drive, fierce, demand for new connections. So that was all, that was, ah, the focus was on services rather. Now, it's gone from sort of a hundred thousand connections, new connections a year down to probably ten thousand now. I don't what the figures are now precisely. So now we have all the staff but we have staff now who are used to being ultra-busy, working overtime, working Saturdays, Sundays, now all of a sudden now they can quite comfortably do their lot in, in the... So what's happened now, is like some of the Networks Services staff aren't changing to, to capital works and the capital works now would be considered, like, they'd be, they'd be inflating the balance sheet in the sense that anything, like, if you replace a pole, if you replace a line, if you, if you upgrade a station, if you do 20KV conversion, you have improved your asset base, you know what I mean?"*
Opportunities	Integration of IWM with work site.	COC: *""*

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Table A.2 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
	Future of Programme management	BG: *"I'd hope that with IWM in the next year we would be fine tuning that, and making sure that everyone was working through the exact same programmes, like obviously they seem to be working on ones that wasn't as important as another one, but a lot of projects run into problems if its planning permission, or you know that delay it, so something else, so you have to have that pipeline, but I'd say, this whole centralise programme management was, in that time scale less than 10 years, and its wherever been developed I suppose, there was a TA database developed by Donal Febal and Carmel O'Connor and then that covered transmission and distribution works, and now the new step now is IWM, so in the past as well the MVNL will be stuff wasn't really part of the scope, I suppose programme management was looking at, because there was plenty of other HVNL HV station projects to be looking at, but now it is becoming a bigger, bigger issue because it's very much part of the PR3 programmes, so we need to be able to programme and manage that, and track that, so I think, so it was more like nothing to do with market opening, it was the setting up of asset management, and then what is asset management about, and it is about the central decisions being made on whatever criteria is needed via stipulating a Path 55, or whatever reason, safety reasons or whatever, and then being in the position then for those policies, to be putting it on the ARM asset system, asset register system, or via the IWM system, so its implementing the policies as agreed, like be they planning standards from a loading perspective, or be they and then monitoring that, so I think SAP is kind of one that kind of gives you that, but it's very much as you say, well it is very much you know refined, and you can only do this or whatever, and there's a lot more that we do need to kind of customise a lot more, to get what we need out of it, so we only learning that as we go along, as we say you know."*

Continued on next page

Table A.2 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
	Better planning	PD: *"Because actually it was crazy there for a few years, we were chasing our tail trying to keep ahead of ...And, and the bigger problem with that was that we couldn't get outages on existing lines because they were so overloaded we had no back feeds for them to keep when people didn't want outages. So that's, at least now there will be better planning around that as well and them dates are more critical now that people are made, more, they're answerable for them now, more so than they were in the past. Because we contract them each month and quarterly and there are quarterly reviews when they look and say listen this is what we envisage we'll get done, did we or did we achieve and if we didn't, why didn't we, did we expect too much, or equally if things were moving better you can, they'd be look, saying we can add something on to the work programme at the end of the year you know. I remember one thing it gives us, it will give you a breakdown of your man years so you'll always know where you are during the year in relation to what manpower you have available to you. Whereas in the past we wouldn't have had that facility, we wouldn't have had,... we would have been based on experience saying we expect that job will take 20 man years but no one knew exactly. Whereas now that has been developed that we have it fairly accurately built into the system that it will spill us out if we put in a work programme into it, it will say you don't have the resources to do that or this is what it is taking and you only have 90% of it you know. So there's, there's an element of that end as well that it all feeds into good planning now that gives us a far more refined plan."*

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Table A.2 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
	Planning impact	BN: *"So from that point of view when the SAP was introduced originally it didn't affect Projects because we were working independently anyway. [Now IWM influences what we do] because it links the material ordering and all that, the whole lot is linked, which incidentally is a very, very welcome...it's very welcome to have integrated systems. We're absolutely crying out for it so, it's just, we need a bit of work to make it, to make it, to build it in and make it happen ... We're going to have to [alter our processes to fit the new IWM system a bit better]. I don't see the processes changing per se as much as I see the need to ensure that we have proper lead times and typically what happens, if there's a lead time on a project, what we tend to have is, we, we're, we're sandwiched at the delivery piece at the end of it, right. We're rightly sandwiched then against that whereas what we need to do is we need to get our programmes identified further in advance so that we can, we can streamline it into the system, but that's something that needs doing anyway, it's just that we need to, we need to bring it more forward than it is at the moment."*
Value	IWM used to drive through incentivised programmes	BG: *"It has to go in through IWM, in relation to managing all that capital work, because we've various incentives hanging off it for the next 5, 4/5 years so, and we're pushing everything goes through IWM"*

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Table A.2 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
Inimitability, Non-substitutability	Programme Management built over time, history.	BG: *"It was always there yeah, now I'm there I'm two years, two and bit years, and it was, well no, it was decentralised I suppose for number of years, and I think in the last, how many years, was Carmel there, I say Carmel was there maybe six, I'd say in the last maybe 8-10 years, it was brought in centrally, so what happened in the past was, it was the network projects people decided what was, like you'd investment people deciding, OK well this operating of a 38kV line is required, because it now looping whatever towns whatever, and that you know, networks projects may not understand the importance of getting it done, they may just get the quick wins or easier jobs, they don't want to go for planning permission, or they want to, so there was, going back I'd say 8-10 years, I'll have to check exactly now, I can check that for you, but in the last say, I'd say 8-10 years, that whole programme management was centralised and wasn't anything to do with market opening, it's a separate thing altogether, market opening, its I think it was when asset, the asset management concept, this department just be distribution department and then asset management then came in, last say 8-10 maybe its longer, just trying to think when we renamed asset management, but I can check that those time scales for you, but and then I suppose there's an awful lot of asset management concepts that it would have been new to distribution department, and this whole thing about having a central programme, and not letting people on the ground decide what's actually going to be done, like you can be dishing out work and they're just going to take cherry pick, whereas if there urgent ones need to be done from, and that's prioritisation, now it can work a lot better, but I'd hope that with IWM in the next year we would be fine tuning that, and making sure that everyone was working through the exact same programmes, like obviously they seem to be working on ones that wasn't as important as another one, but a lot of projects run into problems if its planning permission, or you know that delay it, so something else, so you have to have that pipeline, but I'd say, this whole centralise programme management was, in that time scale less than 10 years"*
Exploitability	Resistance to complexity of ARM.	MK: *"There needs to be an Asset Register. There [needs] to be some way of creating work orders so the system is followed. But, for me to use it is way up and above and beyond what I need. I don't need this. I don't need to know whether the job numbers are there or not."*

Continued on next page

Table A.2 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
	Increased adaptability of people	JC: *"Well, the people are definitely more adaptable I mean there are people there that would be, say to take a simple example now, the people that correct the time sheets, they would just have been thinking in terms of numbers before but now they would think in terms of the activities the guys are doing whether metering, or stringing or ? 0:40:21 or whatever you know so. So I would say, I would say from a development perspective it's, it's good for the people within the organisation, yeah, that it's good but it's not nimble as a system though, no."*
	Increased flexibility	PD: *"Well an example of one, we have a contractor now in low voltage, he's gone into every low voltage group in the country and maintaining it to a specific standard that we have agreed with the Regulator, so that's by and large every group that has been dealt the same. So we've done a generic CU we've put it in there to cover that group. When he goes in, all he has to do is pick that, well, and do an execution factor and things if he's doing a hundred groups in an area. Execute that by a hundred and there's his hundred designs done and it will spit out his costs, his materials - 'cos we know the way it works with the road system, is that it appears by and large over a large number of groups where you average it out, it's near enough the same. And they're very similar, so the benefits in doing that way, ok, you won't get off maybe total 100% accurate on materials, but the time you're saving having someone having to go out and do individual designs, far outweighs it so that's an ideal example so. Every month we just go in and do our group spec and our execution factor and then we'll monitor costs over the month to see if there's any fluctuations."*

Continued on next page

Table A.2 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
		PD: *"But the beauty of that though as well, is that the contractor has got good experience in that and he knows now approximately what time it will take to do a group like that and he has maximised that to his own benefit. Because if, for him ideally, two, two groups a day for every crew is the optimum for him. If he goes below it, he's not getting enough, not making enough money, if he goes above it, he's half finishing a group, he's not held to finishing it even, he has to switch it back in and try and go next morning, so that doesn't suit so, so there's a benefit in him in working closely with keeping his costs, 'cos that's, he'll make his maximum profit. So that's, that's a great driver , he's striving to achieve that and keep within the costs and work as close as possible and that's a huge benefit to us because it gives us a consistency through that we know it's there and we can manage our work more effectively that way. And even the planning in the future, we know that contractor is capable of doing two thousand of them next year and he won't be too far out then by the end of the year then, give or take maybe fifty to sixty or seventy groups now, he'll work very closely to that, unless you get some unknown factor comes in in the middle of the year with savage bad weather or something like that that you just can't ..."*

Table A.3: Building New Assets.

Characteristic	Manifested As	Evidence For
Processes:		PC: *"There was certain amount of checking but obviously there a few things that fell through, and there's few small little things as well, like a guy, one job might involve ordering five, and instead 5 bags of bolts arrived, so there was 500 bolts rather than 5 you know, and suddenly when this was happening like with 20 jobs, storage was filling up with bags of bolts, and went ugh where the hell is this coming from, so the integrated nature of the whole thing caught us, certainly from the stores side of things, we also had issues with the costings, and this is one of the things I was trying to get through as well, I am rambling ... Certain jobs for instance, if a customer comes out and says I want a connection my house here, which is 500 meters from the nearest line, and the nearest, cheapest way of doing this is to build a line straight to the customer an then you discover that because of way leave problem or because there some building in the way if you need to do a line diversion element of the job as well, so from a regulatory point of view, the line diversion element of the job is to be treated differently to the new connection part, OK."*

Continued on next page

Table A.3 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
		PC: *"This is part of what is coming new, in the olden days they were told, this is your work on the Friday they'd speak to the guys, what are we doing on Monday, do we do that yeah OK well put a time down to that, that's all 2001. Now they get a schedule at the start of the week saying, this is where were hoping you'll be from Monday to Friday, and all the numbers are listed on that so they copy them across, and if there's been a change, they find the variation and then, time sheet is updated back in the system again, and then sent off to payroll. They hand it back in to the supervisor/clerical officer, the clerical officer will update it on the system so, and this another issue I had, I might as well get it out, we wanted the payroll, the time sheets integrated into IWM as well, but we had a scanning process, for scanning in our existing time sheets which we were told initially we can change that, but as the project went through its life cycle, we discovered that the support mechanism for changing the scanner was one person there, not 20 that we thought were there, so there weren't resources there to change the scanning process, so the original plan was that we would do the schedule on the system, it would print out, and at the end of the day, on Friday the supervisor would get the updated schedule handed back to him by the NT, and he would update it on the system, and that would be the end of it, but what's effectively happened is, the schedule gets printed out, handed to the NT, the NT transcribes it, from the schedule to his time sheet, the time sheet is then sent to the payroll office, in wherever, Tullamore I think, it is then scanned in Tullamore and converted from scanning, OCR back over to real figures again, trying to correct the handwriting and any misprints and the whole lot, then that pops up on one side of the screen, against what the clerical officer locally has put in as the corrected time sheet, and any errors that have come across from scanning are corrected, so effectively we print it out, we transcribe it, we scan it back in, and we correct it, and I was joking with them and saying, would you not get a combined printer scanner so that you could print it out and scan it in at the same time because it was getting just ridiculous, but it is just the way it went, and we're stuck with that system, and they kept saying to us during the project, well look, because of the number range on the existing time sheet, we have to fix it within 18 months, but certainly once the project came to an end, they discovered the number range would allow them many years to fix it, so the urgency is gone, so we are stuck with this."*

Continued on next page

Table A.3 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
	Automated materials ordering.	JOL: *"The Design Officer goes out to a job, or, we'll say areas they're replacing the line in Sarsfield Road, right. And they goes and says, yeah we need to replace that line. It needs eight poles. It needs, ah, five hundred metres of, of service cable. Or for that purpose it wouldn't be service cable but, ah, it needs this. It needs so many insulators. He designs that job and he, he comes up with a design for that job, alright. At the minute he designs it, he releases that job that orders the specific materials for that job. So, now, the materials, so, that, that, that's a complete turnout in the sense that the materials are ordered now specifically per job and, to a certain timescale rather than just having them on the shelf."* MK: *"I use FMIS for material ordering, looking for PO number - I used to be able create em before they've locked all that down. So, for viewing POs and for, uh, when I have to go looking for job numbers and stuff like that, ah, I can go in there and start lodging costs, then, d'you know what I mean? Looking for WBS numbers then and stuff like that."* JC: *"For your house then you might need a one off design so the designer will design in IWM and they'll also then when they're doing the design they'll be picking off all the different types of materials and that's all going through to the stores as well and putting a requisition on the material, that's all in there as well so should make our stores process more efficient as well because that's integrated and then we can build up the cost for it in here you know."*

Continued on next page

Table A.3 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
	Job Design	OMcC pp11-12, 17: *"Let's say, very often happens a customer lives in the countryside, they're getting a supply of electricity ok and as part of that new supply we have to build a couple of poles, put up a few poles low voltage poles, so I'd have a VCU for that section of the job, poles into a new business supply to a customer ok. But then if I have to change a transformer or a few more poles it would be what we would call a system improvement ok, but we're improving the system generally you know because the transformer maybe is a bit overloaded you know because the location is wrong so you'd have a different VCU for that because of the fact it is a different type of job, it's not the new supply, it's just improvement right. As well as that if it was never a system improvement, let's say I had to put up a transformer, the customer was we'll say 400 metres from the nearest supply and I had to build a high voltage line, or a medium voltage line and a transformer I would have to, I would have to pick another VCU anyway because there's different you know..., can I just show you, where can I show you that now again, ok here. So as I go down through this you'll have the drop downs here ok so these the different VCU types here. So you have overhead single phase, three phase overhead, single phase service, three phase service, substations, there would be ground mounted type, bigger type service stations rather than pole mounted sub station. And then you have underground cables and that yeah. So you have two, four, six different headings there, right. Now, let's say, oh of course you'll have high voltage, medium voltage and low voltage overhead networks. So that's a doubling up of the factor there do you know what I am saying?"*
Integration	Red-threading of existing processes to achieve tighter integration.	JC p12
	BW as integrator	BN: *"It depends on the extent to which it takes our existing systems and takes the information from them, right. I think it's as best as could be done because it was a major, major project and given the, the variation and the complexity in terms of what we do, depends on how well it sucks up the information, particularly the Business Warehouse end of it is the piece that I am interested in, not the IWM per se, or not the SAP element of it. Because that's the bit that we are depending on to interconnect all the systems that we are talking about. They were all developed independently, not communicating."*

Continued on next page

Table A.3 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
	ARM and IWM as integrators	MK: *"Four years ago this wouldn't have been there at all like. You'd have printed a maintenance order. You give it to the lads. You sign off on it and you literally filed it and you report it on a completely different system to the actual printing and the management system thing and that fed up the chain, whereas with ARM they've integrated all of that. And with IWM they've integrated design, construction, reporting and the whole thing so the whole thing is married. Only from the point of view that I have to get materials out of stores, and, uh, I have to use the CU order numbers for time sheets and stuff like that and at the moment we're very early days of the implementation of that, eh, that said it's six months down the track, it's early days cause we've only just seen it in the last month or two in any degree."* JC: *"I'd say we're probably behind where we wanted to be in terms of,..what IWM, IWM can allow us get a better performance view regarding how we're doing with various resources whether it's the time, the materials, and equipment so yeah, I think, there's probably a certain element of catch up there, but again it's to do probably with systems not being integrated and now they've been integrated if I see the costs on a particular job I can go right back into the week, the day the costs were incurred, who it was and all of that."*
Learning	Matching of work practices to computer systems	PC: *"Up until the mid 80's EnerCo's attitude was, we have our way of doing things and we'll build a piece of software that will mimic the way we do things, and that's what DWMS was, we built DWMS from scratch, we created it on a VAX platform and we need to try sell that product onto other companies, but it was based on the way we did work, and since ISU came in, we've discovered that we've had to change our work practices to how the computer systems works and so when IWM came in, IWM was able to mimic quite well what we were doing, because I think they'd looked in the 80's, at our best practice of organising the systems and we seem to have adapted something that this compatible unit, that IWM has, seemed to satisfy nearly all our needs, so there would have been certain amount of customisation, I'm not sure how detailed it went, I do know they were saying that the compatible unit provided the real standard costs of the compatible unit, fitted that very well."*

Continued on next page

Table A.3 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
Reconfiguration, Transformation	Compatible Unit	JC: *"It's a building block but it's multi-dimensional, it's got the financial side of it, it's got the asset side of it, it's got the materials you know so that whole thing of using an entity, a core component that has all of these different dimensions, that everybody uses and everyone feeds off, that's great strength in that but then when somebody wants to change something it can have knock-on, unintended consequences."*
	Automated ordering	OMcC: *"You could pick today or you might forget to pick it and it will default it to today's date and you could go through the whole job, it could be a big job you know there could be a lot of big equipment in it and you'll sign off on the job the whole lot, it goes on to the Construction Supervisor, the electronics behind the screen will automatically order all the materials from central stores to local stores and you'll have trucks coming down the road like with all the stuff that isn't needed for months jamming up the stores so that can create problems."*
	Change in Construction Supervisor's work	OMcC: *"[The Construction Supervisor] will be impacted all right because he hasn't had to deal with that on the computer before so all of his time now would be taken up now pressing keys on the keyboard you know."*
	Supply chain changes	PHa: *"Well that's like, we would have, I suppose years ago, well 9/10 years ago, we would have had 3 main depots, one was here, actually this complex here would have been one of those, and there is one in Limerick and there was one in Dublin, then it was rationalised to one central depot, and all, you know, the smaller depots feeding out of that, and that's still the model that we have, but as I said, to go down, to have demand driven MRP at the top level would have been, it wouldn't have worked in EnerCo, because there's too many, you know, how do say, I suppose risks in EnerCo, and the way we do our work, so we didn't go for that complete model."*

Continued on next page

Table A.3 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
	No changes for crew	OMcC: *"Very little [change for the crew] I would say, well I can't speak for the crew of course but I can say, the bit of paper I'm giving the crew it hasn't really changed a huge amount, it looks different but I mean, no they are putting..., they are compiling a bit more information all right on the assets as we call them so they are transforming information and all that, they are recording more of that, ok. But you know they are still getting the same piece of paper from me, design sheets and materials list, that sort of thing you know, so it hasn't changed a huge amount I would say."*
Positions:		
Technological	ARM, IWM, BW	

Continued on next page

Table A.3 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
Complementary	Organisational structure	PD: *"at the moment now I would have Champions for the Clerical Officers, for the Supervisors, Project Leaders and then Design EOs. Now the bulk of them would be, we'd have five Champions in the COs and we'd have four in the Design. What we done also is different, is totally different to everyone else ... I said [to our manager], listen, I don't want to tie Supervisors up at a desk. One of the problems at the minute is that we don't have enough on the ground doing safety audits and doing. So we looked, how could we ensure that this wasn't going to tie them more to the desk than they would because this was all about managing their projects, dates, percentage complete so there was going to be a little bit of extra computer work. So we looked at it and looked at the value in that and weighed that up and looked at the benefits and said listen, we'd appoint five project coordinators, two for the north, two for the south and one for Dublin who would assist the Project Leaders on a monthly basis and would sit with them and where necessary update their projects. But the Project Leader would still and the Supervisor would still own the project, these would only input information that they were asked to by the Project Leader. The day to day updating they would do themselves, the Supervisor would probably deal with month end when they have to do the reports. They have to go into every project and some of these could...there's a huge variation some Supervisors could have eighty live projects at any one time and others may have only twenty, depending on the nature of the project. That's a fair piece of work, to go into all your elements of your programme and update them. You could find you sit for three or four days at the end of the month and just having that time in fairness. So that worked very well because the Project Coordinators we have were actual Champions as well which, these people have a wealth of knowledge....it would be a devil to let them back to the day job as well and lose all that and so a percentage of their time now goes to updating. Say they might have, each one of those would have twelve or fourteen Supervisors, each one of those Project Coordinators. So they, they sort of manage the projects for them and it frees up the Supervisor and Project Leader."*
Paths:		
Dependencies	No structured system prior to IWM, ARM and xRPM.	MK: *"It was just an Excel spreadsheet. There was no feeding back into a system. We created our own paperwork and managed it that way. I had one system. The crowd that were looking after Cork City and West Cork had another system."*

Continued on next page

Table A.3 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
		PHa: *"Well its, I suppose it's as a result of IWM, but what we did was in the depots, where heretofore where we had reorder points, you couldn't operate reorder points with demand driven MRP, with demand planning if you like, so we had to change our order points to safety stock, and that in turn will then kick off, if you go below your safety stock, well then that kicks orders automatically, because I mean the fundamentals of SAP had to be changed for demand, I mean we were going from, if you like, historical planning to demand driven MRP, I mean there was a huge, the configuration of SAP had to be changed, to suit the local depots, so we had massive uploads to do at the start of IWM, we had to change special procurement keys, I don't know if you are familiar with SAP and how it works."* PHa: *"The regulator I suppose, so far, hasn't delved down into it, now, I mean I suppose, indirectly yes, because corporate finance if you like, in the last 2/3 years have become much more interested in the amount of stock we have, you know heretofore MRP was ongoing, if we had 200 million Euros worth of stock, they weren't that bothered because it was a case of contractors in to work out, we didn't want any shortages of materials, so nobody was looking at, but I suppose in the last two or three years things quietened down, I mean there is more and more, it's not like nobody from the regulator will come to me and say you know, you have x amount of stock you know, but they are as you say through corporate finance, I mean KPMG do audits at the end of the year, and I'm providing them with stuff at the moment about our yearend figures and, but I mean at the same time, like we have to get our, were working towards getting our stock base down, I mean we took I think 15 million out of the stock account out last year, we were reduced by 15 million, so an awful lot of hard work involved in doing that, we won't get the same out of it this year, but we've kind of set a target of somewhere between 8 and 10 million, and well reduce it, it's still a huge amount of money, but like our turnover has dropped from over 200 million at one stage, down to just over 130 million now so you know, you have to keep your stock, you have to bring your stock down in accordance with that."*

Continued on next page

Table A.3 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
	Shift in nature of work	PC: *"As part of my production performance job, I would have to try to predict the number of new connections we are going to have in the coming year, and you, it's hard to do, I mean we, about 6 years ago we peaked at 105,000 new connections, the following year it dropped down to 95, then it dropped down to 65 and last year it dropped down to 34 and its looking like this year, could be around 20,000 new connections, so you can see, we're doing a fifth of what we were doing 4 years ago, so but that's you know, trying to guess what you're going to be connected ... We discovered that because we're running at a fifth of what we were doing we have to reallocate and retrain staff to do project type work. The good thing about EnerCo, is that we have loads of project work to do, and because we have so many new connections and everybody was rushing around like mad, for the last 4 years, we are behind on our planned work, so there's at the moment, plenty of planned work to be done so were are retraining."*
	DWMS	PD: *"DWMS yes was our old system and even with some offline systems as well because with contractors DWMS wasn't even suitable for us because we hadn't maintained DWMS in the last seven or eight years. And the volume of work we were doing with contractors, it didn't suit, so we actually developed what they call a Pendulum System there about four of five years ago. It's just an access based, data financial system, but so had the volume of work we were doing with contractors for the low voltage and they were doing the designs in that and still are but we are putting them into IWM now, the contractor is still collecting this information out in the field on the system, you know so that's where I was landed with that and it was midway, a lot of the groundwork was done when I turned up, they were just finalising I suppose, some of the checks and the testing of it from May and June and July is when it went live."*

Continued on next page

Table A.3 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
	DWMS	PD: *"No, the problem, well the only problem with the DWMS I suppose, number one and I suppose it was a system that wasn't user friendly. Now, it was, if you went into it and didn't know what you were doing you could end up, you hit the wrong button the whole thing would just collapse and you would lose everything you were after. But that was purely because it just, they made a conscious decision, four figures, we're not going to maintain it and spend any more money on this. It didn't have all our materials in it and what do we call them, CUs now, so we would end up doing designs, limited designs, if I can match something, what can I pick that will suit this 'cos we, over the last eight or nine years, our systems have developed so much and we've got so much new materials, new metals, ways of doing work that DWMS hadn't got that and wasn't able to cope with that. So you were getting out very limited information and as a result of that people weren't placing much value on it, they were getting out man days and costs that didn't really reflect what was happening so it was defeating, ok, it was. All it was, it was giving someone an estimate of roughly what, so, and it was probably, as a result of that, it was probably being abused. People were able to hide behind it because when you had over runs no one knew whether it was a genuine over run or, well they did, but they were able to hide it because, well listen, the DWMS said this and we know the DWMS is not accurate. So there were certain people able to hide behind it so you were never, you were always looking, you planned the next one and were never close, they didn't bear any resemblance."*

Continued on next page

Table A.3 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
	DWMS	PC: *"Well we had an old DWMS system, distribution works management system and that was getting to the end of its useful life, it's an old VAX based system, so it wasn't, it wasn't all bell and whistles, but it did the job, you could do a quotation in it, you could quote, the quote went out through ISU, but you could pick out the materials for the job. You could print out, what we call an authorisation, which allowed the supervisor to see what work was involved and drawing went with that and then there was, you would allocate a work centre number for allocating, collecting costs, but all the costs we had were bucket costs, so we have 3 types of costs on the new connections side what we call 30,001, 2 and 3, where a G1, G2 and G3 connection, so G1 are housing schemes, so if you came in and looked for a housing estate, it would be connected with 20 houses in it, we would allocate those costs to 30,001 but if the next guy came in, looking for a housing scheme with 26 houses in it, his costs would go in 30,001 as well, so everybody's cost for housing schemes went into one bucket, similarly 30,002 for the once off domestic connections, so if there were 40 people applied, they all went into the one place, G3 for commercial, all went into the one bucket, so what we wanted IWM to do, is to be able to, if you came in looked for a connection, that we would look at the costs that went to your job only, and have it separate, and when you are talking about 20,000 once off new connections a year, and another 20,000 housing scheme connections, that was 40,000 new cost collecting locations, that were required which DWMS couldn't handle, there was a VAX based system, the accountancy system couldn't handle it, so we wanted to be able to track, the amount of money that we were charging the customer, which is now separate from the work involved, we wanted to track what the EO was authorising the work for, which was sort of the middle one, and the final one we wanted to check, what money was spent in that job, so we could compare money received in to money planned to spend, to money actual spend, and that's what its delivered to us at the moment, we also wanted to look at crew efficiencies, and we wanted a proper scheduling system for the crews, so up until now, we had a web based scheduling system, and so we wanted that pulled into IWM as well, so we get DWMS which is VAX based, we had a linked scheduling system, web based and then we had the accountancy system which was, which had moved to FMIS, but was completely removed from the whole thing, so it was a case of pulling all those things back into the R3 model, and we wanted one big box with everything in it."*

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Table A.3 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
		PC: *"Ten years ago we were a lot further, we were a lot more diverse, in the way we did things, but we centralised a lot of our processes, our new connection processes, we've a bureau in Athlone that does all the new connections, so and that's as an example: ten years ago a person would apply locally for an EnerCo connection, so would arrive into a local desk in an office, and it could sit on the engineering officer's desk for six weeks before he'd look at it, and then when he'd look at it, he'd set it up on the system, set it up today, and quote the guy tomorrow, and it looked like he was being quoted after one day, because it was only set up the previous day, so what we did is, we got the bureau now so that everything, there is no local applications, everything has to go into the bureau, they set it up, if they can, they will quote it straight away, if they can't they will sent it out to the local office but it's on the system and its been tracked."*
	Rapidity of change	PC: *"Well there were just changes, this is our first SAP system, the general public use it, the general workforce using, so things had to change and there were market messages, the market was involved, things had to change quickly, we didn't know what we we're doing with ISU, I remember one guy had a screen with a whole series of questions on it, and the only thing he recognised was division and he was putting down mid west division because he knew that's where he was, but it would take it would only take a number, from 1 to 3 and it turned out division stood for either water, electricity, so the naming was all wrong so we were at a complete loss with ISU, but we were aware of that for IWM, so we were able to use it and we surprised ourselves how quickly we adapted."*
	Move to JIT techniques	JOL: *"And, um, sort of historically in the EnerCo, I suppose, in, in a sense we could probably be guilty of over-stocking in a sense that like you'd have those, all those units fairly readily available in Dublin, that sort of thing. But, now the, that was in the NRP, when the NRP program the drive was, sort of, the focus was get the lines done, get the materials up and that sort of thing and we'll worry about the material costs and the material book-balancing and so on and so forth later. Now there's, now that the work has slowed down and there's a kind of different focus. The focus is we get the materials right, so, trying to implement the sort of just-in-time system. "*

Continued on next page

Table A.3 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
Opportunities	Integration of IWM with work site.	COC: *"It's a nightmare, like it's absolutely the holy grail, is that they have the work orders on the hand held and they literally just tap, tap, that's what they've done, and all of that sort of stuff, and like I say a start was made and I think they're still using them in Finglas, for the substation maintenance, it was relatively well, but like I say, the hardware couldn't, whatever it platform was, couldn't actually roll out, it ended up coming to a complete standstill like two years ago. Oh it was disappointing, it was very disappointing, again I have no doubt that it will form the basis of whatever Paul and whatever that working group that gets set up when that project team gets settled. I'm not sure its next year or the year after, but certainly at some stage over the next five years, a lot of work and time and effort will going in to getting that right.*
	Increased flexibility from IWM	PD: *"So with this system now, I mean, it's, that's the one thing about it, we can develop, even on a daily basis now, it's easy add. Whereas with DWMS, if you wanted to add anything into DWMS, update it at all, it was a hugely laborious task to go in. You had to shut the whole system down, close it down, go in and add your codes or whatever you had to do behind the scenes. Whereas with, we have a, we have a CU librarian now who, if we have a code that has to be changed, it's a simple two minute job. We just ring them, say listen that code now for that piece of equipment is no longer, we're buying off a different supplier with a new, they can change it immediately so it's up on the system the next morning and each of the team, we would have our own CU Liaison Officer as well. You have one person that everyone feeds their information through and he fills out the request forms and sends them off so there's constant updating now, so the information you're getting now is as accurate as it can be you know. So that's the big plus with it, plus it's very flexible in that even for people doing designs so, if, 'cos a lot of our designs are repetitive designs so once you do a design once you can save that design and the next time you go in, you don't have to redesign your job, pick that design and bump and it is gone instead of spending two hours building up a design, you can just copy your designs in a way."*

Continued on next page

Table A.3 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
Value	IWM increases granularity and control of costs.	JC" *"Yeah, I'd say we're probably behind where we wanted to be in terms of,..what IWM, IWM can allow us get a better performance view regarding how we're doing with various resources whether it's the time, the materials, and equipment so yeah, I think, there's probably a certain element of catch up there, but again it's to do probably with systems not being integrated and now they've been integrated if I see the costs on a particular job I can go right back into the week, the day the costs were incurred, who it was and all of that"*
Inimitability and Non-substitutability	Erosion of specific skills due to subcontracting	FOB: *"Big workforce, we use both internal resources and we have a significant contractor management process as well."* BG: *"... from start of 2011, we kind of mobilised contractors separately around the country there last year, to start getting some of these done separately ..."*
Exploitability	Resistance to complexity of ARM.	MK: *"There needs to be an Asset Register. There [needs] to be some way of creating work orders so the system is followed. But, for me to use it is way up and above and beyond what I need. I don't need this. I don't need to know whether the job numbers are there or not."*

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Table A.3 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
	IWM - process misfit	PD: *"We've still issues now, with...for one reason or another people haven't tested the system for big projects. Now we've a big project set up over four or five year and we want to break it up into four or five jobs. System doesn't allow us to that at the moment in that they've no testing done and they're afraid to allow it. We know it can do it but it hasn't been tested and it's obviously something that wasn't pushed or wasn't thought of early enough that we would want to break up a big project into four of five contractors. We wouldn't have done that two or three years ago, it's only now we are seeing that ...with the Regulator and the constraints he is putting on us, he's saying listen, I want... this is your plan of work, I want it done by the end of next year. We've realised that our own staff are depleted so much and we've so many contractors in that a lot of our staff are working with the contractors. We don't have the staff on the ground to do a lot of that work ourselves and contractors, even though, by and large, they can pull in extra resources... but the nature of the work with us, there's a whole training and safety issue so we find now instead of having to pull in extra resources we're having to lump multiple contractors in on the one job and the system is just not tested for that and it's caused us a bit of grief so it is."*
	Supplier uncertainty	PD: *"But now, they're all gone now, that supplier is back to a core staff producing about a quarter of what he produced last year but EnerCo didn't plan for that now. We're after getting caught now where...and to bring a new supplier on it takes six months at least before he produce anything and that's where we got caught as well, when we lose one supplier and bring on the next one, you've a gap there and we've halved that now with some conductors and that. So, this, hopefully it will flag them, the material forecasting will flag the area enough that listen by then, by next year we'll want x amount of transformers so we can go out and then check with our suppliers, and he'll say either we can or we can't so we can go and source another supplier well in advance so should avoid those shortfalls as well, so it should."*

Continued on next page

Table A.3 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
		OMcC: *"one thing we are not actually doing at the moment which we might get into the habit of doing is there are templates set up for IWM like, ok, you know so that if you were doing it, we'll say a housing scheme job that you'd have a list of stuff in front of you that you could put in a number and it would automatically have all the VCUs up there. It would half fill them in and then what you would be doing exactly is subtracting stuff, adding stuff maybe something like, I haven't...got, I've never had the time to actually try and do it you know. But on a bigger job it should certainly help you all right you know, you know what I mean so it will automatically have a load of stuff up there and you'll probably be taking stuff off rather than adding to a large degree and that probably would help all right on a bigger job. But as I say I just never had the time to try and figure out how to do it."*
	Bedding in of BW	PC: *"I suppose one of the things we wanted to get out of it was a proper reporting mechanism as well, and the, we knew from the start, that the reports wouldn't be coming out of IWM, they'd be coming out of business warehouse, which is the, I am sure you are aware, of business warehouse, its this reporting package which sits, it downloads from IWM or from SAP R3 every night whatever, and you can update it, so our experience with ISU was that reports were very slow to run in ISU, so that you we're better off running in the business warehouse environment, you download every night, on one of your XX a day, so our, my hope of it was that we would have business warehouse reports at the end of it, which give us all the answers we needed, and allows you then to breakdown to the smallest detail, and roll it back up again to the very top, very quickly, so that was the plan, whereas IWM itself, is implemented very well, business warehouse has still produce the goods, its producing reports which we've been unable to verify, so, but we'll get there, but it could be another three or four months before we get there."*

Continued on next page

Table A.3 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
	Bedding in and tweaking system	BN: *"I expect we will, we will, first of all we need to bed this in, we've identified problem areas and, and for example in the changeover we've had a number of projects which have actually, in some cases, stopped. In other cases we've had to find fast solutions, because for example we find ourselves not being able to get materials out for critical projects because the system doesn't recognise it. So really I'm saying we're at bedding in stage. At any bedding in stage, there's bound to be teething problems, so, we're at that stage, so, basically. It's a pain in the neck for us at the moment but I've no doubt we need to work through that - it's only a question of identifying where the tweaks are needed and putting those into place."* MK: *"I have a funny feeling that because of the age profile probably of the auditors and what have you they're probably more comfortable seeing paper because that's something they understand.Maybe, I don't know. I've had that experience, d'you know what I mean. We have to file all of this and have it in some semblance of order. And, um, d'you know it's hugely cumbersome. There's a huge clerical side to all of this that, um, doesn't need to be there. But it is there. That's the system we have and it is there. So, we have a huge, cumbersome... you have a wonderful system for the amount of information you can process and handle. You can generate screens and, all, masses of information. We have, we have the whole thing here on the desk in front of us the, the financial management of it, the asset management part of it and all of that don't need to see it. Do I need to care? No, no. All I need is to get work out to these lads, get it back and input it in something that's quick, simple and easy and efficient. And, whatever systems have to be put in place so that I can create stuff in the background or someone works away in the background with other stuff to feed other than, d'you know, very basic information would be nice."*

Continued on next page

Table A.3 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
	IWM as enhancer of stock ordering	PHa: "If in terms of, there are lead times, because each store has delivery time, from that Ballycoolan, so most of the big stores will have 7 days, some of the lesser stores, 14 days, the contractor sites have 30 days, so the system is looking 30 days out, and it says these are all the orders the orders that are rolling up for the next 30 days, and these are the picks that are going to be generated, so that Ballycoolan generates picks on a daily basis, so if for instance Sligo is due to be picked on Friday, that pick will be generated on the Wednesday, picking on the Thursday, and it departs on Thursday or even Friday morning, to arrive Friday morning, so IWM, it will only look forward that far, in terms of deliveries, but for us to order materials off the supplier, it's looking forward a year, so it'll pick up all the demands that are in the system, it'll relate those back to us, and then we can order materials based on a reorder point."
	IWM requirement for stock ordering does not fit stock replenishment processes.	PHa: *"In a lot of cases, now some material, especially for customer services, is as we call it bread and butter material, its stuff that are in use every day, we have high volumes of it coming in and out, if we only get 2/3 weeks notice, we'd be fine because we have enough of it in stock, its where you have projects guys who are looking for specific materials, that they would only use for this project, some of it is 6/12 month lead time, so you imagine if you were project supervisor, and you have a guy designing a job for you, and if you say to him, well you know put that in for next month, well that's fine, he might get 50% of the material, but if he turns down, we don't carry stock of 10 items, anywhere from 6, 3/6/9/12 months lead time, but he can't do that job, so it's in their own interest that they get this whole thing of planning right, and anyway, I would contend that, if you're planning a job that's that big, how could you be at the start of tomorrow only be going through the planning process of it now, so you know, these are the issues that we have, as I say, this was just a presentation that we did to services, just to show some of that stuff so again, I mean you can take it Simon, there is nothing in it that's contentious, there's nothing in it I don't think that, then again it may not be any help to you, so you know, this is very, very old stuff, starting at the very beginning, again there nothing in that wouldn't."*

Continued on next page

Table A.3 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
	Stock visibility	PHa: *"If the dates aren't done, right well then OK that could be kicked off that could be delivered within a week if it falls into the pick cycle, or a month, but if that job really isn't going to be done for 3/6/9 months, all that material for that job is sitting in, now it's in stock, in the depot, it's not booked to the job until the guy comes over and actually physically takes the material, so we have we had visibility of it, which is something we didn't have prior to IWM, because if material came down to the depot, well the first thing the supervisor did, booked it out to a job number and it was gone, we weren't concerned about it, but now it doesn't go out to that job until you as an NT comes in, with your paper, says these are the items I want, they're booked out, the paper work is done, and the NT then books out goods XX as material, and he's gone, so that's I suppose, if there is an advantage to it, the advantage for us is that we have visibility of stock, OK we mightn't like to see it, but it shouldn't be in the depots probably but at least we now have visibility of it, I mean we'll go through and exercise before IWM came in, which involved getting all the MSSs around the country to go out, to all the depots, to talk to all the supervisors, and try and get the direct debit material back into stock, this could have been material there for 6/7/10 years, that had been booked out to jobs, as jobs were never done but it wasn't visible to us, so we took back I think nearly 10 million Euros worth of material, you know, a lot of supervisors didn't want to let it go, because again they felt well once they have it there they can always use it."*

Continued on next page

Table A.3 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
	Stock ordering	PD: *"No, no you...say your Supervisors or Project Leaders wouldn't, they might use it once a week, they might say set aside half a day on a Friday to go in now and just... One thing they want to be checking out right is their materials, see is it accurate, to make sure that the dates are right and to know when it's coming just as a check and equally just to keep an eye on new projects that's coming on. To see, manage the dates on and see that the next project they've planned that...when a project is set up the one, I suppose, big challenge for us here, is, in the past designers worked in lots of cases remotely from the Supervisor of the project. They were given their job by their Project Leader, they designed it and they just handed it, like, there's a job for you now, go and do it. But now, with you know, setting the job up, he's the one that dictates the dates, well he doesn't dictate them, he inputs them, so he needs to talk to the Project Leader and the Supervisor, where are your... because if he puts those data right that's what'll join...he puts them wrong and we've seen that a bit with, with, with...at the start the first week or two the lads didn't recognise the relevance of that because it's a total new phenomena and we would get materials immediately for jobs we weren't even starting 'cos if you don't put in a date you see it will default to the date you design it. Everything straight away, now that causes a problem for supply chain as well, they see all these...'cos they had it a bit with Services now even though they were smaller jobs but they didn't get to grips with either and in the first month they had two and a half thousand jobs all the materials ordered the same day it was designed so that was a teething problem and has been sorted out now. Once people understand the relevance of that date; now that's being managed well."*
	Integration incomplete	MK: *"Uh, well, it's having an impact as it stands, because it's not, the system's not fully integrated as it should be and you start a job in IWM and you can't get materials cause they're not on the design and trying to get them from stores and then suddenly you get two or three items coming on and you don't need them and trying to get them back and sort out material."*

Table A.4: Determining Asset Policies.

Characteristic	Manifested As	Evidence For
Processes:	Pricing round negotiation.	PH: *"We agree what the value of the asset base is and agree what return we are going to be allowed on the value of that asset base and how the asset base is going to be depreciated ... we also agree how much we are going to be allowed over the course of that 5 years to operate the system."*
		IC: *"We have to include proposals for our maintenance ... [including] what the costs will be and the frequency that we would propose to do it. That's open to challenge from the regulator."*
		LR: *"We're always looking at our policies and saying, should we change the policy to reflect the newer or older asset base, our asset class or whatever."*
	Maintenance policy determination.	TL: *"You're better off having as robust a policy you can have ... achieving 100%, as opposed to some aspirational policy ... only completing 40 or 50% of it."*
Integration	Tight coupling of Pricing Round Negotiation and Policy Determination processes.	LR: *"The [policies] for the assets are our responsibility. But ... we work on five year cycles ... with the regulator. We recently made a submission for PR3 and we [had] to include proposals for our maintenance. That's open to challenge form the regulator."*
Learning	Nominal controllable operating costs per unit distributed have dropped from 1.00c/kWh in 2001 to 0.87c/kWh in 2010.	Distribution performance reports CER10122 (2004) p5 and CER11090 (2010) p15.
Reconfiguration, Transformation	ARM introduced flexibility to existing processes.	LR: *"It also has great flexibility in that halfway through the year we decided - pressure was put on us - to reduce our OPEX spend ... It would have been very difficult and time-consuming [before ARM]."*
	Transition from time-based to condition-based maintenance.	TL: *"You literally can work through this specific job card and you're ticking in a lot more defined ranges or criteria ... [it] is fed into the system and it allows you to get a lot more focused ... moving towards condition based maintenance."*
Positions:		

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Table A.4 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
Technological	SAP R/3 Asset Register (ARM). Replaces older standalone asset register.	IC: *"ARM broadly replicated the database that was there."*
	DocuLite Repository for policies.	IC/LR: *"They're paper policies ... and our Doculite repository."*
Complementary	Asset Manager. Asset Manager's ability to formulate and rework maintenance programs contingent on knowledge and experience.	LR: *"When you have the the knowledge and skills and experience to understand what that change is going to mean for end end users, for safety. It's not just about understanding how to do it in ARM, [it's also about] understanding the electrical system outside."*
Paths:		
Dependencies	Asset records originally maintained locally, then on MS Access database and then on ARM. Register built up over time. A lot of data carried over from old system.	IC: *" ... our records of maintenance were kept locally prior to the Access Database... [ARM] fairly replicated what was there previously which had worked for a number of years."*
	Move from asset replacement to asset maintenance.	LR: *"It started out [with] a lot of asset replacement in the first couple of Price Reviews and that it moved on to concentrating on reducing operating costs."*
	Existing policies were restrictive	TL: *"... our current maintenance policy was actually quite stringent, compared to certain regimes they had in the UK."*
Opportunities	New flexibility to modify annual asset maintenance plans mid - year.	IC: *"... if anything needs to be changed over the course of the year, it can be changed very easily in ARM because orders can just be added or removed."*
	ARM provides repository of data to answer future challenges from regulator.	LR: *"The will challenge things ... I have no doubt, if they do send in consultants, they will look for background information to back it up."*
Value	Regulatory pressure to do more for less. Ability to replan allows for savings in operational expenditure.	IC: *"... the regulator is expecting us to do more for less money all the time ... pressure was put on us to reduce our OPEX spend ... without a system like ARM ... you would probably have had to do a lot of trawling."*

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Table A.4 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
Inimitability	Asset manager needs to understand asset register and network. Determining asset policies is contingent on tacit skill, knowledge and experience of asset manager.	LR: *"That's the benefit that [asset manager IC] has is that he has, the full knowledge of both ... understanding how to do it in ARM ... [and] understanding the electrical system outside."*
Non-substitutability	Contingent on accumulation of knowledge of asset manager. Time needed to build this up is a barrier to entry.	LR: *"[Asset manager IC] is an expert user ... where people are not as expert they do get caught up in the system and they find it inflexible. when you know the system inside out you can work it very, very well."* IC: "*I have been involved in the maintenance the last year of the Access Database and the first year of the ARM and the subsequent years and the transition between the two."*
Exploitability	ARM increases ability of Asset Managers to re-plan. Current ARM usage suggests means to improve policy planning in future. ARM drives future PR negotiations.	TL: *"We're primarily using ARM to create maintenance work orders ... we're not capturing qualitative data, that we can capture on a system ... and get more focused maintenance."* COC: *"They've cut us back a lot on OPEX; what we've been able to do, is we've been able to say, we have pretty much got approval that we were going to be allowed to replace X number of particular types of switch gear, over the next 2 years, because of their nature, so what we have said as well, if we know that these particular units are now on a list for replacement, well there's no point in actually doing a proper full maintenance programme on them this year or next year. So using ARM, what the lads are going to do is they're to say right well we can do a hazard inspection alright, which is just a quick look to make sure, but we're not actually going to do a full maintenance, and waste money on units that're going to be replaced in the next two years. If we didn't have ARM, if we didn't have that information on an IT system, if we weren't able go in and actually make those changes, so that the work orders will only come out for the work that we want done, you couldn't do that, like you couldn't have done that a few years ago."*

Table A.5: Servicing Existing Assets.

Characteristic	Manifested As	Evidence For
Processes:	Annual Maintenance Planning.	TL: *"It's done in and around November ... Asset Register Administration manually input [paperwork from the field] into the system ... The create work orders on the system ... Bulk stuff like a 2010 plan for maintenance [is scripted into the system and released]. The next day the supervisors come in, and there's all their [work] orders on the system."*
	Maintenance Execution.	EC: *"There's a detailed inspection done every year an then based on the condition of that there would be corrective maintenance as a result. What the guys do is they go out and they rate the equipment in the sub[station]. There is also condition-based maintenance. If the [38kV] oil barkers operate six times under fault conditions, on the seventh time it trips, there's maintenance called on that particular piece of plant."*
Integration	Consolidation of asset maintenance with other on-site processes like upgrades of network equipment.	BG: *"Rather than going in, having to go into each of the individual widgets, and do a design for that circuit breaker, that circuit breaker, we are combining that into one asset replacement portfolio item, which then the supervisor on the ground, has one WBS number to attribute, [he] does the design on all of that, so the EnerCoI designers are doing it, it may change from upgrade in area insulation switchgear, or it bus bar that to put in the modular, because there's so much other asset replacements and it's much better just put in a pre fabricated module, so it could change the actual design, whereas rather than going in and giving half the job to the designer and then find out later, oh damn we've know other equipment there that should have been done, and its redesign then and all of this redesign, so its, we're definitely going to leverage on IWM in its functionality, to say from the widgets perspective, be they from the asset managers or the operations manager, who needs or to use uprated or whatever, from the load perspective that they have a mechanism to go in when they're doing their initial concept on IWM, to package the work to see what's being called for by other parties in asset management, and then package it, put it together, agree it around the asset management table, and then approve that work package over to the designers."* MK p17
Learning	Reduced asset maintenance cost.	COC p8 specific question on this issue.

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Table A.5 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
Reconfiguration, Transformation	Transition from time based to condition based maintenance. Vast increase in asset data accuracy and detail drives modifications to processes where site work is consolidated and condition based maintenance becomes the norm.	TL: *"It allows you to kind of get a lot more focused on ... moving more towards condition based maintenance."* COC: *"At least we're already starting to think asset management and trying to get asset management thinking out there, like things like condition based maintenance ... as opposed to everything being cyclical"* COC p8, p10 BN p13
Positions:		
Technological	Existing asset base.	All interviews refer extensive to regulated network asset base of distribution network. In addition, CER/EnerDist documents such as the annual distribution performance reports (e.g. CER10118, CER10122 CER11090).
	ARM	EC: *"ARM is the the maintenance asset register ... and it has two main functions: An asset register, obviously and then the maintenance management side."*
	IWM	AB: *"We're hoping that with the IWM introduction that it will enhance the asset register, I know it makes us more dependent on it you know because this is how we earn a lot of our money, how we plan our maintenance, how we count up the value of the company ... so the way IWM kind of enhances the ARM model is that you cannot [approve] a job financially until it's been [approved] through the ARA which means the Asset Information has been returned [from site]. Now it's like oh, you want credit for that job, better give me back the information"*
Complementary	Asset Register Administration.	AB: *"I look after central cite and ARA, that would be the ARM system and the [Asset Register Administration] would look after the Asset Register."*

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Table A.5 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
	Asset Management Forum.	HH: *"The asset managers, the network investment and operations, so bring those three together and say OK, you want to do X, you want to do Y, and you want it do be done with Z .... What we're actually doing is either trying to refurbish, replace or upgrade assets, that's basically what we do, that's the business .... So the Asset Management Forum is me saying, OK, [the] three of ye sit in the room [and] decide, what its is, you have all the requirements, but you have one individual project."*
Paths:		
Dependencies	History of asset maintenance is one of increasing detail concerning assets driving changes in procedures. Transition from time- to condition-based maintenance.	AB: *"So we're given money to effectively manage the assets based on what assets we have, you know if we can't count the assets, place them and accurately predict what kind of work will be done on them well then obviously when we go to the Regulator we'll either come up short or, and like years ago you'd go and they'd say how much do you want and you'd say oh we need it to refurbish all of our poles over six years and he'd say how many then - heaps - and he'd say well we'll do them all and then we'll tell you - that doesn't work anymore you need to know all this in advance."* COC p8369 p10 MK p19

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Table A.5 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
		"[Now] it's like, we can turn around and say oh yeah we know we have so many breakers do we know where they are, do we know [are] they oil and we can't attach the correct maintenance policies to them and this is back to leveraging from the IT systems and we have a system now whereby circuit breakers have to be tested every year or every two years but they trip anyway if something is going on or they might be switched in or out if there was a outage to get work done and we have a system that counts which ones are switched out and what happens and it communicates with ARM and it can tag up a little register so if you are doing a job where you have to go you've, say 14,000 of these, and you know this year you've to visit 7,000 of these and each one of them has to be tripped once."
Opportunities	More detailed knowledge of asset base enables organisation to better meet or exceed regulatory targets in future.	AB: *"But you have a little thing in the system that has told you that of those 7,000, 4,500 to 5,000 of them have tripped anyway because you have been working on them, now you're not going to have to send someone out to them. So you can go to the ones that haven't been tripped, so you can save your people time and effort and energy but that's for let's say air breakers, oil breakers need to be tripped four times right. So if you have a load of breakers and you don't know if they're air or oil then you can't apply the appropriate maintenance policy to them so therefore all of this information is useless to you because you know how many times they tripped but you don't know what type of a breaker that is so you don't know whether that is beneficial or not because if it is oil then you have to visit and do a full refurb and that's a bad thing whereas if it's air that's a good thing so there's this kind of mismatch within the system whereby for a long time we haven't got that depth of information and we're hoping that with the IWM introduction that it will enhance the asset register, I know it makes us more dependent on it you know because this is how we earn a lot of our money, how we plan our maintenance, how we count up the value of the company."*

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Table A.5 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
Value	Consolidating project work on site.	HH: "*... Three of ye sit in the room decide, what it is we're going send out as asset management, because operations is part of asset management as well, so it's what you have is, you have all of the requirements, and the drivers, but you have one individual project.*"
	Moving to condition based maintenance.	TL: "*It allows you to kind of get a lot more focused on ... moving more towards condition based maintenance.*"
		COC: "*At least we're already starting to think asset management and trying to get asset management thinking out there, like things like condition based maintenance ... as opposed to everything being cyclical*"
Inimitability	Current state of capability is a consequence of the build up of the asset maintenance organisation over time, making it unfeasibly costly to imitate.	
Non-substitutability	Some asset maintenance processes are PAS55 compliant and thus standardized. However the resultant organisational and higher level process changes are intrinsic to EnerDist as they are a consequence of its transformation to a regulated open market.	
Exploitability	Driven by ARM and enabled by IWM, EnerDist is well positioned to exploit this capability, a situation that improves all the time as asset register is populated with more and more accurate asset data. this will improve when handheld terminals are rolled out.	AB: "*they want something that is capable of on-site asset updates so in other words hand held tools that will allow the Network Technician or computers or whatever to update the Asset Register while they are there. So in other words they will say well I am on-site, this is a job ID it's been done now and it's you know whatever and the Asset Register's automatically updated or even it just allows them to fill in the information there based on I don't think bar codes because they are gone now but maybe some chip that can be identified something like that.*"

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Table A.5 – *Continued from previous page*

Characteristic	Manifested As	Evidence For
		MK: *"Instead of coming down in a spreadsheet it's there on ARM and you just go in and you view it and pick off whatever work you're doing and so on so forth ... It is an improvement from a work program issuing perspective ... All the assets all there. You can record a whole load of information on it, which is a brilliant thing."*

References

Adam, F., & O'Doherty, P. (2000). Lessons from enterprise resource planning implementations in Ireland - towards smaller and shorter ERP projects. *Journal of Information Technology*, *15*(4), 305-316.

Adam, F., & Sammon, D. (2004). Setting the Scene - Defining and Understanding ERP Systems. In F. Adam (Ed.), *The enterprise resource planning decade: Lessons learned and issues for the ft* (1st ed., p. 298). Hershey, PA: Idea Group Publishing.

Alter, S. (1992). *Information systems : a management perspective*. Reading, MA: Addison-Wesley.

Alvarez, R. (2002). The Myth of Integration: A Case Study of an ERP Implementation. In F. F.-H. Nah (Ed.), *Enterprise resource planning solutions and management* (p. 63-88). Hershey, PA: IRM Press.

Amit, R., & Shoemaker, P. J. H. (1993). Strategic assets and organizational rent. *Strategic Management Journal*, *14*(1), 33-46.

Arnold, V. (2006). Behavioral research opportunities: Understanding the impact of enterprise systems. *International Journal of Accounting Information Systems*, *7*(1), 7-17.

Arthur, W. B. (1989). Competing Technologies, Increasing Returns, and Lock-In by Historical Events. *The Economic Journal*, *99*(394), 116-131.

Avgerou, C. (2000). Information systems: what sort of science is it? *Omega: The International Journal of Management Science*, *28*(5), 567-579.

Barker, T., & Frolick, M. N. (2003). ERP Implementation Failure: A Case Study. *Information Systems Management*, *20*(4), 43-49.

Barki, H., & Pinsonneault, A. (2002). Explaining ERP Implementation Effort and Benefits With Organizational Integration. *GReSI - Groupe de recherche en systemes d'information*, *2*(1), 1-27.

Barney, J. (1986). Strategic factor markets: Expectations, luck, and business strategy. *Management Science*, *32*(10), 1231-1241.

Barney, J. (1991a). Firm Resources and Sustained Competitive Advantage. *Journal of Management*, *17*(1), 99-120.

Barney, J. (1991b). The Resource-Based Model of the Firm: Origins, Iplications, and Prospects. *Journal of Management*, *17*(1), 97-98.

Barney, J. (1997). *Gaining and Sustaining Competitive Advantage*. Upper Saddle river, NJ: Prentice Hall.

Barney, J. (2001). Resource-based theories of competitive advantage: A ten-year retrospective on the resource-based view. *Journal of Management*, *27*(6), 643-650.

Barney, J. (2005). Where does inequality come from? The personal and intellectual roots of resource-based theory. In K. G. Smith (Ed.), *Great minds in management: The process of theory development* (p. 280-301). Oxford, UK: Oxford University Press.

Barney, J., Wright, M., & Ketchen, D. J. J. (2001). The resource-based view of the firm: Ten years after 1991. *Journal of Management*, *27*(6), 625-641.

Beard, J. W., & Sumner, M. (2004). Seeking strategic advantage in the post-net era: viewing ERP systems from the resource-based perspective. *Journal of Strategic Information systems*, *13*(2), 129-150.

Beaudry, A., & Pinsonneault, A. (2005). Understanding User Responses to Information Technology: A Coping Model of User Adaptation. *MIS Quarterly*, *29*(3), 493-524.

Benbasat, I., Goldstein, D. K., & Mead, M. (1987). The Case Research Strategy in Studies of Information Systems. *MIS Quarterly*, *11*(3), 369-386.

Bendoly, E., & Cotteleer, M. J. (2008). Understanding behavioral sources of process variation following enterprise system deployment. *Journal of Operations Management*, *26*(1), 23-44.

Besson, P., & Rowe, F. (2012). Strategizing information systems-enabled organizational transformation: A atransdisciplinary review and new directions. *Journal of Strategic Information Systems*, *21*(2), 102-124.

Beyer, J. (2010). The Same or Not the Same - On the Variety of Mechanisms of Path Dependence. *International Journal of Human and Social Sciences*, *5*(1), 1-11.

Bharadwaj, A. S. (2000). A Resource-Based Perspective on Information Technology Capabilitiy and Firm Performance: An Empirical Investigation. *MIS Quarterly*, *24*(1), 169-194.

Blick, G., Gulledge, T., & Sommer, R. (2000). Defining Business Process Requiremens for Large-Scale Public Sector ERP Implementations: A Case

Study. *ECIS 2000 Proceedings*, *Paper 157*, 1-7.

Botta-Genoulaz, V., & Millet, P.-A. (2005). A classification for better use of ERP systems. *Computers in Industry*, *56*(6), 573-587.

Botta-Genoulaz, V., & Millet, P.-A. (2006). An investigation into the use of ERP systems in the service sector. *International Journal of Production Economics*, *99*(1-2), 202-221.

Botta-Genoulaz, V., Millet, P.-A., & Grabot, B. (2005). A survey on the recent research literature on ERP systems. *Computers in Industry*, *56*(6), 510-522.

Brehm, L., Heinzl, A., & Markus, M. L. (2001). Tailoring ERP Systems: A Spectrum of Choices and their Implications. *Proceedings of the 34th Hawaii International Conference on System Sciences*, 1-9.

Buckingham, R. A., Hirschheim, R. A., Land, R. A., & Tully, C. J. E. (1987). *Information Systems Education: Recommendations and Implementation*. Cambridge, UK: Cambridge University Press.

Butler, T. (2003). Why three pillars are better than one: building pragmatic IS research perspectives using institutional theory. *Management Accounting and Information Systems Seminar Series University of Manchester*, 1-58.

Butler, T., & Murphy, C. (1999). Shaping information and communication technologies infrastructures in the newspaper industry: Cases on the role of it competencies. In *An it vision of the 21st century* (p. 364-377). Charlotte, NC: Proceedings of the 20th International Conference on Information Systems (ICIS).

Butler, T., & Murphy, C. (2005). Integrating Dynamic Capability and Commitment Theory for research on IT Capabilities and Resources. *ECIS 2005 Conference Proceedings*.

Butler, T., & Murphy, C. (2008). An Exploratory Study on IS Capabilities and Assets in a Small to Medium Software Enterprise. *Journal of Information Technology*, *23*(4), 330-344.

Butler, T., & Pyke, A. (2004). Examining the Influence of ERP Systems on Firm-Specific Knowledge Assets and Capabilities. In F. Adam & D. Sammon (Eds.), *The enterprise resource planning decade: Lessons learned and issues for* (p. 168-207). Hershey, PA: Idea Group Publishing.

Byrne, T. (2008). *Examining CSFs for ERP Implementations in Private and Public Sector Organisations*. Cork, Ireland: University College Cork.

Carmeli, A., & Tishler, A. (2004). The relationships between intangible organizational elements and organizational performance. *Strategic Management Journal*, *25*(13), 1257-1278.

Carr, N. G. (2003). IT Doesn't Matter. *Harvard Business Review*, *81*(5), 41-49.

Carr, N. G. (2004). *Does IT Matter? Information Technology and the Corrosion of Competitive Advantage*. Boston, MA: Harvard Business School Press.

Cepeda, G., & Dusya, V. (2007). Dynamic capabilities and operational capabilities: A knowledge management perspective. *Journal of Business Research*, *60*(5), 426-437.

CER. (1999). Draft Principles for the Regulation of Distribution and Transmission Revenues. *Commission for Electricity Regulation. Available at http://www.cer.ie/en/documents-by-year.aspx?year=1999*, 1-34.

CER. (2001). Determination of Distribution Allowed Revenues 2001 - 2005. *Commission For Electricity Regulation. Available at http://www.cer.ie/en/documents-by-year.aspx?year=2001.*, 1-24.

CER. (2005). 2006-2010 ESB Price Control Review CER Decision Paper on Distribution System Operator Revenues. *Commission For Energy Regulation. Available at http://www.cer.ie/en/documents-by-year.aspx?year=2005.*, 1-160.

CER. (2010). Decision on 2011 to 2015 distribution revenue for ESB Networks Ltd. *Commission for Energy Regulation. Available at http://www.cer.ie/en/documents-by-year.aspx?year=2010.*, 1-159.

Cetindamar, D. (2009). Understanding technology management as a dynamic capability: A framework for technology management activities. *Technovaition*, *29*, 237-246.

Chang, S.-I., Gable, G., Smythe, E., & Timbrell, G. (2000). A Delphi examination of public sector ERP implementation issues. *Proceedings of the 21st International Conference on Information Systems*, 494-500.

Checkland, P. (1981). Science as a Human Activity: Its history and its method. In P. Checkland (Ed.), *Systems thinking, systems practice.* Chichester, UK: Wiley.

Chen, I. J. (2001). Planning for ERP systems: analysis and future trend. *Business Process Management Journal*, *7*(5), 374-386.

Chen, W., & Hirschheim, R. (2004). A paradigmatic and methodological examination of Information Systems research from 1991 to 2001. *Information Systems Journal*, *14*, 197-235.

Clemons, E. K., & Row, M. C. (1991). Sustaining IT Advantage: The Role of Structural Differences. *MIS Quarterly*, *15*(3), 275-292.

Cockburn, I. M., Henderson, R. M., & Stern, S. (2000). Untanging the origins of Competitive Advantage. *Strategic Management Journal*, *21*(10/11), 1123-1145.

Daft, R. (1983). *Organization Theory and Design*. New York, NY: West.

Davenport, T. (1998). Putting the Enterprise into the Enterprise System. *Harvard Business Review*, *76*(4), 121-131.

Davenport, T. (2000). *Mission Critical: Realising the promise of Enterprise Systems*. Boston, MA: Harvard Business School Press.

David, P. A. (1985). Clio and the Economics of QWERTY. *The American Economic Review*, *75*(2), 332-337.

David, P. A. (1986). Understanding the economics of QWERTY: The necessity of history. In W. N. Parker (Ed.), *Economic history and the modern economist.* London, UK: Basil Blackwell.

David, P. A. (2007). Path dependence: a foundational concept for historical social science. *Cliometrica - The Journal of Historical Economics and Econometric History*, *1*(2), 91-114.

Dechow, N., & Mouritsen, J. (2005). Enterprise resource planning systems, management control and the quest for integration. *Accounting, Organizations and Society*, *30*(7-8), 691-733.

Dickerson, C. (2003). Supply-Chain Failure. *InfoWorld*, *25*(11), 45.

Dierickx, I., & Cool, K. (1989a). Asset Stock Accumulation and Sustainability of Competitive Advantage. *Management Science*, *35*(12), 1504-1514.

Dierickx, I., & Cool, K. (1989b). Asset Stock Accumulation and the Sustainability of Competitive Advantage: A Reply. *Management Science*, *35*(12), 1514.

Dyer, W. G. J., & Wilkins, A. L. (1991). Better stories, not better constructs, to generate better theory: A rejoinder to Eisenhardt. *Academy of Management Review*, *16*(3), 613-619.

Eisenhardt, K., & Martin, J. (2000). Dynamic Capabilities: What are they? *Strategic Management Journal*, *21*(10-11), 1105-1121.

Elmes, M. B., Strong, D. M., & Volkoff, O. (2005). Panoptic empowerment and reflective conformity in enterprise systems-enabled organizations. *Information and Organization*, *15*(1), 1-37.

ESBN. (2010). ESB Networks Performance Report. *Commission for Energy Regulation. Available at http://www.cer.ie/en/documents-by-year.aspx?year=2010.*.

Fahy, J. (2000). The resource-based view of the firm: some stumbling-blocks on the road to understanding sustainable competitive advantage. *Journal of European Industrial Training*, *24*(2), 94-104.

Gable, G. G. (1998). Large package software: A neglected technology? *Journal of Global Information Management*, *6*(3), 3-4.

Galliers, R. (1991). *Information Systems Research*. Oxford, UK: Alfred Waller Ltd.

Gattiker, T. F., & Goodhue, D. L. (2005). What Happens After ERP Implementation: Understanding the Impact of Interdependence and Differentiation on Plant-Level Outcomes. *MIS Quarterly*, *29*(3), 559-585.

Giachetti, R. (2004). A framework to review the information integration of the enterprise. *International Journal of Production Research*, *42*(6), 1147-1166.

Gosain, S. (2004). Enterprise Information Systems as Objects and Carriers of Institutional Forces: The New Iron Cage? *Journal of the Association for Information Systems*, *5*(4), 151-182.

Grant, G., & Chen, Y. H. (2005). Measuring Enterprise Systems Capabilities: A Dynamic Capability Study. *Proceedings, 9th Annual Pacific Asia Conference on Information Systems, Bangkok, Thailand*, 1520-1526.

Guba, E. G., & Lincoln, Y. S. (1994). Competing Paradigms in Qualitative Research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research.* Thousand Oaks, CA: Sage Publications, Inc.

Guba, E. G., & Lincoln, Y. S. (2000). Paradigmatic controversies, contradictions, and emerging confluences. In N. K. Denzin & Y. S. E. Lincoln (Eds.), *Handbook of qualitative research.* Thousand Oaks, CA: Sage.

Harrison, J. L. (2004). Motivations for Enterprise Resource Planning (ERP) system implementation in Public versus Private sector organizations. *Doctoral dissertation, University of Central Florida*, 1-143.

Helfat, C. M., & Peteraf, M. A. (2003). The Dynamic Resource - Based View: Capability Lifecylces. *Strategic Management Journal*(24), 997-1010.

Henderson, J. C., & Venkatraman, N. (1993). Strategic alignment: Leveraging information technology for transforming organizations. *IBM Systems Journal*, *32*(1), 472-484.

Hendricks, K. B., Singhal, V. R., & Stratman, J. K. (2006). The impact of enterprise systems on firm performance: A study of ERP, SCM and CRM system implementations. *Journal of Operations Management*, *0*(0), 0-0.

Hirschheim, R. (1985). Information Systems Epistemoloy: An Historical Perspective. *IFIP Working Group 8.2: Research methods in Information Systems*, 13-35.

Hitt, L. M., Wu, D. J., & Zhou, X. (2002). Investment in Enterprise Resource Planning: Business Impact and Productivity Measures. *Journal of Management Information Systems*, *19*(1), 71-98.

Howcroft, D., Newell, S., & Wagner, E. (2004). Understanding the contextual influences on enterprise system design, implementation, use and evaluation. *Journal of Strategic Information Systems*, *13*(4), 271-277.

Huang, S.-M., Chen, H.-G., Hung, Y.-C., & Ku, C.-Y. (2004). Transplanting the best practice for implementation of an ERP system: A structured inductive study of an international company. *Journal of Computer Information Systems*, *44*(4), 101-110.

Hurbean, L. (2009). Issues with implementing ERP in the public administration. *University Library of Munich, Germany, MPRA Paper*(http://EconPapers.repec.org/RePEc:pra:mprapa:14160), 1-11.

Jacobs, F. R., & Bendoly, E. (2003). Enterprise resource planning: Developments and directions for operations management research. *European Journal of Operational Research*, *146*(2), 233-240.

Johannessen, J.-A., Olaisen, J., & Olsen, B. (2001). *International Jornal of Information Management*, *21*(1), 3-20.

Kale, S. H. (2004). CRM Failure and the Seven Deadly Sins. *Marketing Management*, *13*(5), 42-46.

King, S. F., & Burgess, T. F. (2006). Beyond critical success factors: A dynamic model of enterprise system innovation. *International Journal of Information Management*, *26*(1), 59-69.

Kraemmergaard, P., Moller, C., & Boer, H. (2003). ERP implementatio: an integrated process of radical change and continuous learning. *Production Planning and Control*, *14*(4), 338-348.

Land, F. (1991). The Information Systems Domain. In R. E. Galliers (Ed.), *Information systems research: Issues, methods and practical guidelines.* Oxford, UK: Alfred Waller Ltd.

Laudon, K. C., & Laudon, J. P. (2014). *Management Information Systems: Managing the Digital Firm*. Harlow, UK: Pearson.

Lee, A. S. (1989). A Scientific Methodology for MIS Case Studies. *MIS Quarterly*, *13*(1), 33-50.

Lee, A. S. (1991). Integrating positivist and interpretivist approaches to organisational research. *Organisational Science*, *2*(4), 343-365.

Lee, J., Siau, K., & Hong, S. (2003). Enterprise Integration with ERP and EAI. *Communications of the ACM*, *46*(2), 54-60.

Lee, J. C., & Myers, M. D. (2004). Dominant actors, political agendas, and strategic shifts over time: a critical ethnography of an enterprise systems implementation. *Journal of Strategic Information Systems*, *13*(4), 355-374.

Lee, Z., & Lee, J. (2000). An ERP implementation case study from a knowledge transfer perspective. *Journal of Information Technology*, *15*(4), 281-288.

Legare, T. L. (2002). The role of organizational factors in realizing ERP benefits. *Information Systems Management*, *19*(4), 21-42.

Leonard-Barton, D. (1992). Core Capabilities and Core Rigidities: A Paradox in Managing New Product Development. *Strategic Management Journal*, *13*(S1), 111-125.

Leonard-Barton, D. (1995). *Wellsprings of Knowledge: Building and Sustaining the Sources of Innovation*. Boston, MA: Harvard Business School Press.

Lorenzo, O. (2004). A Comprehensive Review of the Enterprise Systems Research. *Instituto de Empresa Working Paper*, *WP 12/04*, 1-15.

Lorenzo, O., Kawalek, P., & Wood-Harper, T. (2005). Embedding the Enterprise System into the Enterprise: A model of corporate diffusion. *Communications of the Association for Information Systems*, *2005*(15), 609-641.

Mabert, V. A., Soni, A., & Venkataramanan, M. A. (2001). Enterprise Resource Planning: Common Myths Versus Evolving Reality. *Business Horizons*, *44*(3), 69-76.

Mandal, P., & Gunasekaran, A. (2003). Issues in implementing ERP: A case study. *European Jornal of Operational Research*, *146*(2), 274-283.

Markus, M. L., Axline, S., Petrie, D., & Tanis, C. (2000). Learning from adopters experiences with ERP: problems encountered and success achieved. *Journal of Information Technology*, *15*(4), 245-265.

Markus, M. L., Tanis, C., & Fenema, P. C. van. (2000). Multisite ERP Implementations. *Communications of the ACM*, *43*(4), 42-46.

Maroofi, F., Sadeghi, F., & Mojoodi, A. (2011). The Impact of Enterprise Systems on Corporate Performance. *Middle-East Journal of Scientific Research*, *10*(3), 354-365.

Marshall, C., & Rossmann, B. G. (1989). *Designing Qualitative Research*. Newbury Park, CA: Sage Publications.

Mata, F. J., Fuerst, W. L., & Barney, J. B. (1995). Information Technology and Sustained Competitive Advantage: A Resource-Based Analysis. *MIS Quarterly*, *19*(4), 487-505.

Maxwell, J. A. (1992). Understanding and Validity in Qualitative Research. *Harvard Educational Review*, *62*(3), 279-300.

McGaughey, R. E., & Gunasekaran, A. (2007). Enterprise Resource Planning (ERP): Past, Present and Future. *International Journal of Enterprise Information Systems*, *3*(3), 23-35.

McGuinness, T., & Morgan, R. E. (2000). Strategy, dynamic capabilities and complex science: management rhetoric vs. reality. *Strategic Change*, *9*(4), 209-220.

McKenney, J. L., & McFarlan, F. W. (1982). The information archipelago - maps and bridges. *Harvard Business Review*, *60*(5), 109-119.

Melville, N., Kraemer, K., & Gurbaxani, V. (2004). Information Technology and Organizational Performance: An Integrative Model of IT Business Value. *MIS Quarterly*, *28*(2), 283-322.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: an expanded sourcebook*. Thousand Oaks, CA: SAGE Publications, Inc.

Miranda, R. (2000). The building blocks of a digital government strategy. *Government Finance Review*, *16*(5), 9-13.

Mumford, E. E. (1985). *Research methods in information systems*. Amsterdam, Netherlands: Amsterdam: North-Holland.

Murphy, K. E., & Simon, S. J. (2001). Using Cost Benefit Analysis for Enterprise Resource Planning Project Evaluation: A Case for including Intangibles. *Proceedings of the 24th Hawaii International Conference on System Sciences*.

Myers, M. D. (1997). Qualitative Research in Information Systems. *MIS Quarterly*, *21*(2), 241-242.

Nafeeseh, R. A., & Al-Mudimigh, A. S. (2011). Justifiying ERP Investpment: The Role and Impacts of Business Case A Literature Survey. *International Journal of Computer Science and Network Security*, *11*(1), 185-193.

Nah, F. F.-H., & Lee-Shang Lau, J. (2001). Critical factors for successful implementation of enterprise systems. *Business Process Management Journal*, *7*(3), 285-296.

Nelson, R. S., & Winter, S. G. (1982). *An Evolutionary Theory of Economic Change*. Cambridge, MA: Harvard University Press.

Newbert, S. L. (2007). Empirical Research on the Resource Based View of the firm: An assessment and suggestions for future research. *Strategic Management Journal*, *28*(2), 121-146.

Nordhaug, O. (1994). *Human capital in organisations: Competence, training and learning*. New York, NY: Oxford University Press.

Pan, S. L., & Tan, C. W. (2005). The roles of enterprise systems in e-initiative implementation: A case study of PowerCo. *International Journal of Information Management*, *25*(3), 241-251.

Pare, G. (2004). Investigating information systems with positivist case study research. *Communications of the Association for Information Systems*, *2004*(13), 233-264.

Patton, M. Q. (1990). *Qualitative Evaluation and Research Methods*. Newbury Park, CA: SAGE Publications, Inc.

Pavlou, P. A., & El Sawy, O. A. (2006). From IT Leveraging Competence to Competitive Adcantage in Turbulent Environments: The Case of New Product Development. *Information Systems Research*, *17*(3), 198-227.

Pavlou, P. A., & El Sawy, O. A. (2010). The "Third Hand": IT-Enabled Competitive Advantage in Turbulence Through Improvisational Capabilities. *Information Systems Research*, *21*(3), 443-471.

Penrose, E. (1959). *The Theory of the growth of the firm*. Oxford, UK: Basil Blackwell.

Penrose, E. (1980). *The theory of the growth of the firm*. Oxford, UK: Basil Blackwell.

Peteraf, M. A. (1993). The Cornerstones of Competitive Advantage: A Resource-Based View. *Strategic Management Journal*, *14*(3), 179-191.

Porter, M. E. (1980). *Competitive Strategy*. New York, NY: The Free Press.

Porter, M. E. (1991). Towards a dynamic theory of strategy. *Strategic Management Journal*, *12*(S2).

Prahalad, C. K., & Hamel, G. (1990). The Core Competence of the Corporation. *Harvard Business Review*, *68*(3), 79-91.

Priem, R. L., & Butler, J. E. (2001a). Is the resource-based "view" a useful perspective for strategic management research? *Academy of Management Review*, *26*(1), 22-40.

Priem, R. L., & Butler, J. E. (2001b). Tautology in the Resource-Based View and the implications of Externally Determined Resource Value: Further Comments. *Academy of Management Review*, *26*(1), 57-66.

Rashid, M. A., Hossain, L., & Patrick, J. D. (2002). The Evolution of ERP Systems: A Historical Perspective. In F. F.-H. Nah (Ed.), *Enterprise resource planning solutions and management* (p. 35-50). Hershey, PA: IRM Press.

Ravichandran, T., & Lertwongsatien, C. (2005). Effect of Information Systems Resources and Capabilities on Firm Performance: A Resource-Based Perspective. *Journal of Management Information Systems*, *21*(4), 237-276.

Ray, G., Muhanna, W. A., & Barney, J. B. (2005). Information Technology and the Performance of the Customer Service Process: A Resource-Based Analysis. *MIS Quarterly*, *29*(4), 625-652.

Rikhardsson, P., & Kraemmergaard, P. (2006). Identrifying the impacts of enterprise systems implementation and use: Examples from Denmark. *International Journal of Accounting Information Systems*, *7*(1), 36-49.

Robey, D., Ross, J. W., & Boudreau, M.-C. (2002). Learning to Implement Enterprise Systems: An Exploratory Study of the Dialectics of Change. *Journal of Management Information Systems*, *19*(1), 17-46.

Robson, C. (1993). *Real World Research*. Oxford, UK: Blackwell Publishers.

Ross, J. W., Weill, P., & Robertson, D. (2006). *Enterprise Architecture as Strategy*. Boston, MA: Harvard Business School Press.

Rugman, A. M., & Verbeke, A. (2002). Edith Penrose's contribution to the Resource-Based View of Strategic Management. *Strategic Management Journal*, *23*(8), 769-780.

Rumelt, R. P. (1984). Towards a strategic theory of the firm. In R. B. Lamb (Ed.), *Competitive strategic management* (p. 556-570). Englewood Cliffs, NJ: Prentice-Hall.

Schiflett, K. L., & Zey, M. (1990). Comparison of Characteristics of Private Product Producing Organizations and Public Service Organizations. *The Sociological Quarterly*, *31*(4), 569-583.

Schlichter, B., & Kraemmergaard, P. (2010). Schlichter 2010 A comprehensive literature review of the ERP research field over a decade. *Journal of Enterprise Information Management*, *23*(4), 486-520.

Schumpeter, J. A. (1934). *Theory of Economic Development*. Cambridge, MA: Harvard University Press.

Sclafani, J. A. (2000). Think outside the box. *Government Accountants Journal*, *49*(2), 18-20.

Scott, J. E., & Vessey, I. (2002). Managing risks in enterprise systems implementations. *Communications of the ACM*, *45*(4), 74-81.

Seddon, P., Shanks, G., & Willcocks, L. (2003). Introduction: ERP - The Quiet Revolution? In G. Shanks, P. B. Seddon, & L. P. Willcocks (Eds.), *Second-wave enterprise resource planning systems* (p. 1-19). Cambridge, UK: Cambridge University Press.

Seidman, I. E. (1991). *Interviewing as Qualitative Research: A Guide for Researchers in Education and the Social Sciences*. New York, NY: Teachers College Press.

Shakir, M. (2003). Current issues of ERP implementations in New Zealand. *Research Letters Inf. Math. Sci., A*, *4*, 151-172.

Shang, S., & Seddon, P. B. (2002). Assessing and managing the benefits of enterprise systems: the business manager's perspective. *Information Systems Journal*, *12*(4), 271-299.

Shang, S., & Seddon, P. B. (2003). A Comprehensive Framework for Assessing and Managing the Benefits of Enterprise Systems: The Business Manager's Perspective. In G. Shanks, P. B. Seddon, & L. P. Willcocks (Eds.), *Second-wave enterprise resource planning systems* (p. 74-101). Cambridge, UK: Cambridge University Press.

Shanks, G., & Bekmamedova, N. (2012). Integrating Business Analytics Systems with the Enterprise Environment: an Evolutionary Process Perspective. In A. Respicio & F. E. Burstein (Eds.), *Fusing decision support systems into the fabric of the context.* Amsterdam, Netherlands: IOS Press.

Shanks, G., & Parr, A. (2003). Positivist, Single Case Study Research in Information Systems: a Critical Analysis. *Proceedings of the 11th European Conference on Information Systems, ECIS2003, Naples, Italy*.

Shanks, G., & Seddon, P. (2000). Editorial: Enterprise resource planning (ERP) systems. *Journal of Information Technology*, *15*(4), 243-244.

Siggelkow, N. (2007). Persuasion with case studies. *Academy of Management Journal*, *50*(1), 20-24.

Solis, A. O., Putnam, K. B., Gemoets, L. A., & Almonte, D. (2002). Implementing an Enterprise Resource Planning System for the City of El Paso. *Proceedings of the 2002 Information Resources Management Association Conference*, *Seattle*, 1112-1113.

Somers, T. M., & Nelson, K. G. (2003). The impact of strategy and integration mechanisms on enterprise system value: Empirical evidence from manufacturing firms. *European Journal of Operational Research*, *146*(2), 315-338.

Spano, A., & Bello, B. (2011). The impact of using an ERP system on organizational processes and individual employees. In A. D'atri (Ed.), *Information technology and innovation trends in organizations* (p. 83-98). Heidelberg, Germany: Physica-Verlag.

Stinchcombe, A. L. (2000). Social structure and organizations: A comment. In J. A. C. Baum (Ed.), *Economics meets sociology in strategic management.* Stamford, CT: JAI Press.

Stratman, J. K. (2007). Realizing Benefits from Enterprise Resource Planning: Does Strategic Focus Matter? *Production and Operations Management*, *16*(2), 203-216.

Sutton, S. G. (2006). Enterprise systems and the re-shaping of accounting systems: A call for research. *International Journal of Accounting Information Systems*, *7*(1), 1-6.

Teece, D., & Pisano, G. (1998). The Dynamic Capabilities of Firms: an Introduction. In G. Dosi (Ed.), *Technology, organization and competitiveness:*

Perspectives on industrial and (p. 193-212). Oxford, UK: Oxford University Press.

Teece, D., Pisano, G., & Shuen, A. (1997). Dynamic Capabilities and Strategic Management. *Strategic Management Journal*, *18*(7), 509-533.

Tellis, W. (1997). Application of a Case Study Methodology. *The Qualitative Report*, *3*(3).

Themistocleous, M., Irani, Z., & O'Keefe, R. M. (2001). ERP and application integration: Exploratory survey. *Business Process Management Journal*, *7*(3), 195-204.

Turban, E., Rainer, J., R Kelly, & Potter, R. E. (2003). *Introduction to Information Technology*. New York, NY: John Wiley and Sons, Inc.

Turner, D., & Chung, S. H. (2005). Technological Factors Relevant to Continuity on ERP for E-Business Platform: Integration, Modularity and Flexibility. *Journal of Internet Commerce*, *4*(4), 119-132.

Uwizeyemungu, S., & Raymond, L. (2012). Impact of an ERP system's capabilities upon the realisation of its business value: a resource-based perspective. *Information Technology Management*, *13*(2), 69-90.

Wade, M., & Hulland, J. (2004). The resource-based view and information systems research: Review, extension and suggestions for future research. *MIS Quarterly*, *28*(1), 107-142.

Wagner, E. L., & Newell, S. (2004). Best for whom? The tension between best practice ERP packages and diverse epistemic cultures in a university context. *Strategic Information Systems*, *13*(4), 305-328.

Wang, C. L., & Ahmed, P. K. (2007). Dynamic capabilties: A review and research agenda. *International Journal of Management Reviews*, *9*(1), 31-51.

Ward, J., Hemingway, C., & Daniel, E. (2005). A framework for addressing the organisational issues of enterprise systems implementation. *Journal of Strategic Information Systems*, *14*(2), 97-119.

Ward, M. A. (2006). Information Systems Technologies: A Public - Private Sector Comparison. *Journal of Computer Information Systems*, 50-56.

Watson, E. E., & Schneider, H. (1999). Using ERP Systems in Education. *Communications of the AIS*, *1*(-), 1-47.

Wengraf, T. (2001). *Qualitative Research Interviewing: Biographic Narrative and Semi-Structured Methods*. Thousand Oaks, CA: Sage Publications.

Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management Journal*, *5*(2), 171-180.

Wheeler, B. C. (2002). NEBIC: A Dynamic Capabilities Theory for Assessing

Net-Enablement. *Information Systems Research*, *13*(2), 125-146.

Williams, C. K., & Karahanna, E. (2013). Causal explanation in the coordinating process: A critical realist case study of federated it governance structures. *MIS Quarterly*, *37*(3), 933-964.

Williamson, O. E. (1999). Strategy research: Governance and competence perspectives. *Strategic Management Journal*, *20*(12), 1087-1108.

Xue, Y., Liang, H., Boulton, W. R., & Snyder, C. A. (2005). ERP implementation failures in China: Case studies with implications for ERP vendors. *International Journal of Production Economics*, *97*(3), 279-295.

Yeo, K. T. (2002). Critical failure factors in information system projects. *International Journal of Project Management*, *20*(3), 241-246.

Yin, R. K. (1994). *Case Study Research: Design and methods*. Thousand Oaks, CA: Sage Publishing.

Yin, R. K. (2003). *Case Study Research: Design and methods*. Thousand Oaks, CA: Sage Publishing.