KNOWLEDGE MANAGEMENT WITHIN A MULTINATIONAL KNOWLEDGE LED COMPANY

Gerry McCarthy

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Abstract

The semiconductor industry relies on knowledge sharing and collaboration between its employees and amongst subsidiary companies to remain competitive in an ever changing, market driven environment. Practise has changed from workers supplying *labour* to workers supplying *knowledge*. Technology improvements and investment in automation have provided companies the platform to generate, codify, harness and exploit knowledge as a means of improving organisational performance.

This research explores knowledge dynamics in the organisation and specifically looks at knowledge sharing within a subsidiary and among subsidiaries in a multinational corporation. The corporation in question operates its manufacturing facilities as competing business units. The purpose of the research was to establish if this method of organising business units provides the overall corporation with a competitive advantage, or if competing business units inhibits performance preventing or restricting the potential for a competitive advantage for the corporation.

To determine how knowledge is shared within the organisation a series of semi-structured interviews were conducted. Senior managers and professional staff across a number of disciplines were interviewed. Knowledge sharing within functional area departments, collaboration between functional area departments, knowledge systems and compliance to knowledge systems were used as determinants to establish the extent of the knowledge dynamic in the subsidiary. The relationship between knowledge sharing and how it impacted the “bottom line” performance of the subsidiary was also considered in an attempt to quantify the impact knowledge sharing has on performance.

To determine how knowledge is shared between subsidiaries, two case studies were conducted. The first case study involved a benchmarking visit to allow two of the corporation’s subsidiaries to compare best practice cost systems with multi-disciplines involved. The second case study involved a cross functional team of technical staff to define a manufacturing facility technical yield roadmap.

Significant cost, productivity and yield improvement at the site was attributed to the success of collaborative units established at site. Establishing collaborative units was a precursor to setting up a network within the site to promote knowledge sharing in the organisation. The site was cognisant of the impact of effective knowledge sharing and receptive to sharing knowledge on an informal or formal basis. The site put great stock in codified knowledge and invested heavily in automating knowledge based systems.

Many barriers to knowledge sharing were identified including compliance to codified procedures, departmental conflicts, viewing knowledge sharing as a burden, variation across automated systems, conflicts caused by the internet as a knowledge source and logistics due to geographical dispersion. Knowledge-led teams overcame many of these barriers. Success bred success to the extent knowledge sharing has become a business process in the organisation.

Knowledge sharing is a two way process. It can be a vehicle for trust, respect and improvement. This research has shown knowledge sharing even within competing business units can produce a competitive advantage. An organisation is an accumulation of knowledge. A knowledge-led collaborative approach provides many benefits: it will advance the company, engage staff at all levels and favourably impact the “bottom line”. Knowledge management differentiated the local site from other corporate subsidiaries with the local site demonstrating “best in class” results on its key performance indicators. Encouragingly, there is ample opportunity to improve performance further once knowledge management is fully embedded as a business process across the organisation.

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Table of Contents

List of Tables

Table of Figures

Abbreviations

Abbreviation	Meaning
EHS	Environment, Health and Safety
GOP	Gross Operating Profit
IDM	Independent Device Manufacturer

Glossary

Term	Definition
Activity	Cumulative number of process operations a silicon wafer received in a given period.
Availability	The amount of time a tool is able to run production material in a given period.
Business Partner	A member of a support department assigned to be the main contact with the operations group.
Cost of Scrap	Value of scrap as a proportion of total earnings
Custom and Practice	An occasion where an individual continues to do what they did historically rather than change.
Fab	Semiconductor manufacturing facility
Fabrication area	Designated area of a factory where silicon wafers are manufactured under controlled environmental conditions.
Induction	Employees or contractors about to work at the Site for the first time take part in a safety awareness session prior to performing any tasks on Site.
Megatrends	Substantial product market movement
Process CpK	A comparison of a process distribution compared to the process specification limits
Second Source	Alternative product supplier
Station Controller	A workstation interface common to all tools in the Fabrication area
Utilisation	A measure of how much production material a tool runs as a proportion of total available time
Yield	A measure of silicon wafer waste

Chapter 1 Introduction

1.0 The History of the Semiconductor Device

The face of industry changed in the 1950s when a transistor was created using a solid semiconductor material to control the flow of electricity. In 1959 the first integrated circuit (IC) was created. The same year National Semiconductor was formed with a purpose of producing silicon transistors. Throughout the 1960s manufacturers like National Semiconductor would focus on designing integrated circuits for military, aerospace and industrial use. In the 1970s the electronics industry shifted to consumer applications and the personal computer and microprocessors were developed. National Semiconductor produced the industry's first 16-bit microprocessor in 1975. Technology development continued in the 1980s but focus began to change with the arrival of competitor companies and political uncertainty with the future of military contracts. New strategies and alliances were formed. With the development of the internet browser in the 1990s, interest in the internet exploded. Improved circuit performance and falling prices drove the growth of the PC market as well as mobile computing and mobile communications. The 2000s is an era where the semiconductor industry is more and more customer and solution-driven. Focus has moved from discrete integrated circuits to a broader focus on fully integrated system solutions.

Involvement in the semiconductor industry normally takes the form of:

- *Chip makers* who design, manufacture and sell integrated circuits.
- *Fabless manufacturers* who design and sell integrated circuits but outsource manufacturing to foundry companies.
- *Foundry companies* who manufacture integrated circuits designed and sold by their customers.

1.1 The Semiconductor Market

The global semiconductors and semiconductor equipment industry was valued at $254.9 billion in 2005. In 2010 the global semiconductors and semiconductor equipment industry group is forecast to have a value of $351.4 billion, an increase of 37.9% since 2005. Buoyed by significant demand from the home computers end-market, the global semiconductors and semiconductor equipment industry group has managed to recover from the strong declines of 2000 and 2001, which resulted from over capacity and decreased demand. In 2004 semiconductors provided the industry group's primary source of revenues, with total sales of $225.3 billion, equating to 88.4% of the semiconductors and semiconductor equipment industry group's total value. Rising volume sales and the proliferation of applications and end-markets are creating the need for capacity within the semiconductor market, driving revenue growth in terms of volume sales. However, falling prices within the semiconductor market, resulting from the growing numbers of consumers unable to distinguish between performance at the cutting edge range, will continue to degrade the market's performance until any innovations in software emerge to promote the sale of high end chips. Market price erosion falls straight through to the Fabrication sites of Integrated Device Manufacturers (IDMs). Maintaining an appropriate Gross Operating Profit (GOP) requires manufacturing sites to produce a competitive cost of manufacture, with year on year aggressive cost and productivity improvements usually expected. It is a demanding business. Jack Welch (2001), former Chief Executive Officer of General Electric had a disdain for the semiconductor industry, stating the semiconductor business was "*capital intensive and cyclical, it had short product life cycles, and returns for most players were historically low*".

To meet cost demands semiconductor manufacturing sites must be more resourceful each year. For multinational companies there is the added dilemma of the subsidiaries remaining competitive internally. Subsidiaries prefer to offer the corporation best in class results in an attempt to secure future investment.

This research aims to show how one part of a multinational uses knowledge and the concept of the learning organisation to deliver year on year improvements at or beyond the desired levels. It will examine if an internal competing business unit approach provides a competitive advantage for the Corporation.

1.1.1 National Semiconductor

National Semiconductor is a leading supplier of high-performance analogue integrated circuits specialising in power management, amplifier, data conversion and high-speed interface products. The Company was founded in 1959 and is headquartered in Santa Clara, California. The Company has a portfolio of over 2,550 patents and 10,000 products. There are currently 7,600 employees worldwide.

In the first few decades of the semiconductor industry demand was driven by three “mega trends”:

- The computer (mainframes to personal computers).
- The connected computer (internet personal computer networks).
- The cell phone.

These relatively few volume drivers had an increasing number of semiconductor suppliers chasing a limited number of volume “sockets” such as DRAMs (Dynamic Random Access Memory), CPUs (microprocessors) and personal computer chipsets (companion integrated circuits).The competition for sockets is particularly fierce in digital circuits where original designs and second sources of competitor’s chips are facilitated by a plethora of off-the-shelf digital design tools allowing competitors to easily chase a high-volume socket.

Intense competition and exponentially rising costs of state-of-the-art digital Fabs trifurcated the semiconductor industry:

- Focus on digital integrated circuits but absorb huge and spiralling costs.

- Become “Fabless” by creating the designs but subcontracting out manufacture, assembly and test.
- Focus on analogue integrated circuits. Companies that do not need state-of-the-art Fabrication plants but can still produce leading-edge products in their domain.

National Semiconductor concentrated on its core expertise: analogue. Becoming “Fabless” was not considered a viable option due to strength of the company in terms of manufacturing, process technology, packaging, service, supply and logistics. The company increased its investment in high performance, standard linear analogue products. National’s subsequent performance was propelled by an explosion of new technologies for consumer products, including cell phones, MP3 players, high-definition televisions, notebook computers, personal video recorders, video games and cordless residential phone systems. All of these consumer products are rich in analogue. Analogue makes them easier to use, improves display and audio performance, and extends their battery life.

1.1.2 Knowledge in Manufacturing

National Semiconductor puts great stock in its manufacturing capability. The company has three silicon wafer manufacturing facilities (Fabs). A competitive landscape exists whereby key metrics such as cost, productivity and quality are reviewed at Corporate level. Each site is expected to demonstrate continual improvement by forecasting aggressive targets and meeting these targets by the forecasted due date. Site management use the other sites’ performance as the initial benchmark of performance.

As a senior manager at the UK manufacturing facility, I have had the opportunity to observe the use of knowledge management within and across National Semiconductor’s facilities and departments; relate successes or failures to how people or departments manage knowledge and to finally be in a position to research the topic with a view of improving business processes within National Semiconductor.

A wealth of talent resides in the Corporation. An observation I ilt over time was there were very few occasions where a technical problem or otherwise could not be resolved. There appeared to be however reluctance at the local site for departments to share information with other departments, or seek help from individuals who had expertise relevant to the problem at hand. An underlying theme at department meetings was the lack of goal alignment across departments to meet the Site's primary objectives.

Occasionally managers from other Site's would be in contact to discuss cost initiatives or technical issues. Rarely would contact happen as first port of call. Communication or request for help would be closer to a final resort action. Within the Corporation one individual is responsible for the whole of manufacturing. Within the manufacturing structure there was a reluctance to share specific information yet collectively the resources available were significantly greater than those available at any one Site.

As part of my research it was important to define a hypothesis which would help address the issue of cross department management effectiveness and cross site management effectiveness. My research would focus on how knowledge was managed collectively in the organisation and in each of the departments at the local Site with the hypothesis "*Does a knowledge-led multinational company, who organise their Fabs as competing business units, fully exploit knowledge to produce a competitive advantage*?"

1.2 Aims

The following aims need to be satisfied to address the research question:

(1) Do goals align across departments at the local Site? Departments and individuals work to goals set for them. This could strongly influence department to department relationships.

(2) What is the level of current level of knowledge sharing among departments and Sites? Does the organisation recognise “knowledge management”?

(3) Identify performance trends and the contribution effective knowledge management has made to performance.

(4) Establish the level of support the organisation gives knowledge management

(5) To perform literature survey on the topics of knowledge management and organisational learning and

(6) To provide overall conclusions and recommendations to improve business processes within National Semiconductor.

(7) To provide recommendations and opportunities for further research following the completion of this study

1.3 Problem Statement

This thesis will report research carried out in a multinational corporation which has several competing business units to investigate (1) the extent of knowledge sharing within individual units and how this affects that unit's competitive advantage within the organisation, (2) the extent to which such a corporate structure either encourages or inhibits knowledge exchange between business units and (3) the extent to which current practises may be modified to produce a more effective business model based on a knowledge-led concept of gaining competitive advantage.

1.31 Barriers to knowledge sharing

Through professional experience my expectation is individuals tend to readily identify barriers to doing their job and in the case of this research would articulate reasons why barriers exist in knowledge. An objective of the research exercise was to improve professional practice within the organisation. Knowledge barriers should be understood and where appropriate removed if improvement in a particular area is to be achieved. Consideration was given to the following to determine the impact of knowledge sharing (Reige, 2005)

- Integration of a knowledge management strategy into the Corporation or Sites' goals or strategic approach may be missing or unclear
- Lack of leadership and direction in terms of clearly communicating the basic values of knowledge sharing practices
- Existing practices, policies, procedures, culture may not be conducive to knowledge sharing
- Internal competitiveness within business units, functional areas and subsidiaries can be high
- Hierarchical organisation structure inhibits or slows down most sharing practices
- General lack of time to share knowledge

- Apprehension of fear that sharing may reduce or jeopardise people's job security or advancement

Whilst these are all considerations and all do exist at one level or another, they were not deemed to be over-riding or prohibitive of the knowledge sharing process.

1.4 The New Economy

According to Williams and McNeil (2005) economics, the discipline often defined as the study of how to manage scarcity has, for many years, considered man made capital to be the resource of greatest relevance to the analysis of scarcity. According to Martin and Moldoveanu (undated), the twentieth century is the history of the struggle between capital and labour. MacIntyre (1977), Bryer (2006), Hechter (1979) comment on capitalists or bourgeois owning the capital. The working class or proletariat own only their capacity to work. Workers simply provided labour. They did not, or were not allowed to, contribute to industrial knowledge.

In the century centred on 1800 the British economy shifted from one where real wages related inversely to population size, to a modern economy, with population and real wages growing simultaneously at unprecedented rates (Harley, 2003). Workers were now arguing their case for wages commensurate to contribution. “Classes” arose within the working class.

Economically, according to George (1999) in the 1950s and 1960s in Western countries, everyone was a Keynesian, a social democrat, a social Christian democrat or some shade of Marxist. Either way, it was more about the state, be it laissez faire or interventionist, than the worker. This has changed with the advent of the knowledge-worker leading to the knowledge economy. According to Skyrme (2000) the knowledge economy has “*entirely different characteristics than those economies that came before it*”. America and the world have changed dramatically in the closing decades of the 20th century (PPI, 2008). The industrial order of the 20th century is rapidly yielding to the “new economy” of the 21st century. Webber (2000) cites examples of companies becoming successful since moving away from the “old economy” and into the “knowledge economy”. Future wealth and power will be derived mainly from intangible, intellectual resources: knowledge capital. (Burton-Jones, 2001). With this come implications for the organisation, its people and future factors of business engagement. Workers now define the organisation through knowledge exchange (Webber, 2000).

1.5 The Knowledge Organisation

Foss and Pedersen (2004) claim there is a lack of understanding of how organisational design issues relate to knowledge processes in multinational corporations. Simonin (1997) examined whether or not companies can develop specialised knowledge via experience and then use this knowledge to obtain further benefits. Simonin's (1997) results indicated that firms do learn from experience, mainly relating to collaboration.

Becerra-Fernandez and Sabherwal (2003) state the impact of knowledge management moves up from individuals to groups and then to the entire organisation. Sandrone (1995) stated all employees have intimate knowledge of job conditions and are therefore able to make useful contributions. This has been evolved even further to suggest certain aspects of business have become 'people-centric' due to both the knowledge build up and the technological means to transfer information and knowledge. Keller (2003) argued the then President of the University of California, Clark Kerr during his Godkin Lecture of 1963, contended new knowledge had gradually become the key propellant in the growth and improvement for a "*nation's health, military might, economic competitiveness, artistic excellence, social harmony and political stability*". Knowledge management systems are considered to be state of the art innovation (Adams and Lamont, 2003). Pan and Leidner (2003) discuss how a knowledge management system has to be carefully designed and implemented. Alavi and Leidner (2001) state how organisational and management practise has become more knowledge-focused.

As an organisation builds and expands its knowledge base, it builds its intellectual capital and consequently enhances its competitive advantage. Knowledge becomes a competitive asset, especially knowledge which is firm specific, private knowledge, in particular patents, copyrights and 'secret' procedures (Bailey and Bogdanowicz, 2002). However, as best practices become disseminated within an industry, they become public knowledge (Matusik and Hill, 1998). As individuals master firm specific best practices, such knowledge becomes portable. It is part of an individual's as well as a firm's human capital.

The semiconductor industry is defined by rapid technological advancement, short product life cycles and steep price declines. Semiconductor firms introduce new products quickly to meet demand but this is demanding because new products usually require new manufacturing processes (Macher, 2006).

1.6 Knowledge Management in the Work Place

Martensson (2000) states knowledge management can either be an operational tool or a strategically focussed management tool. Wijnhoven (2003) described knowledge management from an operation perspective stating the importance of knowledge management as a prerequisite for higher productivity and flexibility. According to Denning (2001) referring to a 1998 survey of North American senior executives, managers within organisations recognise the value of managing knowledge stating 77 percent rated "*improving the development, sharing, and use of knowledge throughout the business*" as very or extremely important.

McCann and Buckner (2004) stated several important dimensions for establishing a strategic-level knowledge management model:

- The larger context within which an organisation operates, particularly recognising how information and knowledge is recognised and acquired from the organisation's key stakeholders (e.g. customers)
- How knowledge management is linked to the organisation's strategy formation process, ideally linking not just current but future knowledge requirements to explicit and business-level goals
- Operationally relates core knowledge management processes, including knowledge acquisition, building, sharing, retention and application

Storey and Barnett (2000) commented on "*potential micro-political battles over the ownership of knowledge management initiatives*", due to different meanings and approaches to knowledge management in the organisation.

This research includes an investigation into how a subsidiary of a semiconductor corporation creates and manages knowledge and how its infrastructure is set up to deal with knowledge management.

1.7 Manufacturing within National Semiconductor

Manufacturing sites must support the Company by designing and creating production capacity for existing and new product integrated circuits in the form of silicon wafers. Manufacturing sites must have a very good relationship with corporate headquarters on the basis they set goals and direction, but they can also make decisions which can impact the future of the Fabrication site.

A report which specifically looked at the knowledge sourcing by foreign nationals (Almeida, 1996), reviewed citation data and design patents in the semiconductor industry concluding patenting of new technology designs relies on a successful corporate-subsidiary partnership. All company manufacturing sites have patents or patents pending which relate to process or equipment innovations. Although the research does not look at the patents in any detail it will look at how patent owning departments accept and share knowledge with other departments and other manufacturing sites.

1.8 The Firm's Resources and Knowledge Management

Law and Ngai (2007) suggested firms need to step back and carefully think about the "*capabilities critical to sustaining their competitive advantages in their core businesses*", commenting on the importance of aligning their knowledge management and organisational learning strategies. Grant (1996) stated organisational capabilities rather than served markets have become the basis for the firm determining its long term strategy, driven by innovation and intensity and diversity of competition.

Cyert, Kumar and Williams (1993) commented on proprietary knowledge which creates a comparative advantage for the firm. Choi, Poon, Davis (2006) commented about knowledge being an essential resource for a firm to "*retain sustainable competitive advantage*". They further stated as knowledge is created and disseminated throughout the firm it has the "*potential to contribute to the firm's value by enhancing its capability to respond to new and unusual events*". King (2006) stated "*organisational performance improvement is what knowledge management and organisational learning are, ultimately, all about*". Nonaka, Toyama and Konno (2000) commented the *raison detre* of a firm is to continuously create knowledge. In attempting to associate the relationship between knowledge and performance they said there is "*very little understanding of how organisations actually create and manage knowledge*".

1.9 Research and Development

One means a company has of expanding knowledge is through its research and development program. Coff (2003) refers to research and development as a "*process by which firms transform tacit and complex knowledge into codified outputs like patents or products*". Owing to rapid technological changes, short product life cycles and increasing global competition, acquiring new technology becomes crucial to enable firms to develop new products more quickly (Lin, Tan and Chang, 2002). Research and development programs require firms and their engineers or scientists to reinforce their technological competence by importing external technologies, and then diffusing, assimilating, communicating and absorbing them into their organisations (Prahalad and Hamel, 1990), but they also have the opportunity to look beyond the technology façade for that all-important characteristic or entity that will give, or lead the way towards a competitive advantage.

According to Cassiman and Veugelers (2006) innovation is important to top management and for this reason firms are "*experimenting in their innovation process, combining internal research and development and external knowledge acquisition activities"*. Pisano (1994) argues "*process development is but one of the many possible activities that leads to the creation of new organisational knowledge"*. Process development arguably increases tacit knowledge of the organisation due to the amount of information gained through the number of experiments conducted. This can be knowledge based on both what does and what does not "work".

1.10 Knowledge as a Factor of Production

Knowledge is transforming the nature of production and thus jobs, the firm, the market and every aspect of knowledge activity. Yet knowledge is "*currently a poorly understood and thus undervalued economic resource*" (Burton-Jones, 2001).

Polanyi proposed the knowledge dichotomy of explicit and tacit dimension in the 1950s. Polanyi (1967) said we should start from the fact that *"we can know more than we can tell". P*olanyi termed this pre-logical phase of knowing as tacit knowledge. Tacit knowledge comprises a range of conceptual and sensory information and images that can be brought to bear in an attempt to make sense of something. Many bits of tacit knowledge can be brought together to help form a new model or theory.

In the early 1990s Nonaka (1994) systematically made use of the concept in his theory of knowledge-creating company that triggered a continuous enthusiasm on tacit knowledge in developing business knowledge. If knowledge can be codified then it can be made explicit and thus readily transferable. Companies rely heavily on policies, procedures and guidelines which codified knowledge provides.

The knowledge profile of doctors, lawyers, accountants, engineers and other professional service workers could be typified as following (Burton-Jones, 2001):

- High levels of explicit codified knowledge including both conceptual and theoretical knowledge as well as high tacit knowledge, usually gained on the job
- Focus on a particular body of knowledge and/or specialisation usually linked to a particular academic discipline
- Continuous knowledge acquisition and updating, while on the job
- Most knowledge acquired through the study of theory

The typical knowledge profile of delivery drivers, refuse disposal collectors, milkmen and many more providers of personal business services would tend to include:

- Low levels of explicit codified knowledge, but high levels of idiosyncratic and tacit knowledge, such as individual delivery driver's knowledge of how to get to a destination in the shortest time
- Specialization on a particular and usually narrowly defined job, trade or task;
- Continuous acquisition of local and situation-specific knowledge such as knowledge of client's habits or preferences
- Most knowledge gained on the job

These profiles are 'knowledge intensive' and illustrate the different forms of on-the-job knowledge enhancement within different job descriptions. The profiles also demonstrate the diversity of what might be understood as knowledge management in differing employment contexts.

1.11 The Knowledge-Creating Process

Nonaka's SECI model (Nonaka, 1994) shown in Fig 1-0 became an analytical framework on knowledge activities in business organisation.

Figure 1-0 SECI Model from Nonaka (1994).

from \ *to*	Tacit knowledge	Explicit knowledge
Tacit knowledge	Socialisation	Externalisation
Explicit knowledge	Internalisation	Combination

Nonaka (1994) proclaimed four modes of knowledge conversion. He argued the assumption that knowledge is created through conversion between tacit and explicit knowledge allows us to postulate four different modes of knowledge conversion:

(1) *Socialisation* - from tacit knowledge to tacit knowledge.
This is the mode of knowledge conversion that enables us to convert tacit knowledge through interaction between individuals. The key to acquiring tacit knowledge is experience. Socialisation typically occurs in a traditional apprenticeship. It may also occur in informal social meetings outside of the workplace (Nonaka, Toyama, Konno, 2000).

(2) *Combination* - from explicit knowledge to explicit knowledge.
This mode of knowledge conversion involves the use of social processes to combine different bodies of explicit knowledge through such exchange mechanisms such as meetings and telephone conversations. In the context of the

firm explicit knowledge is collected from inside or outside the organisation and then combined, edited or processed to form new knowledge. The new explicit knowledge is then disseminated among members of the organisation (Nonaka, Toyama, Konno, 2000).

(3) *Externalisation* - from tacit knowledge to explicit knowledge.
This conversion is critical because it is a prerequisite to the knowledge amplification process wherein knowledge becomes part of an organisation's knowledge network (Herschel, Nemati and Steiger, 2001). When tacit knowledge is made explicit, knowledge is crystallised, thus allowing it to be shared by others, and it becomes the basis of new knowledge (Nonaka, Toyama, Konno, 2000).

(4) *Internalisation* - from explicit knowledge to tacit knowledge.
This mode is connected with theories of organisational culture. It is closely related to 'learning by doing '(Nonaka, Toyama, Konno, 2000). Explicit knowledge in the form of procedures and guidelines has to be actualised through action and practice. By reflecting on this explicit knowledge the reader can internalise the explicit knowledge to enrich their tacit knowledge base.

1.12 Absorptive Capacity

Knowledge exchange can be considered a two way process. Even if knowledge can be codified it may also require interpretation and understanding. Absorptive capacity affects how easily the recipient, or firm, can understand the export of knowledge (Burton-Jones, 2001). Cohen and Levinthal (1990) argued that the ability of the firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends is critical to its innovative capabilities. They labelled this a firm's absorptive capacity and suggested that it is largely a function of prior related knowledge. Fosfuri and Tribo

(2006) commented on the greater availability of external knowledge sources in modern economies and having a dynamic capability that influences a firm's ability to target, absorb and deploy the external knowledge necessary to feed the internal innovation process becomes a crucial source of competitive advantage. Zahra and George (2002) recognised absorptive capacity as a "*dynamic capability that influences the nature and sustainability of a firm's competitive advantage*".

To develop an effective absorptive capacity, whether it is for general knowledge or problem solving or learning skills, it is insufficient merely to expose an individual to the relevant prior knowledge. Intensity of effort is critical. Harlow (1959) suggested that if practice with a particular type of problem is discontinued before it is reliably learned, then little transfer will occur at the next series of problems. Zahra and Hayton (2007) commented "*a sufficient knowledge stock is a prerequisite to exploiting new knowledge or acquiring other capabilities from international operations*".

This research will look at the absorptive capacity model of the company. Through semi-structured interviews and case studies, the research will consider how knowledge flows within the company, the role of the individual and that of the company in assimilating and "commercialising" this knowledge. It will consider how much an individual relies on prior knowledge and how knowledge is shared between departments and external sources.

Chapter 2 Literature Survey of the Topic of Knowledge Management

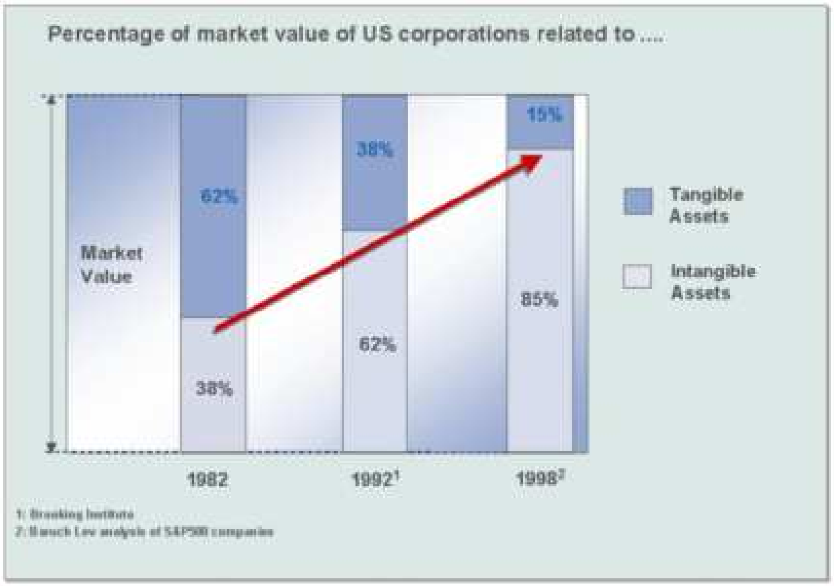
2.0 Knowledge as a Key Resource

According to Wenger (cited in Chauvel and Despres 2000, p205) knowledge is recognised as a key source of competitive advantage but little is known about how to create and leverage it in practice. Traditional knowledge management approaches attempt to capture knowledge in formal systems but Wenger (cited in Chauvel and Despres 2000, p205) argues we should "*foster the communities that take responsibility for stewarding knowledge*". Zack (2003) comments on a common knowledge misunderstanding whereby the more a company's products or services have knowledge at their core, the more the organisation is, by definition, knowledge-led. Zack (2003) believes this to be a dangerous assumption, both for industrial-age businesses that may believe they *can't* change and for the information-age businesses that complacently believe they don't *need* to change the way they operate.

2.1 Intangible Value Creation

With the arrival of the new information technologies, the structure of enterprises have changed dramatically, shifting the focus of value creation from tangible based activities to intangible based value creation. The value of intangible assets has therefore constantly increased in the last two decades from an average of 40% of total market value of business corporations to over 80% at the end of the 20^{th} century as depicted in Figure 2-0.

Figure 2-0. Percentage of Market Value of US Corporations Relating to Tangible and Intangible Assets. From Daum (2001).



In the second half of the twentieth century the value of knowledge was being understood and by the end of the 20th century corporate rules were changed to account for this intangible as physical assets started to become commodities as the value of a company became dependent on its intangible resources. Caddy (undated) said there was a need for a distinction between knowledge management and knowledge measurement. If intangible resources are an asset they must be used to somehow increase the value or worth of the organisation. According to Perez and Ordonez de Pablos (2003) tangible assets no longer provide sustainable competitive advantages. As firms are focusing on their intangible assets, intellectual capital can be viewed as the basis for future sustained competitive analysis.

2.2 Intellectual Capital

Current performance management thinking recognises the need to address the management of intellectual capital and the introduction of frameworks such as the Balanced Scorecard (Kaplan and Norton,1996), the Malmquist Productivity Index (Wu, Tsai, Cheng and Lai, 2006) or the Performance Prism (Neely, Adams and Kennerly, 2002) underline the importance of managing the financial and non financial value contributions of intellectual capital.

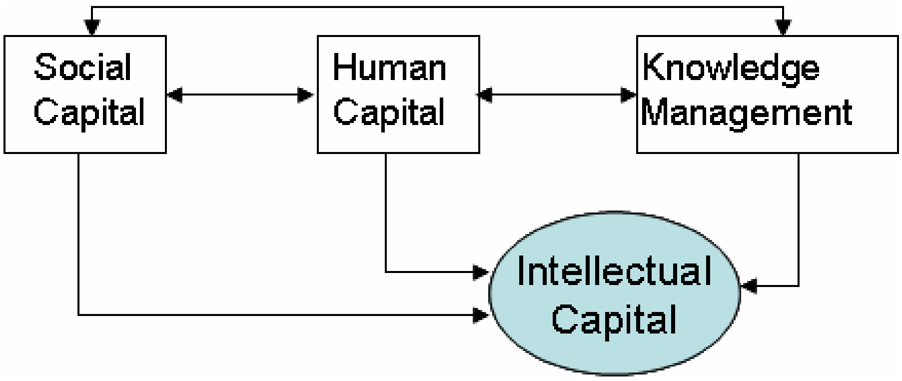
According to Marr, Gupta, Pike and Roos (2003) the management of intellectual capital involves:

- Identifying key intellectual capital which drive the strategic performance of the organisation
- Visualising the value creation pathways and transformation of key intellectual capital
- Measuring performance and in particular the dynamic transformations
- Cultivating key intellectual capital using knowledge management processes
- The internal and external reporting of performance

2.2.1 Knowledge and Intellectual Capital

As companies search for ways to gain a competitive advantage, they are increasingly leveraging their knowledge capital. As we transition from the industrial to the knowledge society, effective use of knowledge is becoming one of the important distinguishing factors between leading companies and also-rans. As the information age supplanted the industrial age, managers sensed that knowledge would be more important than capital in producing wealth (Martin, Moloveanu, undated). Rastogi (2002) states intellectual capital is the nexus of the firm’s social capital human capital and knowledge management. This is shown in figure 2-1.

Figure 2-1 Intellectual Capital Nexus from Rastogi (2002).



2.3 The Value of Knowledge Capital

According to IDC (2001), as shown in Figure 2-2, worldwide, revenue for knowledge management services will increase from $2.3 billion in 2000 to $12.696 billion in 2005, a 40.7% compound annual growth rate. Knowledge management services include consulting, implementation, operation (outsourcing), maintenance and training.

Figure 2-2 Worldwide Knowledge Management Services Spending 2000-2005. From IDC (2001).

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2.4 Knowledge in the Organisation

One of the main matters for organisations managing their knowledge resources is diffusion of knowledge within the organisation. Knowledge resources can be divided into at least two different parts (Haldin-Herrgard, 2000) depending on the possibility of structuring and coding of knowledge. Structured knowledge is often diffused by different systems for storing and sharing knowledge and today there has been much scientific interest in the technology of these systems (Bennett and Gabriel, 1999). Unstructured knowledge is also diffused by different forms of codifying, written or spoken and scientific interest has been aimed at the communication of knowledge in different forms. Different levels of knowledge, regarding the possibility to codify, can be recognised in organisations' knowledge resources. Structured knowledge such as reports or discussions are considered the easiest to code (Augier and Vendelo,1999) with tacit knowledge considered the hardest.

2.4.1 Tacit and Explicit Knowledge in the Organisation

The SECI model discussed in chapter one related to the conversion from one knowledge type to another through internalisation, combination, externalisation and socialisation. In this chapter, knowledge conversion is discussed in the context of the organisation. According to Grant (cited in Chauvel and Despres 2000, p27), if knowledge exists in two principal forms, explicit and tacit, and at two major levels, the individual and the organisation then there are significant benefits to the organisation in shifting its primary knowledge base from individually held tacit knowledge to organisation-wide explicit knowledge.

The critical difference between tacit and explicit knowledge relates to how easy or difficult it is to codify or express the knowledge in terms which enable it to be understood by a broad audience. If knowledge can be codified in this way then it can made explicit and thus readily transferable (Burton-Jones, 2001). In the knowledge management domain, the conversion of tacit knowledge to explicit knowledge is critical because knowledge becomes part of an organisation's network (Herschel, Nemati, Steiger, 2001). Tacit knowledge (Spender, 1996) is acquired through experience.

According to Smith (2001), comparing tacit and explicit types of knowledge is a way to think, not point out differences, illustrating how tacit and explicit knowledge can be used to further professional and organisational goals and enhance the overall performance of organisations. Kakabadse, Kouzmin and Kakabadse (2001) discuss two aspects of the SECI model in the context of the organisation:

- The best vehicle for the *internalisation process* or *knowledge creation* is the availability for 'tinkering' or 'slack' time for learning, thinking and reflecting
- The *socialisation process* or *knowledge sharing know –how* requires underlying common ground and a willingness to share

Exploiting the company's knowledge assets is more complex than making use of its capital assets. Somehow the organisation must identify the areas of knowledge opportunity, harness it and convert it into something that is explicit, usable and provides a competitive advantage for it to be of use. Several researchers (Koskinen, 2003) consider that success of an organisation is formed by the interaction between individuals and several types of knowledge. Thus one organisation might need more tacit knowledge than another. Alternatively there might be differences in the degree to which organisations are able to apply explicit knowledge.

2.5 Core Capabilities

According to Leonard (1998) the starting point for managing knowledge in an organisation is an understanding of core capabilities and, for technology based companies, core technological capabilities. Core competences are based on the skills and experience of many people who do the work, and may not exist in physical form (Bollinger and Smith, 2001).

There are many constituent parts to an organisation when it comes to embedding knowledge management. Wolf (2000) cites three steps to embedding knowledge management in the organisation:

- Determine what kind of knowledge is critical and useful to the business and how it will best support the company strategy
- Identify where this knowledge is to be created, when it is most useful to share it and how this can be done in the context of the organisation
- Institutionalise knowledge management processes as an integral part of the organisation's business processes

Bhatt (2001) argues knowledge management is more than the capturing, storing and transferring of information and states it "*requires interpretation and organisation of information from multiple perspectives*". Bhatt (2002) states knowledge as being more difficult to control than manufacturing activities "*because only part of the knowledge is internalised by the organisation, the other part is internalised by the individual*".

2.6 Communities of Practice

Gieskes, Hyland and Magnusson (2002) argued productivity would increase given a working environment conducive to getting the most out of a diverse resource pool. Wenger (2004) promotes communities of practise as a way of engaging the "practitioner" stating communities of practice relate to groups of people who share a passion for something that they know how to do, and who interact regularly in order to learn how to do it better. Communities of practice are the shop floor of human capital according to Stewart (1996).

In some organisations, the communities themselves are becoming recognised as valuable organisational assets. Whereas the value was previously seen as being relevant primarily to the individual members of a community, it is often now recognised that benefits can also accrue to the organisation itself (Lesser and Storck, 2001). According to Wenger (2004) communities of practice manage their knowledge. "*If you had enough knowledge to micro-manage communities of practice you would not need them*". According to Hildreth, Kimble and Wright (2000) in order to work effectively in a distributed international environment, companies are increasingly turning to the international team. These are seen as an effective and flexible means of bringing both skills and expertise to specific problems and tasks.

2.7 Learning and the Organisation

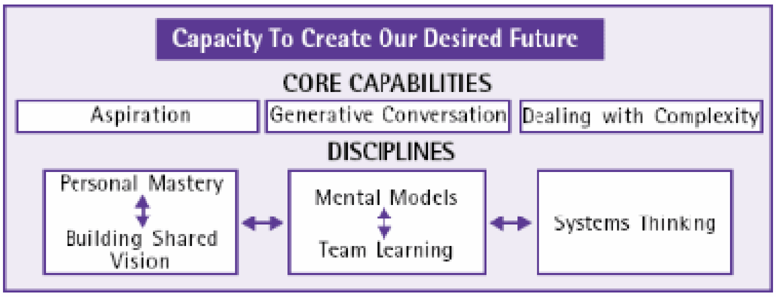
As globalisation has affected business, many organisations have taken steps to downsize, outsource and deskill in an effort to remain competitive (Hildreth, Kimble and Wright, 2000). Unlike manufacturing activities, knowledge activities are difficult to monitor and control, because only a part of knowledge is internalised by the organisation, the other part is internalised by the individual. This duality between individual and organisational knowledge demands different sets of management strategies in knowledge management (Bhatt, 2002).To manage knowledge efficiently a firm needs a highly flexible and adaptable organisational structure. For example Prahalad and Hamel (1990) suggest in present environments, organisations should structure to suit its strengths or 'core competencies', because these kinds of structures are considered "*inherently dynamic and flexible*". There is much debate over whether core capabilities should be defined at the corporate level only or whether a core capability can be located in a division or function within the organisation (Leonard, 1998).

Leonard (1998) argued knowledge is directed by the "nudging" of hundreds of daily managerial decisions, and further argues organisations should understand their core capabilities. Core capabilities could constitute a competitive advantage for a firm; they have been built up over time and cannot be easily imitated.

According to Lee and Seok Lin, (2005), "*Individuals, teams and organisations leading and sustaining change need to develop the following three core capabilities*", and cite required core capabilities based on work by Peter Senge. They include:

1. Aspiration. Focus on the creative as opposed to the reactive, developing a clear sense of purpose and vision at both the individual and organisation level
2. Generative conversation. Focus on expanding our capacity to be more reflective in our thinking and to become more generative when we think and talk , as to enhance the quality of collective thinking and understanding in the team
3. Dealing with complexity. Focus on internalising perspectives and skills that allows us to better understand and manage systemic interconnections that produce complex organisational dynamics

Figure 2-3 Senge's Core Capabilities and Disciplines. From Lee and Seok Lin (2005).



As shown in Figure 2-3, the five disciplines for building up three core capabilities are:

1. Personal mastery: The individual's ability to articulate and create the results he desires in life
2. Building a shared vision: The team's ability to articulate and create the results they want in their organisation

3. Mental models: The individual's and team's ability to know , reflect on, question and clarify assumptions and beliefs they hold about relevant issues, and to understand the impact of these beliefs on their responses, actions and results
4. Team Learning: The team's ability to learn how to learn and work together in synergy
5. Systems thinking: The capacity of the team to understand the inter-relationships between the different variables in the system. This skill integrates the other variables together

However, it is important to recognise an organisation can have core rigidities that can inhibit organisational learning. Newell, Robertson, Scarbrough and Swan (2002) discuss the importance of avoiding the development of particular norms and practices that might constrain innovative behaviour.

2.8 Organisational Culture

According to Drucker (2003) there is no such thing as the one right organisation. There are only organisations, each of which has distinct strengths, distinct limitations and specific organisations. Newell, Robertson, Scarbrough and Swan (2002) state shared values and attitudes shape organisational behaviour.

According to the National Defence University (undated) there is no single definition for organisational culture. Berg and Wilderom (2004) defined organisational culture as shared perceptions of organisational work practices within organisational units that may differ from other organisational areas. Alavi, Kayworth and Leidner (2005) found individual communities' perception of knowledge management technology is shaped by their embedded values which lead to different patterns of technology use.

Chapter 3 Organisational Learning

3.0 Organisational Learning

Organisational learning is a contemporary set of ideas and prescriptions of how organisations should be managed (Rhodes, 1996).

In a way those who work in a learning organisation are "*fully awakened*" people (Larsen et al, 1996) who are engaged in their work and believe in the value of knowledge and value sharing with the team. This is consistent with Senge's view (Infed, 1990) who believes people have the ability to expand their thinking capacity and to be motivated by "*collective aspiration*". Organisational structure however could constrain "*knowledge and value sharing*" or "collective aspiration". It may be through time organisations have to adjust. An example relates to the US Army Corps of Engineers. When asked why the US Army Corps needed to change to a learning organisation their reply was that there was much about their culture which was right and will continue but society was rapidly moving in to the knowledge and service mode of production resulting in the need for a more innovative, flexible, nimble and artful Corp of Engineers (US Army Core of Engineers, undated).

3.1 How Organisations Learn

"All *organisations learn, whether they consciously choose to or not*" (Kim, 1993). Research into the notion and practice of organisational learning has identified distinct systemic levels of learning. Romme and Dillen (1997) discussed how frameworks and instruments developed have been aimed at specifically alleviating the problem of the gap between individual and organisational learning, citing this as the biggest barrier in moving towards learning organisations.

An organisation espouses policies, rules and puts in place management controls that do not reflect what they actually do (Mattia and Dhillon, 2003). In reviewing the work of Chris Argyris as a basis for critical organisational practice, Bokeno (2002) discusses concerns with the individual and the organisation in terms of “defensive routines” and Smith (2001) related to Argyris and Schon’s “theories-in-use and espoused theory”:

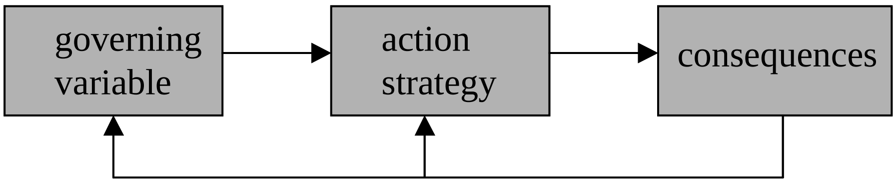
> “*When someone is asked how he would behave under certain circumstances, the answer he usually gives is his espoused theory of action for that situation. This is the theory of action to which he gives allegiance, and which, upon request, he communicates to others. However, the theory that actually governs his actions is his theory-in-use*”.

Argyris (1976) found during a study that most individuals seemed to be able to detect the discrepancies between espoused theories and theories-in-use of others but were not able to detect similar discrepancies in themselves.

In a review of career decision making, O’Hare (1987) found what decision makers espouse and what they actually do is incongruent. Making this distinction allows us to ask questions about the extent to which behaviour fits espoused theory; and whether inner feelings become expressed in actions i.e. is there congruence between the two?

Agyris and Shon presented a theory-in-use model introducing three elements as shown in Figure 3-0.

Figure 3-0 Elements of Argyris and Schon's Theory-in-Use Model. From Argyris (1976).



Governing variables: those dimensions that people are trying to keep within acceptable limits. This could be considered what people do, how they act in normal circumstances.

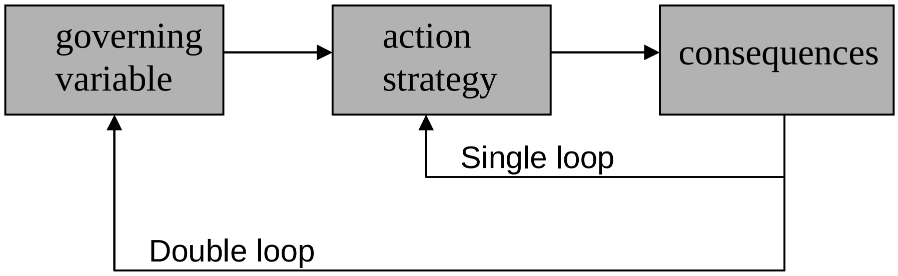
Action strategies: the moves and plans used by people to keep their governing values within the acceptable range. This could be construed as applying standards.

Consequences: what happens as a result of an action. This can be both intended and unintended. In addition those consequences can be for the self and/or for others.

3.1.1 Single-loop and Double-loop learning

Argyris (1976) hypothesised human behaviour, in any situation, represents the most satisfactory solution people can find consistent with their governing values or variables.

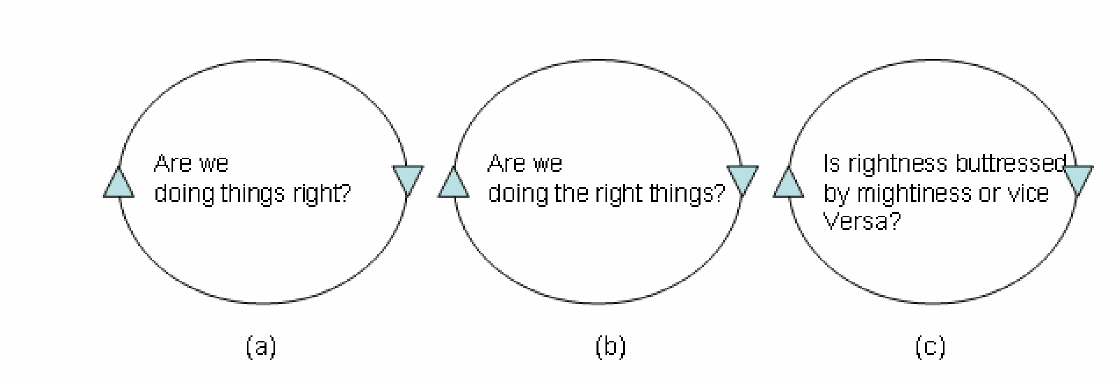
Figure 3-1 Elements of Argyris and Schon's theory-in-use model illustrating single and double-loop feedback. From Argyris (1976).



Single-loop learning involves maintaining existing policies. Analogous to a thermostat that learns when it is too hot or too cold and adjusts as appropriate. Double-loop learning, as shown in Figure 3-1, occurs when error is detected and corrected in ways that involve the modification of an organisation's underlying norms, policies and objectives. Tien Hua (2000) believes double-loop learning advances the organisation whereas single-loop learning maintains the status quo or a means end thinking with task oriented thinkers (Flood and Romm, 1996).

Flood and Romm (1996) recognized three main types of single-loop learning: the "*how*" (figure 3-2a); the "*what*" (Figure 3-2b) and the "*why*" (Figure 3-2c).

Figure 3-2 Flood and Romm's (1996) Single-Loop Learning



The first type of single loop learning (figure a) relates to process design and organisational design. Subject areas include process-based approaches such as business process re-engineering and quality management as well as a range of design proposals that create structural arrangements within which processes flow. By asking if we are doing things right it is attempting to find out *how* we should do it.

The second type of single loop learning (figure b) is about process for debate.
The subject domain is some sort of interpretive based intervention. Interpretive based intervention is a reaction to the obsession with finding structural solutions that preclude the inter-subjective debate processes necessary to define, for example, quality. By asking are we doing the right things it is attempting to find out *what* we should do.

The third type of single loop learning reflects a concern with power knowledge dynamics (figure c). The subject domain is fairer practice. The reaction here is to the obsessive foci of design based and debate based intervention. By asking if rightness buttressed by mightiness, or mightiness buttressed by rightness it is attempting to find out *why* we should do it.

3.1.2 Double-Loop Learning

Double-loop learning is based upon a ‘theory of action’ perspective. An important aspect of the theory is the distinction between an individual’s ‘espoused theory’ and their ‘theory in use’ (what they actually do); bringing these two into congruence is a primary concern of double-loop learning (Mattia and Dhillon, 2003). In their research, Kolb et al (cited in Mabey and Iles, 1994, p146), looked at assessing and facilitating management needs. They highlighted the importance of integrative learning. From the holistic perspective, disagreement, conflict and differences among people are the fuel that energises the integrative learning process. Argyris (1977) questioned why employees are reluctant to report to the top that one of the company’s products is a “loser” stating this inability to uncover errors and other unpleasant truths arises from faulty organisational learning: an action which can be corrected by introducing double-loop learning.

Turner, Mavin and Minocha (2006) explored both the ‘steps’ and ‘dance’ of individual learning through qualitative research and narrative data from individual participants in the organisation. Relating the ‘*steps*’ where an individual is kept within the confines of a job role and the ‘*dance*’ where “*fluidity and flexibility*” is applied enabling individual progression.

Double-loop learning attempts to interplay the centres of learning as expressed in Flood and Romm’s single loop learning (1996) by asking “*are we doing things right and are we doing the right thing*”. Blackman, Connelly and Henderson (2004) addressed questions about the legitimacy of knowledge created by the learning organisation using double-loop learning. Their research focused on a Popperian approach. Popperian’s model of different ontological worlds include a notion of encoded, objective knowledge that resembles the notion of knowledge as an explicit stock available to members of an organisation.

3.1.2.1 Poppers Ontological Worlds

According to Blackman, Connelly and Henderson (2004) Popper distinguishes between three ontological worlds. This is shown in Table 3-0. World 1 consists of the physical world of objects and states. World 2 is the world of subject which consists of consciousness, of subjective experiences and understanding. World 3 consist of objective knowledge, knowledge which is independent of the knower.

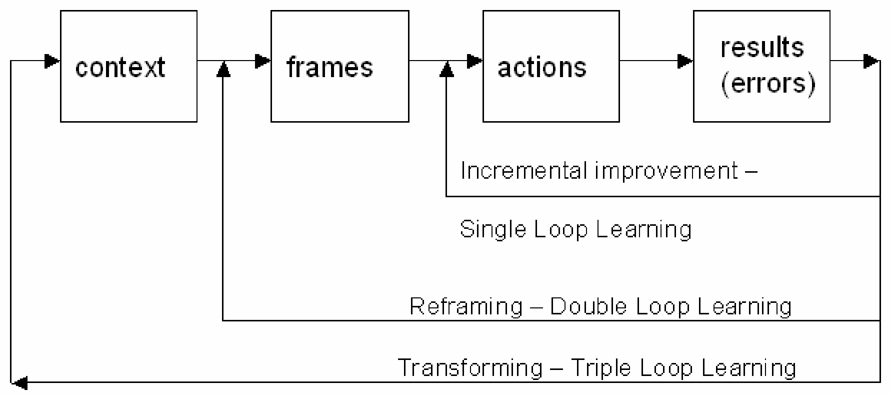
Table 3-0 Popper's Ontological Worlds. From Blackman, Connelly and Henderson (2004).

	Organisational elements	Example problem
World 1	Physical environment People	Tin mine Miners at the mine Owners and managers at a remote site
World 2	Tacit knowledge Individual experiences Individual interpretations Questioning of differences Doubts Organisational conflict	Miner's experience - no tin present Confusion in manager's minds over differences between the miner's accounts and the surveyor's report Conflict between finance and operations management over whether or not to keep looking for tin Anxieties about differences between returns promised to stockholders and likely returns
World 3	Shared mental models Routine actions and processes manuals of best practise Post project evaluation reports Strategic plans Software for automated systems Knowledge databases	Surveyor's report saying tin is present Financial projections Budgets Costings for further exploration Standard operating procedures (safety and environmental) for closing depleted tin mines.

3.1.3 Triple-Loop Learning

Triple-loop learning involves learning how to learn by reflecting on how we learn in the first place. In this situation, participants would reflect on how they think about the 'rules' not only on whether the rules should be changed (LCC, undated). According to Bast (1999) Triple-Loop or transformational learning involves transforming who we are by creating a shift in our context or point of view about ourselves. Single, double and triple-loop learning is shown in Figure 3-3.

Figure 3-3 Single, Double and Triple-Loop Learning. From Bast (1999).



Triple loop learning wants to establish tolerance between all three centres of single and double loop learning and preserve the diversity therein. It does this by consolidating the three questions from the three loops: are we doing things right, and are we doing the right things, and is rightness buttressed by mightiness and/or mightiness buttressed by rightness. Triple loop learning is about increasing the fullness and deepness of learning about the diversity of issues and dilemmas faced (Flood and Romm, 1996).

3.2 Individual Learning

According to Gherardi and Nicolina (cited in Dierkes, Berthoin Antal, Child and Nonaka, 2003, p35) sociologists approach learning not as something that takes place in the mind but as something produced and reproduced in social relations of individuals when they participate in society. They further surmise that knowledge is communicated and institutionalised through:

- The community of practice based upon it
- The organisational subsystem where the community interacts with other communities
- The organisation as a corporate actor that possesses the power to legitimise some forms of expert knowledge and discredit others
- The inter-organisational network created by a system of practices and within which they circulate, by imitation, diffusion, or translation
- Varyingly institutionalized forms of knowledge reproduced by knowledge-brokering organisations, such as training agencies, consortia for certification, and organisational consultants
- The institutional environment that creates the conditions for the reproduction (or change) of knowledge institutionalized into rules and regulations or granted to universities, natural research institutes, and similar institutions authorized to manage knowledge

Malhotra (1996) defines the learning organisation as an "*organisation with an ingrained philosophy for anticipating, reacting and responding to change, complexity and uncertainty*". According to Sadler (cited in Dierkes, Berthoin Antal, Child and Nonaka, 2003, p415) organisations need to acquire and store knowledge for employees to leverage. According to Bhatt (2002) an organisation is a "*problem-facing and problem-*

solving entity” where learning in the organisation is significantly affected by the complexity of tasks and the organisational environment.

According to Ramperstad (2002) and Ghalib (2004) an organisation will gain an advantage if workers can be innovative and manage to commercialise knowledge more quickly than the competition.

3.3 Knowledge Management within the Learning Organisation

This thesis is concerned with the advancement of knowledge management within a learning organisation. Heath (2003) believes knowledge management is more about the organisational technical and cultural infrastructure than it is about “*managing knowledge*”. Jones, Herschel and Moesel (2003) argue knowledge can be built up exponentially by integrating the individual’s knowledge with the “*shared organisational memory*”. Drucker, relating to the progression and influence of the knowledge worker comments on there being fewer “subordinates” even in low-level jobs. Smith and Rupp (2002) looked into the challenge of managing knowledge workers and reported that management’s recognition of the importance of personal and family life is the most important characteristic in a knowledge-based environment.

As knowledge increased, organisations restructured. A ‘flattening’ of management styles occurred by eliminating layers of hierarchies (Ghalib, 2004). The focus was on teamwork. Gieskes, Hyland and Magnusson (2002) argue that the environment reflects how people feel and that their feelings are developed through shared perceptions of daily practises.

Friedman (cited in Dierkes, Berthoin Antal, Child and Nonaka, 2003, p398) stated by definition, organisational learning is a process that can be fully understood only at the group or organisational level. The link between individual and organisational learning appears to occupy a critical position in theories of organisational learning.

Simons, Germans and Ruijters (2003) discuss how educationalists and business scientists discovered learning at the workplace and organisational learning, stating how the two cannot exist without each other. Ikehara (1999) states how the spirit of the learning organisation is founded on the learning processes of the individuals in the organisation, although expresses concern about learning being viewed as the *end* rather than the *means* to the learning organisation. Nonaka (1994) argued that any organisation that dynamically deals with a changing environment ought not only to process information efficiently but also to create information and knowledge.
Nonaka, Toyama and Konno (2000) state knowledge needs a context to be created contrary to the Cartesian view of knowledge which emphasises the absolute context-free nature of knowledge.

Encompassing individual learning, the cognitive perspective of organisational learning takes on two approaches (Turner, Mavin and Minocha, 2006). The first views individual learning as a model for organisational action, where organisations are able to learn, presuming that they have identical or at least similar capacities to those of humans. The second approach proposes that organisational learning is individual learning in an organisational context (Bhatt, 2002). Within this approach, theories present organisational learning as more the sum of the learning of individual members of an organisation and the role of organisational culture is to raise the desire to learn in the individual.

3.4 Building a Knowledge Management System

Clarke and Rollo (2001) argue knowledge generated by the individual is only of economic value when it is "*embodied in the organisational routines*". They further comment companies tend to invest in information technology when they should invest in social relationships. This is required to create a knowledge transformation in the company. Hedberg (cited in Despres and Chauvel, 2000, p269) ascertains that modern organisations often trade hierarchies for markets and replace tightly coupled structures with more loosely coupled networks allowing shared resources and competencies to represent good customer value.

Knowledge transfer is nominally associated with the process of moving useful information from one individual to another person (Ladd and Ward, 2002). According to Davenport, De long and Beers (1997) finding the person with the knowledge one needs, and then successfully transferring it from one person to another, are difficult processes.

3.5 The Learning Organisation

Choo (2001) stated that organisations use information in three arenas: sense-making, knowledge creation and decision making. The basic idea of *Sense-making*, according to Weick (1993) is that reality is an ongoing accomplishment that emerges from efforts to create order and make retrospective sense of what occurs. According to Patriotta (2003) Sense-making is conceived of as a trajectory leading from equivocal action-based processes, unfolding in the work setting, toward agreed facts and epistemological closure. Important to this research, Patriotta argued the “*descent to the shop floor*” was an attempt to gain hands-on experience of empirical knowledge-related phenomenon associated with “*real actors, concrete problems and everyday organisational practices*”. Weick (1993) states sense-making emphasises that people try to make things rationally accountable to themselves and others. Sense-making is how the individual e.g. person, group and/or organisation make sense of stimuli (Woodside and Wilson, 2003).

Knowledge creating is precipitated by a situation which identifies gaps in the existing knowledge of the organisation or the work group. Such knowledge gaps stand in the way of solving technical or task-related problems, designing a new product or service, or taking advantage of an opportunity. In knowledge building (Leonard-Barton, 1992) core capabilities are created and enhanced through experimentation and developing new processes and tooling.

Decision making is precipitated by a choice situation, an occasion in which the organisation is expected to select a course of action.

According to Wang and Ahmed (2003) learning at the organisational level was generated through the combination of individual learning, training and development. Through literature review Wang and Ahmed (2003) identified five focuses of the concept of organisational learning:

(1) Focus on Individual learning

Reagans, Argote and Brooks (2005) discuss how performance typically increases as organisations gain production experience and how "learning curves" have been found in many organisations in different industries. They further state the ability of individuals to use knowledge accumulated by their colleagues turns on the rate of knowledge transfer within the organisation. Griggs (1985) discusses individual learning in terms of individuals with a high need for structure and individuals with a low need for structure. Rainbird (2000) discussing how both intrinsic factors such as skills and qualifications, and extrinsic factors such as job classification and potential for job progression must be considered as they will impact on the individual's motivation to learn. Cabrera, Collins and Salgado (2006) suggested a sense of personal competence and confidence may be a requirement for a person to engage in knowledge exchanges.

(2) Focus on process or system

According to Deng and Chaudhury (1992) learning takes place as a result of the dynamic interaction between a system and its environment, and better performance is expected to evolve through the learning process. Unnikrishnan Nair (2001) describes organisations as "*collective human systems capable of higher-order functions*"

(3) Focus on culture or metaphor

Within the organisational learning literature, there is a strong emphasis on the cultural perspective of the learning organisation (Wang and Ahmed, 2003). According to Berg and Wilderom (2004) organisational culture forms the glue which holds the organisation together and stimulates employees to commit to the organisation and to perform. Morrison, Brown and Smit (2006) state organisational culture can be a dysfunctional factor. Nonaka (2007) describes metaphor as a distinctive method of perception. It is a way for individuals grounded in different contexts and with different experiences to understand something intuitively through the use of imaginations and symbols without the need for analysis or generalisation.

(4) Focus on knowledge management

From an economic perspective, in the knowledge based economy knowledge is becoming the primary factor on which competitive advantage rests (Uit Beijerse, 1999). From a company perspective companies today are facing important challenges such as the need to reduce time-to-market, the development and manufacturing costs, or the management of products with more and more technology (Chamorro Del-Rey, Roy, Van Wegen, Steele, 2003). Organisational learning and knowledge management are two parallel-developed concepts in the new economy and often refer to each other in their definitions and practises (Wang and Ahmed, 2003). Gooijer (2000) states knowledge management is a radical innovation or change to an organisation's operation. Suggesting it intervenes with organisational culture.

(5) Focus on continuous improvement and incremental innovation

Przysuski (2008) cited incremental process improvements as the means by which firms create or sustain their competitive advantage. Ng (2004) however discussed the importance of a revolutionary rather than an incremental approach to innovation. Dewar and Dutton (1986) believe the depth of organisational knowledge should co-vary with the adoption of radical innovations. Przysuski (2008) doubted the luxury firms have in engaging in expensive research which may lead to radical breakthroughs.

3.6 Barriers to Learning

Gieskes, Hyland and Magnusson (2002) suggests organisational learning is neither automatic nor effortless. In the context of the multinational company and how to surmount inter-unit barriers, Barner-Rasmussen and Bjorkman (2005) suggest inter-unit communication is of significant importance and recommend joint training and development programmes for employees. Miles, Miles, Perrone and Edvinsson (1998) view knowledge itself as a strategic level barrier stating managers have traditionally been comfortable with things which are easily measured and accountable. Knowledge however, is not easily accounted for within traditional systems.

McCracken (2005) discusses the leadership role and the need for line managers to have requisite motivational skills to professionally and personally develop their staff for the good of the organisation.

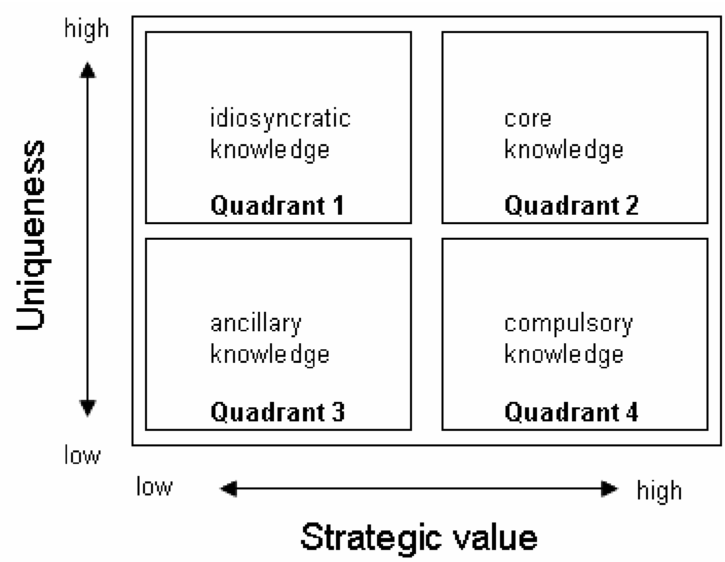
3.7 Knowledge Types

Economic globalisation has put pressure on organisations to speed their technological innovation processes and to exploit the synergy of intangible assets (Perez-Bustamante, 1999). Market globalisation and market segmentation have reinforced in organisations the need to differentiate, to exploit the advantages derived from the selective integration of core competencies and to lever intangible assets.

According to Ordinez de Pablos (2006), the competitive environment provides a unique opportunity to examine how organisational globalisation is affecting knowledge transfer and organisational learning in a globalised world. Ordinez de Pablos (2006) states every foreign subsidiary provides some geographically unique knowledge which allows parent to exploit opportunities that exist in local resource and/or markets, the competitive advantage of trans-national organisation lies, to a great extent, in its ability to identify and efficiently transfer strategic knowledge between its geographically dispersed and diverse locations.

Idiosyncratic Knowledge is not especially useful for creating customer value (Guns and Valikangas, 1998). Idiosyncratic knowledge is considered to be very unique, but of limited strategic value. This is demonstrated in quadrant 1 Figure 3-4. Within a manufacturing context, idiosyncratic knowledge it could be argued as this knowledge type is not codified it could be a burden on the company should employees with idiosyncratic knowledge leave.

Figure 3-4 Knowledge Value from Ordonez de Pablos (2006).



An important task is identifying how a firm can develop potential value of this resource while preserving its uniqueness. With the increasing need of reducing costs many firms have analysed the value of this form of idiosyncratic knowledge. In some cases the decision has been to disinvest. Managers must avoid an over-investment in idiosyncratic human capital but at the same time they must warrant competitiveness in the long run (Ordonez De Pablos, 2004). The key factor to increasing this form of knowledge is linking it to other forms of knowledge as with relational, organisational and technological capital.

Quadrant 2 represents core knowledge. When knowledge is highly valuable and unique it provides strategic benefits which exceed the bureaucratic costs associated with their development and deployment. Organisations have incentives to internally develop and invest in human capital to maximise its value creating potential and differentiating characteristics.

Quadrant 3 represents ancillary knowledge. This is a form of knowledge which is neither useful for creating customer value nor is it particularly specific to the firm (Ordonez de Pablos, 2006). This form of knowledge is simply generated as a result of activity of the corporation.

Quadrant 4 represents compulsory knowledge. This may be a valuable resource however it is not firm specific which means investment decisions for this form of knowledge differ from those forms in quadrant 3. Compulsory knowledge is not specific to any particular firm and employees are free, within certain limits to sell their talents wherever they can achieve the highest returns.

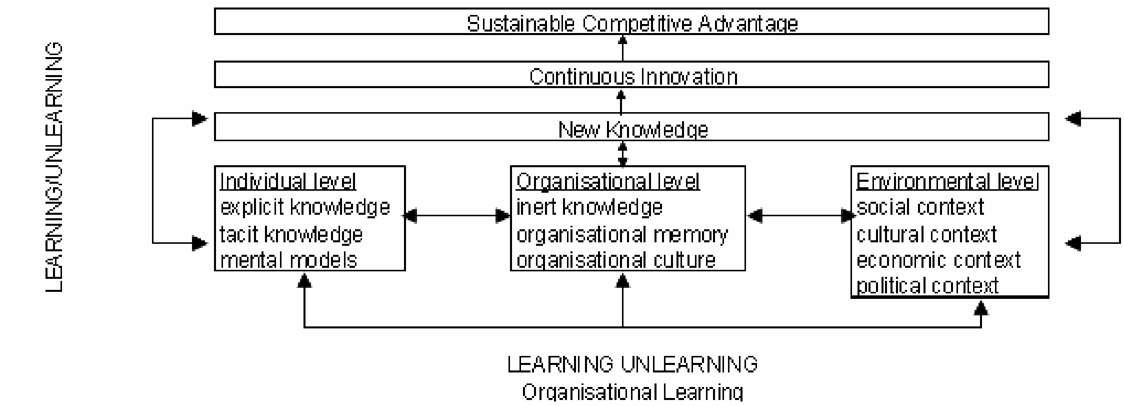
3.8 Harvesting and Exploiting Knowledge within the Organisation

According to Heath (2003) knowledge management has been a ten year ‘buzzword’, yet few successful knowledge management projects have been written up in literature and few organisations seem to claim strategic advantage from knowledge management. Heath (2003) states knowledge management is not really about the management of knowledge. It is more properly concerned with the establishment of appropriate policy, technical, managerial and cultural infrastructures in which knowledge can be more effectively created, shared and used. Rebernik and Sirec (2007) proposed a typology of attributes needed to create new knowledge and likened tacit knowledge to the iceberg: much of it lies beneath the surface of the organisation.

Rebernik and Sirec (2007) further states the key driver of superior performance today is the ability to change when the environment calls for it and to find the shifting sources of advantage. The ability to create new and valuable breakthroughs offers companies an unambiguous competitive advantage. Such an imperative requires a shift in the role of management. It must be managed at individual and organisational level, as well as in the social, cultural, economic and political contexts. This is demonstrated in figure 3-5.

There has been a growing realisation that successful technology flows in relation to supporting technology transfer and sustaining a firm's competitive advantage depends on the way knowledge is generated, articulated and shared within the organisation (Malik, 2004). Eisenhart (2001) stated knowledge gathering or harvesting has a place in almost any enterprise knowledge management strategy but does infer a company must avoid the "*catastrophic error of beginning the harvesting process before the company is culturally ready for it*". Taylor (2006) discusses exploiting the opportunity to harvest knowledge from frontline staff through vehicles such as feedback sessions and defining a "knowledge champion".

Figure 3-5 Organisational Learning from Rebernik and Sirec (2007)



At the individual level, researchers and writers have identified the difference between explicit and tacit knowledge. Knowledge creation involves and combines different sources of information (Rebernik and Sirec, 2007). The locus of knowledge can be found internally within local boundaries, or externally through intra-firm collaboration (Becker and Gassmann, 2006).

On an environmental level companies face the challenge of exchanging knowledge among different agents (Rebernik and Sirec, 2007).

Gillingham and Roberts (2006) commented on the importance of information systems and the burden of responsibility software systems have in the organisation. Heath (2003) supported this adding databases set up by one part of the organisation should be readily accessible by another.

According to Gillingham and Roberts (2006) reinforced the importance of three elements of knowledge management: people, process and technology. To ignore technology would be to restrict knowledge sharing in the organisation. This approach supports the SECI process (Nonaka, Toyama and Konno, 2000) where socialisation is about bringing people together to share tacit knowledge and combination which sorts and reconfigures existing explicit knowledge.

3.8.1 Soft Aspects of Knowledge

Gillingham and Roberts (2006) state the role of people in knowledge management is one of the most important and complex elements to work with. The behaviour of people is often influenced by their beliefs, different values and attitudes as well as the organisation culture of the environment in which they work. Influencing what people believe should lead to changes in values, attitudes and ultimately the way in which knowledge is shared. Trying to get people to do things differently is not so straight forward because people can easily fall back on defensive routines (Argyris, 1977). Hwang (2003) believes that unlearning is often as difficult as learning, if not more so.

According to Hwang (2003), managing knowledge is a "*skill, like financial acumen, and managers who understand and develop it will dominate competitively*". There is an increasing recognition of the importance of knowledge acquisition and management for Multinational Corporation success (Vance and Paik 2005). How to capture the expertise or experience, package them and make them available to people in the organisation are the challenges faced by the information revolution.

3.8.2 Hard aspects of knowledge

Knowledge needs to be distributed and shared throughout the organisation before it can be exploited at the organisation level (Bhatt, 2001). The interactions between organisational technologies, techniques and people can have a direct bearing on knowledge distribution. For example organisational structure based on traditional management minimises the interactions between technologies, techniques and people. This reduces the opportunities in knowledge distribution. Similarly, knowledge distribution through supervision and predetermined channels will minimise the interactions and consequently reduce the opportunity to question the validity of the transferred knowledge.

One of the main roles of information technology in knowledge management programmes is to accelerate the speed of knowledge transfer and creation (Carvalho, 2001). The knowledge management tools are intended to help the processes of collecting and organising the knowledge of groups of individuals in order to make this knowledge available in a shared base.

Due to the largeness of the concept of knowledge the software for knowledge management seems quite confusing. Technology vendors are developing different implementations of the knowledge management concepts in their software products. Carvalho (2001) suggested because of the variety and quantity of knowledge management tools available on the market, a typology may be a valuable aid to organisations that are looking for answers to specific needs.

Figure 3-6 Means of Converting Knowledge Using Information Systems. From Carvalho (2001).

	To Tacit	To Explicit
	Socialisation	**Externalisation**
From Tacit	knowledge maps	groupware
	knowledge portals	workflow
		knowledge based systems
		knowledge portals
	Internalisation	**Combination**
From Explicit	innovation support tools	intranet
		electronic document management
		business intelligence
		competitive intelligence
		knowledge portals

Figure 3-6 represents the categories of knowledge management software representing the four knowledge conversion modes. Carvalho (2001) states a wise selection of knowledge management software requires a previous analysis of the organisation's knowledge needs. Among the considerations are in some organisations for instance, a low level of socialisation may be the critical point; in others externalisation may need to be improved. It is likely due to the natural progression of software technology many organisations are relying very heavily on knowledge management tools. This could give organisations potential for improvement at their fingertips.

Marwick (2001) also attempted to focus on the processes by which knowledge is transformed between its tacit and explicit forms. This is demonstrated in Figure 3-7.

Figure 3-7 Means of Converting Knowledge Using the Individual or the Team. From Marwick (2001).

Tacit to Tacit	Tacit to Explicit
Socialisation	**Externalisation**
e.g team meetings	e.g dialogue within team
Explicit to Tacit	**Explicit to Explicit**
Internalisation	**Combination**
eg. Learn from a report	eg email a report

As all the processes are important it seems likely knowledge management solutions should support all of them although the balance between them in a particular organisation will depend on the knowledge management strategy used.

3.9 Knowledge Management in Multinational Companies

According to Michailova and Nielsen (2006), a growing body of literature has suggested that international businesses need to create conditions for efficient knowledge sharing between headquarters and subsidiaries as well as between subsidiaries and themselves in order to build competitive advantage both at home and abroad. Minbaeva, Pedersen, Bjorkman, Fey and Park (2003) state it is the ability to create and transfer knowledge internally which gives multinational companies a competitive advantage. Martin and Salomon (2003) say however, possession of a knowledge-based advantage does not by itself guarantee that a firm will be able to exploit the sources of this advantage in foreign operations. Rangan (1998) advises on the importance of looking at multinationals from a flexibility perspective relating to currency changes, concluding European, Japanese and US multinational companies in the manufacturing industry do operate flexibly. In the context of the geographic location of the primary site involved in this research and the influence exchange rate mechanism can have, this observation holds relevance.

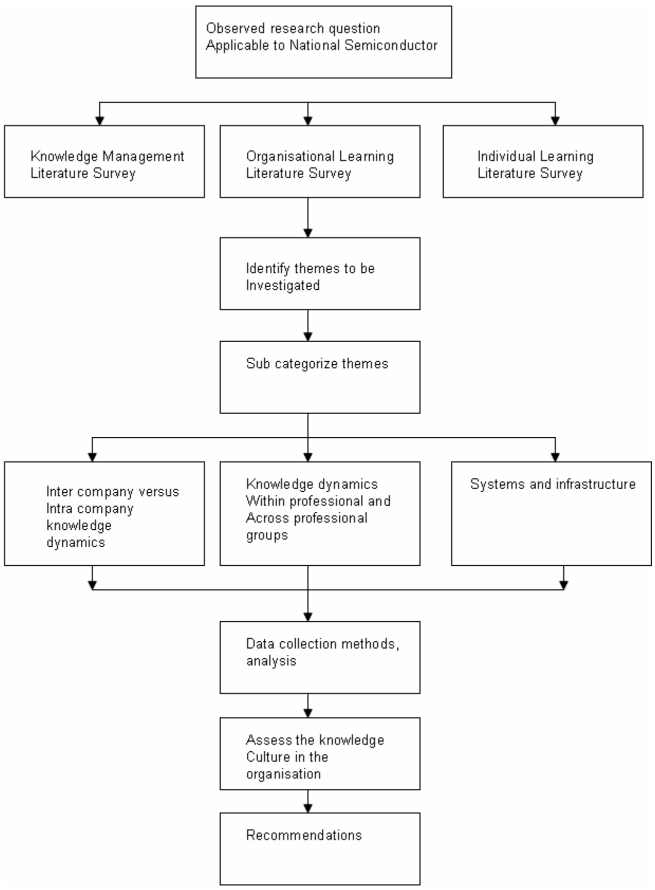
According to Coakes (2006) trans-national organisations have specific issues relating to space and time, and increasingly relating to *virtuality* in their working practices. Technology in a trans-national will have the effect of mediating the distribution of economic activity and power between the various entities of the organisation. Chung, Gibbons and Schoch (2006) argued the nationality of the multinational company influences information management and managers management practices used for performance evaluation and control in the overseas subsidiary.

Chapter 4 Research Methods

4.0 Research Themes

This research was conducted within a manufacturing facility of National Semiconductor Corporation with the objective of understanding knowledge dynamics within and across the organisation. In doing so the researcher looked at how systems, policies and procedures at the local manufacturing site support or inhibit knowledge exchange, how or if the Site supports knowledge management as a way of doing business and considered the level of interaction between individuals and or groups within a knowledge management context. Figure 4-0 presents an overview of the research themes

Figure 4-0 Overview of Research Themes



4.1 Revisiting the Research Problem

The following factors encompass the research structure:

- The need to develop a knowledge management theoretical structure was assessed through the literature survey phase, which showed how important knowledge and knowledge management activities were for remaining competitive within a multinational corporate setting.

- Through natural attrition or ever-demanding productivity requirements, semiconductor manufacturing, from a cost of manufacture perspective, has become leaner over time. As a result fewer people share the burden of sustaining a knowledge led facility.

- When a reduction in force (RiF) takes place, there can be an immediate impact on performance which can take time to correct. This could suggest:

    - Explicit knowledge not acknowledged leaves the site;
    - Implicit knowledge not realised leaves the site;
    - A combination of both.

- Some groups interact with one another more than others. It is possible groups with a greater level of knowledge exchange are more effective than those working in isolation, irrespective of how well they meet their departmental goals.

- Investment in new technology and the rise of equipment automation has moved responsibility to engineer and operator discipline and compliance.

- The Corporation’s three manufacturing facilities have similar organisational structure but an internal competitive spirit exists. It was deemed important to understand how the manufacturing facilities compared in knowledge dynamics and whether internal competition possibly stimulated or stifled a knowledge-led competitive advantage for the Company.

The following were considered as part of the research process

- Underlying Company and local Site goals and how these are measured, identifying existing knowledge management initiatives:

  - Senior staff at the local facility identified the need for better strategic awareness in October 2003 and developed the concept of ‘Vision into Action’. This is shown in Figure 4-1. This process was an attempt to marry Corporate goals to an internal local vision or ‘view of the world’ and create an infrastructure which would support this vision.

  - In November 2006, Senior Staff worked with Corporate on defining a ‘statement of values’. These included statements on accountability, promoting innovation and creativity, acknowledging social responsibility, promoting involvement and teamwork and creating and delivering value to customers. This is shown in Figure 4-2.

- Cognisance of individuals or departments who strive to enhance performance through collaboration or sharing of knowledge. This may be despite a lack of supporting infrastructure and whether the company acknowledges or recognises such individuals or departments. It is possible a scenario may exist whereby individuals promote the flow of knowledge management but it is not supported by the organisation irrespective of their level of success.

- The understanding of the term ‘knowledge management’ and how an individual or group would readily know or accept the context of what they do in knowledge management terms.

- The level of compliance to processes and procedures across the organisation and how this relates to generating, harnessing and exploiting knowledge management in the organisation.

Fig 4-1 National Semiconductor ‘Vision into Action’

The local site considered the “Corporate” strategic view and its own capabilities. By adopting a balanced scorecard approach (Kaplan and Norton, 1996) it was able to define departmental goals. This research would investigate departmental knowledge sharing and how well it could assimilate this and produce a competitive advantage for the local site.

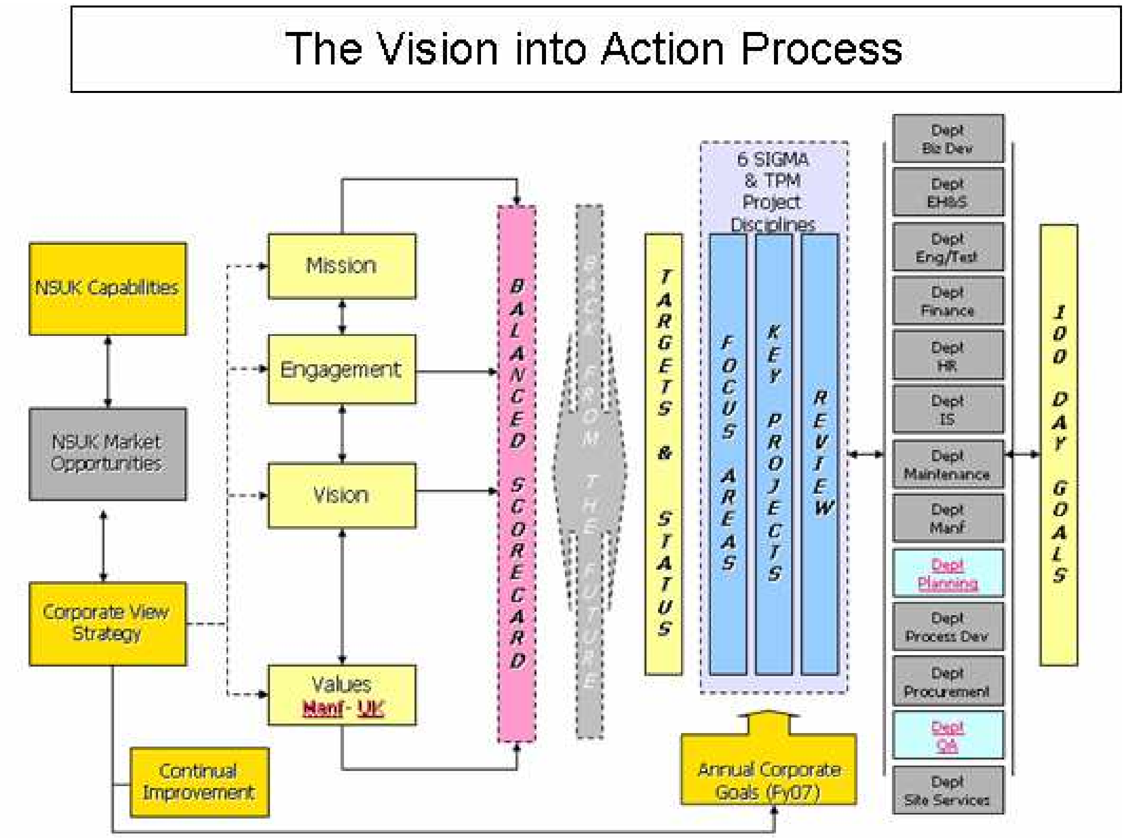


Fig 4-2 National Semiconductor (UK) LTD ' Statement of Values'.

National Semiconductor

STATEMENT OF VALUES

Our core beliefs are based on the following principles:

- ✓ *We will display and promote accountability in all that we do*
- ✓ *We promote an innovative approach to improving our business and operational performance*
- ✓ *We will work with integrity in all our dealings with all our stakeholders**
- ✓ *We will acknowledge our social responsibilities*
- ✓ *We will promote involvement and participation through teamwork and collaboration across the organisation*
- ✓ *We will create and deliver value to our customers*

****Stakeholders:***

Corporation
Customers
Employees
Suppliers
Communities

We will display and promote accountability in all that we do. Specifically:

- *We value commitment to achieving results.*
- *We will encourage full participation to maximise personal and organisational achievement.*
- *We value speed, simplicity and an efficient approach to getting actions executed.*
- *We will value everyone's contributions and aim to give credit where credit is due.*
- *We do what we say we'll do*

We promote an innovative approach to improving our business and operational performance. Specifically:

- *We will encourage new ideas for breakthrough results*
- *We will encourage creativity and responsible risk taking*
- *We will strive for continuous improvement*

We will work with integrity in all our dealings with all our stakeholders* Specifically:

- *We will base our relationships and decision making on an understanding and respect for each other*
- *We will promote an environment which encourages employees to speak up freely and tell it like it is*
- *Our decisions will be based on data and, where appropriate, through consultation*
- *We will endeavour to behave in a fair and equitable manner with all our stakeholders*
- *Decisions will be openly communicated*
- *We expect everyone to take ownership, be accountable and lead by example*

We will acknowledge our social responsibilities. Specifically:

- *We will always work safely.*
- *We actively promote the health and well-being of our employees with a balance between personal and work life.*
- *We will always consider economic, social and environmental impacts in our decision making.*
- *We will be an active participant in our local and business communities.*

We will promote involvement and participation through teamwork and collaboration across the organisation. Specifically:

- *We will actively share ideas and information across the organisation, in order to capitalise on opportunities.*
- *We value and solicit inputs from stakeholders.*
- *We value putting company objectives ahead of individual department goals.*
- *We recognise and encourage the importance of listening to each other.*

We will create and deliver value to our customers. Specifically

- *We make it easy for people to do business with us.*
- *We will deliver best value as defined by meeting the customer's requirements.*
- *We will deliver our new and current products on time.*
- *We strive to produce high quality products at a competitive cost using proprietary technology.*
- *We will provide an excellent and flexible service to NSUK's internal and external customers*

4.2 Types of Research

Scientific research paradigms are *"overall conceptual frameworks within which some researchers work"* (Healy and Perry, 2000). Deshpande (1983) argues the most commonly accepted definition among students of philosophy of science is that proposed by Thomas Kuhn in his seminal book, The Structure of Scientific Revolutions (1962) referring to a paradigm as a set of linked assumptions about the world which is shared by a community of scientists investigating that world. According to Hussey and Hussey (1997) research design, data collection and presentation of results will reflect basic beliefs about the world. There are two main research paradigms or philosophies: positivist and phenomenological. Alternative terms for these research paradigms are shown in table 4-0.

Table 4-0 Positivistic and Phenomenological Paradigms from Hussey and Hussey (1997).

Positivistic paradigm	Phenomenonological paradigm
Quantitative	Qualitative
Objectivist	Subjectivist
Scientific	Humanistic
Experimentalist	Interpretivist
Traditionalist	

4.2.1 Positivism

The positivist paradigm of exploring social reality is based on the philosophical ideas of French philosopher August Comte, who emphasised observation and reason as means of understanding human behaviour (Dash, 2005). According to Comte (Dash, 2005) true knowledge is based on experience of senses and can be obtained by observation and experiment. Positivistic thinkers adopt his scientific method as a means of knowledge generation. It has been criticised however for its lack of regard for the subjective states of individuals (Dash, 2005).

4.2.2 Phenomenology

Durgee (1985) contrasted a phenomenological approach to a positivist approach and stated the phenomenologist puts aside theoretical suppositions and instead works from scratch. Fischer (1979) stated a phenomenological approach integrated the practitioner's sensitivity to the client. Churchill and Wertz (1985) concluded phenomenology is a means by which researchers examine presuppositions in every day and scientific life.

4.3 Assumptions of the Main Paradigms

Creswell (cited in Hussey and Hussey, 1997, p48) draws on a number of other authors to show the different assumptions of the two main paradigms. These are shown in table 4-1. In this instance the positivistic paradigm is referred to as quantitative and phenomenological as qualitative.

Table 4-1 Assumptions of the Main Paradigms. From Hussey and Hussey (1997).

Assumption	Question	Quantitative	Qualitative
Ontological	What is the nature of reality?	Reality is objective and singular, apart from the researcher	Reality is subjective and multiple as seen by participants in a study
Epistomological	What is the relationship of the researcher to that researched?	Researcher is independent from that being researched	Researcher interacts with that being researched.
Axiological	What is the role of values?	value-free and unbiased	Value laden and biased.
Rhetorical	What is the language of research?	Formal. Based on set definitions. Impersonal voice. Use of accepted quantitative words.	Informal. Evolving decisions. Personal voice. Use of accepted qualitative words.
Methodological	What is the process of research	Deductive process. Cause and effect. Static design- categories isolated before study. Context free. Generalisations leading to prediction, explanation and understanding. Accurate and reliable through validity and reliability	Inductive process. Mutual simultaneous shaping of factors. Emerging design- categories identified during research process. Context bound. Patterns, theories developed for understanding Accurate and reliable through verification

4.4 Research Methodology

Cross, David, Baker Graham, Thralls (1996) stated methodology "*is a way of connecting the research to the world; a way of supplying a framework for posing questions and answering them*". Walker (1996) discussed the skill involved in matching a research approach to a particular research problem, where developing an "*innovative methodological solution*" was important. According to Hussey and Hussey (1997) methodology refers to the overall approach to the research process, from theory to data analysis listing the main issues of methodology as:

- Why you collected certain data
- What data you collected
- From where you collected it
- How you collected it
- How you will analyse it

4.5 Research Strategy

Research of this size or scope had never previously been undertaken at any of the Corporation's manufacturing facilities. The local facility had undergone a significant number of changes over the last decade and even came "back from the brink" of closure following a strategic decision reversal. It was at this juncture the local management team realised their destiny was in their own hands through focussing on the correct strategic and tactical metrics and imperatives. From the researcher's standpoint, the years which followed the reversal of the closure decision, establishing a suitable management team and implementing courses of action for sustained local site longevity would hopefully provide the primary material for this research. It was a general consensus at senior management level that the local site would continue to receive investment as long as it demonstrated excellent cost, productivity and quality results.

The consideration is on how the appropriate research data is extracted, validated and analysed. In order to gain access to this material the following considerations were taken into account before employing the appropriate research strategies:

Functionally the structure of the local site can be broken down into two main groups; Operations and Support:

- Operations relates to the core manufacturing activity of the site. This community consists of a number of technical functional areas each led by a senior engineering or manufacturing manager who report to the operations director. It would be important to understand the systems and procedures which govern the management of this group, how knowledge is shared within each functional area and how readily it is shared between functional groups and the formality or informality of this knowledge sharing.

- Support relates to the professional support groups at the Site. It includes Finance, Human Resources (HR), Procurement, Information Systems (IS), Facilities and Environmental Health and Safety (EHS). In terms of the reporting structure to the plant director, these groups are all stand-alone with specific responsibilities. It would be important to understand how knowledge is shared within each Support group and the level of sharing across groups.

Specifically, the researcher would be examining the conditions under which knowledge is shared such as: does it only happen when it is seen as part of doing business? Does evidence exist of unconditional knowledge sharing as a means of individuals or groups keeping each other up to date? Does evidence exist of individuals or groups using the power of knowledge and collaboration to enhance company performance?

The research methodologies employed should be conducive to providing the researcher this level of detail.

4.6 Research Methodologies for Consideration

A number of research methods were considered**.**

4.6.1 Surveys

A survey is a positivistic methodology. A sample is taken reflective of population size and studied (Hussey and Hussey, 1997). According to Lewin (cited in Somekh and Lewin, 2005, p215) having decided on the sample it is necessary to decide how to ask the survey questions.
Questionnaires provide a way of gathering structured and unstructured data from respondents in a standardised way. This can take the form of a structured interview or completion by the respondent of a questionnaire form. According to Sapsford and Jupp (2006) closed questions specify a task and also the range of possible responses to it. These questions are relatively unproblematic at the pre-analysis stage: the numbers can be entered directly into a database. Open-ended questions pose a question or specify a 'task' just as closed questions do, but the informant has the freedom to answer in his or her own way rather than in terms of the researcher's pre-defined answer category.

Vinten (1995) has considered the pros and cons of open versus closed questions. Closed questions find favour as they tend to be easier to handle and more cost effective with less time and fewer skills needed to complete. Open questions have the potential advantage of "*unearthing genuine attitudes and views*" (Vinten, 1995). Due to the average length of service of the local site employee, the number of management changes and scope of technological advances an "open question" approach was deemed to be more appropriate to gain the complete insight required to test the research hypothesis. A summary of pros and cons adapted from Vinten (1995) is shown in Tables 4-2 and 4-3.

Table 4-2 Advantaged and Disadvantages of Open Questions. From Vinten (1995).

Open Questions

Advantages	Disadvantages
Freedom and Spontaneity of the answers	Time Consuming
Opportunity to probe	In interviews: costly of interviewer time
Useful for Testing Hypotheses about ideas or awareness	Coding: very costly and slow to process; may be unreliable
	Demand more effort from respondent

Table 4-3 Advantaged and Disadvantages of Closed Questions. From Vinten (1995).

Closed Questions

Advantages	Disadvantages
Require little time	Loss of spontaneous response
No extended writing	Bias in answer categories
Low costs	Sometimes too crude
Easy to process	May irritate respondents
Make group comparisons easy	
Useful for testing specific hypotheses	
Less interview training	

4.6.2 Open ended Interviews

According to Cohen, Mannion and Morrison (2007) the interview is a flexible tool for data collection where data can be gathered on what is said, how it is said and any relevant "body language" observations. It also allows the interviewer to remain on a question or topic until satisfied they have the complete interviewee "picture". A theme pertinent to the research is "relationships". An open-ended interview methodology would allow the researcher to gain detail on individual and departmental relationships and go through a triangulation process once all interviews were complete.

4.6.3 Closed questions

The closed question interview technique was discarded as an option for this research process due to the additional information the open ended interviews would provide.

4.6.4 Design of Semi-structured interviews

Semi-structured interviewing is more flexible than standardised methods such as the structured interview or survey (ESDS, 2007). Although the interviewer in this technique will have some established general topics for investigation, this method allows for the exploration of emergent themes and ideas rather than relying only on concepts and questions defined in advance of the interview.

According to Caplow (1956) the principles of interviewing most generally agreed on are:

- The interviewer should not interject his own attitude or experiences into the conversation or express value judgements
- The interview schedule should have the minimum number of questions in the simplest form adaptable to the problem
- The response which can be anticipated from a question is often quite different from the logical complement of the question
- All interview schedules and questions entail certain unpredictable efforts
- The attitude of the interviewer toward the respondent should always be extremely attentive and concentrated
- The expert interviewer is much more than a recording device. The interviewer should pursue questioning to the point where no significant ambiguities exist

The design of the interview questions would be critical to providing an appropriate outcome. That is, a number of different professional groups with different goals would be part of the survey as would a number of professionals across a number of layers within each group. To maintain the element of consistency it would be important to design a common set of interview questions which would be pertinent to the research hypothesis but relevant to the interviewees work, observations and understanding of the business.

The following process of what information the interview process would glean was designed as a precursor to designing a list of questions to be asked:

- The quantitative measure of the interviewees personal or group performance
- The qualitative measure of the interviewees personal or group performance
- A précis of interviewees understanding of site performance over this duration
- How knowledge is shared across the interviewees group
- How knowledge is shared between interviewees groups and other groups
- To what extent is knowledge sharing is valued
- Understanding of knowledge systems within the organisation
- Compliance to systems within the organisation
- Level of cross site knowledge exchange

4.7 Ethical Issues

Interviews have an ethical dimension; they concern interpersonal interaction and produce information about the human condition (Cohen, Manion, Morrison, 2007). Richards and Schwartz (2002) considered ethical issues which arise when planning and carrying out qualitative research and supplied two considerations appropriate to this research:

- **Misrepresentation**

  The analysis of qualitative data inevitably is influenced by the theoretical framework, epistemological commitments, personal characteristics and preconceptions of the researcher. The interpretative nature of qualitative research means that the published results are only a version of 'the truth' and the validity of the findings must be judged in relation to the care with which the data were analysed.

- **Identification of the participants by self or others**

  If identification occurs, it potentially may lead to serious harm such as prejudice or reprisal to their participant or their wider social group. Interview transcripts contain multiple clues to the person's identity. Even after protocols relating to confidentiality are applied, quotations, speech mannerisms and context may provide enough information for participants to be identified by themselves or others, and is not always easy to predict which data will lead to identification.

According to Wax and Cassell (1981) the "*perceived power*" of the researcher and "*control of the research settings*" can impact the quality of the research. To mitigate this potential to constrain feedback from the interviewee the researcher reinforced impartiality and ensured an interview environment conducive to an informal interview was available.

Smythe and Murray (2000) suggested the professional practice executed by interviewees in their normal professional role would remain during research interviews.

4.8 Reliability

Reliability is concerned with the findings of the research. Under a phenomenological paradigm the criterion of reliability may not be given so much status, or it may be interpreted in a different way (Hussey and Hussey, 1997). In qualitative research reliability can be regarded as the fit between what a researcher records as data and what actually occurs in the natural setting which is being researched (Cohen, Manion, Morrison, 2007).

4.9 Validity and bias

Validity is the extent to which the research findings accurately represent what is really happening in the situation (Hussey, and Hussey, 1997). Validity is a requirement for both quantitative and qualitative/naturalistic research (Cohen, Manion, Morrison, 2007). Parry and Crossley (1950) stated researchers and social scientists describe validity as '*predictive* accuracy' with some applying a broader term of 'prediction of behaviour'. Harvey and Myers (1995) deemed validity to be "*a word for the standardisation of quality across a particular interest group, a key sign in the legitimacy of knowledge practices*".

4.10 Scope of Pilot Study

To enhance the chances of a successful outcome to the semi structured interviews a pilot study was designed. According to Teijlingen and Hundley (2001) pilot studies are a crucial element of a good study design. Conducting a pilot study does not guarantee success in the main study, but it does increase the likelihood. Pilot studies fulfil a range of important functions and can provide valuable insights for other researchers.

For the semi-structured interview, an interview consisting of a senior member of finance staff was deemed appropriate for the coverage required. The pilot Study would allow the researcher to determine if the semi structured interview process was appropriate to fulfilling the requirements above.

4.11 Pilot Study Introduction

As a means of giving the interviewee context of the research an introduction was planned. The power point presentation can be found in appendix A.

4.12 Case Studies

To fully test the research hypothesis, a case study approach was considered to complement the semi-structured interview methodology. The semi-structured interviews were an opportunity for the researcher to generate data based on a “one on one” approach. Case study methodology would enable the researcher to expand the approach by observing team work involving local site and U.S. site employees.

Yin (1981) refers to the case study as an alternative research strategy likening it to an experiment, history or a simulation. Darke, Shanks and Broadbent (1998) highlight practical issues involved in undertaking a case study as a rigorous and effective means of research. Case studies while commonly used for educational purposes have been viewed in a less favourable light in terms of research (Patton and Appelbaum, 2003). According to Cohen, Mannion and Morrison (2007) it is the study of an "*instance in action*" providing a "*unique example of real people in real situations*". Verschuren (2003) argued the difficulty with case study is it is based on a study of a single object rather than a complete methodological approach.

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4.12.1 Types of Case Study

A number of case study types were considered for this research.

4.12.1.1 Exploratory (pilot)

Exploratory case studies condense the case study process: researchers may undertake them before implementing a large-scale investigation. Where considerable uncertainty exists about program operations, goals, and results, exploratory case studies help identify questions, select measurement constructs, and develop measures; they also serve to safeguard investment in larger studies.

The greatest pitfall in the exploratory study involves premature conclusions: the findings may seem convincing enough for inappropriate release as conclusions. Other pitfalls include the tendency to extend the exploratory phase, and inadequate representation of diversity.

4.12.1.2 Descriptive (narrative)

Case studies that present findings in a narrative format are called narrative case studies. This involves presenting the case study as events in an unfolding plot with actors and actions.

4.12.1.3 Explanatory

Explanatory case studies may be used for doing causal investigations. According to Tellis (1997), explanatory cases are suitable for doing causal studies. In very complex and multivariate cases, the analysis can make use of pattern-matching techniques.

4.12.2 Triangulation

Soy (1997) stated case study research excels at bringing us to an understanding of a complex issue or object and can extend experience or add strength to what is already known through previous research. Hall and Rist (1999) state the importance of triangulation relating it to a "*three legged stool*", referring to the three legs in qualitative research as interviewing, observation and document analysis.

4.12.3 Six Steps to a Successful Case Study

Soy (1997) recommended six steps towards conduction a successful case study in Research:

- Determine and define the research questions
- Select the cases and determine data gathering and analysis techniques
- Prepare to collect the data
- Collect data in the field
- Evaluate and analyse the data
- Prepare the report

Two case studies will be undertaken. The first case study would involve a project between the local site and one of the U.S. sites. The second case study would involve a project between the local site and both U.S. sites. The first case study relates to a cost project. The second case study relates to a technical project.

The following is how the research in this study will attempt to follow Soy's six steps:

Step 1 Determine and Define the Research Question

The first case study was a benchmarking visit involving three senior members of one of the U.S. sites visiting the local site for three days. Both sites have common spend goals. The purpose of the benchmarking exercise was to determine if there were any "best in class" approaches or improvement plans the sites could share with each other.

The second case study was involved a cross-functional, cross-site team involving senior technical members of staff from the three manufacturing facilities. The object of the team was to provide a standardised technical continuous yield improvement roadmap which all sites could adopt.

Step 2 Select the Cases and Determine Data Gathering and Analysis techniques

Data gathering would include:

- Observe how the other sites share knowledge with each other and contrast this with how the local site does likewise in the form of the semi structured interview output;
- Compare and contrast the interaction between the visitors and the host site employees.

- review the conclusions and recommendations from the case study exercises and identify areas which would not have come about if the case study exercises had had not taken place.

Step 3 Prepare to collect the data

Systematic organisation of data is important as case study research can generate a large amount of data. The following would form the basis of data gathering:

- An overview of how site organisation charts differ in terms of numbers of managers and professionals in each department
- Clearly define each spend and yield categories to be compared and discussed.
- Understand the cost model for each spend category and how the data is stored and subsequently used. Understand the yield methodology currently employed by each site
- Compare levels of tacit and explicit knowledge between sites. A procedure found at one site but no the other could be construed one site successfully converting tacit to explicit knowledge

Step 4 Collect Data in the Field

Data would be collected and stored comprehensively and systematically. All presentations and emails would be stored electronically. All scheduled meetings recorded. Shortly after the exercises are completed all notes from local site representatives will be collated and analysed.

Step 5 Evaluate and Analyse the Data

All data will be examined to find linkages between the research object and the outcomes with reference to the original research question. The case study method provides an opportunity to triangulate data in order to strengthen the research findings and conclusions.

Step 6 Prepare the Report

The outcome of Case Study and the semi structured interview form the basis of the analysis, discussions and recommendations in chapters 8 and 9.

4.13 Employing Research Methods

A number of research methodologies were considered. The following methods were selected to best test the research hypothesis, with references:

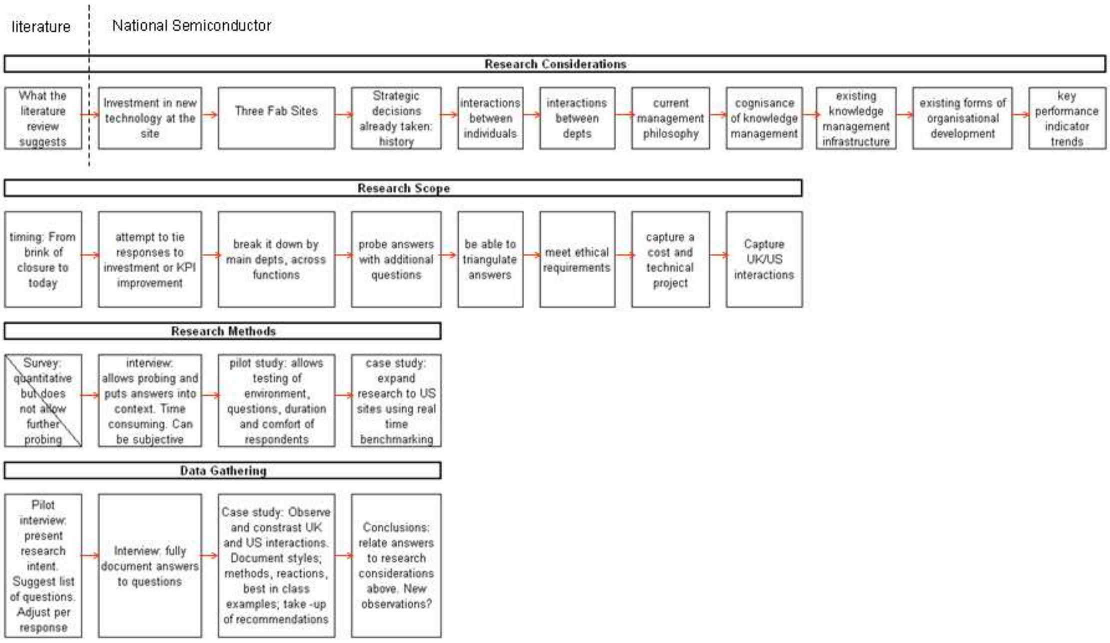
- A pilot interview with a senior member of staff (Teijlingen and Hundley, 2001). I had a structure of how I would do the research formulated. Interviewing someone who had a similar knowledge of the organisation as me would help keep the process impartial and ensure all questions were asked from a researcher rather than senior manager standpoint. Interviewing on person would result in a limited view of the process.
- Semi-structured interviews with a cross-section of Site staff featuring open ended questions (Caplow, 1956; Vinten, 1995). I considered these as the most effective method of gaining data required to test the hypothesis. It allowed me to spend considerable time with each interviewee discussing points and rationale. Table 4-2 indicates the advantages and disadvantages of open questions.
- Two Case Studies representing three Sites (Tellis, 1997). This would allow me to gather data on teams of engineers who ordinarily would not work closely together and who normally operate competitively. Two teams working

together for the first time may not be fully representative of how cross Site teams operate. Compiling case study data and semi-structured interview data would minimise any impact this would have to the research. Two case studies over three sites can be considered limited in terms of scope.

- Interview of members of the Spend Case Study Team and Yield Improvement case study team (Vinten, 1995; Tellis, 1997)

Figure 4-3 diagrammatically shows research considerations, research scope and contextualises research methods employed. All appropriate levels of the local Site and of the U.S. sites would be represented using these methods.

Figure 4-3 Flow of Research and Methods Employed



4.13 The Researcher's Role

As a member of the Site's senior staff consideration had to be put into any influence or bearing this may have on the research process.

I had a discussion with individuals prior to the semi-structured interview process. I explained the background to my research, the potential sensitivity of discussion points and the importance of receiving information representative of the individual's experiences. At this discussion I emphasised that it was a completely voluntary process and anything said would remain confidential. In all cases the interviewees stated they were willing to go through the interview process and the information provided would be representative. In most cases I had worked with the interviewees for a number of years covering many projects or problem solving issues. A high degree of two-way trust already existed. Once the interview process was completed I sent each of the interviewees a transcript of the interview. All comments quoted in the thesis were verbatim. To reduce the potential for misinterpretation of how departments interacted I used a ranking process where I asked the interviewee to scored department interactions from 0-10. This data was not intended to produce statistically significant data but to be used as a judgement on an individual's opinion.

At the beginning of each of the case studies I stated my role as both senior manager and researcher. Since both case studies were considered benchmarking opportunities my dual role was not deemed by the teams to be in conflict. Indeed, contributing as a researcher allowed questions or observations from a different dimension to be included. I was present during regular team updates on the Spend Reduction case study and used this information in my research. Project methods and best practices employed by each site are in the Company domain. Some business sensitive material was not included in the research analysis.

Information used for the Yield Improvement case study is also documented. To negate any effect of bias on representing how effective the teams worked with each other I interviewed a member of each team.

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Chapter 5 Data Gathering and Analysis

5.0 Data Gathering and Results Obtained

Data gathering activities comprised of an initial process of piloting the interview format and questions to validate the research methodology and to give a sense of the level of response and reaction the initial questions would attract. This would allow the questions to be clarified and modified where appropriate before entering the full main study phase.

5.1 Pilot Study

According to Teijilingen and Hundley (2001) there are several advantages of conducting a pilot study. These include an indication if the interview process is not appropriate for the research question, where protocols may not be valid or whether proposed interview methods or instruments are not conducive to the study in-hand. Referring to questionnaires, Hussey and Hussey (1997) comment on it being "*essential that you pilot or test your questionnaire as fully as possible before distributing it*". For the semi-structured interview it was decided to conduct an interview with a senior member of the organisation within an informal setting. This was to principally gain an appreciation of the response the questions would invoke but to also determine if the environment and the interaction between the researcher and the interviewee were conducive to eliciting responses to the desired level.

5.2 Pilot Interview

By means of an over-head presentation (appendix A) the researcher explained to the interviewee the purpose of the pilot discussion, the expected outcomes of the meeting and the proposed next steps. The interviewer attempted to follow the principles set out by Caplow (1956) as discussed in chapter 4. Approximately two hours were set aside to conduct the interview. The researcher took notes through the course of the interview and read these back to the interviewee at the end of the process. The researcher sought clarification and further explanation where necessary. Following the meeting, the researcher typed the notes then sought agreement from the interviewee that these were a direct reflection of the conversation and there was no confidential or sensitive information included or inferred.

5.2.1 Interview Questions, Responses and Analysis

Question 1: What metrics do you review to determine performance of the Site?
I look at Key Performance Indicators (KPI) such as cost, yield, cost of scrap, Profit before Tax (PBT).

Question 2: What do these metrics tell you?

They tell us the direction we are heading in, how we balance our performance or how effective we are at “spinning all plates at one time”. If one metric goes off, others are likely to follow.

Question 3: How would you characterise the trend of these Key Performance Indicators?

There has been a rapid improvement on most key Performance Indicators with particular changes over time:

1997/8 - There was an element of fear factor or panic mode due to the decision to spin the Site out. A vast improvement followed but it was not a comfortable time. If we didn’t show the corresponding level of improvement the Site would not have survived.

2000/1 The Site became a little complacent once it got its reprieve. The sense of urgency diminished and people had to be prompted to do things. It was a time when we did not show our true level of ambition.

2002/3. We took control of our own destiny. We became competitive and had self-belief. Our attitude became one of ‘we have a right to be here’ as we were producing high performance analogue products which were now at the forefront of the Company’s strategy. In addition we helped the other sites develop their analogue capability.

Question 1-3 analysis:

From the discussion it was clear the company focuses on a set of high level hard metrics. The interviewee understood these metrics and their interdependencies. This suggested there was a reasonably high degree of knowledge sharing or knowledge availability as the metrics in question cut across many departments. During the main study the Researcher would now craft additional related primary or secondary questions in an attempt to understand the awareness of Site metrics and the level of knowledge each interviewee had on all Site metrics.

The discussion led to the realisation there were no ‘soft metrics’ such as a record of morale, engagement or understanding of Site strategy. A specific question relating to such soft metrics would be added to the main study semi-structured interview questions. The purpose of the question is to fathom other areas in which the organisation is involved and to establish the degree of knowledge sharing at the Site.

Breaking the performance of the site into three separate life cycles was intriguing. From the interviewee’s perspective there were particular influences during each of these cycles. During this time the interviewee said the people side of the organisation over this time was analogous to “watching a child grow up”, it was evolutionary rather than revolutionary. The local site was considered the “analogue expert”. By helping another site develop their analogue expertise, the local site and the U.S. site engaged in a collaborative venture, exchanging technical and systems knowledge. When asked if this diminished the local site’s competitive advantage, the interviewee responded how it was important to share knowledge and expertise if the site wanted to be an overall benefactor when the company decided where to invest in sites – to do otherwise would be to go against Company strategy. Michailova and Neilson (2006) discussed how a company’s competitive advantage was strongly influenced by the ability to transfer knowledge between international subsidiaries.

Question 4: **How would you characterise department relationships with respect to performance over this time?**

I would break it down into three time cycles:
1997/8. The biggest driver during this time was cost. The Site was not competitive compared to the Company’s other manufacturing sites. To establish a cost saving drive the operations group needed the help of the finance group. There was an aspect of operations not knowing how to set the direction and they enlisted the help of finance. A business partner role was established but it was not one of “share all knowledge together” for the greater good. The finance group understood the business but there still appeared to be reluctance by the operations group to accept the group as part of the team. From a learning organisation standpoint, finance was pushing to make things happen rather than waiting to be asked. Knowledge potential between both groups was not being realised to the extent it could be.

2000/1: Operations and finance worked side by side but not together. Operations were not open to a different way of working and this caused a degree of frustration. The groups worked together to resolve financial related operational issues but this was situational. The two groups did not leverage each other’s skills. Knowledge was only shared during the times the groups had to work together.

2002/3: Finance and operations “came out of the box” tentatively at first. The modus operandi had suddenly changed. The difference was operations changed the way it wanted to do things and realised in full the potential of the finance organisation. The senior “protagonists” were like-minded. Equality was established. Operations and finance group standards were very similar as was the notion of how to do business. Knowledge sharing between the departments became prolific and unconditional which resulted in a vast improvement of key performance indicators. Establishing the cross functional productivity team was a good example of formal knowledge sharing. The performance effect rippled through both groups. The senior members of the respective groups were setting an example and the next level managers and professionals were now working side by side. Formal systems, structures and policies followed. It was important to embed this way of doing business for the future.

Question 4 analysis:

The interviewee was able to identify site performance issues during the periods in question to specifically relate to how departments were interacting with one another. The interviewee held great stock in all departments being here to “manage the business” and was surprised a strong willingness to do this was not greeted with acceptance more readily and widely. The impression was one of a horse ready to bolt the trap but it only opened when the operations group was ready and even then it was conditional. Knowledge sharing was limited or even incidental until the last phase of 2002/3 when a change-in-state appeared to occur. Prevalent throughout this phase was a single individual’s desire to exchange knowledge, build an infrastructure across both departments conducive to unconditional knowledge sharing and to generate a model for success.

The formation of the productivity team was cited as a prime example of cross functional knowledge sharing. At the outset of 2002/3 period, the finance group suggested establishing a formal method of capturing and managing productivity. By generating a template it allowed the managers to decide on who should be at the meetings and their responsibilities. Figure 5-0 depicts the productivity template used to manage productivity on a bi-weekly basis. Meetings were scheduled to include all dayshift and shift work personnel. The format of the meeting and its participants were crucial to meeting the productivity objective. It was an all inclusive meeting with everyone “owning the issue”.

The following departments were represented at the meetings:

- **Finance**

  The Site’s financial controller was the team leader who provided the holistic view on how to define and manage a productivity success model. The controller calculated and presented productivity data on a bi-weekly basis. The controller became the natural leader of the process.

- **Training**

  Training direct labour to increase skills and flexibility was an essential part of the productivity model. The team leader worked closely with the training manager to ensure all proposed training was appropriate and agree the data to be used on a bi-weekly basis. Knowledge in the context of what we were doing and why was shared with manufacturing technicians. Feedback from manufacturing technicians was solicited. This has led to full involvement of manufacturing technicians in training decisions. Inputs included agency worker training, stop/start nature of training, no time to bed-in training. Knowledge sharing grew and grew. It had to. Sharing this knowledge with those involved brought everyone into the process. Previously there was concern about the amount and effectiveness of training.

- **Human Resources**

  Managing direct labour absence and dealing with employee relations issues which may arise should employees be asked to change shifts was part of the responsibility of the human resources department. The Site adopted a flexible agency worker approach. As business increased or decreased the number of agency workers would increase or decrease. Agency workers who had the requisite level of knowledge and application which met the business model were converted to permanent employees. Taking the opportunity to 'sense' the temperament of the permanent staff resulted in the decision to not allow agency workers holidays over the summer period.

- **Business Planning**

  Business planning would provide visibility on the change of business to allow proactive decisions on direct labour requirements. They would glean feedback on holiday and training requirements and adjust activity in line with personnel requirements whilst simultaneously ensuring business was supported.

- **Information Systems**

  The information systems group was not involved at the outset but the team quickly realised this was an important omission. The importance of activity models and direct labour management databases under the auspices of an information systems group proved to be a key factor in improving productivity. Through being a member of the productivity team the Information Systems engineers were able to build an automated holiday management database. This effectively enabled the process to take out the "ask the manager and wait" element of the process. Holiday teams were formed and the automated system became the "manager". Almost overnight it removed the tension from holiday planning. Heath (2003) stressed the importance of making software data accessible to all. The automated holiday system was available to all via the internet which all employees have access to.

- **Operations**

  The operations group represented the direct labour element of the productivity programme and executed actions agreed at the bi-weekly productivity meetings. Operations were a central resource which bound everything together demonstrating the push and pull of information and knowledge. Prior to establishing the productivity team the operations group "wholly owned" the productivity metric. Formally setting support departments productivity responsibilities was an attempt to improve collaboration and knowledge sharing.

At the outset group responsibilities were not explicitly articulated. There was an assumption someone representing e.g. Human Relations would know when to step forward and deal with Human Relations related issues. In retrospect this may have caused some confusion. Some departments appeared not to know when they should have taken accountability for an action. Inherent leaders naturally step forward and take control to ensure process is successful.

Focus was on data driven improvement through good cross department team work with clear direction setting by the productivity team. Regular reviews would give team members an opportunity to discuss progress and use the collective knowledge in the room to make decisions appropriate to increasing Site productivity. The dynamics of the meetings rapidly changed over time: apprehension progressed to trust, involvement in all aspects and questioning out-with normal areas of expertise. The team leader ensured continuity throughout by always attending meetings when on site; it was noted the success of teamwork had failed in the past due to poor or erratic team leader attendance at meetings.

The productivity team reported regularly at first to the Managing Director. Productivity improvements were significant but initially took time to materialise as the application of knowledge took effect. For a period, reviews with the Managing Director were difficult and there was a level of debate about achieving the results. This however progressed to pride in improvement then to total trust and no interaction from the Managing Director at all.

The method and resulting success was a first for the Site. As Figure 5-1 shows, the results which followed were significant. Typically the Site was expected to generate a 5% year on year improvement in productivity. At one stage, productivity had increased 30% from the previous review point amounting to a savings for the Site of almost £4m per annum. This supported the notion that pulling together a cross section of appropriate department professionals in an environment where they can share information and knowledge will result in a bottom line improvement for the organisation.

The success of this information sharing was widely recognised as demonstrated by the further involvement of other areas - everyone wanted to be included. In the case of training, it will increase the level of tacit to explicit exchange as suggested by Nonaka (1994) as a training gap can only be closed by asking someone to comply with a written down procedure or even generating a procedure for the first time. It should give the participants the opportunity to exchange "know how". By ensuring all managers on all shifts are represented it gives a platform to maintain a consistency of communication and policy. This also encourages a similar method and process to be used to address other areas or issues.

The Site was able to make month-on-month improvements as it was able to codify the actions driven by the productivity meetings. All manufacturing process tools have the same computer 'front-end' even although the tools themselves are significantly different from one another. Users log on to the tools and their use and actions are recorded for training purposes. The Productivity meeting is viewed as a holistic management system which frequently coordinates and reviews all manufacturing improvement actions.
The method and approach are easily understood and accepted as a successful model across the site due to the fact there have been measurable, substantial improvements which can be directly related to the productivity meetings.

Figure 5-0 Productivity Template

	Act P1	Act P2	Act P3	Act P4	Act P5	Act P6	Act P7 W1	Act P7 W2	Act P7 W3	Act P7 W4
Full time heads										
Total Agency Workers										
Shiftsharers - actual heads										
Shiftsharers - Equivalent heads										
Available heads										
DL Heads charged to Projects										
Heads not fully utilised										
Not trained to adequate level										
On restricted duties										
Short term Absence - heads										
Long term absence - heads										
Unproductive Heads										
Productive Heads										
Equivalent hours										
Holidays - no.of shifts										
Holidays - hours										
Overtime for production - no. of shifts										
Overtime for production - hours										
Overtime for training - no. of shifts										
Overtime for training - hours										
Lunch										
Total Productive Hours										
Total on line calculated heads per shift										
Mask Layers										
Actual Productivity Metric										

Productivity is the measure of units produced per person hour worked.

Units Produced

This was a manufacturing number of units produced over the course of one week.

Person Hour Worked

This relates to the number of manufacturing technicians available over the course of that week:

- Overtime would counter productivity unless the units produced fully compensated for hours worked. Overtime plans would be discussed at the bi-weekly meetings. On occasion overtime may have been necessary to complete essential training.

- Training experienced manufacturing technicians would counter productivity but be a valuable investment in future productivity through having a more highly skilled and flexible workforce. If training new-hires, the first four weeks would be discounted after which it would counter productivity.

- Sick absence would counter productivity through not being able to produce requisite units due to people shortages. A small amount of sickness absence would be factored in as the norm.

- Holiday absence would counter productivity if too many skills in a particular area were to be allowed off. This could be further exacerbated if there was an element of sick absence in these areas.

Through good collaboration, knowledge sharing and an understanding of what can impact the bottom line, the productivity team worked very closely to produce month-on-month productivity improvements as demonstrated in Figure 5-1. The team were able to closely monitor business activity and reduce headcount using a temporary headcount model when the need arose. This is demonstrated in Figure 5-2.

Figure 5-1 Productivity Trend over Time

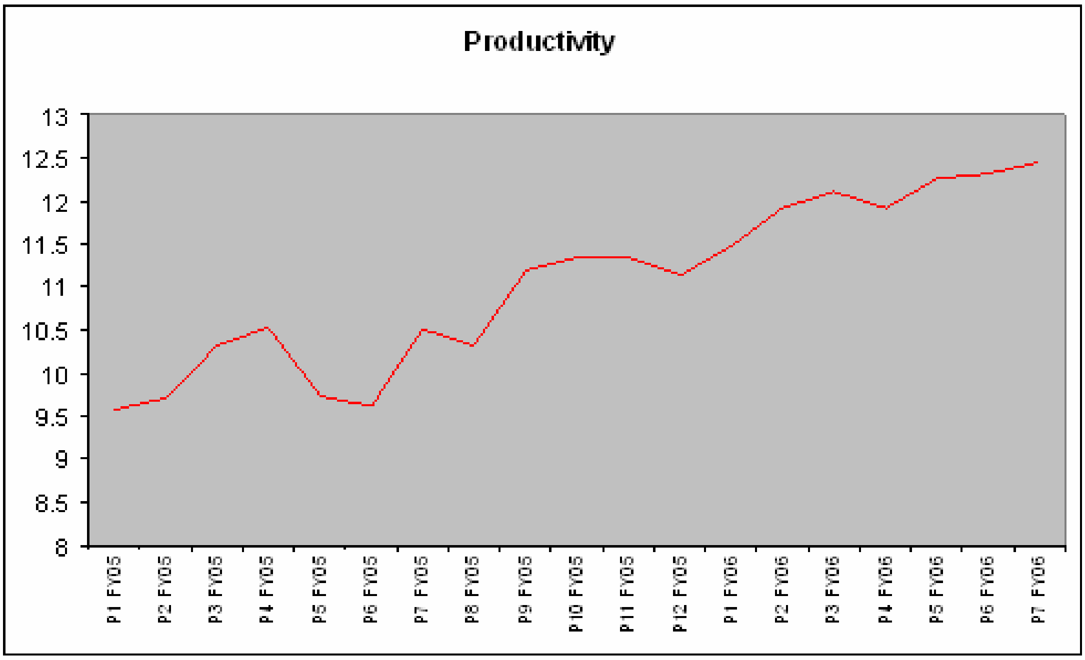
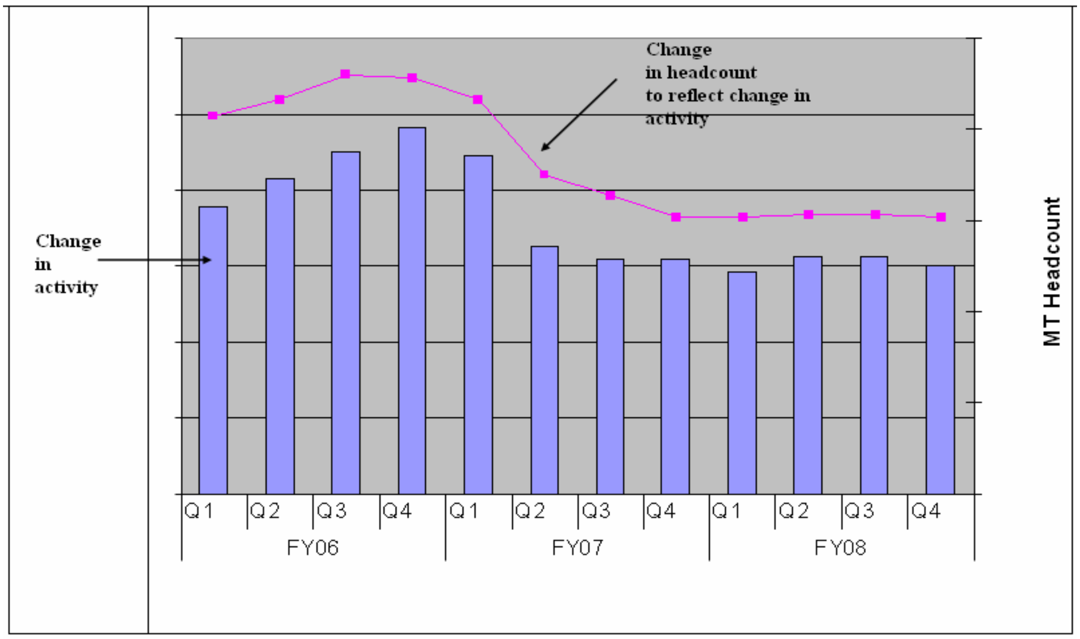


Figure 5-2 Reducing Headcount in line with Reduction in Activity



Question 5: How would you describe knowledge sharing in your own department?

The department is strong on explicit knowledge. A significant part of our work is written down in either policies and procedures or models used to generate or analyse financial data. We operate on a policy of rotating tasks annually to give us flexibility. Everyone has a working knowledge of everything and we do not rely on the need to have key individuals.

Tacit knowledge also exists. Tacit knowledge within the organisation leads into the sharing of explicit knowledge. The group will share knowledge with other groups and are very comfortable for other groups to use this data in formal presentations.

Question 5: Analysis:

Within this department there appears to be due cognisance of the definition of explicit and tacit knowledge, what it means, the relative strengths and weaknesses in the department or in individuals and how a strategy should be adopted to manage it. There were two examples cited of particular note:

- Rotating tasks annually. This could be seen as a burden to some yet the group think it important enough to maintain this policy
- The group train graduate professionals before sending them on permanent transfer to Corporate headquarters. This prompts a continuous knowledge sharing theme in the department

Individuals have their own areas of expertise. The department would not view their policy of rotations as successful if they could not do without the individual for periods of holidays or project assignments.

The department also maintain and use “how to” documentation and flow charts. This helps promote and encourage knowledge sharing and at the same time ensures consistency in application of policies and procedures.

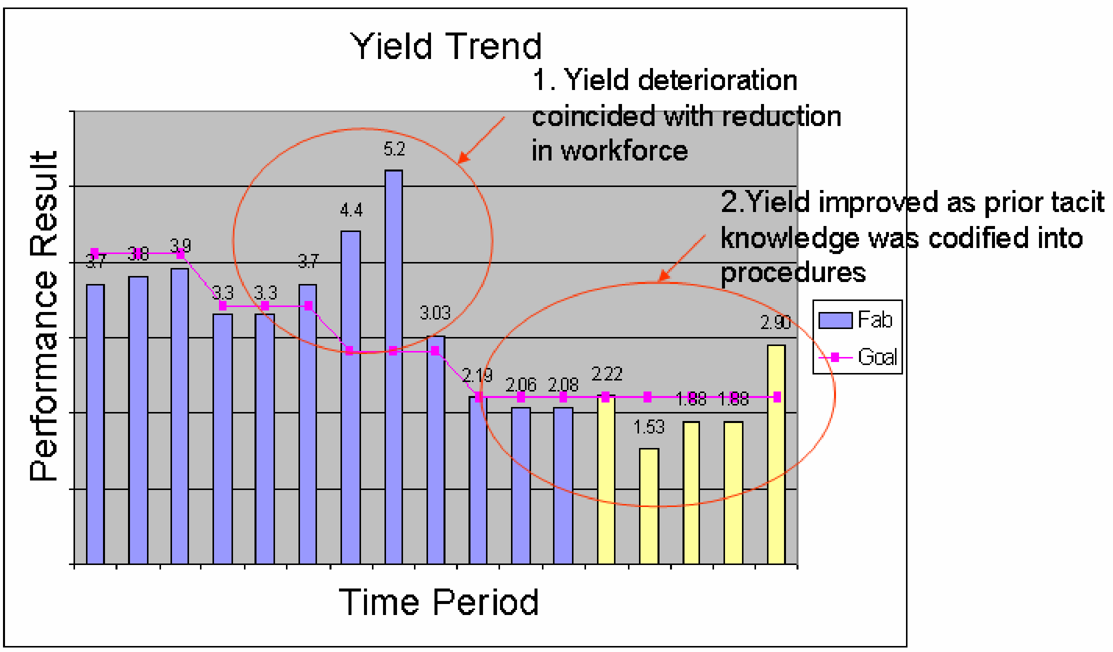
Question 6: How much do professionals in your department comply with written procedures? How do you think this compares to other departments?

There has to be full compliance due to the legal and audit demands on producing balance sheet, profit and loss and forecasting reports. I believe compliance to specifications or procedures varies depending on profession or job function. If I were to guess at the level of compliance of engineers and manufacturing technicians I would say engineers are the least compliant with manufacturing technicians a little more compliant. Engineers are responsible for writing down their procedures but I do not believe they always follow them. They know of other ways of producing results, safely. Manufacturing technicians should follow specifications. It is possible “custom-and-practise” is prevalent for those who have been doing the job for some time.

Question 6 Analysis:

Smith (2001) and Bokeno (2002) discussed Argyris and Schon’s espoused theory and theories in use. This department appears to be fully compliant by doing what they espouse they do. The discussion about levels of compliance can be central to tacit to explicit knowledge transfer. The manager states professional levels are not always fully compliant. The nature of engineering is to transfer knowledge from an engineer and codify it into a specified procedure. If there are questions over level of compliance then it could defeat the purpose of the whole exercise of tacit to explicit knowledge exchange through codified procedures. This would become an important part of the research process. By asking questions on compliance and ensuring a representative cross section of professionals were part of the interview process, it allows potential improvement recommendations to come from the research study. It was suggested when employees separated from the company, key performance indicators were impacted due to the levels of tacit knowledge each individual has. Figure 5-3 is a trend of yield performance. The area circled shows a deterioration in yield which coincided with a number of employees leaving the company. Further analysis showed the deterioration to be associated with very experienced manufacturing technicians who did not previously have any yield issues. Investigation highlighted some of the equipment was operating with minor faults and the previous manufacturing technicians found ways round this. Prior to leaving the Company there was no precedence for them to share this tacit level of knowledge with their replacement and the yield began to deteriorate. The trend was not arrested until the tacit knowledge phenomenon was realised and corrected. This supports the commentary made by the manager about some areas not being fully compliant and does introduce an area of risk to the organisation if there is a "custom-and-practise" way of carrying out individual tasks.

Figure 5-3 Yield Trend: Deterioration followed by Recovery



Skapinker (1999) commented on how companies soon found issues in the 1990s with "de-layering" their organisations to make them leaner. Suddenly these companies lost valuable "know how". Figure 5-3 attests to this. The subsequent length of time to recover the situation is dependent on how quickly the problem can be identified and replacement skills or codified procedures put in place to correct the problem. The common denominator would appear to be lack of recognition of tacit skills. It would appear all skills *should* take the form of explicit, codified knowledge which can be easily transferred. There does not appear to be provision for transferring, or even recognising tacit knowledge in the context of employee separation.

Question 7: **How would you describe the knowledge sharing between your department and other departments (using a scale of 0-10, where zero is knowledge sharing is "non-existent" and ten is a very healthy "unconditional sharing" platform?:**

Department A	10
Department B	9
Department C	6
Department D	6
Department E	5
Department F	2

I considered the level of knowledge within each group, strength of leadership, ownership, level of contribution to the bottom line, level of trust, whether or not individuals accepted knowledge sharing and if knowledge sharing did exist, was it a natural process?

A balance is evident across the Site now where previously silos existed. There is a level of equality between departments. If we can focus on improving "scores" across departments then Site performance will improve.

Question 7 Analysis:

The level of knowledge sharing appears to differ across departments. Question four analysis discussed the formation of a successful productivity team. Some departments are represented in the answer to question seven above. If departments are not fully bought into the knowledge transfer process then it would suggest an opportunity exists to introduce a process to help promote this and potentially improve the performance of the Site. McDermott and O'Dell (2001) commented on how best practice organisations could easily describe how sharing knowledge contributes to business goals. If the range of knowledge sharing across departments in the answer to question seven is indicative of what the rest of the organisation believes then it provides an opportunity to recommend actions which will improve the Site's performance.

The broad range of answers given in question seven, 10 to 2, suggest representatives from all the departments involved should be interviewed in an attempt to establish knowledge dynamics from a department level perspective.

5.2.2 Summary of the Pilot Interview in the context of the interviewee's own perspective:

- There is a focus on hard interdependent metrics (Site goals) with information on these readily available.

- Each department has its own set of goals which ultimately tie up to Site goals. There is a combination of tacit and explicit knowledge within the department and a level of rotating tasks to keep knowledge at the requisite level.

- The interviewee characterises the performance of the site in three separate phases over the last decade and believes the level of performance relates to the degree of mutual collaboration or knowledge sharing at that time. In some cases knowledge exchanged between departments is elevated due to a situational need but reverts back to “norm” once the situation is resolved.

- At project level the interviewee cites a team which has representatives from almost all major departments on the Site. Creating this cross-functional team has resulted in increased collaboration on site and a significant improvement in productivity and cost.

- There is variation in the level of ‘mutual’ knowledge exchange and collaboration across departments with a view of improved performance if this level can be increased.

- There is variation in the level of compliance to codified systems across the Site which may relate to job function.

- There is an element of performance being impacted when tacit knowledge leaves the organisation. The loss of tacit skills appears to be replaced only when a consequent issue arises, such as yield deterioration. There does not appear to be a “preventative” means of replacing tacit skills. It is important to ensure tacit knowledge is not simply replaced with more tacit based knowledge. This would lead to a repeat of the cycle should a reduction in force happen again.

- The level of knowledge exchange and information sharing improved every time the team met. Some representatives were cautious or even “resentful” about discussing issues in their own areas. This abated as representatives began to value the success of the team.

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5.3 Conclusions on Approach used for the Pilot Interview

The purpose of the pilot semi-structured interview was to determine the level of additional information which could be elicited from each question asked. It would allow the researcher to determine if there was potential relevance in this additional information pertinent to the study.

The interviewee very readily answered all questions going into considerable depth in each one. The interviewee ably articulated responses in the context of knowledge management in a knowledge-led organisation. An insight into the degrees of inter-department and intra-department collaboration was given and the impact this level of collaboration has on performance.

The interviewee's own department has a number of professionals each with their own area of expertise. Cook and Brown (1999) argued every individual in a group is not expected to possess everything that is in the "body of knowledge" of that group stating to do so would likely be *"impossible, unnecessary and perhaps even undesirable"*. To avoid a situation of a knowledge gap should one of the experts be unavailable, the interviewee has tried to ensure the difference between the "collective knowledge" of the group compared to "individual knowledge" is kept as close as possible through skills rotation, specified procedures and a high level of compliance to those procedures.

With particular experience in managing cross functional teams and designing data and review methodologies, the interviewee shared all the positive and negative aspects of working in a collaborative manner. Previous experience had shown there were ways of showing data in a particular way, but the underlying trend was not improving. This was viewed as a data manipulation exercise.

To achieve a long term productive gain involved complete transparency showing all relevant data with no gaps. This made initial meetings with the Site director uncomfortable. By building knowledge in each of the key areas of productivity such as headcount allocation, sick absence, training, overtime and skills the interviewee was able to identify gaps, assign a department head to manage and devise a template to review on a bi-weekly basis.

5.4 Changes to Data Gathering Technique

The proposed interview list was changed based on the pilot discussion. The list was changed to capture all relevant department heads to identify the level of knowledge sharing and collaboration between departments. Interviewees consist of both managers and individual contributors and were grouped by department level as appropriate. This is represented in Figure 5-4

Figure 5-4 Interview Groupings

Department Grouping	Level	Area of Expertise
Operations	Manager	Manufacturing Engineering
	Manager	Manufacturing Engineering
	Manager	Manufacturing Engineering
	Manager	Manufacturing Engineering
	Individual Contributor	Manufacturing Engineering
	Individual Contributor	Manufacturing Engineering
	Individual Contributor	Manufacturing Engineering
	Individual Contributor	Manufacturing Engineering
	Manager	Manufacturing Production
	Manager	Manufacturing Production
	Manager	Manufacturing Production
Finance	Manager	Finance
	Manager	Finance
	Individual Contributor	Finance
	Individual Contributor	Finance
Environment, Health and Safety	Manager	Environment,Health and Safety Policy
Human Resources	Manager	Organisational Learning and Development
	Manager	Organisational Learning and Development
	Individual Contributor	Organisational Learning and Development
Business Planning	Manager	Product Planning and Process Modeling
	Individual Contributor	Product Planning and Process Modeling
Facilities	Manager	Building and Site Services Management
Information Systems	Manager	Information Systems Engineering
	Individual Contributor	Information Systems Engineering

5.4 1 Sample Plans

There are seven functional groups at the Site. Representatives of each of these groups were included in the semi-structured interviews.

In the Operations group there is thirty five professional or technical staff of which ten are managers. Seven of these managers were included in the semi-structured interviews. Four individual contributors in this group were interviewed. The selection process was skewed towards managers as they are responsible for setting goals, management decisions and influencing cross department relationships.

In the Finance group there are five chartered accountants, two of which are managers. Both managers and two chartered accountants were included in the semi-structured interviews.

In the Environmental, health and Safety group there are three professional staff of which one is a manager. The manager was interviewed as part of the semi-structured interview process.

In the Human Resources group there is four professional staff of which one is a manager. Two managers and one individual contributor were interviewed as part of the semi-structured interview process.

In the Business Planning Group there is three professional staff of which one is a manager. The manager and one other member of the group were interviewed as part of the semi-structured interview process.

In the facilities group there is four professional staff of which one is a manager. The manager was interviewed as part of the semi-structure interview process.

In the Information Systems group there is five professional staff of which one is a manager. The manager and a member of the professional staff were interviewed as part of the semi-structured interview process.

All but one manager has held their position for at least ten years. All but one individual contributor has held their position for at least fifteen years. Due to the length of service responses are expected to be accurate, thought out and in context of the questions being asked.

The pilot interview did not highlight any concerns about the questions being asked, the environment, note taking or the process of sending the interviewee a copy of the transcript. These aspects therefore would remain unchanged.

5.4.2 Responses to Questions Posed:

Responses are grouped by 'Dept Grouping' as shown in Figure 5-4. The format for each response is as follows:

- Question asked
- Purpose of question
- Summary of response by department grouping
- Selection of individual responses by department grouping

5.4.2.1 Question (1): Which metrics do you use to determine performance of the site, how readily available is information relating to these metrics?

Purpose of Question: To gain an understanding of what individuals looked at to determine the performance level of the Site and if the required information was available and accessible. At completion of the interview process it would be possible to determine the relationship between knowledge management and Site goals. For example using different metrics could be a result of a lack of information sharing or using the same metrics could imply there is information sharing and common understanding.

Operations Group Summary of Question (1):

All operations staff interviewed responded with site goals or elements of these goals. Individual responses were biased towards the individual's job function. For example, a yield engineer within the operations group would cite cost of scrap as one of their metrics. This is part of the site goals and very specific to a yield engineer. A process engineer within operations would cite cost of scrap, but may also include 'process cpk'. This is not directly a site goal but one an engineer will work on to indirectly improve a corresponding site goal.

All interviewees noted cost as a primary metric stating this is what determines the Site's future.

Information relating to metrics was considered to be readily available. Site goal metric performance is published at a weekly management review. All functional groups hold daily production meetings with updates on key metric performance. Numerous databases provide real time status on key metrics. There were no examples of interviewees having to search for data to determine status of a key metric: hard metric data is considered readily shared by all.

Operations examples of responses included:

- *Cost*
- *Yield*
- *Daily activity*
- *Inventory balance*
- *Material cycle-time*
- *Products shipped*
- *Daily earnings*

Finance Group Summary of Question (1)

Almost all Finance staff stated plant goals as the metrics used to determine performance of the Site with particular emphasis on unit cost, profit before tax and margin.

Information relating to metrics was considered to be readily available. Cost information was provided through systems set up through the finance group. Information on other key metrics was obtained mainly through weekly management reviews or through direct access to relevant database systems. Members of the finance group frequently use the same databases as the operations group to determine current status on particular key metrics.

Finance examples of responses included:

- *Profit Before Tax*
- *Cost*
- *Plant Goals*
- *Profit and Loss Performance*
- *Yield*
- *Cycle-time*
- *Cost of Scrap*

Environmental, Health and Safety (EHS) Group Summary of Question (1)

EHS responded with Plant Goals and other goals specific to the EHS group.

Information relating to metrics was considered to be readily available. In the case of goals specific to the EHS group, information is provided through a bespoke safety database system. The EHS group provide regulatory bodies with required information on environmental, health and safety performance of the Site.

Environmental, Health and Safety examples of responses included:

- *Safety Performance*
- *Plant Goals*
- *EHS Specific Goals*

Planning Group Summary of Question (1)

Planning staff responded with Site Goals and other goals specific to the Planning group. Information relating to metrics was considered to be readily available. In the case of goals specific to planning, the information is provided through database systems and outputs of model simulations which the Planning group provide on a weekly basis.

Planning examples of responses included:

- *Yield*
- *Cost*
- *Cycle-time*
- *Productivity*
- *Product shipped dates compared to target dates*

Human Relations (HR) Group Summary of Question (1)

HR staff responded with Site goals and other goals specific to HR such as turnover, absence, grievances and discipline. Information relating to metrics was considered to be readily available. In the case of information on staff turnover, absence and grievances this is provided through weekly reports generated by HR using a dedicated database.

Human Relations examples of responses included:

- *Site Goals*
- *Absence*
- *Employee turnover*
- *Grievances*
- *Training Performance*

Information Systems (IS) Group Summary of Question (1)

The IS staff stated they spent time reviewing the daily performance of the site. They believed this would help them decide on current and future priorities.

Information systems examples of responses included:

- *Site Goals*
- *Site Spend*
- *Daily Activity*

5.4.2.2 Question (2): Is there anything these metrics do not tell us?

Purpose of Question: With the Site's business goals determined through analysis of question one, this question would help to identify areas of activity or responsibility which may be influencing knowledge flows between departments.

Operations Group Summary of Question (2):

Individually and collectively the information suggested there were two forms of metrics: "hard" and "soft". Data on hard metrics covered in question one was easily available and the names of departments and groups involved in generating these metrics widely known. Soft metrics were considered very important to interviewees. Getting information on them involved asking other employees or managers, referring to department reports or emails or attending meetings specific to these metrics.

Operations examples of responses included:

- *They do not tell us how we achieve metrics*
- *They do not tell us what other tasks people are working on*
- *They do not indicate overall efficiency dynamics*
- *They do not tell us about people aspirations or career development*
- *They do not tell us about style of management or employee engagement*

Finance Group Summary of Question (2):

Examples of responses included: they do not tell us how we managed to achieve our metrics or the impact it had on our employees; they do not tell us the strength of our management team or the wealth of talent available in the site, for example, our maximum potential as a manufacturing facility.

Finance examples of responses included:

- *They do not tell us about collaboration*
- *They do not tell us anything about departmental contributions to goals*
- *They do not tell us about other work which is not (directly) goal specific*

Environmental, Health and Safety Group Summary of Question (2):

Example of response included: they do not tell us about people performance and the plant goals do not cover every department. Those interviewed commented on the importance of employee morale with respect to site safety and provision of a healthy working environment. More accessibility to “soft” data would be considered an advantage.

Environmental, Health and Safety examples of responses included:

- *There are so many aspects of our business the Site goals do not cover*
- *They do not tell us about individual or department effort*
- *They do not tell us how our employees are feeling*

Planning Group Summary of Question (2):

Examples of responses included: they do not tell us how effective we are as an organisation or what our leverage is versus our potential; they do not tell us how we achieve the hard metrics.

Planning examples of responses included:

- *They do not indicate the level of communication required between sites*
- *They do not tell us about levels of morale*
- *They do not indicate the amount of cross-group effort required*
- *They do not tell us the story behind the metrics*

Human Relations Group Summary of Question (2):

Examples of responses included: they do not tell us the effectiveness of individuals, where people contribute or how effective manager are. The HR group commented on the opportunity to analyse “hard” and “soft” data provided as a means of understanding more about the organisation.

Human Relations examples of responses included:

- *They do not indicate the level of “feel good factor”*
- *They do not tell us about individual or group workload*
- *They do not tell us about individual or group efficiencies*

Information Systems Group Summary of Question (2):

Examples of responses included: they do not tell us the effectiveness of individuals, where

Information Systems examples of responses included:

- *They do not tell us how effective our systems are on a day to day basis.*
- *They do not tell us how we achieve our metrics*
- *They do not tell us anything about how our people are feeling*

5.4.2.3 Question (3): How is knowledge shared within your department?

Purpose of Question: To gain an understanding of the level of knowledge sharing and the way knowledge is shared in the department. This would generate an overall Site perspective as well as a department and individual perspective which is a fundamental requirement of understanding knowledge management at the Site.

Operations Group Summary of Question (3):

Accompanying commentary concluded engineers preferring tangible rather than abstract data. There was a preference for knowledge sharing done through informal discussions at other engineer's desks and having unscheduled conversations, asking other engineers or managers to join the discussion as appropriate.

Operations examples of responses included:

- *Hard metric performance is shared at morning meetings and through formal reviews such as engineering review boards, management review boards and senior staff meetings*
- *Most knowledge is shared through informal means, almost word of mouth. If information becomes available we will codify it through adding it to a specification. There is a lot of tacit knowledge exchange. Informal knowledge sharing is a frequent occurrence. This could be a good thing as informal sharing implies there is a desire to have the information*
- *Through databases, systems and access to sister- site's specifications*
- *Knowledge sharing between manufacturing technicians is generally verbal or tacit, as is knowledge sharing between engineers and manufacturing technicians and between different shifts in the organisation*

- *There are a number of formal reviews attended by a cross- section of the operations group but these do not form a significant part of knowledge transfer*

Finance Group Summary of Question (3):

Practices and procedures in finance appear very structured. The department insists on minimum post graduate professional qualifications. There is a high degree of enthusiasm to work with other departments to share knowledge and to improve the Company's bottom line. An accountant "business partner" is assigned to all departments. The business partners are encouraged to get to know about the operational aspect of their assigned department.

Finance examples of responses included:

- *The group is strong on explicit, codified knowledge. Procedures are documented and accountants are compliant to these procedures*
- *Each accountant has an area of responsibility and the onus is on them to bring others up to a desired level of knowledge*
- *There is a specified procedure for anyone new into the business*
- *As a matter of course, tasks are rotated annually*
- *Through regular meetings and reviews*

Environmental, Health and Safety Group Summary of Question (3)

The EHS department have a proud history of helping the Site secure an exemplary safety record with a responsible attitude towards the environment and employee wellbeing. Sound environmental, health and safety performance is considered a pre-requisite to carrying out daily business duties. Most people demonstrate good EHS practises and lead by example. The EHS team believe they demonstrate good knowledge sharing practices internal and external to their group.

Environmental Health and Safety examples of responses included:

- *Through formal staff meeting. Each member of staff has an area of expertise and these meetings are used to update one another*
- *Through formal project meetings relating to regulatory requirements or well being programmes*
- *Through participating in local community initiatives*

Planning Group Summary of Question (3):

Decisions on what products to make are made at corporate headquarters. The planning group is responsible for interpreting the planning database and making decisions based on this. They are heavily reliant on systems. The group work with manufacturing engineering and production on equipment and resource utilisation requirements.

Planning Examples of responses included:

- *Knowledge is exchanged through informal discussions and through our systems approach. The company has invested a great deal in codified systems*
- *Through formal training and development. This builds in flexibility*

Human Relations Group Summary of Question (3):

The HR department is responsible for employee development, employee compensation and benefits and employee training. Feedback suggested there was good knowledge sharing between HR and the other departments on the subject of training. The team were beginning a programme of improved knowledge sharing on employee development and compensation and benefits.

Human Relations examples of responses included:

- *Knowledge is exchanged at department meetings. Prior to doing a workshop, trial runs are done and this is a good opportunity to exchange knowledge with colleagues*
- *Through cross referencing departmental knowledge with external bodies such as CIPD or government agencies*
- *Through feedback from disciplinary or grievance hearings*
- *The training coordinator works very closely with manufacturing managers, defining training plans and working very closely with the trainers and trainees*

Information Systems Group Summary of Question (3):

The IS commented on the informal nature of knowledge sharing in the group. They believe the technology available could support a greater degree of knowledge sharing.

Information Systems examples of responses included:

- *Through shared databases*
- *Through informal discussions*
- *Through discussions when preparing data reviews*

5.4.2.4 Question (4): How would you characterise performance of the site over the last decade. Where possible please explain your reasons.

Purpose of Question: To get the interviewee's perspective on performance over a suitable period of time. From a knowledge and collaboration context, the purpose is to understand relative successes or failures at individual, department or site level with the possibility of identifying particular examples.

Operations Group Summary of Question (4):

There was a broad consensus on Site performance. Those interviewed viewed the Site as being particularly successful in its current state. The Operations group believe they are very good at delivering year on year improvements. The organisation has evolved each year. The group appear to put great stock into team work and cross department knowledge sharing.

Operations examples of responses included:

- *The Site is much more productive now, unit cost is cheaper, yield is higher. There is a more direct focus on metrics. Maintaining the status quo was not an option. The change to manufacturing was significant and down to personalities*
- *The Site is now run as a business. It is cost driven. Previously we were a cost centre and if we got money we spent it. Now we look at how much we really need to spend and endeavour to spend less. It is a mindset and down to management changes*
- *Metrics have improved year on year by applying resources and maintaining a programme of continuous improvement. A manager's function has changed from being precise to global. Managers have more accountability and a greater understanding of the business now*

- *The Site has improved enormously over the time, especially over the last three to four years. We know what we want, why we want it and are more technically advanced than before*
- *The improvement of the Site is down to a few key individuals who are able to leverage collaboration across departments and not allow those departments who do not collaborate, impact performance*
- *Engineers are encouraged to work together. In previous years silos existed but this is no longer the case*

Finance Group Summary of Question (4):

Those interviewed all believe the Site is performing at a very high level. They emphasised strongly the reason as being the level of knowledge sharing and collaboration between key departments.

Finance examples of responses included:

- *It has become better and better. The Site took ownership of costs which involved a complete mindset change. Improvements were incremental but we achieved quantum improvements on key initiatives such as cost and yield.*
- *It can be broken down into three distinct periods*
    - *1997/1998 The Site was fighting for survival. Relationships were about getting the job done to ensure survival. Once the job was done, relationships reverted back to previous states*
    - *2000/2001 The Site got its reprieve. Relationships between key departments were distant. These departments worked side by side but not together. Rate of improvement slowed*
    - *2003/4 The Site took control of its own destiny. It became competitive, confident and had self belief. The turning point was when key departments worked together to 'run the business'. A new modus operandi followed. This set the example and others followed*

Environmental, Health and Safety Group Summary of Question (4):

The EHS department believe a successful manufacturing facility is a safe facility. A successful manufacturing facility is established through clear direction setting and compliance to specified procedures. They acknowledged the contribution of some departments and identified other departments who should cross department boundaries to improve knowledge sharing.

Environmental, Health and Safety examples of responses included:

- *It is much improved. It is a better organisation now. Staff are strong, some exceptionally so. Individuals can make the difference*
- *It is important to build on infrastructure and systems to ensure continuous improvement*
- *Department heads are articulating progress to goals very clearly. If there is an issue they will state it, even if unchallenged. Previously managers would not act in this way*

Planning Group Summary of Question (4):

The planning group believe performance over time has improved due to clearer focus on plant metrics and improved tool and automation capability.

Planning examples of responses included:

- *Performance wise it has improved from a '2' to an '8'. There was an initial step, then lengthy grind then next steps taken*
- *Investment in new tools has helped to deliver productivity results*

Human Relations Group Summary of Question (4):

The HR department believe performance of the Site changed for the better when the Site's senior staff team worked together on a renewed Site strategy. They believe this helped to create the environment necessary to exploit the full potential of the organisation.

Human Relations examples of responses included:

- *It is a much smarter, leaner company. A leaner organisation helps pull people together*
- *The structure is conducive to success now. It was not a decade ago*
- *There is much more goal alignment between departments*
- *It has evolved. Six years ago the senior staff set a strategy and with good communication executed to this strategy. There was a common sense of ownership. Everyone could, and would, contribute*
- *The performance difference has been significant and is down to management structure and the subsequent focus on productivity. As a result of this the site secured important investment*

Information Systems Group Summary of Question (4):

The IS group believe the Site has improved its performance considerably over the last decade. A stronger management team from a decade ago with openness to risk taking were considered the main reasons for the improvement.

Information Systems Group examples of responses included:

- *A decade ago the company made commits it could not meet. We are very good at doing what we commit to now*

- *We accepted what we were given back then. Now we have some flexibility to take on processes or products which fit our local business model*
- *It began to change when manufacturing was re-organised at corporate level*
- *Manufacturing became a more important function in the Corporation and as a result the local Site became more important*
- *A decade ago we had a "victim" mentality, we were "bottom of the heap"*
- *It is possible to say what you think now. It was not possible in the past. Managers are much more secure about their abilities now*

5.4.2.5 Question (5): How would you quantify knowledge sharing between your group and other groups and why? Ranking used was per the Pilot Interview question. Although not considered statistically significant the tables were used as a guideline.

Purpose of Question: To gauge interaction both within and between departments. The level of interaction coupled with the explanations would give insight into areas where there was successful knowledge sharing. This would also highlight areas where knowledge sharing could be improved.

Operations Group Summary (Table) of Question (5):
The operations group felt Finance and the Information Systems (IS) group supported them extensively. The consensus was the Finance department is always prepared to work towards solutions to problems and share the responsibility for actions. The group commented the IS department is very efficient with IS and Operations engineers forming good working relationships. The Operations group considered procurement and HR departments too "distant" and reluctant to share knowledge.

	IS	Finance	Facilities	EHS	Procurement	HR	Planning
Operations interviewee 1	8	9	5	5	4	4	3
Operations interviewee 2	7	9	4	4	3	0	6
Operations interviewee 3	7	8	4	4	4	5	5
Operations interviewee 4	7	6	8	4	2	2	4
Operations interviewee 5	7	6	7	5	5	6	3
Operations interviewee 6	8	6	7	6	7	5	7
Operations interviewee 7	7	5	4	5	4	5	6
Operations interviewee 8	8	8	8	4	5	5	4
Operations interviewee 9	8	8	6	7	7	7	5
Operations interviewee 10	7	8	6	5	5	4	5
Operations interviewee 11	9	8	7	6	4	3	4
Operations interviewee 12	5	5	7	6	5	5	4

Operations examples of responses included:

- *Finance together with manufacturing is value added. By being collaborative and sharing knowledge formally or informally means both jobs become easier and people* *are inclined to work like this. It is quid pro quo. This collaboration has impacted the bottom line*

- *The level of synergy happens by function. Some relationships happen more naturally than others. This encourages knowledge exchange and ultimately improves an aspect of the business*
- *I.S. is very customer focused. They are the premiere support group and they realise they are a support group. Groups which figure highly in the scoring tend to do so because they realise what is required of them and they provide the level of service required*
- *Setting up specific meetings such as cost and productivity brought everyone involved closer together. Groups which score highly are generally those involved in collaborations or joint ventures. Those who do not score well tend to be at a distance from the other parts of the organisation*
- *Finance and manufacturing have the same end-goals. Management in both areas is very similar. This way of working has resulted in an improvement to the bottom line. There is little contact with e.g.. HR and no overlap. If the level of collaboration and knowledge exchange was to increase it would improve site performance*
- *Groups who score highly are transparent with one another and have more interaction. They are generally groups who admitted their faults early on in their relationship and worked to develop systems to improve business processes. Groups who do not score well may be reluctant to share their issues*
- *Groups who score well tend to have a lot of knowledge of how the Fab works and employees in the groups have an appetite for knowledge sharing and collaboration. They build an infrastructure to suit. There is good connection between these groups and the engineers and technicians. Groups who do not score well take the 'ivory tower' approach*
- *I.S. and manufacturing score very highly if it is engineer to engineer. Similarly finance and manufacturing if it is engineer to accountant. However the score drops when it comes to manufacturing technician support as there is less exposure. Knowledge sharing occurs more at peer level*

Finance Group Summary (Table) of Question (5):

The Finance group cited the IS and Operations groups as being very responsive, willing to share information and willing to ask the Finance group for help. The Finance group commented the scoring for Procurement and HR groups was they possibly did not realise the benefit of cross group collaboration and did not therefore practice it.

	IS	Manufacturing	Facilities	EHS	Procurement	HR	Planning
Finance interviewee 1	7	9	7	8	5	6	5
Finance interviewee 2	10	9	7	6	5	2	3
Finance interviewee 3	9	9	6	4	7	4	4
Finance interviewee 4	9	8	6	7	4	4	5

Finance examples of responses included:

- *The level of knowledge sharing or collaboration can be down to how much an individual is willing to get involved. There is a great willingness for knowledge sharing possibly in the 85:15 ratio*
- *Engineers and accountants will work together as they have complementary skills. There is a great deal of overlap and both like to understand each others' area of expertise and how it fits the business*
- *Groups will work together if they are of the right calibre, accept responsibility, have the right make-up and accept issues should things go wrong. Manufacturing and finance have a strong relationship as they share a likeminded, logical approach and have a high level common methodology. Lower scoring groups tend to be 'islands' and can be reluctant to share their issues*
- *Groups who score highly have a greater level of knowledge, stronger leadership and drive. They take ownership. They impact the bottom line. There is a mutual trust and an initial 'agree on how to do something and what to do' becomes a natural process*

EHS Group Summary (Table) of Question (5):

The EHS group were very complimentary about the Operations, Facilities and Finance groups. The interviewee stated the EHS group work very closely with these specific groups and appreciated the amount of collaboration and knowledge sharing. The interviewee thought the other groups did not advocate or practice knowledge sharing.

	IS	Manufacturing	Facilities	Finance	Procurement	HR	Planning
EHS interviewee	6	10	10	9	5	5	6

Environmental, Health and Safety examples of responses included:

- *It is imperative EHS build good strong relationships with departments. If this fails to happen there could be issues implementing and maintaining important environmental, health and safety projects*
- *Although all departments work safely, some promote safe working and employee well being more than others*

Planning Group Summary (Table) of Question (5):

The planning group falls within the Operations organisation. For the purpose of this research, commentary from the group was considered a worthwhile exercise.

The planning group scored facilities and IS highly when they could cite specific examples of knowledge sharing and collaboration. The group commented on the lack of knowledge sharing and collaboration from the Procurement and HR groups.

	IS	EHS	Facilities	Finance	Procurement	HR
Planning interviewee 1	4	6	5	6	4	2
Planning interviewee 2	9	7	9	8	3	4

Planning group examples of responses included:

- *Relationships have generally improved although issues exist between some departments to do with personal relationships*
- *Some groups are formal and structured. In some cases a group can be too structured which inhibits knowledge sharing*
- *Some groups are very good at what they do and some can be docile*
- *IS and manufacturing do a very good job of converting tacit to explicit knowledge through the use of systems and databases. Groups who do not score highly tend not to be visible to the rest of the organisation*

Human Relations Group Summary (Table) of Question (5):

The HR group thought there was a reasonably consistent level of knowledge sharing across the organisation. They commented on the “independent nature” of the Operations group and how this could be inhibiting knowledge sharing. They did comment however sharing within such groups was much stronger than knowledge sharing across groups.

	IS	Operations	Facilities	Finance	Procurement	EHS	Planning
HR interviewee 1	4	4	4	6	6	5	5
HR interviewee 2	7	5	6	7	6	7	7
HR interviewee 3	9	5	7	8	4	6	7

Human Relations examples of responses included:

- *Individuals within some groups should take more time to build relationships with individuals in other groups. The opportunity to do so exists in the organisation*
- *Technical groups can build silos preventing department to department collaboration or knowledge sharing. Knowledge exchange within technical groups is very good*

Information Systems Group Summary (Table) of Question (5):

The IS group stated problems often highlighted areas were there was not good knowledge sharing between departments. They said there were good systems to support knowledge sharing but further commented on the lack of knowledge about where these systems reside.

	HR	Operations	Facilities	Finance	Procurement	EHS	Planning
IS interviewee 1	4	8	6	6	2	1	5
IS interviewee 2	4	6	6	7	7	6	5

Information Systems examples of responses included:

- *Knowledge sharing between departments is predetermined by the working relations between individuals in those departments*
- *Some groups believe knowledge is power and do not make any attempt to share information or knowledge*
- *Site performance is impacted because some groups do not seek input from other departments prior to deciding on policy changes*
- Some people or departments believe they collaborate when in fact they are just answering the questions asked
- It is clear to see the benefits of collaboration and knowledge sharing between departments

5.4.2.6 Question (6): How much value do you put on cross group collaboration and knowledge sharing?

Purpose of Question: To ascertain the interviewee's attitude towards cross group collaboration and knowledge sharing.

Operations Group Summary of Question (6):
A collaborative and knowledge sharing approach has been credited with the improved performance of the site. Most interviewees offered examples where cross group knowledge sharing improved site metrics.

Operations examples of responses included:

- *A great deal of value. Face to face discussions are important. In a previous existence department silos were very evident and this prevented the site from making the inroads it was capable of*
- *Cross group collaboration has resulted in the Site at any given time being the most productive, lowest cost highest yielding Fab in the Corporation. Successful cross collaboration ventures have resulted in a number of spin-offs with other departments following suit and producing very effective results*
- *Cross group collaboration has allowed us to leverage skills across the organisation. Departments may have different functions and areas of expertise but skills are not mutually exclusive. This has allowed us to run leaner and be more competitive. It can create a certain amount of exposure as there are very few individuals dedicated to one task only*
- *It has broken down barriers. Individuals in different departments get to know each other well and this creates a positive energy on the Site*
- *Cross group collaboration promotes the ability to design and implement systems and reduce the dependency on individuals*

- *Collaboration between groups must have happened for us to get the results we have from 2004. Sometimes we do not acknowledge groups. The advent of the new collaborative approach was establishing a productivity meeting. This moulded everyone else*
- *It is of significant value. Engineers are receptive to new knowledge and listening to other experts presents this opportunity to gain new knowledge*

Finance Group Summary of Question (6):

The finance group recognise, and were able to articulate the benefits of, collaboration and knowledge sharing. This group felt they had promoted knowledge sharing and collaboration to a great degree.

Finance examples of responses included:

- *It is a crucial business requirement as it adds value*
- *It can highlight improvements which can lead to cost savings*
- *It is beneficial to individuals as once they have gained the knowledge they are able to make more valued contributions in discussions*
- *It is of immense value. It promotes good working relationships and high levels of trust*
- *It can improve confidence as other departments ask you to do something which is critically important to them or ask for advice on a subject which is not necessarily my area of expertise*

Environmental, Health and Safety Group Summary of Question 6:

The EHS group recognise collaboration and knowledge sharing as a prerequisite to having a successful and safe working environment. The interviewee stated environmental, health and safety requirements change very rapidly and it takes a great deal of collaboration and knowledge sharing to keep pace with the changing regulations.

Environmental, Health and Safety examples of responses included:

- *It is an important part of the way business should be done*
- *For an EHS programme to be successful it requires a mix of individuals on site to bring together the right level of expertise*
- *Individuals add thought processes. They provide innovative solutions to problems*

Planning Group Summary of Question (6):

The Planning Group recognise the value of collaboration and knowledge sharing but stress the importance of the individual to rate of success.

Planning examples of responses included

- *It is of high value*
- *It is also important to have the correct cross section of people – self starters*
- *Having the correct mix of individuals can create ten times the value*

Human Relations Group Summary of Question (6):

The HR group cited collaboration and knowledge sharing as an important aspect of current business requirements. The HR interviewees appeared to understand the importance of knowledge sharing and collaboration.

Human Relations examples of responses included

- *It is vitally important. We need to learn from each other*
- *We cannot all be experts so need to get together to share knowledge, bounce ideas off one another to generate new ideas*
- *Promoting collaboration allows us to evolve policies and principles more frequently and to get things done quicker*

Information Systems Group Summary of Question (6):

The IS group understood knowledge sharing was fundamental to the Site meeting its performance objectives. They did not think it was lack of opportunity which prevented knowledge sharing in come quarters.

Information Systems examples of responses included

- *It is of significant importance. It is a lot easier to do it now than in the past. Identifying issues is now considered constructive*
- *Not sharing knowledge would be working single dimensionally. We would not progress*
- *Department heads should discuss knowledge sharing as a topic in its own right*

5.4.2.7 Question (7): What value does the organisation put on cross group collaboration/ knowledge sharing?

Purpose of Question: To determine if the Site supported the individuals on their collaboration or knowledge sharing endeavours and perhaps also to determine if it was a decision or a dictate.

Operations Group Summary of Question (7):

If individuals or departments worked on successful collaborative or knowledge sharing activities, some recognised this as the Site supporting collaboration and knowledge sharing. Some interviewees said the Site supported the initial collaborative or knowledge sharing efforts. Some interviewees questioned the level of support the Site, or senior managers, placed on collaboration and knowledge sharing stating it was individuals who supported it.

Operations examples of responses included

- *The Site does not encourage silos. All meetings involve most departments not just the relevant departments. This was a huge change*
- *Senior staff set direction for the groups and expect cross group collaboration to come from this*
- *Not a great deal of value. It is about getting the job done and not so much about how the job is done*
- *A bigger organisation doesn't necessarily take it into account. An example is I.S. Manufacturing has improved significantly due to the introduction of systems. This has created a burden for IS yet we do not recognise it. It was not considered. An under resourced situation has occurred because cross group considerations where not taken into account*
- *Department heads say all the right things but I do not believe the organisation acknowledges the value of exchanging knowledge*

- *I do not see a big influence or drive coming from senior staff. I believe it is more down to individuals and we are too dependent on this*
- *I do not think the organisation recognises the level of this*

Finance Group Summary of Question (7):

The finance group question if the level of existing collaboration and knowledge sharing at the site is acknowledged by the Site. Interviewees commented they were part of a series of cross group knowledge sharing forums.

Finance examples of responses included

- *Departments are entities. They may not necessarily recognise the level of collaboration or its impact. I met with a senior manager from another Site and took him through one of our cross-department programmes. He introduced this at his Site, acknowledging the power of collaboration. There has been no such acknowledgement in this Site*
- *Senior management must view collaborative projects as being successful. It is possible the full degree of collaboration between departments is not recognised*
- *The Strategic Business Planning Process involves cross department and cross site knowledge sharing and collaboration. All other processes or initiatives rely on individuals driving for a knowledge sharing and collaborative approach*
- *Knowledge sharing and collaborative forums are beginning to become an embedded part of the plant's business process. Senior manages who endorse the process have setup forums and are persevering with them. They are producing results and other managers are beginning to recognise this method of operating*

EHS Group Summary of Question 7:

The EHS group cited collaborative and knowledge sharing projects, stating many senior managers were now involved in these projects. The interviewee thought however the Site as a whole put more value in communication than in endorsing collaboration and knowledge sharing.

Environmental, Health and Safety examples of responses included

- *The Site demonstrates communication exercises. This is not collaboration*
- *Recent reviews, such as the Capital Project Review has helped to promote collaboration and creates another opportunity for senior management to recognise the part it can play in the Site's success*

Planning Group Summary of Question (7):

The planning group thought there was more encouragement to collaborate if the potential for results was significant. The group argued there may be a conflict between collaboration and creativity.

Planning examples of responses included

- *At department level it differs*
- *Departments that have moved on were the ones which had the greatest impact. Lower scoring departments need to follow suit*
- *The organisation may be choosing to restrict collaboration as it does not want to lose creativity*

Human Relations Group Summary of Question (7):

The HR group believe collaboration to be a corporate driven theme, whereby progress is hampered by lack of time dedicated to creating collaboration and knowledge sharing forums.

Human Relations examples of responses included

- *Collaboration is shaped by Corporate*
- *There is intent but not as it should be. Constraints exist such as finding time or forums to improve collaboration and knowledge sharing*
- *The organisation sees the results. They possibly do not realise how the result was achieved. Corporate wide there are now more formal knowledge sharing initiatives such as business and engineering mentoring*

Information Systems Group Summary of Question (7):

The IS group stated the intent of organisational support was evident through the behaviour of the Site managers. They further stated urgency to get an action done prohibited good knowledge sharing.

Human Relations examples of responses included

- *The organisation curtails knowledge sharing through allowing conflicting priorities*
- *In one respect it supports knowledge sharing in another it has not provided the infrastructure to make it a way of doing business*
- *There are fewer defensively-minded managers in the organisation. This has created an opportunity for them to be more open and collaborative*

5.4.2.8 Question (8): What level of compliance exists across the organisation using accountants, engineers and manufacturing technicians for the comparisons? Ranking used was per the Pilot Interview question. Although not considered statistically significant the tables were used as a guideline.

Purpose of Question: On the premise professional staff code instructions and procedures in the form of a specification which is then followed to produce a given output, the purpose of this question was to get an appreciation of the degree of conformity to those procedures.

Operations Group Summary (Table) of Question (8):

The Operations interviewees thought accountants were compliant to their systems because of potential legal implications of incorrect accounting. The interviewees believed they had latitude on following engineering procedures as they had written them. Most interviewees stated a large part of their job was to design in automated systems which would increase the likelihood of manufacturing technician compliance, or shut a tool down if the system detection an action which was not compliant.

	Accountants	Engineers	Manufacturing technicians
Operations interviewee 1	9	7	7
Operations interviewee 2	9	7	7
Operations interviewee 3	8	6	7
Operations interviewee 4	9	7	6
Operations interviewee 5	9	7	4
Operations interviewee 6	6	4	6
Operations interviewee 7	6	9	9
Operations interviewee 8	9	5	9
Operations interviewee 9	9	7	8
Operations interviewee 10	9	7	6
Operations interviewee 11	9	9	5
Operations interviewee 12	10	7	5

Operations examples of responses included

- *Accountants may be higher due to the level of auditing they experience. Engineers always think there is a better way of doing things even if it is beyond the specification*
- *A codified system is difficult to change – even if it is changed engineers would not necessarily follow it*
- *Engineers believe they need scope. Not everything can be codified. The premise is to 'do the right thing'*
- *Engineers assume manufacturing technicians will not be compliant. They build automated systems to get round this*
- *Manufacturing technicians start at a high level when they begin employment but compliance reduces over time as they pick up habits from more experienced manufacturing technicians*
- *Manufacturing technician compliance can be down to the complexity of the written procedure or the tool they are operating*
- *Systems are not rigid enough. They allow people to think or to make choices. Some systems are locked out such that there is only one way of carrying out a specified procedure, others will allow non compliance and scrap may follow*
- *If a new system is introduced it is difficult to get someone who typically does not have a high level of compliance to be fully compliant*
- *Engineers prefer to be creative. They comply with the spirit of the specification. They have knowledge above the specification level*
- *Specifications are not updated in line with process improvements or changes particularly when a new system is introduced removing the need for manual checks. There is a belief there are some instructions which if not followed are not important but others are of critical importance must be followed. This results in an onus on the manufacturing to make a decision about every instruction. This is not feasible and will result in non compliance*

- *What are the consequences of non-compliance? Greater for accountants – can lose CA qualification, court, fail audit, qualified accounts. Immediate for engineers e.g. yield loss. If checked later an accountant would be found out. Unlikely an engineer would be found out unless discovered at the time*

Finance Group Summary (Table) of Question (8):

The Finance interviewees suggested if engineering systems were audited to the same degree as Finance systems it would increase the level of compliance by engineers and manufacturing technicians. They thought compliance by these functions was high due to the good quality of product shipped from the site. An interviewee suggested hiring Charted Accountants ensured a high degree of compliance was demonstrated.

	Accountants	Engineers	Manufacturing technicians
Finance interviewee 1	10	9	8
Finance interviewee 2	9	9	9
Finance interviewee 3	10	6	7
Finance interviewee 4	10	8	8

Finance examples of responses included

- *Rating engineers or manufacturing technicians is based on the implications on the product if procedures are not followed. It is in their best interest to follow specified procedures*
- *It is easier to follow a finance procedure as Sarbanes-Oxley requirements have resulted in documented procedures making it easier for an individual to cover for a colleague should the need arise*
- *It is possible the engineering groups do not remove existing specifications or instructions when new ones are introduced. This could cause confusion and foster non compliance*

EHS Group Summary (Table) of Question (8):

The EHS interviewee believed the finance group followed their procedures rigidly. The interview suggested some engineers and manufacturing technicians were very compliant whereas others were not.

	Accountants	Engineers	Manufacturing technicians
EHS interviewee	10	7	7

Environmental, Health and Safety examples of responses included

- *There is a large degree of variation in compliance across the engineering population*
- *There is no metric covering compliance therefore no continuous improvement programme exists to improve it*
- *The true yield impact of non compliance will not be known. People will not state they have caused a problem through non compliance if it is not evident to others*

Planning Group Summary (Table) of Question (8):

The planning group interviewees believed accountants were very compliant to systems as latitude would not be tolerated by the accounting profession. The interviewees believed manufacturing technicians followed the standard set by engineers. They believed engineers had freedom to decide whether or not to be fully compliant to systems and procedures.

	Accountants	Engineers	Manufacturing technicians
Planning interviewee 1	10	5	5
Planning interviewee 2	9	5	5

Planning examples of responses included

- *Accountants score very highly as it is a historic embedded profession*
- *Cross group collaboration and formal reviews will encourage engineers and technicians to be more compliant*
- *We give engineers freedom. If the engineering score improves we are reducing or removing variation. We do however value good 'scramblers'*

HR Group Summary (Table) of Question (8):

The HR group believed accountants were compliant to procedures because of their professional code. They believed the level of compliance demonstrated by manufacturing technicians was greater than engineers due to the yield implications of not following a procedure correctly. The HR interviewees thought it would be very difficult to ensure every procedure was without error. They also believed it would be very difficult to monitor every member of the manufacturing department on their compliance to these procedures.

	Accountants	Engineers	Manufacturing technicians
HR interviewee 1	10	6	8
HR interviewee 2	10	7	9
HR interviewee 3	9	7	8

Human Relations examples of responses included

- *There is an element of measure in the scoring. There is not a strict management review process of compliance*
- *Engineers do not always update specifications. They inform manufacturing technicians of changes and trust they will carry these out even though by doing so the manufacturing technician will not now be compliant to the specification*
- *There is a degree of engineers transferring between groups to build flexibility and knowledge. This can result in specifications not being updated*
- *Engineers know more than the specification and they like to go beyond the specification when working on their process*

Information Systems Group Summary (Table) of Question (8):

The IS group stated engineer and manufacturing technicians compliance levels should be high based on the level of automation in the factory. If a procedure was not being followed the likelihood is factory automation would detect it and highlight the issues. The IS group thought the level of compliance demonstrated by the accountant function was higher than the other functions as they are governed by very strict financial rules.

	Accountants	Engineers	Manufacturing technicians
IS interviewee 1	8	7	7
IS interviewee 2	9	7	8

Information System examples of responses included

- *If engineers are not compliant it is because they feel they do not need to be*
- *The site is more quantitative than qualitative than it was. Procedures are much more automated with fewer manual interactions required*
- *The Finance community have fewer specifications to follow, increasing the probability of full compliance*

5.5 Semi-Structured Interview Summary

The purpose of the semi-structured interviews was to establish through research the degree of knowledge management within the local Site by:

- ***Researching the degree of information shared***
  A very high degree of information across a number of disciplines is shared across the site. There has been a particular emphasis on generating automated data as part of manufacturing technological advances.

- ***Establishing how accessible this information is.***
  There is a vast amount of information collected. With the right level of knowledge this information is readily accessible with the exception of Site goals. These are made very visible to the employees at all times.

- ***The level of knowledge sharing within a department***
  Knowledge sharing across the Site is prolific with analysis from the semi-structured interviews indicating tacit exchange the most common method. Some departments are more cognisant of the impact of knowledge sharing than others.

- ***The level of knowledge sharing between departments***
  Advocates of knowledge exchange in a department excel in sharing knowledge between departments. This is the principal reason attributed to the significant improvement in Site performance.

- ***How much an individual values knowledge sharing***
  Analysis from the semi-structured interviews indicated a strong desire to gain knowledge at the site and it is highly valued. In some corners there is a feeling too much information and knowledge exists. It is over complicated.

- ***How much the organisation supports knowledge sharing***
  The Site supports knowledge sharing through its actions rather than its words. Through investment in automated systems it has invested heavily in the ability to generate, harvest and exploit knowledge.

5.6 Conclusions

All departments demonstrated an acute knowledge of Site metrics. Of those interviewed many stated Site metrics as the sole metrics reviewed or included them with department specific metrics. A number of interviewees thought departments were good at delivering to metrics which could be quantified easily. On employee relations, morale and engagement, they were not able to articulate how well they were performing. Many assumed strong performance to Site metrics suggested morale was high and employees were engaged with Company objectives. Some interviewees suggested devising suitable employee-related metrics.

There was no evidence of intentional reluctance to knowledge share by any individual. All stated or suggested they worked in an industry which relied on knowledge sharing to achieve its goals. Where appropriate, interviewees described the process of writing company procedures as a means of codifying knowledge. They stated this was a form of converting tacit knowledge to explicit knowledge. When asked about how compliant to procedures different functions of the organisation were, the accounting function was considered highly compliant to procedures. The engineering and manufacturing technician functions were considered less compliant..

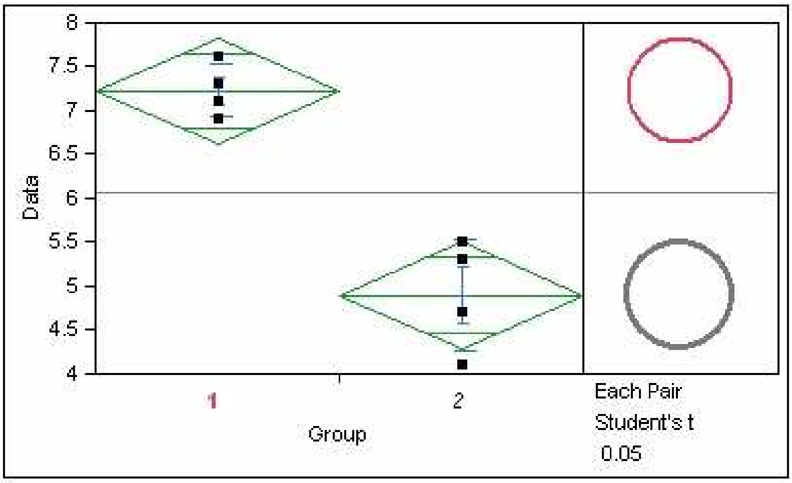
The accounting function appears to command much respect and trust in its ability to conform to procedures. Accounting procedures appeared to be a group focal point and were thought to be meticulously followed and maintained. Process specifications, which relate to the engineer and manufacturing technician function, were thought not to be entirely current and deviation from following them accepted in some circumstances. It was thought manufacturing technician compliance was affected by "custom and practice" whereby the technician found process instructions cumbersome and sought more productive ways of carrying out the process routine. As the writers of the process specifications, the perception was engineers had the discretion to choose whether or not to follow their own specifications.

Every interviewee commented on how well the site was performing now compared to a decade ago. Most interviewees were able to go into great depth on what had changed at the Site. A common response was the level of cross department knowledge sharing and how particular individuals were responsible for significant improvements at the site.

Departments who espoused knowledge sharing as part of their business process were generally recognised by other departments as operating in this way. Statistically, the departments can be separated into two groups: Operations, Finance, IS and Facilities forming one group, EHS, Planning, Procurement and HR forming the other.

Figure 5-5 shows these groups are statistically different at the 95% confidence level. The groups considered more receptive to knowledge sharing could be considered more operational and business oriented than the other groups. Although not part of this research, the level of knowledge sharing exhibited by group function could form part of subsequent research. Interestingly, senior managers identified as those who lead and drive knowledge sharing, fall within the top two groups in Table 5-1. It is possible those who consider themselves as business drivers or leaders understand the need for knowledge sharing. Those who do not take part in or promote knowledge sharing could be considered as playing a supporting role or followers of those who do.

Figure 5-5 Splitting Knowledge Sharing into Two Distinct Dept. Groupings



The organisation was generally considered as supportive of knowledge sharing as a process. Most interviewees acknowledged some senior managers advocated and practised knowledge sharing whilst some did not. They associated success with the former.

The pilot interview and subsequent semi-structured interviews met the requirements of the original research question objective. Furthermore it justified the method used and provided an excellent insight into knowledge sharing within the Site.

Chapter 6 Spend Reduction Case Study

6.0 The Case for a Case Study

As a multinational company, a particular point of interest in this research is whether or not the manufacturing sites within the corporation which are geographically dispersed, collectively share knowledge to best leverage the full potential of the sites. The semi-structured interviews gave the researcher the opportunity to establish the value and efficiency of internal knowledge sharing. Two case studies would be used to determine cross-site knowledge sharing. Hoskin (1998) stated case study is one of the "*major vehicles of learning*". By taking part in two case studies across the three manufacturing sites the researcher would hope to generate input which would be reflective of all three manufacturing sites' attitude towards subsidiary to subsidiary knowledge sharing. Coupled with the semi-structured interview analysis, this would allow the original hypothesis to be tested.

6.1 Existing Spend Operating Model

The Company has set up a model of competing business units across its manufacturing sites. It is likely this is in the belief that internal competition drives improved collective performance. In the responses to the questions in chapter five, almost all interviewees mentioned hard metrics or Site goals as the indicator of how the Site was performing. Corporate headquarters used performance to hard metric targets when comparing manufacturing facilities' performance. Regular communication with corporate headquarters is not unusual. In their paper Ghoshal, Korine and Szulanski (1994) comment that the headquarters represents the strategic apex of the multinational company. Ultimate responsibilities for strategic direction, decision making, and overall coordination rest with the headquarters. Effective communication with each subsidiary is a necessary condition for the headquarters to effectively carry out these direction setting and coordination tasks. Corporate headquarters and the three manufacturing sites operate across four different time zones. This normally results in each of the manufacturing sites having separate discussions with corporate headquarters. It is possible the inability to have very regular inclusive discussions can lead to three individual entities in discussions with corporate headquarters rather than a collective manufacturing entity equivalent.

6.2 Case Study Purpose and Plan

For the first case study it was decided to do a case study with one of our U.S. sites. The reason for this is the technology across both sites is very similar and therefore would remove the need to take other factors into account when making observations or completing the analysis. For example, the two manufacturing sites involved in the case study manufacture 150mm diameter silicon wafers. The other manufacturing site produces 200mm diameter silicon wafers. This has a significant bearing in how the Site is run in terms of technical and non technical staff through productivity and technological gains. The second case study used for this research includes representatives from the 200mm manufacturing site. A second case study was done to include the other manufacturing site. This is captured in Chapter 7.

The U.S. and local site's cost performance data is readily available to either site. Following some significant differences in cost and productivity metrics the operations managers agreed a benchmarking visit would be appropriate. The purpose of the benchmarking visit would be to understand how each of the sites approached Spend analysis and improvement.

The decision was made to investigate operational spend, namely facilities spend (infrastructure) and Fab spend (product generation) which together account for a significant percentage of total site spend.

6.2.1 Facilities Spend

Facilities spend includes spend such as facilities personnel salaries, utility costs for the site, external contractor services and leases and the running, servicing and maintenance costs for in-house generated services such as chilled air, process cooling water, heating and humidification.

6.2.2 Fab Spend

Fab spend includes Fab personnel salaries, servicing and maintenance costs for equipment required to process silicon wafers, consumable costs for materials to process silicon wafers and equipment and material required to determine if the process used is in control.

6.3 Team Members

Three senior members of the U.S. site were selected for the benchmarking visit. Prior to the visit they collected data to use for comparison during the visit. A number of senior managers and engineers in the local site were assigned to the exercise as shown in table 6-0 below.

Table 6-0 Benchmark Areas and Teams

U.S Site	Benchmark Areas	Local Site
Senior Facilities Engineer	**Facilities spend**	Facilities Manager Senior Facilities Engineer Senior Accountant
Senior Process Engineer	**Fab Spend - materials**	Process Engineering Managers Senior Process Engineers Senior Accountant
Senior Equipment Engineer	**Fab spend - equipment**	Equipment Manager Senior equipment engineers Senior Accountant

6.4 Case Study Data Gathering

To enable an efficient and successful data gathering and investigation exercise the case study included:

- ***Facilities Spend***
  The researcher would interview a senior member of the facilities team

- ***Fab Spend – Materials***
  The researcher would take part in a number of the benchmark meetings and interview senior members of the process engineering team

- ***Fab Spend – Equipment***
  The researcher would interview a senior member of the equipment engineering team.

- ***Internal Notes***
  Local site participants would provide feedback to the researcher through discussion, presentation and meetings and discussions transcripts.

6.5 Benchmarking Visit

The benchmarking visit provided the opportunity for a case study. Where appropriate, data pertinent to the case study would be coupled with cross referencing information from the semi-structured interviews. This would allow a degree of triangulation. Prior to the visit the researcher identified a number of points important to the study within a knowledge management context.

- Who should be involved in the visit
- An agreement on the outcome of the visit
- An opportunity to exchange tacit and explicit knowledge
- An opportunity to gain an understanding of how tacit and explicit knowledge is exchanged at the U.S. site
- How the researcher would capture notes, discussions and conclusions of the various meetings happening during the visit

6.5.1 Introductions and Agenda

The first action of the visit was for the operations director to welcome all present and confirming the reason for the visit and expected outcomes with a particular emphasis on a knowledge sharing approach.
A representative from each site presented organisation charts. This enabled the teams to determine the similarity of reporting structure, both in terms of hierarchy and total resources available. The local site's manufacturing managers took particular note of their counter-parts organisation with a view of having further discussions with the U.S. site's representatives on a more informal basis. If a contact name for a given process area on either side is known it allows the respective manager to make direct calls to the individual in question. This will allow engineers to gain knowledge such as how their respective area operates, compare formal embedded systems, progress on existing projects and discuss any new projects planned. A basic level of knowledge sharing is seen as beneficial – a simple exchange of names. It is not necessarily the volume of sharing or the magnitude of what is being shared it is the inherent value to the recipient which appears to be important. This point was re-iterated a number of times during discussions.

The Sites' organisational structures did not exactly mirror image one another but everyone was of the opinion the structures were very similar and comparisons between the two sites' structures would be valid.

6.5.2 Benchmarking by Area

For ease of analysis the study has been broken into the three benchmark areas as described on table 6-0, namely,

- Facilities Spend
- Fab Spend Materials
- Fab Spend Equipment

The format of how the data was compiled is similar across each of the areas. The following pages are written in the context of each of the sites explaining their cost improvement process to allow comparisons and knowledge sharing.

6.5.3 Methodologies

The teams had a discussion about methodologies employed at the sites and preferred tools to use such as QOS charts, Pareto analysis, Six Sigma, etc. One of the points coming out of the discussion was the U.S. site use formal tools for analysis. They assemble what they believe to be the appropriate group of experts to get involved in a project. The local site are more individual centric where they rely on specific people to establish a cross functional team to address a specific topic.
The teams agreed to go through each of the site's methods in detail.

6.5.4 Methodology Employed at the U.S. Site

The U.S. site used a six sigma approach to cost saving. The six sigma method was invented by Motorola and has evolved over the last two decades (Motorola, undated). The term 'six sigma' is often used as a scale for levels of 'goodness' or quality. Using this scale, 'Six Sigma' equates to 3.4 defects per one million opportunities (DPMO). Therefore, Six Sigma started as a defect reduction effort in manufacturing and was then applied to other business processes for the same purpose. As Six Sigma has evolved, there has been less emphasis on the literal definition of 3.4MDPO, or counting defects in products and processes. Six Sigma is a business improvement methodology which focuses an organisation on:

- Understanding and managing customer requirements
- Aligning key business processes to achieve those requirements
- Utilising rigorous data analysis to minimise variation in those processes
- Driving rapid and sustainable improvement to business processes

There are five process steps involved in the six sigma model for process improvements. These process steps are referred to as the DMAIC model.

Define Opportunity (D)
Measure Performance (M)
Analyse Opportunity (A)
Improve Performance (I)
Control Performance (C)

6.5.4.1 Define Opportunity (D) on Fab Spend – Materials

The U.S. site reviewed overall Spend and defined areas of opportunity, one of which was chemicals costs. The team agreed the Six Sigma method was a good way of bringing the right level of expertise together. This method would help to ensure an accurate spend analysis was done. Part of this process was to sub categorise the areas of opportunity to help define the level of resource required to carry out improvement actions. The team defined these as:

- *Procedures*. Review manufacturing procedures causing wasteful spending. An example given was the amount of ultra pure water used whilst tools were in standby (not processing silicon wafers). A flow of water should be maintained to prevent bacterial growth but when checked, there was a great degree of variation across a number of tools.

  *Local Site Input***:** The local team cited the use of test silicon as excessive. Test silicon is used to ensure a process is in control but similar to the wet-deck example, there is great variation in how this is done tool to tool or group to group.

- *Waste*. Identify various sources of waste such as leaks. The team's greatest observation of waste was when chemical or gas bottles were changed when there was material remaining in the bottle. An example of leaks was vacuum leaks. This would require the vacuum pumps to increase output to compensate requiring additional electricity.

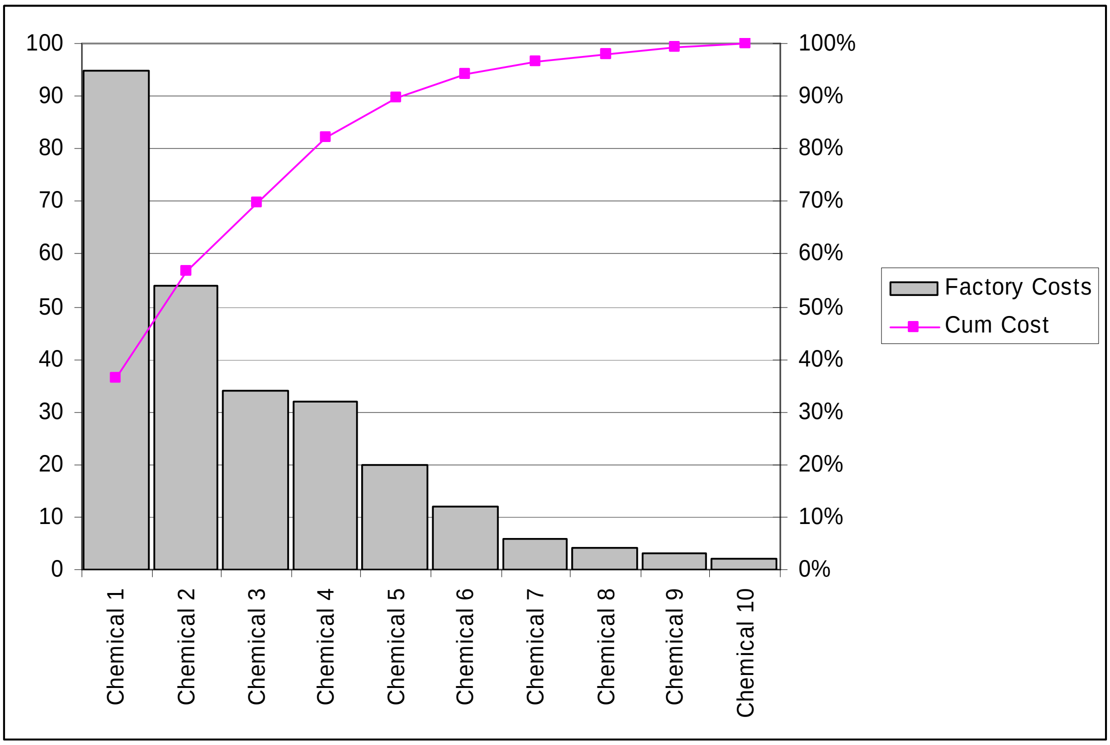
- *Best Known Methods*. Process settings or limits which increase material consumption. The teams agreed this was the category which would benefit most from knowledge exchange across the Sites. It would allow a comparison of how much material each site takes to generate the same number of silicon wafers.

- *Equipment*. Waste caused by inefficient or malfunctioning equipment. Both teams had good examples of the gains achieved by substituting highly productive equipment for older less efficient tools. It was agreed to do a comparison and analysis of equipment and efficiencies between the Sites.

6.5.4.2 Measure Performance (M) on Fab Spend – Materials

The U.S. site analysed chemical usage. They explained their rationale for doing this. A pareto chart plots values in descending order and includes a line depicting the cumulative total. An example of a pareto chart is shown in figure 6-0 below. The team indicated they preferred this method as it highlighted the main areas of opportunity. The local site agreed pareto analysis was a very effective method for doing this type of analysis adding it was frequently used as a continuous improvement tool at the local site. The teams agreed using a common analysis methodology enabled data comparison between sites to be more readily understood.

Figure 6-0 Example Pareto Chart



The pareto analysis showed of the forty two chemicals used on Site to manufacture silicon wafers, six contributed to fifty percent of the total cost of chemicals.

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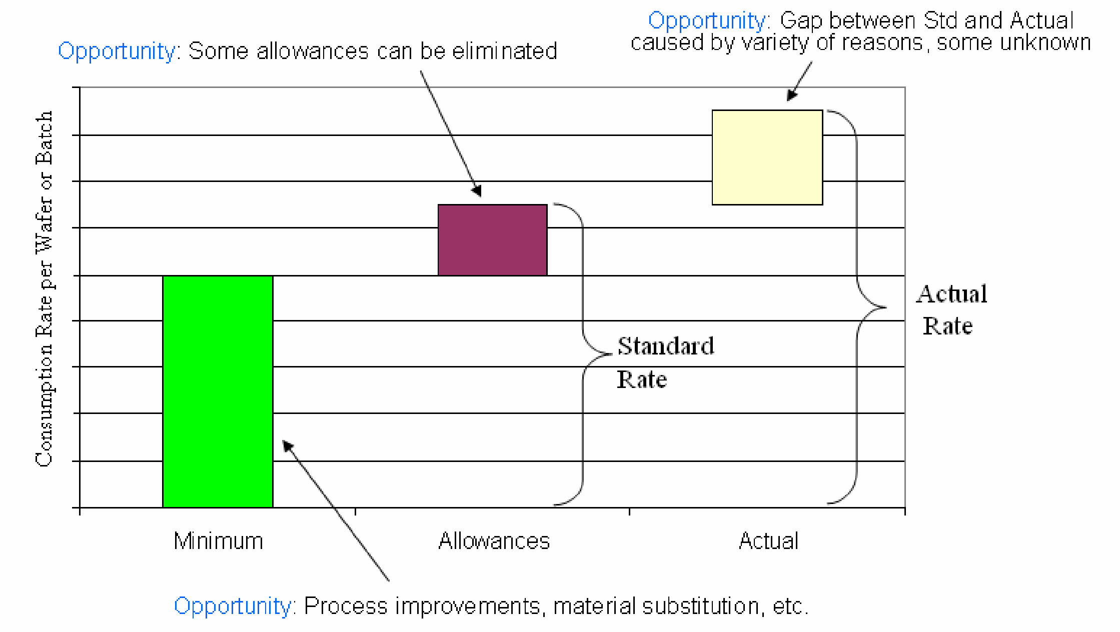
6.5.4.3 Analyse Opportunity (A) on Fab Spend – Materials

The team analysed each of the top six chemicals in turn. Based on a process recipe they established the minimum amount of chemical which should be dispensed. An allowance for reasonable variation was included. Anything above chemical dispensed plus tolerated variation was deemed as waste or opportunity. The process followed is demonstrated graphically in Figure 6-1.

Figure 6-1 Consumable Usage Analysis



The local site thought this was a very good way of analysing data. It was unique and the local site adopted it as a shared learning. The discussion centred on how to best determine the minimum quantity of material required in a process. The theoretical number is typically based on what the process recipe dictates. Additional material however is used. For example test wafers, line purging, reworking wafers. The local site agreed to look at the process recipe requirement, add a variation allowance and treat the remaining quantity as opportunity.

All agreed this was an effective way of analysing opportunity. By standardising a methodology it would expand the level of knowledge in any given matter, within a site and across sites.

6.5.4.4 Improve Performance (I) on Fab Spend – Materials

The team used the opportunity data generated in 'Analyse' to determine the cost saving per chemical which could be achieved. An engineer was assigned to develop an improvement roadmap. The prerequisite was the engineer had to be knowledgeable in one of the categories identified in 'Define':

- Procedures
- Waste
- Best known methods
- Equipment

The engineer was subsequently asked to develop an improvement roadmap.

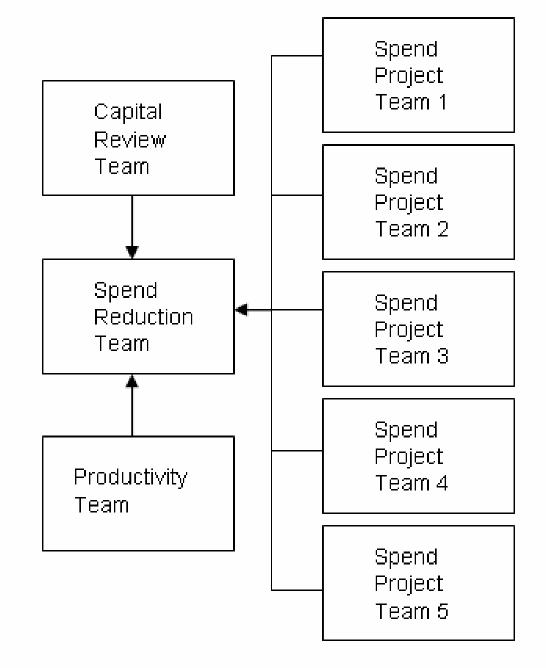
6.5.4.5 Control Performance (A) on Fab Spend – Materials

Control is implemented once the improvement plan has been put into place. This is to ensure control is maintained. At this juncture the chemical improvement process had not been completed.

6.5.5 Methodology Employed at the Local Site.

The local site established a finance group led cross-functional Spend team. The site has a number of formal cross-functional teams which have been in existence for some time including productivity and capital teams. The output of these teams is considered complementary. When a major cost initiative is required it is normally a cross-section of existing teams which is asked to take on the initiative. According to the local site this is the best way to leverage skills and to avoid lengthy delays generating data and bringing people up to speed if the initiative is urgent. By comparison, the U.S site will respond to an initiative with a formal model such as Six Sigma. The local site pulls together a cross functional team. Figure 6-2 depicts the local Site's cross functional team layout

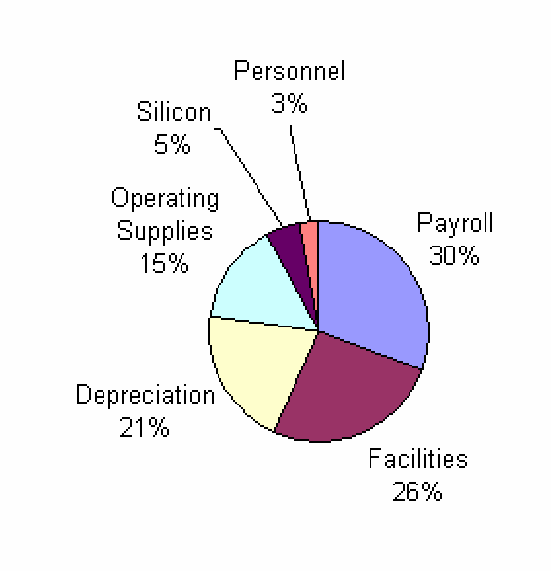
Figure 6-2 Local Site Cross-Functional Project Review Layout



6.5.6 Spend Reduction Team

The local site spend reduction team looked at total spend. An example of their macro analysis is shown below. The actual numbers are not used. The team produced a pie chart analysis to show the relative magnitudes of each spend category. For example in the pie chart below, the payroll costs amount to thirty percent (30%) of total plant spend. Raw material amounts to five percent (5%). This is shown in Figure 6-3.

Figure 6-3 Pie Chart Breakdown of Total Costs



6.5.7 Cost Models

The local Site had an established cross-functional team to ensure good cost discipline. Previous experiences had shown cost would rise if focus was not maintained in this area of the business. Manufacturing managers worked with finance to establish a cost model for each of the consumables. The mantra needed to be "*users of cost own cost*".

6.5.7.1 Predicted Cost

The team looked at all process technologies and all chemicals used in these technologies. At the end of each time period in question the anticipated chemical cost was calculated as shown in Table 6-1. The table shows 89,900 litres of chemical A used to manufacture 8633 silicon wafers. Multiplying number of litres by chemical cost per litre would generate total anticipated cost for chemical A. This chemical in question was of relatively low usage but high cost. The implication of this is cost reduction would likely be more feasible if a supply contract negotiation was entered into. The alternative would be to assign an engineer to design out the chemical.

Table 6-1 Chemical Cost Predictor

		Number of Passes			
	Number of wafers	Chemical A	Chemical B	Chemical C	Chemical D
Process A	2350	18	3	12	13
Process B	1250	4	2	12	2
Process C	233	0	5	3	4
Process D	300	2	7	4	2
Process E	1000	5	6	5	3
Process F	1000	7	1	2	2
Process G	2500	12	0	1	1
Usage	8633	89900	19815	54599	42082

6.5.8 Improvement plans

A weekly spend review was established at the site and chemical usage was one of the items on the agenda. The team leader looked at both strategy and tactics as part of a spend improvement roadmap:

- Review actual costs against predicted costs, define opportunity and an action plan (QOS Chart) to show who was responsible for the action, resources required and date when impact of change would take effect.
- Define a strategic roadmap illustrating plans to significantly reduce cost through e.g. more efficient tools. Following this a business case was put together.

Table 6-2 shows each action, the saving required and the manager responsible for updating the team on progress. To protect confidential information numbers below are not in any way accurate.

Table 6-2 Assigning Savings Projects to the Management Team

	Existing Spend	Savings	Revised Spend	Owner
Operating supplies				
Maintenance supplies	1,000	50	950	**Manager 1**
Freight	900	30	870	**Manager 2**
General Operating	800	40	760	**Manager 3**
Precious metals	700	25	675	**Manager 4**
Quartz	600	80	520	**Manager 5**
Test Wafers	500	120	380	**Manager 6**
Chemicals	400	200	200	**Manager 7**
Resist & Develop	300	150	150	**Manager 8**
Gases	200	100	100	**Manager 9**
Total	**5,400**	**795**	**4,605**	

The nine projects were reviewed within the five project reviews as depicted in figure 6-2. This ensured the entire management team involved on all spend actions on site and created an environment for knowledge sharing on the site.

6.5.9 Capital Asset Reviews

When an action involved investment of new capital equipment the cost leader would organise a capital review meeting. All capital requirements had to be specified and justified. The purpose of the meeting was to ensure the justification for this capital equipment was pushed through the approval process and subsequently followed progress of this equipment until it was commissioned into production use. This is shown in table 6-3.

Table 6-3 Capital Asset Review

Description	Project Number	Date Approved	Budget	Receipts	Labour	PO raised	PR raised	Balance
Capital Equipment A	UK08100	18th July 2007	389,000	404,696			-	(15,696)
Capital Equipment B	UK08106	7th Sept 2007	9,700	7,995		-		1,705
Capital Equipment C	UK08107	30th July 2007	55,300	51,498			-	3,802
Capital Equipment D	UK08108	23rd July 2007	850,000	216,376	69,636	121,903	42,699	399,386

Due the inter-linkage between all spend meetings on the site, as shown in figure 6-2, some of the members of the capital review board would already be familiar with new capital requests prior to them reaching the capital review board. With members of the team already knowledgeable it added to the efficiency of the team. All involved thought this was a good demonstration of a knowledge infrastructure working.

6.5.10 Facilities Representative Interview

For this part of the case study data gathering exercise the researcher interviewed a senior member of the local site's facilities team.

Question 1: How would you recount the benchmarking visit from a facilities perspective?

Summary of answer:

- The guest site got more from the visit than the host site. The guest site came prepared with questions and requests. The local site responded to these by showing appropriate data or demonstrating physical systems
- Without sufficient time for preparation, the local site did not ask for data in advance and had a limited scope of questions to ask which could be answered
- There were a number of ideas which could lead to improvements
- A number of follow-up conference calls between both manufacturing sites have taken place

- The local facilities team have not introduced any new methods or adjusted current practises based on the visit
- As far as the local team know, the U.S. site has not introduced any new methods or adjusted current practices based on the visit

Question 2: How do you think the benchmark visit worked as a knowledge sharing exercise?

Summary of answer:

- It was an effective means of encouraging open conversation. I believe discussions were more open through these face to face meetings than video or teleconferencing
- The U.S. site commented on our adaptable and flexible engineering team. Their feedback was the U.S. site had more areas of demarcation
- There appears to be more credibility when groups of people share experiences face to face

Question 3: What did you take from the benchmarking visit?

Summary of answer:

- The importance of collaboration. Although nothing had changed from the visit it was clear there could be a great potential benefit in collaborating
- The importance of preparation
- It can be difficult to do comparisons across sites if parameters are not measured in the same way or costs not accounted for in the same way

6.5.11 Fab Representative Interview

For this part of the case study data gathering exercise the researcher interviewed a senior member of the local site's equipment team.

Question 1: How did you become involved in the benchmark visit?

I got an email from my equivalent at the U.S. site who supplied a list of topics he would like to cover. These were:

- Systems. What we use to control day to day maintenance scheduling and cost predicting
- Organisation. Dayshift and shift technician cover and tasks
- Comparison of cost and usage of maintenance parts

Question 2: What did you present to the benchmarking team?

I presented all worksheets and systems relating to maintenance scheduling. I also presented cost models.

Question 3: What feedback did you get?

They thought our cost modelling was excellent and were impressed by the level of interaction between operations and finance. I get a lot of feedback about this. When we hosted a visit from one of our assembly sites they said our operations/finance model was very impressive.

When we did comparisons of parts usage we found the U.S. site used more parts in some areas due to gaining an understanding from previous yield excursions. When I discussed with the tool expert he said he was very familiar with the yield excursions. He already put preventative measures in. Interestingly he took the other site's practise and modified it. I do not believe this modification was shared with the other site.

Question 4: What do you think the U.S. site took away from the presentation?

They took away a very good understanding of how the local site runs its maintenance department in an efficient and cost effective way. My understanding is their overall costs are much higher, yet unit price for parts are cheaper. I suspect between our systems and efficient spending we have generated a lower cost maintenance model.

Question 5: Has there been any subsequent follow-up meetings or discussions?

There has been no follow up on this specific subject although we now have maintenance technicians on secondment on other sites. They are helping to close some knowledge gaps in those sites based on experience gained at the local site.

Question 6: What did you take from the benchmark visit?

As the host I believe it can be a bit of a burden. I was not as well prepared as I could have been. I think it is an effective means of sharing knowledge but would prefer to go off-site when hosting. This would allow us to concentrate on the visit rather than distracted with other daily business however is in the formation of new relationships.

6.5.12 Finance Representative Interview

For this part of the case study data gathering exercise the researcher interviewed a senior member of the finance team who was involved in the visit.

Question 1: How did you become involved in the benchmark visit?

The operations group informed me about the visit and said they would like me to participate due to my knowledge of spend and of the operations and facilities business models.

Question 2: What did you present to the benchmarking team?

I presented the model and assumptions data for each operations and facilities line items and the resulting spend profile for each of these areas. I presented how we account for each item of spend.

Question 3: What feedback did you get?

The U.S. team were very surprised at the level of knowledge I had on technical operational detail. They mentioned their finance team are not involved to this level of detail in operational matters. They were also surprised at the financial acumen the engineers possessed. I would say this site operates very differently from the U.S. site who possibly do not realise the benefit of sharing knowledge across departments. It reminded me of how the local site operated four or five years ago.

Question 4: What do you think the U.S. site took away from the presentation?

I got the impression they were keen on the visit as one aspect of their Spend was much greater than the local site's equivalent spend. In part they satisfied themselves this was due to the different way the sites account for similar Spend items. I would imagine they would consider replicating our control methodology at their own site.

Question 5: Has there been any subsequent follow-up meetings or discussions?

There has been no follow up with finance but there has been follow-up with the operations groups.

Question 6: What did you take from the benchmark visit?

It helped to reinforce the model of collaboration and knowledge sharing at our site as effective and possibly unique. When a site takes time to do comparisons they do not get down to the full level of detail required to do a like for like analysis. There are still too many assumptions.

6.6 Meeting Conclusions

Towards the end of the benchmarking visit the bench-marking team got together to discuss the visit. An informal discussion took place where everyone gave their views and opinions of the meeting. These included:

- General Observations and Conclusions
- Chemical Spending Pareto Analysis
- U.S. and Local Site Comparison
- Local Site Saving Opportunities
- U.S. Site Savings Opportunities
- Local Site Forecasting and Analysis
- U.S. Site Forecasting and Analysis

6.6.1 General Observations and Conclusions

1. Both Sites have methods to calculate expected spending
    a. The local site has extensive spreadsheets for each area. Results are compiled manually.
    b. The U.S site use spreadsheets to calculate standard costs. Database converts standard costs to expected spending.
2. The local site updates cost models regularly
    a. Local site engineers and engineering managers are closely involved in estimating spending.
    b. U.S. models were prepared several years ago by process engineers. Updates are infrequent.
3. Both Sites review spending regularly.
    a. The local Site holds weekly meetings with engineers, managers and the Finance business partner to review spending.
    b. U.S. engineers and managers meet once every four weeks to review spending.
4. Chemical spending patterns are similar for both sites with exceptions noted.

The consensus of the team was the local site had a much more involved spend process. The U.S. team commented on the effectiveness on the manufacturing and finance reliance to the extent they were surprised at the level of knowledge sharing and collaboration between these groups. In addition to this they noted the local site method was much more fluid with regular meetings taking place to ensure Spend forecasts were based on current knowledge and anticipated changes. In comparison, the U.S. site established process models a number of years ago with infrequent updates. The nature of the semiconductor business, productivity improvements and investments support regular updates to process models.

6.6.2 Benchmark Team Recommendations

1. The U.S. site would benefit from
    a. Involving engineering managers and process owners in routine spending forecasts.
    b. Simplifying input data and standards calculation (process managers do not know how standards are calculated).
    c. Evaluate savings opportunities in noted proprietary chemicals.

2. The local site would benefit from
    a. Automating spending forecasts
    b. Evaluate savings opportunities in proprietary chemicals.

The U.S team agreed to replicate the manufacturing/finance model used at the local site across their own site. This was noted as the most important observation and recommendation of the visit and all agreed this one point more than justified the benchmark trip. The Team agreed the benchmark trip allowed them to conclude the area of chemical cost saving opportunities.

6.6.3 Local Site Savings Opportunities

The Team generated a chemical cost comparison between the sites where forecasted spend at the local site is significantly higher than the U.S. site.

The local team agreed to investigate the spend pattern of each of these chemicals. An engineer and finance business partner would be assigned to this task. Based on knowledge gained from discussions over course of the benchmarking study the team agreed to do the investigation using the following process:

- Assign an engineer and finance business partner to the investigation
- Assign a contact name in the U.S. for the engineer or account to discuss findings and observations
- Assess the spend model for each of the chemicals
- Compare process recipes across the Sites for these chemicals
- Trend empirical U.S and local site chemical usage and spend for each of the chemicals
- Reconcile all data and present recommendations to the benchmark team

6.6.4 U.S. Site Savings Opportunities

The Team generated a chemical cost comparison between the sites where forecasted spend at the U.S. site is significantly higher than the local site.

The U.S site agreed to investigate the spend pattern of each of these chemicals. An engineer and finance business partner would be assigned to this task. Based on knowledge gained from discussions over the last few days the team agreed to do the investigation using the following process:

- Assign an engineer and finance business partner to the investigation
- Assign a contact name at the local site for the engineer or account to discuss findings and observations
- Assess the spend model for each of the chemicals
- Compare process recipes across the Sites for these chemicals
- Trend empirical U.S and local site chemical usage and spend for each of the chemicals
- Reconcile all data and present recommendations to the benchmark team

The U.S. team would meet with the finance department on return to their facility to take them through the proposed Spend model methodology. This exercise would provide a good opportunity to determine if the local Site's spend model methodology could be replicated at the U.S. site.

6.7 Conclusions

The case study allowed important information to be elicited and important interactions to be observed in the meetings, including:

- Comparison of group and management structure
- Comparison of methodologies:
  - Information systems, formal analysis tools
  - Individual, group and management expectations and interactions
- Reliance on cross-site communication
- Identification of best practice processes or procedures
- Establishing contact names for the future

Chapters 8 and 9 discuss the importance of this information.

Chapter 7 Yield Improvement Case Study

7.0 Case Studying Involving Every Manufacturing Site

This case study is written in the context of the researcher being involved in the decision to establish a cross-functional team. Cross functional teams have proven to be very effective at producing desired objectives as discussed as part of the outcomes of the semi-structured interviews. This is thought to be predicated on the basis team members have the correct level of skills and knowledge and a have a propensity for collaboration and knowledge sharing. The purpose of the international cross-functional team was to generate a team with expanded and collective knowledge to improve a common manufacturing issue.

7.1 Establishing the Cross-Functional Team

During performance reviews with corporate headquarters it became apparent all manufacturing sites could be sensitive to variation in specific semiconductor circuit device parameters. In the vein of competitive spirit, the sites view each other's data prior to the reviews. A site always felt better if their metrics were ahead of the other sites. In the spirit of collaboration and knowledge sharing however, the site directors agreed to discuss some of these metrics together.

Performance to plant goals was discussed. Discussions were very open without a hint of any guarded discussions. The data generated showed all sites had similar yield sensitivities. It was agreed this should be the area to look at in greater detail. Subsequent calls were arranged and from this a team was chartered to do the following:

- Generate and compare yield data across all Fabrication sites
- Identify root cause reasons for the majority of yield excursions
- Compare root cause reasons across sites
- Establish and adopt best practise methods from each site.

The make–up of the teams was primarily governed by technical ability, followed by analytical skills. A discussion about knowledge sharing or collaborative style was not discussed in their own right. The managing director of one of the sites agreed to take on overall responsibility for the team and appointed a member of his staff as team leader of the cross-functional team. By sponsoring the team, the organisation through the managing directors, was showing it supported knowledge sharing.

The site's managing directors worked with their senior staff to decide on team members. In the case of the local site two of the most knowledgeable senior engineers were selected. The director's precursor was the engineers selected had to have significant experience in yield, a vision of how to improve yield consistent with the sites strategic roadmap and experience of previously successful cross functional teams.

Once the teams were established members of the teams took the time to generate and analyse the data in preparation for a scheduled call involving the other sites. Issues surrounding yield are multi-dimensional. Data would only be part of it. Aspects of "why", "how", "who" and "when" had to be formulated. For example:

- ***Why?***
  It is generally accepted people do things for the "right reasons". Almost every yield investigation has offered up mitigation. Chapter 5 discussed levels of compliance. This appears to support the case there could be conflicting instructions in process specifications which can lead to yield deterioration.

- ***How?***
  A "fix" may have been introduced following a previous yield excursion which was subsequently removed when a tool upgrade was scheduled. Carrying out actions in the belief you are improving a process may create an issue. Evolving

knowledge systems which cover all aspects and implications of change must be considered.

- ***Who?***

  There is a multitude of people in a organisation who could unwittingly create a yield problem. This could be as a direct consequence to an action (dropped a silicon wafer) or an indirect consequence (engineer put too much of an expectation on a manufacturing technician to follow a complicated procedure because the tool was not performing as it should).

- ***When?***

  Ideally tools should run error free between scheduled maintenance. If they do not then analysis may suggest reducing the time between scheduled maintenance.

The cross functional teams would not be just about sharing “hard” data. It had to share experiences and culture and agree those areas where they just did not know why a yield occurrence happened.

The team had several conference calls, mainly to discuss data. Over the course of a few weeks they had all established the essence of what impacts yield and how they should start to think about improving it. They decided this would be a good time to hold a conference together to discuss “face to face”. The concern was they would all have enough data from their own sites to contribute to a discussion which would lead to yield improvement.

7.2 Initial Meeting

The initial meeting was considered very informal. As it was a scheduled week long conference the team leader suggested they take time to have informal discussions to familiarise themselves with one another. All were known to each other but most had met just briefly prior to the conference.

Spending the first few hours getting to know everyone appeared to work very well. Discussions were very open and frank. The engineers were able to give their own thoughts on how their own sites were doing and their perception of the other sites. Not only did this help with knowledge exchange but helped to build trust between engineers: there did not appear to be any reluctance to share information. If a question was asked it was answered openly and honestly. It was noted knowledge sharing between engineers from two subsidiaries was similar to knowledge sharing between engineers in the local site.

The team moved into a semi-formal discussion. In a round table format with overhead facility to present and explain data, each of the sites gave a high level account of yield over the last twelve months. The objective of this first round of discussions was to:

- Understand each sites' yield performance
- Note yield issues unique to any one site
- Note yield issues common across one or more sites

This rationale suggested to technically bring everyone up to date with each other's yield performance and to make some initial observations into potential common issues. Although not mooted at the time, the thought was if one issue was common across all sites they would make this issue the main priority for the conference.

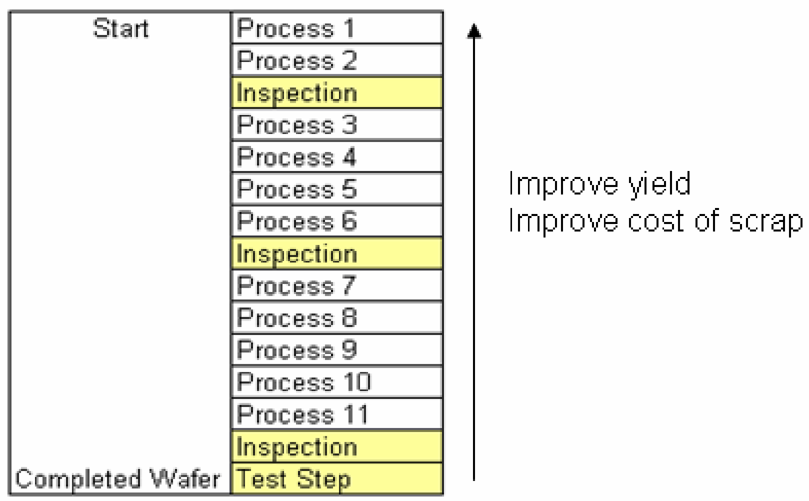
7.3 Outcome of Data Analysis Session

In recounting the data from the first round of the yield presentations, one of the engineers commented "*we all have similar issues to varying degrees but the biggest resource drain we all seem to have is getting into lengthy yield investigations. If something fails at the tool stage and is obvious we can easily address this. If it fails at the test stage not only is it expensive, we then have to investigate and surmise what may have happened*".

This was considered a significant cross-site learning. The team was formed to improve yield, but quickly realised yield and subsequent cost of yield could be improved if they could increase the number of failed products detected at the causal operation. This gave the team reason to feel good very early on. As one of the engineers commented, "*this project is about detection, not just about yield*".

Figure 7-1 demonstrates a typical process of manufacture. Silicon wafers receive a number of processes to build up the integrated circuit. These are termed process one to eleven in the diagram. Cost of manufacture increases with each process step. To ensure physical and electrical quality a number of inspection and testing steps are included.

Figure 7-1 Sequential Process Steps



- If the cost of manufacture is £5 per process including inspection and testing steps then total cost of manufacture per silicon wafer would be £5x15 process steps or £75. If a wafer is scrapped after the test stage it costs the company £75.

- If the fault occurred after process step two and not detected until the testing step then cost opportunity would be £75-(£5x2) or £65

As it was an important observation, the team agreed to pull together some additional data on yield and where the yield issue was detected. Prior to having this discussion the team wanted to have a discussion about what methodology they should use to help facilitate the team to a successful conclusion. As engineers, they agreed there was a risk they would lose time getting into debates about how to do something at each step of the way without a formal process to hand.

7.4 Improvement Process to be Used

The team had a discussion about what business process to use. Case study one discussed the U.S. and local site improvement methodologies. The U.S. preferred a six sigma methodology whereas the local site preferred a team alliance methodology. This cross functional team agreed to go with Six Sigma as an improvement process. All three sites were familiar with the process and all had qualified Six Sigma experts.

From a researcher's standpoint, the first case study included a comparison between a six sigma method and an "alliance" method. This provided a good opportunity to look at how the different sites share knowledge with a consistent method adopted.

The team spent time re-familiarising themselves with the six sigma process and agreeing team roles. They unanimously agreed to use the Six Sigma format for presenting out progress to their respective managing directors. This would help to avoid one site getting a different slant on progress than another. The team agreed they wanted each of the managing directors to sense they were getting a team presentation rather than a site representative presentation.

7.5 Problem Definition

Section 7.3 discussed the revelation about detecting yield problems earlier in the process. The team agreed to pull together data which would show:

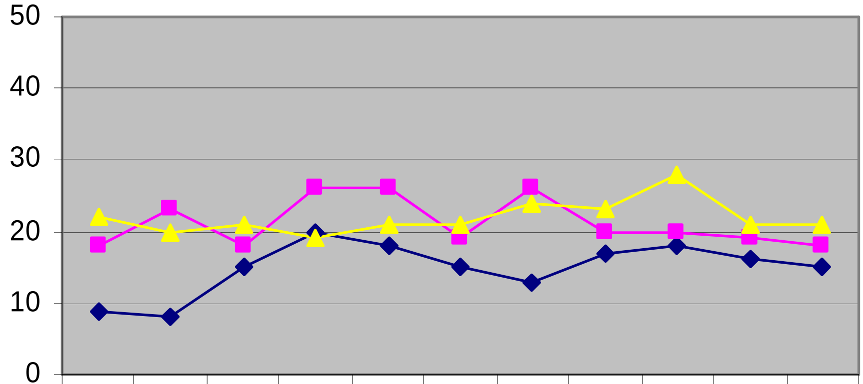
- Amount of scrap over last twelve months
- Percentage of this scrap detected at causal stage

By doing so, the team thought this would help to justify spending time on improving the early detection of a yield issue. This was an important point. Initially they thought the process would be about greatly reducing or wholly eliminating scrap. They were given a charter from their respective managing directors to work together to do this. Through a knowledge sharing forum they had discovered a different approach which could benefit all sites. Generating data would be important to justify this to the managing directors.

7.5.1 Amount of scrap

Figure 7-2 charts the amount of a particular scrap per site. The numbers in the table are for demonstration only.

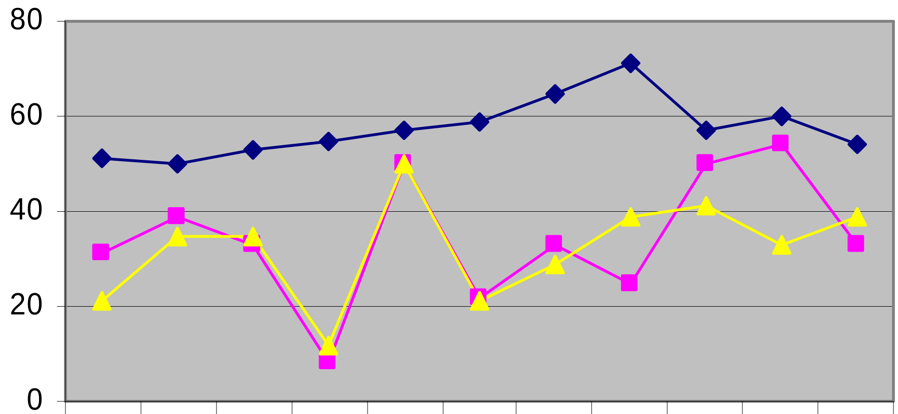
Figure 7-2 Volume of Scrap by Site



	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
Site 1	9	8	15	20	18	15	13	17	18	16	15
Site 2	18	23	18	26	26	19	26	20	20	19	18
Site 3	22	20	21	19	21	21	24	23	28	21	21

The next part of the process was to generate a chart showing the percentage of scrap detected at the causal stage. This is shown in Figure 7-3. The numbers in the table are for demonstration purposes only.

Figure 7-3 Percentage of Scrap Detected as Causal Stage



	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
Site 1	51	50	53	55	57	59	65	71	57	60	54
Site 2	31	39	33	8	50	22	33	25	50	54	33
Site 3	21	35	35	12	50	21	29	39	41	33	39

The data supported what the engineers had been discussing. A high percentage of scrap is not detected at causal stage. This ties up resource as the problem is harder to understand once the remaining process steps are added.

"*What does this all mean*?" was the question the team now had to ponder. After an initial meeting and sharing of data the team came up with something which could change the complexion of the project. They agreed the following:

- Detecting lots early should be a fundamental part of the project
- Present this out as a consensus view supported with data
- Discuss and analyse what "detection" means

7.6 Representing the Team's View

With the managing director of each site supporting the project and an important discovery on yield detection found, the team thought it best to now publish a problem statement. By doing so they would get the buy-in from the managing directors and begin the process of educating other engineers across the sites. An early discussion promoted the idea of "*letting others know what we know, when we know*".

The team worked together to come up with the following statements on the problem and team objective. This proved to be time consuming with the team agreeing they were more at home with technical challenges than communiqués. They did however acknowledge the importance of communication.

7.6.1 Problem Statement

- Fab manufacturing excursions causing product scrap in many cases are not detected until multiple batches of product are run. These excursions turn into large scrap events and cause customer delivery issues.

7.6.2 Team Objective

- Eliminate multiple batch scraps through improved detection and process control. One batch is defined as one lot or multiple lots committed to a single recipe selection and run on a tool.

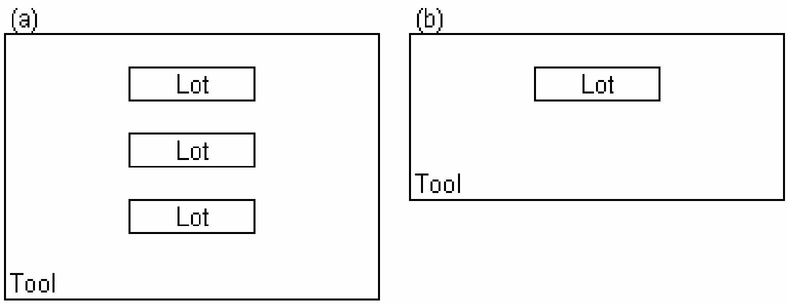
7.7 Criticality of Detail

Early on in the discussions on yield comparisons it became clear there were different definitions and terminologies for how wafers are counted. This caused a great deal of confusion. Before moving to the next stage it was deemed important enough to clarify:

Understanding the exact silicon wafer quantity in a scrap event was important for both cost and detection purposes.

Figure 7-4 (a) shows three lots of silicon wafers in a tool. The batch is therefore three lots. Figure 7-4 (b) shows one lot in a tool. In this instance a batch is one lot.

Figure 7-4(a) and 7-4(b) Three lot and One lot Tool Configuration Respectively



From a ***detection perspective*** the significance of this is if one of the lots in Figure 7-4(a) is proven to have a yield issue and the other two do not then it is possible the tool has not caused the problem. If all lots in Figure 7-4(a) have a yield issue then it is probable the tool has caused the problem.

7.8 Discussion and Analysis on Early Lot Detection

The team agreed progress made and agreed they had:

- Presented yield data.
- Agreed on the significance of detecting yield occurrences earlier.
- Revised the original charter and presented back to respective sites.
- Agreed on terminology with respect to data analysis moving forward.

The agreed next step was to share the common reasons for yield issues and where these issues could and should be detected. If they could do this they would start to understand why issues are not detected and what would be needed in terms of knowledge, skills or investment to allow for detection. As a group they felt they had successfully completed the first phase of the exercise and they were now moving to a next phase.

The team spent two days on listing, explaining and characterising reasons for yield issues. The process they agreed to follow was:

- Each site would present their reasons for yield issues. A pareto format was agreed.
- Analyse and group the reasons under a common theme
- List the top ten reasons or themes. The number was somewhat arbitrary but not considered too important for the moment.
- Suggest potential solutions
- Agree on next stage

The teams came up with a list of themes. This list was the culmination of a very intense period of analysing yield information, convincing oneself of the root cause reason prior to convincing others, relying on data from other engineer's reports and using the collective knowledge of the team to identify potential solutions. Once these themes were agreed they would form the basis of the next phase of the process. If not correct it could lead to team failure.

The themes agreed were:

- Post Intervention Recovery
- Recipe Management
- Chipped Silicon Wafers
- Wafer Slip
- Inability to Measure a Fail Mechanism
- Problem with Incoming Material
- Test Wafer Frequency
- Manual Inspection Efficiency

- Culture

A discussion of each theme with a potential solution identified by the team is contained in appendix D.

At this juncture the team took a little time to reflect based on the importance of this stage of the process. When the question was asked “*does this list feel right*?” the overwhelming response was it did. They commented intuition and prior knowledge played a part and confidence was high. It was time to move to the next phase.

7.9 Engineering Knowledge Systems

Following agreement on common themes and potential solutions the team discussed tools and systems which should be employed. Identifying the themes was an important part of the process. Determining a method to help answer all the appropriate questions which would come up was considered essential.

7.9.1 Detection Matrix

One of the members of the team stated there was an industry standard for analysing failures and classifying the effect of the failure. All sites use this method. Someone commented however body language in the team suggested they were not comfortable with it as a means of delivering their objective.

Failure Mode and Effects Analysis (FMEA) is a procedure for analysis of potential failure modes within a system for the classification by severity or determination of the failure's effect upon the system. It is widely used in the manufacturing industries in various phases of the product life cycle. Failure causes are any errors or defects in process, design, or item especially ones that affect the customer, and can be potential or actual. Effects analysis refers to studying the consequences of those failures.

Significantly, the team decided this mode of analysis would not drive the project to a satisfactory conclusion.

Through a lengthy discussion and exchange of professional experiences the team decided they should design a bespoke analysis tool which they believed could be more suited to the purpose. Working together the representatives from the three manufacturing sites came up with the "*Early Lot Detection Matrix*".

The team discussed what purpose the existing systems served and listed important gaps. They agreed high level items needed to accurately map a process to provide early detection. These included:

- Failure classes that cause possible scrap
- Possible detection points
- Measurement or observation validity
- Gauge capability
- Data recording and analysis
- Response plan and actions

The dynamic of the team appeared to change. As the process was moving forward there appeared to be more time spent "*going off on a tangent*" as one member put it. Some members of the team were more specialised in some of the areas mentioned above than others. This led to a distorted amount of time spent on some of the topics. The team leader brought this point up as something which may affect the outcome if not addressed. As a solution they appointed a team facilitator. An engineer from the local site was appointed with the sole purpose of keeping the team "on track".

The team agreed they had achieved their objective of identifying gaps in the current detection system and the time was now right to design the matrix. This would be a complicated part of the process but with a facilitator on board they would harness all information and knowledge provided to ultimately come up with a suitable matrix.

An example of the matrix is shown in Figure 7-5.

Figure 7-5 Bespoke Analysis Method

Detection Questions

Detection Categories

Equipment Failure	Detection Points	95% Confidence Questions for Detection Point																				If Detection Relies on a combination of Detection Points then note them.
		Valid				Gauge								Recording and Analysis					Response			
DATA_START		1	2	2f	2u	3	4	4f	5	6	6f	7	7a	8	9	10	11	12	13	14	15	
Heater Temperature Variation	Refl Quals (product measurements - Al)	Y	Y	2	B	Y	Y		Y	Y	lot	Y	prod wafer	N	Y	Y	Y	Y	Y	Y	Y	
	Refl Quals (TW quals - all alloys)	Y	N	24	H	Y	Y		Y	Y	daily	Y	test wafer	N	Y	Y	Y	Y	Y	Y	Y	
	Heater Temperature Interlocks	Y	Y	0.042	B	N	N		N	N		N	N	N	N	N	N	N	Y	Y	N	
	EOL_Elec_Test	Y	Y			Y	Y		Y	Y	lot	Y	prod wafer	Y	Y	Y	Y	Y	Y	N	N	
Power	Sheet Rho Quals (Product Measurements - Al)	Y	Y	2	B	Y	Y		Y	Y	lot	Y	prod wafer	N	Y	Y	Y	Y	Y	Y	Y	
	Sheet Rho Quals (TW - All alloys)	Y	N	24	H	Y	Y		Y	Y	daily	Y	test wafer	N	Y	Y	Y	Y	Y	Y	Y	
	Power Interlocks	Y	Y	0.042	B	Y	N		N	N		N	N	N	N	Y	N	N	Y	Y	N	
	EOL_Elec_Test	Y	Y			Y	Y		Y	Y	lot	Y	prod wafer	Y	Y	Y	Y	Y	Y	N	N	
Chamber Pressure (Ion Guage)	Refl Quals (product measurements - Al)	Y	Y	2	B	Y	Y		Y	Y	lot	Y	prod wafer	N	Y	Y	Y	Y	Y	Y	Y	
	Refl Quals (TW quals - all alloys)	Y	N	24	H	Y	Y		Y	Y	daily	Y	test wafer	N	Y	Y	Y	Y	Y	Y	Y	
	Sheet Rho Quals (Product Measurements - Al)	N	Y	2	B	Y	Y		Y	Y	lot	Y	prod wafer	N	Y	Y	Y	Y	Y	Y	Y	
	Sheet Rho Quals (TW - All alloys)	N	N	24	H	Y	Y		Y	Y	daily	Y	test wafer	N	Y	Y	Y	Y	Y	Y	Y	
	RGA wafer-level monitor	Y	Y	0.042	B	Y	Y	QTR	N	Y	wafer or lot	Y	Oversight HW/SW	Y	Y	Y	Y	Y	Y	Y	N	
	EOL_Elec_Test	Y	Y			Y	Y		Y	Y	lot	Y	prod wafer	Y	Y	Y	Y	Y	Y	N	N	
Chamber Argon Flow	Refl Quals (product measurements - Al)	Y	Y	2	B	Y	Y		Y	Y	lot	Y	prod wafer	N	Y	Y	Y	Y	Y	Y	Y	
	Refl Quals (TW quals - all alloys)	Y	N	24	H	Y	Y		Y	Y	daily	Y	test wafer	N	Y	Y	Y	Y	Y	Y	Y	
	Sheet Rho Quals (Product Measurements - Al)	N	N	2	B	Y	Y		Y	Y	lot	Y	prod wafer	N	Y	Y	Y	Y	Y	Y	Y	
	Sheet Rho Quals (TW - All alloys)	Y	N	24	H	Y	Y		Y	Y	daily	Y	test wafer	N	Y	Y	Y	Y	Y	Y	Y	
	RGA wafer-level monitor	N	N	0.042	B	Y	Y	QTR	N	Y	wafer or lot	Y	test wafer	Y	Y	Y	Y	Y	Y	Y	N	
	EOL_Elec_Test	Y	Y			Y	Y		Y	Y	lot	Y	prod wafer	Y	Y	Y	Y	Y	Y	N	N	

7.9.2 Additional Analysis Tools

Populating the matrix would be a combination of straightforward accessible data and data which was the result of an investigation, experiment and subsequent analysis. There was recognition the three sites analysed data in different ways using different systems. Agreeing on a standardised format would remove much variation due to interpretation of data.

7.10 Provisional Analysis and Next Steps:

At this juncture the teams had discussed, shared and concluded that they had now reached the most important phase of the project. They had:

- Presented site yield data
- Identified an early lot detect element to the process
- Agreed on common themes and potential solutions
- Designed a matrix which would allow them to now improve these common themes

From a team perspective they had:

- Shared unique and common experiences
- Made decisions as a team with full team buy –in
- Accepted they required help to stay focused
- Designed an matrix which they agreed to deploy at their respective sites

There was an agreement they had achieved the first part of the objective and it was now about making it happen. They now thought it best to present a summary of the team's findings and recommended next actions to the sites' managing directors who had set the original charter.

7.11 Detection Team Recommendations and Next Actions

- The exercise was recognised as the first ever pro-active cross site risk assessment
- Comparison of like-tools across the Fabrication sites shows opportunity to share resources to solve common detection issues.
- Sharing resource is critical to success – knowledge is a resource.

- Early lot detection methodology if used correctly is a quantitative management tool for driving a pro-active culture in risk reduction.
- A high percentage of failures are not detected at one batch.
- Significant opportunities exist for optimisation by addressing flawed and frequency related detection issues.
- Established a data driven knowledge sharing methodology for prioritising and driving solutions. Through a cross functional team they had identified root cause corrective action, potential solutions and a method for introducing corrective action.
- Due to the success of this project establish new cross-site projects. Internal cross-functional teams can be very successful.

7.12 Benefits to the local Site

The early lot cross functional team was considered a success. In case study one it was evident a cross functional team can spawn other teams or benefits.
Based on the "*Early Lot Detection*" exercise there are three areas where the local site has added to its current methods of yield detection.

- A wafer scrap database
  A system used to harness knowledge and data on yield occurrences
- New tooling
  Introducing capability to prevent a yield occurrence
- A wafer handling initiative
  Through replicating a system in place at another site

All of this was achieved through a company wide, knowledge-led initiative.

7.12.1 Wafer Scrap Database

Participating in the Early Lot Detection exercise enabled engineers at the local site to view the systems and databases available to the other sites and compare against existing systems. Knowledge sharing across sites is crucial. It can take the form of a discussion or demonstration. It is particularly potent if demonstrated.

The database for collecting data relating to wafer scrap at the U.S. sites was deemed to be far superior to the database used at the local site. A team was established to analyse the U.S. sites' databases and to design a database compatible to the local site's systems which would generate the same level of data and allow a much more thorough analysis of wafer scraps. This was completed successfully and yield improved dramatically as a result of the visibility it produced. Engineers had more information to hand and could introduce root cause corrective actions through timely investigations. Knowledge sharing:

- Allows comparison of systems. What they can do, what is required to maintain them and the potential to expand their use
- Brings in the next level of expertise. A production problem can lead to an operations engineer getting involved can lead to information systems engineers getting involved
- Leads to a knowledge led improvement which impacts the bottom line of the business directly and normally prompts additional areas of improvement

7.12.2 Investment in New tooling

One of the U.S sites and the local site and identified a particular mode of failure which had impacted their sites historically. The local site had not experienced this mode of failure. The Early Lot Detection Matrix identified this potential failure as a reasonable risk. Based on this the local site introduced an appropriate detection tool. Recently the local site experienced the failure mode in question but was able to detect it quickly. Through knowledge sharing:

- A site can gain important investment
- There is less possibility of an issue which can impact a customer
- Engineers feel they are adding value through making the right choices
- Confidence at site improves

7.12.3 Wafer Handling

One of the topics discussed was the number of wafer handling incidents. The teams were unaware of each others performance. After quickly generating a chart they realised there was a stark difference between the sites. Hard data provides a solid basis of information sharing much easier to share than tacit knowledge.

A subset of the Early Lot Detection team worked together to understand why the difference between the sites was so significant. After working together to compare physical handling and storage and compliance to procedures and systems the following changes were made at the local site.

- WIP (work in progress) delivery system redesigned
- WIP (work in progress) storage system redesigned
- Workstation workflow optimised

- Highlighted awareness of the importance of following Standard Operating Procedures.

An important aspect of yield is to be satisfied the action taken has indeed improved yield. There may be a case where there is a coincidental improvement only to find the yield issue returns. The wafer scrap database improved confidence due to the level of detail available on the wafer scrap database system and its ability to quantify the cause and effect relationship

7.13 Interview with Member of the Early Lot Detection Team

A member of the team was interviewed to get the individual's perspective on the process.

Question 1: why do you think the idea of a cross functional team was put forward to collaborate on yield improvement?

I think it was done in the spirit of enhancing cross site cooperation. All sites have had yield issues on the past and share information with each other. This was just a site receiving information on what to avoid. The sites do not actively collaborate together on improving yield.

Question 2: Can you describe the first meeting?

There were a lot of people in the room with similar engineering backgrounds. We knew one another by name but had never previously met before. We spent a reasonable amount of time discussing the concept of yield improvement through early detection. This helped bring everyone up to a similar level of knowledge. It also helped to gain an appreciation of how others were thinking and to some extent their level of technical or otherwise expertise.

Question 3: How did you arrive at Six Sigma as an improvement process?

We looked at the options available and this was one already in use. It was by no means a perfect option but there were no alternatives put forward. This decision making process remained throughout. If a proposal was put forward it would be accepted within reason unless a more acceptable option was suggested.

Question 4: Was it an effective process?

It was but it involved a lot of work which I don't believe is necessary. It was not unusual for the team to become pre-occupied with minutiae. Some parts of the team were happy taking things to the "*n^{th} degree*" others had to "*dot the i's and cross the t's*". Two sites preferred to do the former and one site the latter. I believe this is why we had some problems maintaining focus on the detection matrix.

Question 5: Why did you design a detection analysis matrix rather than use the industry standard FMEA?

The sites use FMEA and are very comfortable with it. It is a valuable, recognisable and relatively easily maintained analysis tool. It would not however serve the purpose of getting to the level of detailed required to make an impact on detection.

Question 6: Can you discuss the design process?

We worked together to establish the gaps in our systems. This involved looking at historical data and understanding every incident to root cause level. Once gaps were established we produced a matrix which would prompt an engineer to ask all the right questions to ensure they had the right level of detection on their process. There was a broad agreement on what had to happen but we probably made the matrix far too complicated. The team became very familiar with it but when passed on to engineering teams it became apparent the level of upkeep required was too time consuming. The problem was to satisfy every question in the team and cover every eventuality we had included far too much detail. It was a powerful tool which worked. With modifications it could be widely accepted and used.

Question 7: How have the sites benefited from the process?

Meeting everyone and having the opportunity to discuss yield and various other manufacturing topics was invaluable. The engineers across the sites are very similar in their level of expertise, openness, need for information and the commitment towards continuous improvement. It felt like a technological breakthrough designing a dedicated matrix system which could be employed across the sites. We are now investing in tools across all sites which would not have happened in such a timely manner, if at all, had the meetings had not taken place.

Question 8: What has happened since the team disbanded?

A certain modus operandi has been established in the way we detect yield. We categorised and published detection points. This document will prompt engineers to consider very carefully how they set up a process. The detection points are:

- Pre-flight Ability to detect a fail prior to start of processing
- In-flight Ability to detect a fail during the process
- Post-Flight Ability to detect a fail post processing but prior to moving to the next operation
- Downstream Ability to detect a fail at a subsequent operation to where fail occurred
- Customer The customer detects the fail

7.14 Conclusions

Site directors elected to improve a common issue through setting-up a cross-functional team of engineers. The Spend case study involved the local site and one of the U.S sites with engineers and accountants involved in the study. The Yield case study involved the local site and both U.S sites where all participants were engineers.

The Yield case study allowed the researcher to:

- Observe knowledge sharing and collaboration between two oversees subsidiaries.
- Observe knowledge sharing and collaboration between the local site and each of the subsidiaries.
- Establish the success of the team.
- Establish problems the team encountered.
- Observe each of the sites' organisational attitude towards knowledge sharing and collaboration.

It was now possible to triangulate data from the semi-structured interviews, the Spend case study and the yield case study.

Chapter 8 Analysis of the Data Gathered

8.0 Revisiting the Research Methodology

The researcher wanted to understand the dynamics of knowledge management principally within the local site and how this related to the performance of the site. In addition, as a multinational company who ostensibly operate their manufacturing sites as internally competing business units, the researcher broadened the study to look at knowledge management across all of the manufacturing sites. In effect, does a knowledge-led multinational fully leverage knowledge across its manufacturing sites to generate a competitive advantage? Does it fully leverage knowledge within a Site to produce the level of performance it is capable of?

Two research methods were used, semi-structured interviews and case studies:

- **Semi-structured interviews**
  These were used to elicit a high degree of feedback from local site employees. This data proved to be particularly powerful when a number of employees from different departments came up with the same observations and conclusions or when department scoring was very consistent relating to collaboration levels. The semi-structured interviews were used to gauge how knowledge is shared, exploited, embedded and supported within the local site.

- **Spend Case Study**
  This allowed the researcher to assess how knowledge is shared across two of the three manufacturing sites. A comparison was done of spend control systems and it was particularly encouraging when employees from the U.S. site noted observations consistent with observations or comments made during the semi-structured interviews with local site employees.

- **Yield Case Study**
  The three manufacturing sites were involved in this process enabling the researcher to determine if the observations and conclusions from the Spend case study involving two sites were consistent with those made when analysing knowledge dynamics with all three sites involved.

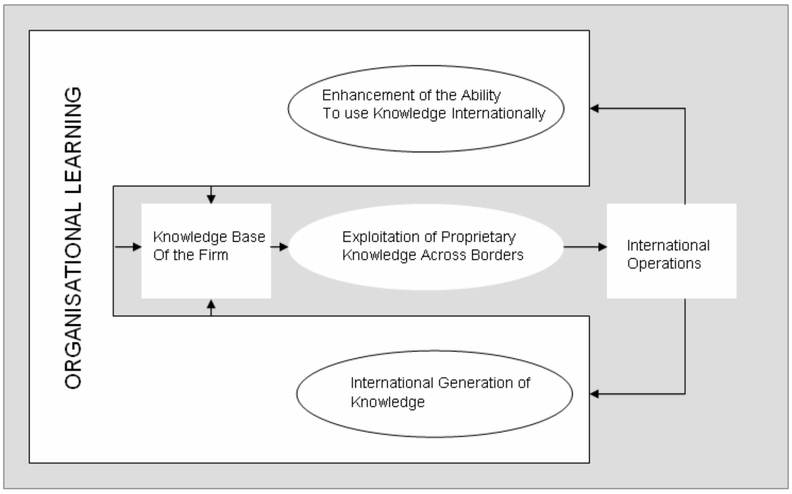
This Chapter considers all the data produced in the previous chapter and will look to identify the salient points.

8.1 Knowledge Transfer in Multinational Companies

According to Dierkes, Berthoin-Antal, Child and Nonaka (2003), effective management of multinationals requires a decentralised and flexible approach to learning and knowledge transfer.

Macharinza, Oesterle and Brodel (cited in Dierkes, Berthoin-Antal, Child and Nonaka, 2003, p631) defined international firms as instruments through which individuals or groups achieve their objectives in a process of creating and applying knowledge about efficient international operations. This process involves the use of knowledge across borders in order to generate new knowledge internationally. They further comment on important issues to be addressed: how internationality can help improve the existing knowledge base and which measures can facilitate the creation of knowledge within a network of trans-border activities under common governance as shown in Figure 8-0. The two case studies within this research consider knowledge flows across borders in this context.

Figure 8-0 Knowledge Across International Operations. From Macharinza, Oesterle and Brodel (2003).



8.2 Corporate Relationships in a Multinational Company

According to Schollhammer (1971) maintenance of proper organisational relationships between corporate headquarters and its operating units abroad is one of the most crucial issues with which multinational corporations are faced. Schollhammer (1971) concluded all companies perceive the role of corporate management is to determine overall corporate objectives, to specify organisation-wide strategies and policy guidelines, to decide on the allocation of corporate resources to the various operating divisions and to institute a uniform information system. Within this boundary managers of the individual operating units abroad are supposed to be free to determine a specific course of action for achieving the expected contribution to corporate objectives

Ghoshal and Nohria (1989) stated within an multinational company imperfect knowledge and fluctuations in the environment induce both the headquarters and the subsidiary to engage in reciprocal exchange relationships. This would make the realisation of even independently disparate goals more predictable over time. The interaction in these circumstances is usually characterised by a high degree of cooperation and problem-solving as opposed to high levels of bargaining.

8.3 Subsidiary to Subsidiary Relationships

In their paper “Managing Knowledge Transfers in Multinational Companies” Bjorkman, Barner-Rasmussen and Li Li (2004) commented the significance of the political aspects of knowledge transfer is further supported by a review of research showing that internal competition between subsidiaries is a critical determinant of subsidiary survival. In their study of inter-unit (subsidiary to subsidiary) communication in multinational corporations, Ghoshal, Korine and Szulanski (1994) found while subsidiary autonomy has almost no effect on either subsidiary to headquarters or inter-subsidiary communication, interpersonal networking has significant positive effects on the ongoing communication of subsidiary managers, both with their counterparts at headquarters and with managers in other subsidiaries.

8.4 International Operations within a Multinational Company

This research looks at the knowledge dynamic within international operations. The level of knowledge input and output from internal operations could be governed by the receptiveness or resistance to knowledge. This in effect could affect the performance of the operation and the level of usefulness it has to the firm itself. In the case of National Semiconductor this would be the local site’s usefulness to National Semiconductor Corporation.

Figure 8-0 depicted one line of communication into international operations. The local site has a vice president who has sole responsibility for the Site and is the primary senior management contact for the Site. However, a number of departments at the Site report “dotted line” to the vice president and “solid line” to their counterpart department head at corporate headquarters.

8.5 Corporate knowledge

This is the knowledge base of the firm as shown in captured in Figure 8-0. Within each specialist department this will be influenced by information flow between the corporate department and the corresponding local department. Grant (1996) stated with regard to knowledge, the issue of transferability is important, not only between firms, but even more critically, within the firm.

8.6 Transferred knowledge

The local department will work with corporate headquarters to enhance the level of knowledge and expertise in the local department. Change in corporate objectives, guidelines or strategies will be communicated directly to the local department by the corporate department. Importantly for the Site, the local department will articulate the progress and performance of the Site to Corporate. Lack of communication or misinterpretation could impact the credibility of the local site. Foss and Pedersen (2004) stated in reference to the multinational as a knowledge-based entity it has become almost axiomatic that knowledge and learning are at the root of understanding how competitive advantage is gained and sustained.

8.7 Dispersed knowledge

The local department uses its own knowledge and knowledge gained from Corporate and puts it into a local perspective. An example may be the finance group asking a support department to reduce spend based on a corporate finance initiative. The knowledge dispersed can be filtered to make it more useful or it can be “regurgitated” with no local department ownership.

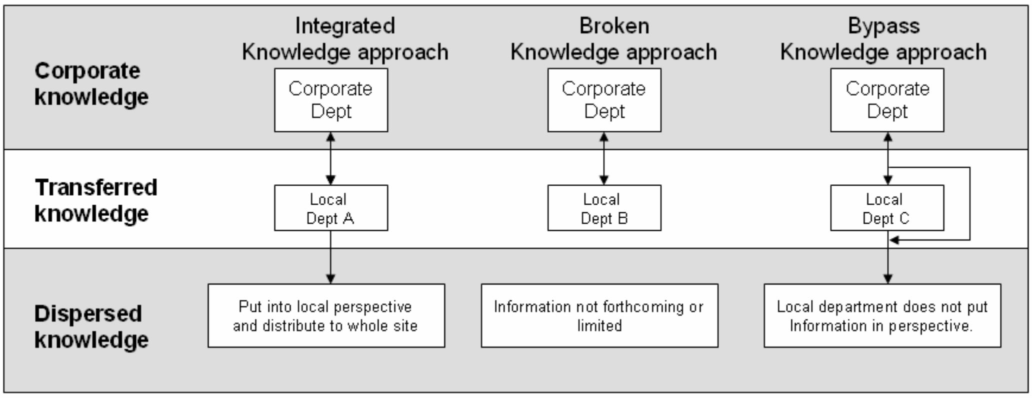
Within a multinational context this research has shown:

- The Finance group hire and train accountants at the local site then transfer these accountants to corporate headquarters
- Knowledge flows freely between international professional staff when meeting "face to face"
- "Best practice" procedures performed at one site is acknowledged by the other sites. Representatives of those other sites to intend to replicate the "best practise" procedure on return to their site

8.8 Knowledge Approach

McGlynn (2008) identified three pillars of knowledge exchange across three knowledge tiers. This is demonstrated in Figure 8-1.

Figure 8-1 Knowledge Approach Across Tiers. From McGlynn (2008).



McGlynn (2008) described each approach as follows:

- The *integrated approach* model is where there is a high degree of knowledge sharing exists between corporate and the corresponding local department. The local department uses its skills and expertise to interpret corporate requirements. Through good collaboration and communication it disperses this knowledge across all relevant departments in the local site. The department considers itself as a knowledge conduit. In this model it is seamless as to where corporate knowledge ends and local knowledge begins. Corporate and local department are an integrated unit.

- The *broken approach* model is where the local department works closely with Corporate to enhance existing knowledge but does not pass this onto the relevant departments. This can be problematic as departments will not be aware of the full expectation put on them by Corporate. This model can cause issues especially if the information, knowledge etc gets through to the site from other sources. This can be seen as a lack of trust either from corporate or from the local department not sharing the information. This can result in frustrations for both Corporate and the Site neither fully understanding the other.

- The *bypass approach* model is where there is a level of knowledge sharing between corporate and corresponding local group but the information is not analysed and put into a local perspective it passes straight through to the rest of the local departments. This style of approach begs the question of how value added a department is and since there is no local interpretation can lead to confusion about why certain decisions have been made. In this model the local group shows a lack of ownership of the knowledge and information. The rest of the Site then does not trust the information because it is not delivered in the correct manner. "*You know what I know*" does not make it meaningful. The lack of trust is often passed back to Corporate. This results in more time questioning the data rather than using and understanding the data.

Malnight (2001) described how organisational research on Multinational companies has emphasised the emergence of network structures, with strategic advantage associated with their ‘combinative capacity’ reflecting both the strength of individual operating units and the links among them.

8.9 Site Performance

The research has shown the local site, as one of the manufacturing arms of a semiconductor company, is intensely focused on hard plant metrics. The organisational structure, communications, systems and knowledge, flow throughout the local site appears to start and end with plant performance and in particular cost and quality performance. This impacts the bottom line which appears to be of primary importance to the site.

Over the last decade there has been a significant change in the local site organisation whilst simultaneously a significant improvement in plant performance has been observed. This is supported by the responses of the interviewees during the semi-structured interviews. One interviewee specifically cited three phases of plant versus organisation performance which could be summarised as the reaction phase, the complacent phase and the control phase (Table 8-0). Each of these phases has an associated knowledge and collaboration element to them as described during semi-structured interviews

Table 8-0 Performance versus Knowledge Sentiment

Phase	Site Performance	Knowledge Sharing
Reaction	Not competitive	*Reluctance to cross collaborate*
Complacent	Competitive but stagnant	*Side by side, but not together*
Control	Maintaining competitive advantage	*Intense cross-group collaboration*

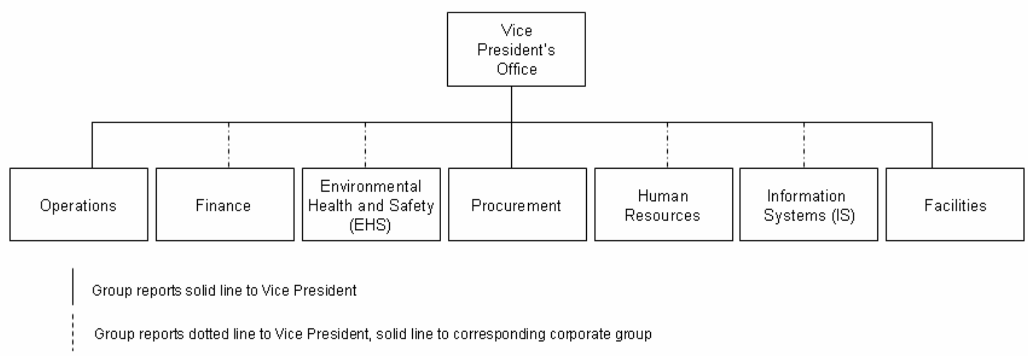
Most interviewees could closely relate to the performance over the last four years and the reason for this performance change. With a vast improvement in performance, everyone appears to want to own the success and when successful everyone wants to understand why. Lack of success appears to lead to lack of ownership and perhaps even a blame culture.

From a multinational company perspective Dhanaraj et al (2004) found the ability to exchange explicit knowledge between the corporation and the subsidiary had a positive impact on performance.

8.10 Knowledge Sharing Within and Between Departments

With the exception of procurement professionals across all departments were interviewed. The organisation structure involving those groups are as depicted in Figure 8-2.

Figure 8-2 Local Site Organisational Structure



All departments recognised the term “knowledge management” but it was not a commonly used word or conscious notion. Drucker (2003) argued productivity of the knowledge worker is likely to become the centre of the management of people, just as the work on the productivity of the manual worker became the centre of managing people a hundred years ago, that is, since Frederick W. Taylor. Through close collaboration two departments at the local site became the architects of the greatest productivity results observed at the local site and managed to catapult productivity at the site above the other manufacturing sites.

Team Work and Collaboration

As discussed in Chapter 5 a productivity team was formed where at the outset the objective was to leverage knowledge between departments to improve productivity of the direct labour population. Department heads from four of the groups shown in Figure 8-2 were represented at the meetings. Representatives from these groups were interviewed and all fully recognised the achievements of the productivity team. Most interviewees thought the example set by the productivity team was the reason why the Site had performed so well over the last four years: the date of the turnaround in plant performance and the setting up of the productivity team was not deemed coincidental.

Representatives of the productivity team were interviewed. Although all recognised the level of achievement some felt specific departments did not share knowledge or collaborate to the expected level. These departments are the same departments who operate on the broken or bypass knowledge approach (Figure 8-1).

8.11 Knowledge Sharing within Departments

There is a high level of knowledge sharing within all departments. Discussions during semi-structured interviews suggested finance and operations departments both recognise the importance of a professional employee understanding a subject matter and codifying the associated level of knowledge into a specification or procedure. There was a concern raised however over the level of compliance to these specifications and procedures during the pilot interview. Based on this the researcher included a question on compliance in the semi-structured interview.

Most groups meet regularly to share site and department metrics. There are a number of other formal meetings where explicit knowledge is exchanged. Tacit knowledge exchange is frequent and appears to be the vehicle for knowledge exchange with which most employees interviewed are comfortable with. All departments use a number of systems to store, generate or exploit knowledge. In the operations group there is a mistrust direct labour employees will follow specifications or procedures, yet the data generated from the semi-structured interviews suggest the operations professionals could be considered least compliant to systems and procedures.

In the finance group the level of expertise and knowledge is recognised to the extent they hire qualified chartered accountants, train them on local policies and procedures and transfer the accountant to corporate headquarters. This has become a regular event.

Within the operations group employees either work dayshift or rotating shift rotas. Knowledge exchange between dayshift and rotating shifts typically happens when the employees working rotating shifts are on their dayshift rota. This happens two out of every four weeks. Those interviewed said this inhibits knowledge sharing. Emails and other forms of electronic means of communicating exist but those interviewed valued the opportunity to have face to face discussions. Indeed when the shift rota was reviewed, the shift review team who were carrying out the review of shift patterns met every shift employee face to face and held numerous meetings and presentations. Shift patterns are a very sensitive subject and everyone appreciated direct feedback and the opportunity to gain knowledge of patterns used in other companies directly from the shift review team.

Some departments keep up to date with legislation through direct contact with their professional bodies or institutions. Human relations will check with the Chartered Institute of Personnel Development (CIPD) for legislative updates on employee relations matters or EHS will check SEPA for environmental legislation updates. Knowledge made readily available has caused some departmental tension in the company. For example, government agencies publish up to date information on employee relations matters on the internet. On a number of occasions there were disagreements about employee’s rights based on a department head referencing the web and wishing to execute on an employee matter consistent with the government agency guideline.

8.12 Knowledge Sharing Between Departments

There was a large variation in the degree of knowledge sharing between departments. The close links between two departments in particular spawned a number of teams which were considered to be very successful. Interviewees identified the reason as having "*the right likeminded senior managers in place who led by example and generated success*" as the reason for this. Interviewees articulated the reason it continues to be a success is down to the level of trust and respect between the departments. There appears to be an ethos of success breeds success.

8.13 The burden of knowledge exchange

Some interviewees considered knowledge exchange a burden. This was highlighted during semi-structured interviews and as part of case study observations and discussions. Employees said they have to balance day to day activity with taking time to work on a knowledge initiative. Those who took the time said it was worth the effort.

The Spend case study appeared to have an element of burden for the host site and element of benefit to the guest site. This was due to the guest site wishing to benchmark in an area where they had a disadvantage over the host site. In this example it was maintenance and consumable costs.

The benefit to the sites for the Yield case study exercise was similar. The burden and benefits were equally shared, although a different burden appeared to exist. During a case study interview one manager commented there were many examples of generating additional workload as this is the way one of the other sites worked. Indeed, the interviewee further stated the reason the "bespoke matrix system" the team designed was not readily accepted across the organisation was because it was just far too detailed and required extensive maintenance to upkeep. Knowledge sharing alone therefore does not appear to guarantee success.

Jones (2005) stated if technological progress leads to an accumulation of knowledge, then the "*educational burden on successive cohorts of innovators will increase*". The local site has invested heavily in technological advances over the last decade. The innovation of the IS (information systems) engineers working with operations was cited heavily as an area which has helped direct and indirect productivity of the site. There were areas identified however where there is not the knowledge on site to deal with technology issues. These are outsourced and could create an issue if the vendor withdrew their support or service away from the site – the vendor effectively removes explicit and/or tacit knowledge from the site.

8.14 Workforce Reductions

Due to the cyclical business nature of the semiconductor industry it is not unusual to have enforced work force reductions. Those interviewed said each time this situation has occurred there has been a corresponding problem with at least one of the hard metrics the sites uses to judge performance.

The last reduction in work force resulted in a yield deterioration problem. This was discussed in Chapter 5. The engineers investigating the yield deterioration at first could not understand the problem as it was assigned to direct labour employees with extensive experience. On investigating the yield problems further the engineers ascertained the yield deterioration related to failures in the operating equipment. The direct labour employees who had been operating this equipment had found manual methods of working around the equipment issues. When the direct labour employee left the company tacit knowledge was not transferred over to their replacement. As a result yield deterioration occurred. There appears to be no provision to capture tacit knowledge as it is assumed explicit codified knowledge contains all the appropriate information for a direct employee to perform their routine tasks.

On a previous occasion, the Site completely removed a level of the technical organisation on rotating shifts. Almost immediately equipment availability reduced. In advance of the action the managers had indicated to the engineers on dayshift, who are ultimately responsible for all processes and equipment, to expect a flurry of activity. The consideration was engineers on dayshift were not addressing all recurring problems and the technical cover on rotating shifts was being used to put in temporary fixes. The Site did not want to build a knowledge infrastructure on how to perform temporary fixes. It wanted to concentrate on knowledge which would result in addressing root cause corrective action following a minimum number of failures. When the "Reduction-in-Force" action was taken a number of engineers had to work extended hours to deal with the subsequent problems. Since this time however, process and equipment availability improved significantly. In effect engineers appeared to have improved tacit to explicit knowledge exchange by improving working procedures relating to equipment availability.

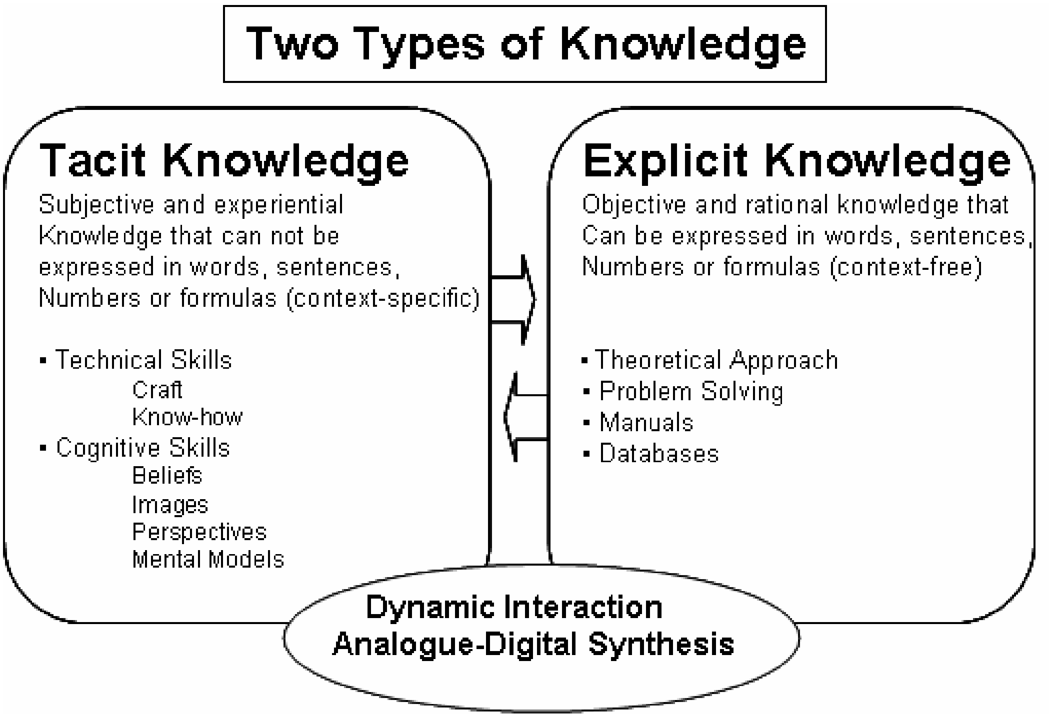
There is a broad agreement about knowledge being the Fabric of the organisation and each time a reduction in workforce occurs it changes the complexion of the organisation.

8.15 Compliance to Systems

According to the Asian Productivity Organisation (APO, 2008) knowledge is intangible and essentially resides within individuals (as tacit knowledge), the challenge in knowledge management is how to capture and harness individual-based knowledge to make it explicit and common knowledge for use across the entire organisation. At the Site it is generally accepted professional engineers and accountants have a wealth of individual-based knowledge and convert this tacit knowledge in the form of specifications and guidelines for others to follow. There is however a difference in attitude towards specifications and guidelines when comparing departments.

Figure 8-3 shows the exchange of tacit to explicit knowledge and suggests how tacit knowledge can be enhanced through the awareness of explicit knowledge. In the case of engineers writing specifications for direct labour employees to follow, these will become 'how to' specifications. The employee should replicate instructions exactly and as a result the processing of silicon wafers should occur with no human induced issues. Reality appears to be somewhat different.

Figure 8-3 Tacit to Explicit Knowledge Sharing. From the Asian Productivity Organisation (2008).



To gain a measure of the perception of compliance all interviewees were asked to quantify the level of compliance of three groups of employers to procedures and systems.

Perceived Compliance Levels

Level of Compliance		
Accountants	Engineers	Manufacturing Technicians
9.0	6.8	6.9

A scoring of zero to ten was used, where zero was perceived to be completely non-compliant and ten was perceived to be fully compliant. The table above summarises the results. Accountants are rated the most complaint, followed by manufacturing technicians and engineers who have very similar scores.

8.15.1 Finance Community Perceived Compliance

Almost all of those interviewed had complete faith in the finance department to follow specifications and procedures. Members of the finance community referred to legal and professional implications of not complying with procedures and specifications. This was echoed by other non-finance members of the organisation. Although the question was not specifically asked, the impression the researcher got was the finance group were trusted implicitly as an organisation responsible for the financial well-being of the Site. Finance hold great importance in being open and honest. One member of the group commented "*if finance believe it and demonstrate it others believe it and demonstrate it*".

8.15.2 Engineering Community Perceived Compliance

Engineering did not score at the same level of the finance group. Interviewees, including engineers concluded engineers believe they hold knowledge above the level of specifications and are free to carry out procedures in the knowledge they know it will not be to the detriment to the material being processed. A number of interviewees said engineers would often ask direct labour to carry out tasks which would conflict with instructions noted in the specifications. These were always deemed to be safe and not to the detriment to the material being processed. When asked specifically about their thoughts on specifications engineers said upkeep of specifications could be laborious. Commenting:

- Specifications historically were ‘why’ and ‘how to’ documents. They became lengthy documents and difficult to upkeep based on the number of changes required over time

- The advent of automation enabled engineers to design processes whereby checks and balances would be introduced to the automated system. Failure to comply with any of these checks and balances would result in the system being shut down and the material being processed would be protected. In some cases however, specifications were not updated in-line with these automation advances

This appears to call into question the effectiveness of converting tacit to explicit knowledge. If multi-sources of information are available and open to the employee, in this instance direct labour following specifications, then conversion to explicit codified knowledge may have an associated risk

It was a general observation by the researcher that an immense amount of resource is allocated to the development and advancement of automated systems. In many cases there are two or three different monitors on tools accessing similar data. Some points were brought up during interviews about these systems not in operation when a yield problem occurred. This could be deemed similar to not keeping specifications up to date. To maintain an effective codified system be it electronic or otherwise, needs a level of discipline and compliance attached to it

8.15.3 Manufacturing Technicians Perceived Compliance

Managers of manufacturing technicians commented how it would appear a manufacturing yield issue was at first glance due to the manufacturing technician not following a specification. On further investigation they would find mitigation through confusing or conflicting elements of the specifications to be followed. In some cases manufacturing technicians were asked to run a process using verbal instructions from engineers rather than follow their specifications. In many cases this was done to work around a problem with the equipment. Once the equipment was repaired the manufacturing technician would be expected to return to fully complying with specifications.

Everyone interviewed thought engineering should set the example of full compliance. If manufacturing technicians were not compliant it was due to engineering not setting the example.

Salient points from the interviews included:

- Many interviewees did not think the engineering group led by example with respect to compliance to specified procedures. Once someone was asked not to comply with the system they thought this introduced discretion to compliance to specifications and procedures

- Some interviewees thought compliance levels among the direct labour community reduced with length of experience. They said newly hired manufacturing technicians would comply fully with systems per their induction instructions. However, over the course of time reduce their level of compliance in-line with other employees. An interviewee suggested two reasons for this using a parent-child analogy

- *"The child (new hire) copying the more experienced adult (experienced peer)*
- *The child (new hire) with a 'why should I if they (engineers) do not attitude'"*

- One interviewee commented all tasks associated with a process are typically controlled through multiple specifications. When someone counted the number of tasks called for in the various specifications and the theoretical time taken to complete these tasks, it amounted to a significant part of one person's activity for the day

- It was suggested there is a general acceptance of non compliance relating to process and equipment specifications

8.16 Compliance Summary

Mattia and Dhillon (2003) discussed how an organisation espouses policies, rules and puts in place management controls that do not reflect what they actually do. From the semi-structured interviews the following could be observed:

- Accountants' espoused theory and theory-in-use is broadly the same. As a department they believe they are fully compliant to procedures and guidelines and their beliefs are supported by the organisation as a whole

- Manufacturing Technicians' espoused theory can be different from their theory-in-use. When a new hire is introduced to the facility their espoused theory is considered the same as their theory-in-use. Over time it becomes quite different as they adopt custom and practise behaviours of their longer serving peers. The manufacturing technician population appear to follow the standard set by the engineering group. The way specifications are written may not allow for full compliance without some form of manufacturing implication.

- Engineers' espoused theory and theory in use is quite different. They are the custodians of the specifications and procedures but do not hold themselves to the same standard they espouse. During the Yield case study it was observed one site was very much into the detail but the other sites, including the local site were not. This behaviour suggests a questionable discipline to update specifications when necessary to allow for full compliance. Engineers put great stock in automation to remove the potential for human error. They do not necessarily realise they are increasing this potential for error with the limited maintenance of the specifications they are responsible for.

8.17 Reliance on Knowledge Systems

The topic of site automation percolated through as a very important topic for the site with considerable human and financial investment dedicated to it. There was no specific acknowledgement of the implications of following an "automation roadmap" with respect to transitioning to a more automated infrastructure. Almost all of those interviewed agreed the Site's investment in automated systems was fundamental to its strategy. Table 8-1 summarises data from the semi-structured interviews showing the reliance change from employees over to systems.

Table 8-1 Reliance Ratio

	Reliance Ratio	
	Employees	Systems
Past	80	20
Now	30	70
Future	10	90

8.18 Operations and Information Systems

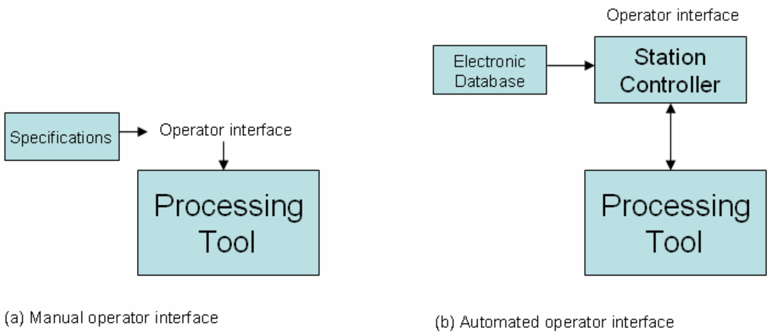
Engineers and engineering managers interviewed commented on the ability to generate important data from tools and how this was important to ensure processes remained in "control". New tools brought into the Site must have communications ability and older generation tools have been modified to allow communication interfaces.

Figure 8-4(a) and 8-4(b) illustrate a typical configuration to a processing tool. In the past, with a ratio of 80:20 in favour of employee reliance, manufacturing technicians would do the following as depicted in Figure 8-4(a):

- Select a lot for processing
- Place the lot onto the tool
- Select the recipe for the tool from a paper specification
- Load the recipe onto the tool manually
- Manually adjust parameters to meet product specification
- Run tool
- Remove lot from tool once processing completed

Operations engineers and information engineers have worked extensively together and through shared knowledge and expertise designed an automated system which is now proliferated through-out the Site.

Figures 8-4(a) and 8-4(b) Pre and Post Automated Operator Interface Respectively



As Figure 8-4 (b) shows, there is an automated system known as a station controller between the operator and the tool. The revised flow is:

- Select a lot for processing
- Place the lot onto the tool
- Run tool
- Remove the lot from the tool once processing completed

All complexity has been removed and process steps shortened. The system shown in Figure 8-4 (b) removes the need for a degree of “human intervention”. This in turn removes a layer of tacit and explicit knowledge from an organisational perspective. Accountability is effectively transferred to the system and those who comply with this system. Table 8-1 has shown the transition away from “employee” accountability to “systems (automation)” accountability to be substantial.

8.19 Does the Organisation Support Knowledge Management?

When asked if the management of the site supported knowledge sharing and collaboration amongst its employees most responses included an example where there has been a financial investment in a piece of equipment, support on benchmark visits and internal and/or external training. Most interviewees commented knowledge and the ability to use knowledge effectively was critical to the Site's success. On his book about Peter Drucker, Flaherty (1999) said it is possible to learn from excellent companies. Drucker concluded their one common denominator was the focus on results in improving financial assets. Always paying attention to qualitative performance, excellent companies were not deluded by "*quantitative gymnastics and misdirected activities*". This appears to be a fair reflection of the advent of the productivity team whereby prior to the cross-functional team taking over there was a lot of misdirected quantitative effort. Through supporting the team the organisation supported knowledge management.

8.19.1 Support through the Advancement of Systems

Previous chapters have discussed in detail the advancement the company has made on creating an information-network where engineers can readily access important process control data from their processes. Other examples include:

- Implementing a Station Controller on every piece of equipment in the Fabrication area
- Converting all paper specifications to electronic specifications
- Introducing a yield database
- Introducing a safety database
- Introducing web reports which all manufacturing managers use to determine the performance of the area and set tactics for the coming day. All site employees can access this data

- Linking Fabrication area data to test and assembly

The premise is any individual can sit at a desktop and exploit information from many sources. Knowledge is exchanged by means of technology resulting in a more productive operation.

8.19.2 Support through the Advancement of Training

According to interviewees training is recognised as a formal way of transferring both explicit and tacit information.

8.19.2.1 Direct Labour Training

Some interviewees gave examples of the training system which supports the direct labour organisation. According to most of the engineers interviewed, the Station Controller system almost immediately removed any level of intimidation new hires or inexperienced manufacturing technicians had about running new tools. By putting on the same “front end” as shown in Figure 8-4(b), on the interface computer all tools would be operated in the same way, irrespective of their function. This reduced the training time by over fifty percent and in some cases eighty percent. The amount and type of knowledge to be exchanged for training purposes was greatly reduced and training became more effective. In this instance less knowledge was deemed to be of value.

These training advances have helped to build a more confident manufacturing technician population. With the use of standardised automated systems, more technical ownership has been transferred to the manufacturing technician population. The use of systems has enabled the company to up-skill manufacturing technicians. This in turn has allowed the company to create an additional grading and wage structure which before now was afforded to indirect labour employees only.

8.19.2.2 Indirect Labour Training

There are three elements to indirect labour training at the Site, namely internal, external and cascade.

Internal training relates to an engineer training other engineers or technicians on a piece of equipment, a process or a service. This will normally involve transferring tacit and explicit knowledge. The process followed is not as formal as is used for direct labour training with the exception of safety related where there is a formal system.

External training relates to engineers attending training courses organised through vendors and normally associated with the purchase of new equipment. This training is formal and engineers are given “on the tool” training and will receive training and tool operation documentation. The engineer translates this into user and maintenance specifications prior to releasing the new tool to production.

Cascade training relates to engineers who have received internal or external training cascading this down to the rest of the workforce identified as requiring these skills. This has the benefit of the trainer, being an employee of the site, being able to temper discussions based on his knowledge of the trainee. There has been a lot of feedback from employees supporting this method of training.

8.19.3 Benchmark Visits

The company will support visits of engineers to other sites to learn about equipment operation or process cost of ownership. Case study one and case study two are examples of this. In some cases there are extended periods of training. Engineers from the site knowledgeable about systems and procedures would work with other sites to implement and embed these same procedures.

8.20 Knowledge Sourcing by Foreign Multinationals

Almedia (1996) investigated the learning and contribution patterns of multinational firms in the United States semiconductor industry through the analysis of citations to their patents and through field interviews. He found that knowledge used in innovation by foreign subsidiaries in United Sates regions is local (at the regional and country level). Almedia (1996) further commented firms located in innovative regions have greater access to new technological knowledge than their spatially distant counterparts. Semi-structured interviews highlighted where natural leaders have worked together to improve performance of the site using an innovative approach of inter-linkage meeting set-ups. This is a method of Alliance and Association. The site could be construed as a knowledge-intensive district. Analysing case study data was an opportunity to observe and to compare knowledge management between manufacturing sites in different countries.

8.20.1 Case Study Observations

The Spend case study related to a benchmark visit between two of the manufacturing sites. According to Appleyard (1996) access to knowledge can occur through channels such as email, telephone, face to face meetings, visiting other companies' Fabrication plants, consortia or benchmarking studies. This is represented in Figure 8-5.

Figure 8-5 Restricted and Unrestricted Knowledge Channels. From Appleyard (1996).

	Restricted	Unrestricted
Public	▪ Reviewing patents ▪ Reverse engineering Patented technology	▪ Newsletter ▪ Popular Press ▪ Trade Journals ▪ Conferences
Private	▪ Visit other Fabs ▪ Consortium ▪ Benchmarking Studies	▪ Email ▪ Telephone ▪ Face to face meetings

Both case studies undertaken involved benchmarking studies as depicted in quadrant *Private-Restricted* and email, telephone calls and face to face meetings as depicted in quadrant *Private Unrestricted*. Semi-structured interviews and case studies identified areas of knowledge channels within the remaining quadrants of Figure 8-5.

As represented in table 6-0 the benchmarking visit was arranged to look at specific spend elements of the operation. The guest site observed the department relationships in operation at the host site commenting on how effective it was and the wish to replicate it back at their own site. It was not a case of there being an apparent lack of skills or knowledge at one site versus the other. It was the recognition of how one of the sites set up a process of knowledge sharing between professional groups and how they used this knowledge to build on their success model.

Figure 8-6 International Knowledge Exchange

One site has an attitude of inter-linkage where every project has to ultimately link into a master strategy team as discussed in Chapter 5. This way of working was not presented directly to the visiting site. The guest site began to realise the knowledge sharing platforms in use during their visit. They also realised the level of knowledge operations engineers had about financial systems and the level of knowledge accountants had about operations and project management. Figure 8-6 depicts knowledge exchange flows between the Sites.

The host site believed they offered knowledge to the visiting site. According to Gupta and Govindarajan (2000) the greater the value of a subsidiary's knowledge stock for the rest of the multinational company, the greater would be its attractiveness for other units. This idea is broadly consistent with the concept of “relative advantage” in the literature dealing with diffusion of innovations which has argued that the adoption rate of an innovation is positively related to its advantage. Cohen and Levinthal (1990) stated when exposed to the same environment and even when there are insignificant differences in the desire to acquire new knowledge , individuals and organisations may differ in their absorptive capacity, that is, their ability to recognise the value of new information, assimilate it and apply it to commercial ends. The visiting site appeared to understand the value of the knowledge demonstrated by the host site.

8.21 Business Process

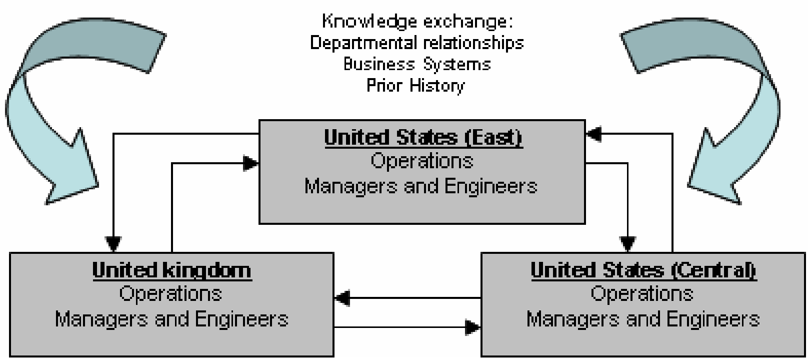
The guest site presented a logical step by step process of project management where the key imperative was to ensure everything could be reconciled. The guest site presented their Six Sigma means of project management of which the host site was already familiar. Neither site discussed the option of replicating the business process used.

8.22 Cross-Border Relationships

At the outset the relationship between all the members of the team was very good. There was an openness about and willingness to share knowledge. Styles were not dissimilar and both parties were as comfortable with formal knowledge sharing through presentations as they were with informal knowledge sharing through discussions when they were on production line tours.

The Yield case study related to a benchmarking visit involving three sites in different locations. Figure 8-7 depicts knowledge exchange flows between the sites.

Figure 8-7 International Knowledge Exchange by Location



The team's objective was to improve yield through using their collective knowledge and experience. Almost immediately the team established a very good working relationship and made a fundamental observation about where a yield problem is detected in the manufacturing process. The level of knowledge residing in the cross functional team appeared to boost their confidence as demonstrated when they rejected an industry standard means of analysis and designed a bespoke system. According to Ghoshal and Bartlett (1988) national subsidiaries carry out different tasks in the different processes through which innovations are created and institutionalised in multinational companies. They can develop and adopt new products, processes or administrative systems locally using their own technical and managerial resources to respond to local circumstances. Ghoshal and Bartlett (1988) further add subsidiaries may also be required to diffuse their local innovations to the parent company or to other subsidiaries, and the ability to facilitate such intra-organisational diffusion of subsidiary innovations allows a multinational company to exploit the scope economies of learning inherent in its geographically diversified operations.

As a cohesive team they were also capable of detecting their own faults and appointed a facilitator to help them avoid being distracted by lengthy "non value added" technical discussions. The Spend case study highlighted where the sites looked at continuous improvement in different ways. One site held a team central to all other teams and had clearly established linkages between the teams. The other site set up a dedicated team as and when an initiative or improvement project occurred. Feedback from a senior member of the corporation centred around one of the sites' strength of having "*very strong and collaborative managers who use and embed systems for competitive advantage*". Feedback on another Site was having "*very strong engineers who would follow systems and address root cause corrective action*". This would suggest the Sites have complementary skills.

The team on the Yield case study used a standard business system. What became apparent on this team and what may have proven to be a failure of the collective team was the extent of maintenance the bespoke system required to keep it current. It required a lot of time to keep it updated. Only one of the three sites appeared to have the culture or discipline to do this. The other two accepted the level of discipline required to keep it updated was probably beyond expectations.

The Yield case study team demonstrated the same openness and willingness towards knowledge sharing as the Spend case study team. Professionals within the company appear to hold very similar and comfortable views about the importance of knowledge sharing.

In his analysis of the firm as an integrator, Grant (1996) viewed organisational capability as the outcome of knowledge integration: complex, team based productive activities. Grant (1996) further commented this analysis of organisational capability offers insight into the linkage between organisational capability and competitive advantage. The extent to which a capability is 'distinctive' depends upon the firm accessing and integrating the specialised knowledge of its employees. The higher the level and sophistication of common knowledge among the team, whether in the form of language, shared meaning, or mutual recognition of knowledge domains, the more efficient is integration likely to be.

Communication between sites relating to the case studies has not been prolific. Once the benchmark visits were completed limited communication followed. Within a matter of weeks or months communication with respect to the topics discussed during the case studies, stalled. In the case of internal semi-structured interviews there were observations about how departments like to work with other departments and keep communication channels open. There has not been a like example when discussing knowledge sharing or communication between any two of the three sites discussed.

8.23 Conclusions

Corporate relationships in a multinational company are important (Schollhammer, 1971). They can dictate strategies and policies organisation-wide. McGlynn (2008) identified three forms of knowledge approach: integrated, broken and bypass. Chapter 5 summarised departmental knowledge sharing (Table 5-0). There is evidence in this research to suggest departments who operate under the "integrated" approach tend to be more receptive to knowledge sharing than departments who do not.

Some departments have significantly invested in automated systems as "knowledge databases". These automated systems also act to protect the product from operator non compliance. This research has shown there is a perceived variation between departments in how they comply with these systems. It has also shown those who invest in these systems do not set the standard for compliance.

The case studies undertaken demonstrated how employees from U.S. sites worked with employees from the local site. This relationship appeared to be devoid of any feelings of "competition" between the sites. No quantitative data was gathered to measure compliance with systems at the other sites. There was however qualitative data to support one Site as being particularly compliant. The local Site was the only one to demonstrate a structure of formal knowledge-sharing project teams.

Chapter 9 Discussion and Conclusions

9.0 Introduction

The original hypothesis to be tested was “*does a knowledge-led multinational company, who organise their Fabs as competing business units, fully exploit knowledge to produce a competitive advantage*?”

This research has provided an opportunity to explore the extent of knowledge management within a local site and explore how knowledge is transferred between sites with a view of testing the research hypothesis.

Chapters 2, 3 and 4 formed the literature surveys in knowledge management, individual learning and the learning organisation. Chapter 5 collated the data from the semi-structured interviews, Chapters 6 and 7 collated the data from case studies and Chapter 8 was an analysis of the collated data. Chapter 9 is an attempt to summarise the data analysis from a business perspective and introducing my own business perspective from the position of Operations Director at the local site.

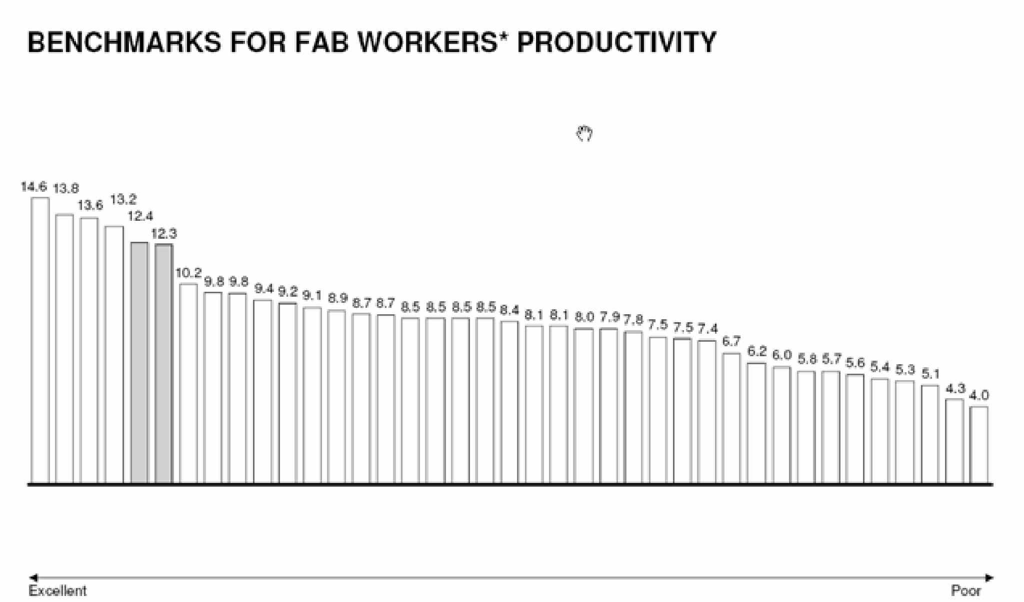
Answering the following research questions were considered fundamental to the research:

1. Do goals align across departments at the local site?
   All significant Site goals were aligned across all departments at the site. Goal alignment was not shown to be a barrier to effective knowledge management.
2. What is the current level of knowledge sharing within and across National Sites.
   Knowledge sharing through formal or informal communications within departments was considered healthy. Knowledge sharing between departments was viewed as limited or associated with specific departments or department managers. Knowledge sharing across sites was viewed as an occasional or scheduled event (business forecast reviews).

3. Identify performance trends and the contribution effective knowledge management has made to performance.
   The data gathered produced evidence of successful cross department teams resulting from the effective use of knowledge management. Where a successful team was identified, further teams were established providing a holistic knowledge management business process approach. Further evidence exists whereby some department managers have gained a knowledge management ethos. Analysis of the data supports the use of effective knowledge management teams as being the main contributor to the Site's much improved Key Performance Indicators.
4. Establish the level of support the organisation gives to knowledge management.
   Data supported the Site's management style and infrastructure to be supportive of knowledge exchange. An open communication policy and drive for system automation was cited as two key areas in which the Site supports knowledge management initiatives. There was no evidence of formal knowledge management networks in use at the Site.

Through the existence of an internal competitive landscape, the local Site has made use of knowledge through internal improvements and initiatives, such as automation, and complementary team work. Furthermore National Semiconductor manufacturing has shown collectively it has demonstrated a competitive advantage over like-Fabs. Figure 9-1 represents National Semiconductor's performance when compared to other Fabs. The shaded columns represent the local Site and one of the US Sites. All data to the right of National Semiconductor relate to external Fabs.

Figure 9-1 Fab Comparison Data as published by an International Benchmarking Company.



Operating its business units competitively does give National Semiconductor a competitive advantage. Furthermore the effectiveness of knowledge management within the local site has given it a competitive advantage over the other Sites. The leftmost shaded column relates to the local Site. This confirms the local site as the most productive internal Fab. Prior to the time this research was undertaken the local site was the least productive Fab.

9.1 Knowledge Sharing

The discussion points in this chapter relate to how knowledge is shared and in particular:

- Knowledge sharing within local departments
- Knowledge sharing between local departments
- Knowledge sharing between sites

9.1.1 Knowledge Sharing within Local Departments

There are a number of professional and technical groups. Representatives from all groups were interviewed as part of the semi-structured interview process. Case studies mainly involved engineers and accountants.

9.1.2 Engineering Knowledge Sharing within the Local Department

There is both a strong semblance of informal knowledge sharing and formal knowledge sharing between engineers and technical staff of all disciplines. Engineers value informal knowledge sharing opportunities. Groups of engineers are located in the same offices on site and prolific informal knowledge exchange occurs. In their opinion many breakthrough situations have occurred following, in some cases, happenstance situations. A deliberate attempt was made to move away from engineers spending time putting together formal presentations to senior management. The plan was to release them from this and create an environment conducive to knowledge sharing which in turn would improve site performance consistent with observations noted by Dhanaraj etc al (2004).

Engineers are responsible for defining a process and translating this information into codified instructions for manufacturing technicians to follow. Data gathered from the semi-structured interviews suggested the level of compliance to procedures in the engineering community to be comparatively low. Engineers during discussions agreed they themselves were not fully compliant to procedures but not in a manner which would compromise safety or the product. Reasons for this included the level of maintenance required to keep procedures updated and the level of trust between engineers and manufacturing technicians such that verbal instructions would suffice. Additionally engineers believe they have knowledge above the procedure and the procedure is not necessarily the only way a task can be performed. From a management perspective, the expectation is the task will always be carried out correctly and safely. It is not unreasonable for someone who has written a defined procedure to be knowledgeable about other means of carrying out the task in a different way.

Engineers put great stock in automation – the ability to pull parametric data directly from equipment and use this data to build process control systems which is central for the robust manufacture of silicon wafers. Investment in automation has increased year on year. It should be noted this investment may have indirectly led to the reduced level of compliance to procedures by engineers – automation can remove the potential for human error. If the product is protected in this way it appears to reduce the priority of engineers updating procedures. Specific strategic plans to deal with written specifications with the advent of automation were not put in place. Engineers would informally keep manufacturing technicians up to date with changes rather than relying on a formal knowledge exchange process. A management team strategy should be considered to work hand in hand with the migration towards automation.

According to some interviewees the manufacturing process relies on a custom and practice method of manufacturing technicians performing tasks to achieve manufacturing aims. It was suggested the level of compliance to written procedures by manufacturing technicians reduces in-line with experience gained. It should be noted it is likely the custom and practise procedure is correct and the written procedure outdated. Custom and practise itself can be a hurdle to overcome. It is a result of replicating tasks continuously over time. If a specification changes an employee may find it difficult to adhere to the new instruction following a natural tendency for them to do what they have always done. It could be the case tacit knowledge exchange will help adherence as this exchange normally occurs through discussion and demonstration. A codified instruction such as a written change to a procedure may not be enough for someone to immediately change how they do something.

Yield jeopardy due to reduced compliance is mitigated due to the continued reliance on automated systems as discussed earlier.

With the ability to automatically generate information from their equipment of responsibility, engineers invariably spend less time on the manufacturing line. This reduces the opportunity for informal knowledge discussions between engineers and manufacturing technicians. This effectively reduces a line of sight for knowledge sharing. In addition engineers can become 'one step removed' from the equipment they are responsible for.

9.1.2.1 Advancement of Automated Systems within Manufacturing

As discussed in Chapter 8 there have been significant advances in tool automation. This has resulted in strong working relationships between information systems engineers and operations engineers. The unspoken mantra could be described as "control the process and equipment through desktop computers". Chapter 5 discussed how some of the equipment used is 1980s vintage. For the equipment in question there was no communication interface. Engineers took time to work with external suppliers to build bespoke control systems which would interface with these tools. A prerequisite to bringing new tools on to the site is they are equipped with communications interfaces.

Engineers will readily move into un-chartered territory and will "push boundaries". They always appear to look for technological advancement. According to some interviewees, there are as many in-house engineering designed innovations as there are 'off the shelf' solutions from suppliers. Engineers rue the opportunity to maximise data gathering. Two potential issues of this approach were highlighted by interviewees:

- Automation provides the means to harness data but it has to be interpreted. Some interviewees feel some data is generated for data's sake and it impacts productivity
- There are potentially too many ad hoc data-gathering systems. Engineers who introduce them have the tacit know-how of maintaining them. If this knowledge is not codified there may be problems should these engineers leave the company

The change in direction towards automation has increased the requirement for Information Systems engineers. Through semi-structured interviews data suggests neither the engineers nor the company were cognisant of the implications of this. Chapter 8 discussed automation and the migration away from "people-centric" systems to automated systems. There is a need to maintain and potentially further develop these systems. Information Systems engineers therefore would have a greater responsibility moving forward with the burden somewhat eased on manufacturing technicians and engineers. This increases the need for knowledge sharing. Information Systems engineers need to know manufacturing impact of what they are doing.

The development of automated system involves writing bespoke software to meet engineers' specifications. Discussions highlighted the style and substance of what different engineers specify may not always be consistent. This can lead to variation of automation on a tool by tool basis. This has been identified as a potential problem for the future. It was commented earlier in this chapter engineers are aware of written specification non-compliance but believe automation mitigates this. If variation in bespoke automation software programmes is not consistent it will not correct the compliance issue which may subsequently lead to potential yield or product delivery issues.

9.1.2.2 Investment in Engineer-Led Knowledge Systems

Engineers are an integrated part of the Site's capital asset investment programme. The site introduced a capital asset review board which standardised the capital asset review process. On previous occasions some engineers would ask for a particular specification to control a particular parameter whereas others did not. This introduced variation to what could and could not be parametrically controlled.

The capital asset review board introduced a pro forma which ensured all engineers complied with specification standards. The process involved brining all appropriate engineers together to discuss all capital equipment to be proposed. This knowledge sharing forum led to a greater standardisation of equipment purchased. A change in organisational planning has now taken place whereby the Site Director will not approve a capital asset request unless it is approved by the capital asset review board. This part of the process has now effectively been embedded.

9.1.3 Engineers Working Between Local Departments

Historically engineers would focus entirely on technical solutions to problems and let others deal with the financial aspects of manufacturing. Over the course of the last four years, the relationship between the engineering and finance groups has resulted in engineers making decisions from a sound financial basis. This has resulted in an improvement to the bottom line as noted in internal company records.

The whole complexion of the way the site does business since has changed wholly down to this newfound engineering-finance relationship. Both professions can relate to one another as they want to understand each other’s business. They both want to run the business and have a desire to make the business successful. They both thrive on knowledge sharing and gain benefit from accumulated knowledge.

9.1.4 Accountants Working Within the Local Department

Accountants rely on and support codified knowledge transfer. They comply with procedures and have the support of the organisation as reflected in the feedback from semi-structured interviews. Although comfortable with informal knowledge sharing they appear to prefer standardised policies and procedures. Accountants have their own specialist areas of knowledge but rotate tasks on a frequent basis to ensure everyone meets a minimum knowledge requirement. They insist on a minimum professional qualification criterion and would rather do without an accountant for a period until a suitable qualified candidate can be found. From a knowledge perspective, the accountants interviewed said this enhances the ability to exchange knowledge due to the additional tacit and explicit knowledge the professional qualification generates. It also results in a group who according to a senior member of the organisation "*think the same way*".

The finance department hire and train accountants for transfer to corporate headquarters. They believe this endorses their view of the standard of locally educated accountants. In addition they say having "ex-patriots" helps knowledge exchange between corporate and the local site. In part due to "*speaking the same language*" and in part due to this process being a "*builder of trust*". Corporate headquarters also gain first hand knowledge of the level of experience and expertise within the Site providing a solid foundation to a successful knowledge sharing relationship.

9.1.4.1 Accountants Working Between Local Departments

There was a watershed in terms of how the organisation collaborated, shared knowledge across departments and ultimately prospered. For some time accountants held the view they should be "operational", that is, be part of the process of running the business. This notion came out very strongly during semi-structured interview discussions. The relationship between the operations and finance groups previously kept professionally parallel. There were no knowledge sharing forums and as one interviewee profoundly commented "*we worked side by side but not together*".

An organisation change within the operations group led to a new approach. The finance team requested to get involved at the outset and suggested a cross-functional knowledge sharing team be set up to manage the site's direct labour productivity programme. This was chosen as it fundamentally draws together the operational and financial aspect of the business. This was described in chapter 5. The productivity team was a finance-led initiative but one where it focused heavily on leveraging knowledge from relevant departments. Data from the semi-structured interviews scored the finance department more highly than all other departments from a collaboration and knowledge sharing perspective. From this perspective, it was not unusual to find the finance team wishing to initiate a cross-functional team initiative.

The direct labour productivity programme was established. This was the beginning of the turnaround of plant performance. Accountants and engineers interviewed who had been with the company prior to the advent of the productivity team all acknowledged the importance of the productivity team to the change in cost and productivity performance. Accountants and engineers interviewed who joined the site after the productivity team was established, recognised the close collaborative and knowledge sharing style between engineers and accountants as the norm.

9.1.5 Cross Functional Team Work – The Productivity Team

From the pilot interview and subsequent discussions there were two imperatives important to the productivity team:

1. Demonstrate period on period improvement on local site direct labour productivity
2. Propel the local site to become the most productive site between the three sites

Both points demonstrate the competitive spirit within and across the organisation. Competitive advantage was mooted during semi-structured interviews, but as a competitive advantage between manufacturing sites as opposed to a company-wide competitive advantage.

A central tenet of the productivity team was to be productive an employee had to be physically present, be trained and be flexible. It is important to discuss this further as this topic brought out most ‘emotion’ during semi-structured interviews:

- **An employee had to be physically present**

Attendance issues had to be addressed. Holiday systems had to be improved. Headcount issues around absolute numbers and skill sets arose particularly at weekends as this is when shift employees want to take time off. Sick absence and holiday absence combined allowing headcount to fall below critical mass at weekends. The productivity team pulled together all appropriate departments. It leveraged these collective skills and knowledge to address sickness absence and to introduce automated holiday management systems. It is how knowledge is used which impacts the bottom line. Having knowledge is not enough on its own.

- **An employee had to be trained**

Direct labour training had always been prolific but skills gaps were still plentiful. It transpired each of the shift managers would close training gaps pertinent to their own shift or perception of what they thought needed to be done. When all shift training plans were pulled together by the productivity team it was clear they were not synchronised. The productivity team made the decision to hold bi-weekly meetings to cover all shifts. The leader worked with the training co-ordinator to design a training plan which would meet business requirements. This was a good example of shift managers using knowledge within their own horizon to improve company performance. It did not extend however to having suitable knowledge to look at training plans and how they fit company needs at a macro level. This highlighted the benefit of cross-functional teams where functions out with operations added substantial benefit to operational issues.

- **An employee has to be flexible**

If an employee is trained on a number of process operations they are expected to move between these process operations depending on the situation of that day. This could include a manufacturing technician calling in sick absent requiring another manufacturing technician taking over their process operation for the day. Prior to the setting up of the productivity team, managers did not consider moving employees between shifts as this was deemed to be a sensitive topic. The productivity team, through good communication and presentation of strategy to the manufacturing technicians, moved employees across shifts. This was accepted by the manufacturing technicians as they supported the business need. Communication is an important knowledge tool. Knowledge can be good persuasion tool.

9.1.5.1 Using Knowledge Systems to Introduce a Flexible Workforce

Chapter 5 included a discussion on the topic of direct labour agency workers and how they were used to help with permanent staff holidays. The introduction of agency workers was possible due to the advancement in knowledge systems at the site. Automation reduced Direct Labour training time and protected the product from human error. Training and yield knowledge systems were found to be complementary. Agency workers could be hired and trained within a matter of weeks. Previously it would take months. By introducing agency workers it would protect permanent staff from business perturbations: if business increases an agency worker would be hired. If business decreased an agency worker would leave the business if appropriate.

Some interviewees who had been with the company long enough to remember the last influx of agency workers stated there were a lot of activity and yield deterioration issues. They acknowledged there has been no such concerns and put this down to the automation discussed above and the robustness of training plans and review meetings. This was an endorsement of the productivity team’s philosophy and methods.

9.1.6 Knowledge Sharing: Department to Department.

There is no direct corporation or site edict to exchange knowledge. The level of knowledge sharing between departments is traditionally governed by performing tasks required to meet site or department goals.

Two likeminded department heads contracted to leverage the full extent of knowledge between these two departments. A productivity team was formed and this initiated the process of department to department knowledge sharing on an explicit basis. The complexion of the two departments has since changed with members of the departments sharing knowledge in a much more open manner.

Data from the semi-structured interviews confirmed knowledge sharing between these two departments is viewed as responsible for an improvement in plant performance. Managers interviewed commented they had changed their department behaviours based on trying to follow the example set. This demonstrates success breeds success, a successful method adopted by many.

The semi-structured interviews identified departments who were not viewed as being receptive to knowledge sharing. These departments all have direct responsibility to corporate departments. It should be noted however, the department viewed as the primary knowledge sharer also has direct responsibility to corporate. Further research into corporate and local department relationships suggest three approaches exist between a corporate and local department. The departments identified as not being receptive to knowledge sharing fall under the “Broken” or “Bypass” approach as defined by McGlynn (2008). Department to department knowledge sharing was stimulated by the set up of the productivity team originally and subsequently by desire for the team to inter-link all relevant meetings.

9.1.7 Expanding Cross Functional Team Work: Alliance and Association Method

Most decisions and actions on site generally involve an operations and a finance perspective. With this premise the key managers within these groups agreed there should be linkage between all appropriate meetings and decision making forums across the site, where relevant. The idea was first put forward not necessarily to build on knowledge. It was to use collective knowledge to avoid potential issues such as different groups of engineers procuring equipment to different standards, or to prevent budget over spend.

Those interviewed commented on how this style has helped increase knowledge between individuals and groups, improved communications and generally created a series of meetings with purpose and "value add": the interviewees commented on getting everything they requested from an investment point of view due to the level of control on the process. They all commented they had to give in return was their presence at meetings and a commit to following the standard set out at the meeting rather than "*doing their own thing*". Engineers in particular commented they felt the organisation was supporting them through participation in these meetings.

As meetings progressed and everyone began to see the benefit through acquiring a greater knowledge of all topics discussed and all meetings producing successful results, the sense of support became greater. This method is still in its infancy however, and still relies on key department heads to maintain the momentum. A concern still exists until the organisation embeds this method of knowledge sharing, there is a risk the process of exchanging knowledge will fall back to "type". All interviewees who discussed department to department knowledge sharing categorically stated the Site's performance would significantly improve in line with improved knowledge sharing and collaboration between departments. At this juncture the improvement in performance is being realised. Knowledge needs momentum. Knowledge must be embedded. Employees can improve performance through collaboration and knowledge sharing. If the knowledge is not embedded into the organisation it could result in performance deterioration if holders of knowledge leave the company.

Of those interviewed who form part of at least one of the teams in the Alliance and Association method, most said there were certain obstacles which had to be overcome. Most obstacles discussed related to department or individual's attitude towards a new way of doing business. Meetings take the form of "*we want to go through the whole detail together and come up with a solution togethe*r". In some cases this would highlight deficiencies in some department's operations. This created an element of discomfort for those department heads or members. Some would not have a problem pointing out areas for improvement others would be more reluctant. Cross-referencing this data with data gathered on department to department collaboration gathered during the semi-structured interviews suggest the departments who are reluctant are the same departments who are perceived not to be receptive to knowledge sharing and collaboration between departments.

9.2 Knowledge and the Organisation

This research has uncovered what could be considered ample proof the Site supports knowledge sharing. The Site's primary concern is performance of goals agreed with corporate at the beginning of each financial year.

Status of Site goals is readily accessible to every employee at the company, real-time for most of the goals set.

The Site will invest significantly in what it requires to meet year-on-year improvements. It determines this investment based on senior members of staff's recommendations. There was a strategy to pull all inputs together to ensure the correct decisions were being made. This method proved to be successful as the Site's year-on-year performance was considered respectable.

Through two significant investment periods, capital assets were reviewed using the Alliance and Association method. This integrated approach resulted in the right classification of tools being ordered and brought in on-budget and on-time. This was deemed to be a breakthrough in terms of plant performance. Resulting in:

- Improved equipment with communications interface ability to allow process control

- Significantly improved productivity following focus on direct labour attendance, training and flexibility

- Adoption of best practises from other sites following benchmark visits.

At any given time the Site was now producing the best cost, productivity and yield performance of all sites. A like-for-like comparison of equipment would put the site at a disadvantage which made these results all the more remarkable. If harnessed and used correctly knowledge will provide the opportunity to produce a competitive advantage.

9.2.1 Knowledge and the Individual

There was no doubt the organisation supported knowledge led programmes to produce the performance it desired. Data gathered from semi-structured interviews suggested the knowledge breakthrough was down to select individuals. As individuals form part of the organisation this may not be a surprise. However, these discussions also highlighted the obstacles these individuals had to overcome to ensure success. The level of success prior to and after this knowledge breakthrough is so stark it is worthwhile discussing this further. Future success may hinge on how knowledge initiatives are supported by the organisation. Appendix E contains a comparison of the traits of knowledge leaders and knowledge laggards to those demonstrated by managers at the local site.

9.2.2 Knowledge: Subsidiary to subsidiary

Case studies gave the researcher the opportunity to compare knowledge sharing between engineers from different sites and between those engineers and engineers from the local site.

Within the case study environment, in terms of behaviours it was difficult to distinguish between engineers. There appeared to be a very consistent language used between all involved in the meetings. One point to note was one of the sites was much more into detail and preferred expansive systems which covered all eventualities. These systems could be difficult to maintain if there was a lack of discipline. The ‘Detection Matrix’ designed by the “Early Lot Detection Team” demonstrated the “good and bad” of knowledge sharing:

- The ‘good’ was the success generated through bringing an international alliance party together who designed a break-through system to address yield

- The ‘bad’ was all sites do not appear to have the discipline to maintain this break-through system. Data generated from semi-structured interview regarding compliance supports this observation

Engineers across the corporation appear to exhibit the same norms and values. The case study data did not suggest any form of competition when engineers were working together to come up with a common solution to a problem. Both case studies identified areas for improvement in at least one of the sites. They proved to be effective. Where it is possible to identify improvement programmes without the need for expensive benchmarking visits it should be done. International benchmarking visits have their place but should be thought through as a programme rather than a one-off approach to problem solving.

9.2.3 Knowledge and the Corporation

All sites communicate to corporate on a regular basis. These meetings are normally done via telephone although video-conferencing is also used.

Knowledge shared during these calls typically relate to current performance, future goals or particular initiatives. These meetings normally involve the top two tiers of the management organisation. When data is exchange in this way it tends to be formal and even sometimes guarded.

Where a department has a direct line responsibility to a corporate department, knowledge sharing is dependent on the relationship between these respective departments.

9.2.4 Autonomous Decision Making within a Knowledge Environment

Chapter 8 discussed custom and practise referring to compliance to procedures. It also relates to expectations of the individual or clique. Changing attendance behaviour is "easier said than done", not necessarily just from an employee's perspective, but also from a management team's perspective in terms of actions which should be taken. This subject created the most knowledge 'clashes' according to a number of interviewees across a number of relevant departments.

Many company and government websites contain legislative information appropriate to managing a business. According to the interviewees there were a number of discussions about how to control absence rates on the site. Many of these led to disagreements based on what one department said should be done based on employment law and the other department based on custom and practise procedures. All discussions were satisfactorily concluded but the discussion demonstrates how accessible external knowledge can influence internal company policy. Knowledge coupled with opinion can cause conflict.

9.3 The Business Case for a Knowledge Management Approach

The semiconductor industry is a fantastic source of knowledge. Processes are complex, there is a heavy reliance on capital equipment and a significant support infrastructure is required to run this type of business. A wealth of employee talent work together to ensure the Company is successful, profitable and grows. This research has been an insight into how a particular part of this whole operation uses and leverages the knowledge potential which is at its disposal.

As Operations Director within the local facility it has been possible to maintain a knowledge perspective throughout the duration of these studies. I was extremely fortunate to be in the position of beginning these studies at a time when a new knowledge opportunity was presenting itself to the organisation.

The way knowledge-led teams have evolved is discussed in detail. Initially it was about setting up one team to look at the potential for a cross functional knowledge-led team. Subsequently it was about expanding these teams to involve the breadth and depth of the organisation.

The chronology of teams discussed and who were involved is shown below. The level of involvement has expanded considerably. From including specific department managers the structure of the teams has extended to majority of the Site's employees being involved in at least one of the teams shown in **Table 9-0** below.

Table 9-0 Chronology of Local Site Teams

Team Name	Participants
Productivity Team	Specific Department Managers
Site Absence Team	Specific Department Managers
Capital Review Team	All Department Managers and Engineers
Consumable and Project Spend Team	All Department Managers and Engineers
Shift Review Team	All Shift Staff Managers and Employees

It has been widely recognised the performance of the local site has improved significantly over time and in particular during the last four to five years. During this time the local site became extremely competitive on all site metrics. This success can be attributed to setting a knowledge mould which would become the way to do future business. Throughout this process there have been many obstacles to overcome.

In any organisation it is not atypical to set up an organisation structure and set an expectation amongst senior department heads on their departmental deliverables. In my view it is rarely the case the department heads will be asked to collaborate and share knowledge amongst themselves for the greater good of the company. If not the case within the local site, then it would be very unlikely for it to be the case for subsidiary to subsidiary.

Appendix F contains a description of each of the teams shown in Table 9-0.

9.4 The Burden of Knowledge

There was an opportunity to review knowledge sharing from many different groups which involved many of the same departments over lengthy time frames. McGlynn (2007) likened the movement of groups towards a collaborative state as a progression within a spiral. This is shown in Figures 9-0(a) and 9-0(b).

Figure 9-1(a) and 9-1(b) The Collaboration Spiral. From McGlynn (2007).

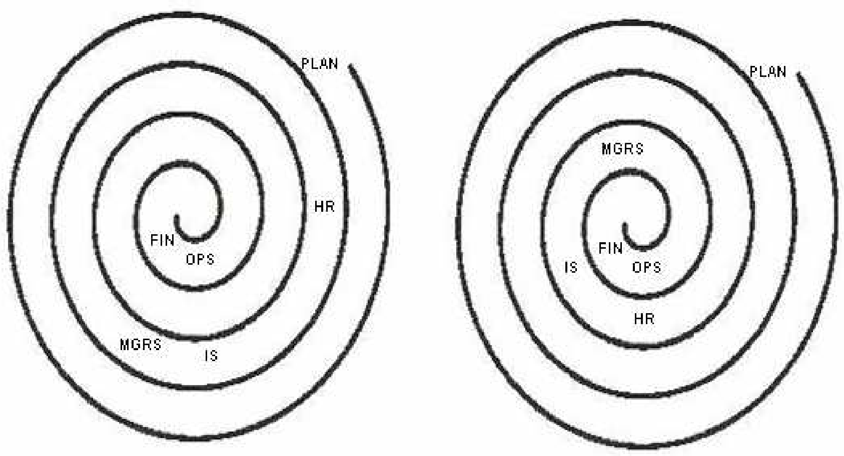


Figure 9-0(a) Location of Groups in the Spiral at the Advent of Collaboration

Figure 9-0(b) Location of Groups in the Spiral Following Collaborative Ventures

The group leaders tended to orchestrate proceedings from a central position in the spiral and as groups became more collaborative they moved closer to the centre of the spiral. Uncollaborative groups would remain static or remain in the outer region of the spiral.

Knowledge-led teams at the local site are becoming the standard for continuous improvement. Striving for a continuum of knowledge-led teams can highlight concerns relating to people and systems:

- There can be an over reliance and lack of acknowledgment for those who are the greatest advocates of knowledge sharing. An individual can put their own career and reputation on the line by becoming associated with a knowledge-led team. All teams discussed during this research relate to critical aspects of the business. Should any fail it would have serious implications for the site. There have been cases, one in particular where a knowledge leader's teams have achieved world class levels of success and cemented the reputation of the site. Those involved widely recognise these achievements but the site as an organisation has not openly recognised it. The individual in question did not need to move out of their direct area of expertise to get involved with establishing a knowledge-led organisation. A legacy however has been established.

- Knowledge sharing in some quarters is considered dissemination of information to those who 'do not need to know'. Getting everyone on the team up to the same knowledgeable level was important to the knowledge leaders. It did however create discomfort elsewhere. An example of this was demonstrated during the Site Absence team process relating to limited knowledge sharing.

- Managers and engineers put great stock in automation to remove the need for a level of knowledge. Contingency needs to be made for where these automated systems are custom made through a single supplier. Similarly with bespoke in-house solutions it is important to follow a single standard for the purposes of ongoing maintenance or development of these systems.

- The whole operation becomes dependent on automated systems. Redundancy must be built in as a single issue could shut down the whole operation.

9.5 The Importance of Knowledge in a Changing Organisation

The semiconductor industry is cyclical by nature. Within the design and assembly operations headcount changes normally occur through attrition. The amount of tacit knowledge leaving the operation at any time is limited. Within the manufacturing sites, attrition is typically very low but cost and productivity focus results in a ‘reduction in force (RIF)’ every few years. This normally involves a number of employees leaving the organisation.

Figure 5-3 captured how important metrics in a manufacturing site can deteriorate when clusters of the operation leave. That is, a number of similarly skilled employees working within the one area leave and take their tacit knowledge with them. Ostensibly a skill or set of skills has left the operation. In reality it is the more practical ‘how to’ trait which causes the damage.

There are a number of areas where a headcount resizing can have an impact:

- The ‘how to’ knowledge as discussed above
- The ‘informal contact’ where an individual has built up a goodwill relationship with other departments, sites or suppliers
- The ‘hidden’ issues where a previous incumbent has used their own particular skills to keep problems at bay
- The resizing selection procedure. Every resizing iteration will result in a more experienced and skilled employee leaving. At some stage the ‘knowledge Fabric’ of the operation may start to become compromised. This can be particularly the case if a company accepts voluntary applications ahead of compulsory notifications.
- The weight of responsibility on remaining employees to manage the operation and to resolve the issues highlighted in the bullet points above.

If there is notice of a resizing exercise then the impact on tacit and explicit skills must be put forward for consideration:

- Explicit skills are considered more obvious based on typically being codified. Managers should understand the impact to the business and ensure there is sufficient coverage prior to resizing the organisation. This coverage should include the inherent skills of the individual leaving the organisation and an understanding of systems the individual has implemented or supported.

- Tacit skills of an individual are considered less obvious to managers. They may be more obvious to peers. Prior to an individual separating with the company, there should be a risk assessment done and a list generated of the ‘most likely’ issues to occur once the individual has gone. The manager can then monitor the ‘most likely’ metrics to be affected and react quickly if deterioration occurs.

Knowledge leaving the organisation can have a significant impact. It is possible to mitigate this impact. By adopting the method described above the local site has ensured good business continuity on recent rising programmes.

9.6 Summary of Results

Table 9-1 represents how departments rate their level of knowledge sharing with all other departments. In some cases responses are identical in others some departments believe they communicate well with another department yet that department believes there is limited exchange between them. Achieving best practice collaborative approach between all departments was accepted as an action which would further improve the Site's performance. The content of the table is based on the ranking process used and my interpretation of the results.

Table 9-1 Department Knowledge Sharing Matrix

	Operations	Finance	EH&S	Planning	HR	IS
Operations	-	Best practice collaborative approach	Good advisory relationship	limited knowledge exchange	limited knowledge exchange	Best practice collaborative approach
Finance	Best practice collaborative approach	-	Good communication between groups	limited knowledge exchange	limited knowledge exchange	Best practice collaborative approach
EH&S	Best practice collaborative approach	Best practice collaborative approach	-	limited knowledge exchange	limited knowledge exchange	limited knowledge exchange
Planning	Good communication between groups	limited knowledge exchange	limited knowledge exchange	-	limited knowledge exchange	limited knowledge exchange
HR	limited knowledge exchange	Good communication between groups	limited knowledge exchange	Good communication between groups	-	Good communication between groups
IS	Good communication between groups	Good communication between groups	limited knowledge exchange	Good communication between groups	limited knowledge exchange	-

Analysis of results identified a number of common themes across departments. All recommendations from this research will be applied to all departments at differing levels based on common and unique themes.

9.7 Final Conclusions

Knowledge sharing impacts the Site's Key Performance Indicators as supported from analysis of semi-structured interviews, two case studies and personal observation as a member of staff at the company. Knowledge sharing is an established business process. Advocates of knowledge sharing effectively questioned traditional headcount hierarchy by setting up knowledge based collaboration units and expanding the control and influence of these units horizontally and vertically in the organisation. More and more managers and professional staff are becoming engaged in this way of doing business as more and more teams are returning vital successes in a very demanding manufacturing environment.

Knowledge sharing has provided structure. Responsibility and accountability is clear through effective two-way communication. Knowledge sharing is a maturing process. As support mushrooms the organisation is becoming increasingly comfortable with it as a process rather than a notion. It encourages innovation and spawns ideas. All functions and disciplines are becoming more aware of how decisions they make or actions they perform impact other areas of the organisation.

Knowledge sharing crosses international boundaries. However, working across multiple time zones is not conducive to establishing informal, regular nature of communicating and sharing knowledge. This was deemed to be the prerequisite to having successful knowledge led teams in the organisation. There is more scope to nurture and improve knowledge sharing between subsidiaries, although somewhat negated by the competitive spirit in which people appear to be comfortable operating under.

Failure to comply with an automated knowledge based system can have many times more implications than failure to comply with a traditional manual procedure. More "checks and balances" tend to be associated with manual systems. There has not been a great deal of thought or discussion on a knowledge standardisation. Adopting a standard allows one knowledge based system to be present across many tools. If no standard is present the knowledge based system may be different tool to tool.

Knowledge advocates are proponents of the knowledge led method. Not all senior managers are knowledge led proponents. Every interviewee stated bottom line performance at the site would increase if knowledge sharing achieved levels to those displayed by the knowledge sharing advocates.

Knowledge management should be embraced as a continuous improvement programme. Effective knowledge management:

- Recognises the skill and not the title
- Is an inclusive process promoting inter and intra department collaboration
- Promotes team effort and team rewards
- Offers transparency as a process encouraging employees to share all data
- Joins all activity in an organisation together under one knowledge umbrella
- Acknowledges the importance of codified systems
- Eliminates silos
- Impacts an organisation’s bottom line

9.8 Research Limitations

As with all research, there are limitations to the interpretation of the results. The following is a discussion of such limitations:

- Managers may respond differently than individual contributors due to the nature of their jobs and responsibilities. Individual contributors may be more comfortable than managers discussing questions of a sensitive nature with a senior member of staff, or vice versa.
- It was not possible to completely standardise yield or spend in the two case studies when comparing results against other sites.

- Manufacturing or maintenance technicians were not included in the overall sample. It is possible inputs from these groups could change interpretation of results.
- Case studies were a “point in time” and may not be completely representative of how organisations behave over time.
- The scope of the case study was limited to yield improvement and spend.
- Time was a constraint. The number of semi-structured interviews was limited due to including two case studies as part of the research.
- It is possible the outcome of this research is not relevant to other industries. This was not a consideration of the research.

9.9 Recommendations for Further Work

During the course of this research a number of possible further research topics have arisen:

- Compliance to procedures. Interviews identified levels of non compliance in the manufacturing environment. “Custom and practice” was mooted as one of the reasons. It would appear “custom and practice” could be a tolerated behaviour.
- Investment in Automation (1). There is an underlying engineering drive to remove the “person” aspect from the manufacturing operation. By investing heavily in automation, in some cases completely replacing the communication infrastructure in a machine, it is removing the responsibility from the operator to the machine. Much of this may be down to technology advancement but there is some evidence to suggest it is due to lack of trust in the operator.
- Investment in Automation (2). As productivity in a manufacturing site increases due to technology advances, companies can shrink the size of their engineering organisation. It is possible companies are not cognisant of the responsibility the

Information Systems group absorb as automation increases and fail to adjust headcount accordingly.

- This research identified two occasions where performance deteriorated due to the loss of tacit knowledge from the organisation. This can be very costly to an organisation and may even be irrecoverable. It may be possible to find ways of measuring and potentially mitigating tacit knowledge loss from an organisation.
- The relationship between corporate headquarters and its subsidiaries is very important. At the local site, three methods or “styles” of communication were identified between a corporate department and a local department. Interviews confirmed these affected the ability to knowledge share at the local site.
- Interviews identified specific individuals who were responsible for the turnaround of the Site’s fortunes. This involved working in areas not classed as their own domain which other department managers were not comfortable with. With the progression of technology and rise of the knowledge led company there is potentially an opportunity to remove traditional job titles and assign tasks and projects to the most knowledgeable people.

9.10 Contribution to the Body of Knowledge

The principal aspects from this research study which form part of existing research are:

- The contribution of empirical research into the subject of organisational learning. Knowledge begins with the individual and extends to the organisation (Becerra-Fernandez and Sabherwal (2003). This study has shown this to be the case at the local Site. Ostensibly the organisation supports a knowledge sharing approach but there is no provision to encourage it between departments. It supports the view managers have traditionally been comfortable with things which are easily measured and accountable (Miles, Miles, Edvinsson, 1998).
- The weakness of the organisation to codify tacit knowledge. Two occasions were identified whereby key performance indicators deteriorated due to the loss of tacit knowledge from the organisation.

- The existence of communities of practice as a means of improving Site performance. Wenger (2004) stated communities of practice “manage their knowledge”. This study has shown this is done on a formal and ad hoc basis.
- A demonstration that espoused theory and theory in use may not be congruent (O’Hare 1987). This was supported by the perceived variation in compliance with procedures and guidelines.
- A demonstration international businesses need to create conditions for efficient knowledge sharing between headquarters and subsidiaries as well as between subsidiaries themselves (Michailova and Nielson, 2006). This is done through formal and informal networks.

The principal aspects from this research study which form unique findings are:

- The research highlighted how fully codified procedures can be unwittingly translated to tacit knowledge and the impact on the organisation should the individual with this knowledge separate from the company.
- The demonstration of a knowledge conversion mechanism. The study has shown how the organisation converts tacit knowledge to explicit knowledge to provide codified process procedures in the context of enhancing productivity through automation.
- The research identified three methods of Corporate to subsidiary communication: integrated; broken and bypass.

9.11 Professional Contribution

An objective of the research exercise was to improve business processes within a knowledge context at National Semiconductor. The following has been implemented prior to completion of this research:

- Training programmes have been modified in an attempt to capture tacit knowledge within manufacturing technician procedures. This takes the principle form of manufacturing technicians being involved in writing training schedules.

- Daily meetings take place in the auditorium with all day shift professional and technical operations staff and representatives from all support departments. This 45 minute meeting discusses operations performance from the previous day, requirements of the day, project status and updates from all support departments.

- Each shift holds a 15 minute review with all shift manufacturing and maintenance technicians on the first shift and last shift of their rotation. Site (local and other subsidiary) performance is published and updates relating to manufacturing changes are discussed.

- Important strategy meetings now include representatives from all departments. Other than department communications and specific technical meetings there are very few meetings which do not include full departmental representation.

- A site automation roadmap programme has been developed in parallel to removing non value added tasks. Previously automation would protect the product from manual misprocessing but did not consider the inefficiency of not removing manual checks.

- The use of “custom and practice” procedures was considered a significant finding of this research. Resolving this would take time due to complexity and cultural element. The process of implementing procedures to eliminate these practices has begun. In the interim the potential for “custom and practice” procedures was considered significant enough to be problematic in a new line the Site is developing. Checks and balances have been implemented to ensure it does not develop in the new line.

The following will be developed or implemented upon completion of this research:

- A training module is being developed in conjunction with National Semiconductor Corporate Training Campus as part of the company's "Front Line Leadership" programme. The programme originally consisted of six modules but will now include a "knowledge Management for a Competitive Advantage" module following the completion of this research. The module is expected to be cascaded to other sites.
- The findings of this research will be presented to:
    - All department managers at the local site
    - Senior staff at the local site
    - The senior vice president of operations who is responsible for the whole of manufacturing in the Corporation
    - The vice presidents of manufacturing at the two other subsidiaries

  The presentations will include recommendations on how business processes should be changed to take advantage of knowledge management in respective departments and sites.

Appendix A Pilot Study Power Point Presentation Introduction

Knowledge Management
Introduction

- National operates in a global market environment
- We have entered into a knowledge economy c.f. previous industrial or agrarian economies.
- Future wealth and power will mainly be derived from intangible and intellectual resources
- Knowledge management refers to a range of practises used by the organisation to identify, represent and distribute knowledge for re-use, awareness and learning across the organisation

Knowledge Management
Types of Knowledge

- Explicit
  - What can be easily codified – eg a PM procedure
  - What is espoused and physically done can be different
- Tacit
  - Normally acquired through experience – e.g fault finding techniques
  - Difficult to harness

Knowledge Management
Exploiting Knowledge Assets

- Exploiting knowledge assets more difficult than exploiting capital assets
  - Creating new knowledge
  - Codifying knowledge
  - Establishing a framework to share knowledge
  - Continuous learning
  - Establishing a competitive advantage

Knowledge Management
Mosaic or Melting Pot

- Does National's set-up of 'competing' business units promote or inhibit knowledge flow
- Does each attempt to develop competitive advantage weaken the organisation
- Are some of the parts greater than the whole

Knowledge Management
Local vs International Cooperation

- Comparing NSUK to Front-end Fabs:
  - Where does cooperation occur, where does it not
  - What are the areas of cooperation
  - Why does cooperation occur in some areas and not in others

- What are the potential implications of above outcome
- Are there areas of commercial competition precluding cooperation

Knowledge Management
Internal Knowledge Exchange Map

- Manufacturing / Finance
  - What level of cooperation exists
  - Is there evidence of knowledge exchange and if so what has it achieved both qualitatively and quantitatively
  - Have any issues occurred due to above
  - How does this compare to other areas in the organisation

Appendix B Pilot Study Interview Questions

	Pilot Study Interview Questions	Data Analysis
1	What metrics do you use to determine performance of the site?	
2	What do these metrics tell you?	
3	How would you describe performance of the site over the last 10 years?	
4	How would you characterise the relationship between your department and other departments?	
5	How would you describe knowledge dynamics in your organisation?	
6	Can you provide examples of where your department enhances knowledge formally?	
7	What level of compliance to systems exist in Finance, engineering and manufacturing?	
8	What level of knowledge sharing occurs across UK,Texas and Maine?	
9	Do you have an understanding how knowledge is shared in Texas or Maine?	

Appendix C Cross-Site Benchmarking Agenda

Spend Benchmarking Visit

Agenda

	Tuesday 6 Nov	**HOST**
08:00 - 9:00	Introductions (ALL)	Operations Director
09:00 - 10:00	Site Tour (Non Fab): Facility, Office, Support Areas, Ect	Facilities Manager
10:30 - 12:30	Facilities Staffing/Roles/Responsilities	Facilities Manager
	Facility Systems Review	Facilities Manager
10:30 - 12:30	Fab Tour	Manufacturing Manager
LUNCH 12:30 - 13:00		
13:00 - 17:00	Utility Consumption, Facilities Cost	Facilities Manager
	Facilities Benchmark Data. Measurement/Trends	Facilities Manager
	Facilities Reduction Accomplishments, Improvement Plans	Facilities Manager
15:00 - 17:00	Maintenance Tech roles, resp & org structure, Maintenance	Equipment Manager
15:00 - 17:00	Material Spending parento, trends, standards	Finance Business partner
	Wednesday 7 Nov	
10:00 - 11:00	Outside service/contracts - where do you use outside support (wether by contract or not?)	Equipment manager
	Maintenance cost comparison - like tools for PM's and repairs. See next tab	Equipment Manager
10:00 - 11:00	Compare process and tools	Manufacturing Manager
LUNCH 12:30 - 13:00		
13:00 - 14:00	Fab Main Historical improvement actions/best practices, & current projects	Manufacturing Manager
13:00 - 14:00	Historical improvement actions/best practices, & current improvement projects	Manufacturing Manager
	Thursday 8 Nov	
09:00 - 12:30	Test wafer management process including reclaim	Production Manager
	Test wafers use (top users of test wafers) & comparison on common tools	Production Manager
	Test wafer reduction/control Historical improvement actions/best practices & current projects	Production Manager
	Historical improvement actions/best practices, & current improvement projects	Yield Manager
	Compare processes and tools	
LUNCH 12:30 - 13:00		
14:00	Final Comments (ALL)	Operations Director
	Review Action Items	
	Depart	

Appendix D Cross site Sharing of Common Problems with Potential Solutions

- **(1) Post Intervention Recovery**. All sites had examples of yield excursions happening following a scheduled or unscheduled tool event.
  Potential Solution: Adopt a culture which treats all interventions as high risk. Establish a detection matrix.

- **(2) Recipe Management**. All tools have automated systems controlling flow and volume of materials used in the process for example. A programmed recipe is used to dictate units of measure and time. Problems have occurred when a recipe is confirmed as being good on one tool but somehow corrupted when transferred to other tools.
  Potential Solution: Design an automated recipe manager which checks recipe following any changes made and requests validation once the recipe is transferred to another tool.

- **(3) Chipped silicon wafers.** Any silicon wafers showing signs of chips at the edge are scrapped.
  Potential Solution: Invest in an automated chip / stress inspection tool.

- **(4) Wafer slip.** This refers to thermally induced dislocations at atomic level of the silicon.
  Potential Solution: Prevention through input parameter control solution.

- **(5) Inability to measure a fail mechanism.** In some cases it was found the site did not have the capability to measure a potential fail at the process and could only detect when electrically tested at the test .

Potential Solution: Define the parameter on the detection matrix (mentioned in intervention recovery above). If a site does not have the capability to measure the parameter then justify investment in a capable tool. Benefit can be demonstrated using other sites data – good example of knowledge sharing

- **(6) Problem with incoming material.** This related to raw materials where a vendor has historically shipped e.g. a chemical of gas which fails to meet specification.
  Potential Solution: Define a list of all critical suppliers and request material parameters are tested to 4 sigma limits.

- **(7) Test Wafer frequency.** A test wafer is used to determine if the process is in control. Specific electrical or physical parameters are measured and compared to a standard. In some cases process failed in between scheduled test wafer events.
  Potential Solution: Generate fail data relating to test wafer frequency and change frequency where appropriate.

- **(8) Input parameter control.** Test wafers above measure the output of a process. The input is where the elements which come together to generate a process step are measured.
  Potential Solution: Define all input parameters for every process recipe and introduce testing where appropriate.

- **(9) Manual inspection efficiency.** Wafers are optically inspected at times. There have been excursions relating to human error of efficiencies during the inspection process.
  Potential Solution: Invest in automated inspection tools for two of the sites. The other site already uses an automated inspection tool.
- **(10) Culture.** This relates mainly to attitude and work ethic at the sites. There were cases of process checks not being followed.

Potential Solution: Although a healthy debate surrounded this topic, the teams agreed there was no easy way to affect this. Everyone agreed however if data on problems is very visible and shared across all sites, employees would find it difficult to ignore them and continue to be non compliant or vigilant.

Appendix E Knowledge Champions and Knowledge Laggards: Traits

Entovation (undated) case studied thirty three leading companies and came up with recurring characteristics which separated knowledge leaders from knowledge laggards. A comparison was made between these recurring characteristics to those characteristics demonstrated at the local site in an attempt to classify particular behaviours. The ten characteristics of the knowledge leaders along with a local site perspective were:

- They have a clearly articulated **vision** of what the knowledge agenda and knowledge management is about. Their thinking about their business, their business environment and their knowledge goals was clear.
- **Local Site Perspective:** Setting up a cross functional team to leverage knowledge was visionary. Knowledge leaders were familiar with their own environment and that of all others which would be required to pull together to deliver a successful outcome.

- They have enthusiastic **knowledge champions** who are supported by top management.
- **Local Site Perspective:** They had knowledge owners. The champions were the select few. Through good leadership they did however manage to champion knowledge as a cause. They were supported by top management in an indirect way through capital investment and use of resource.

- They have a **holistic perspective** that embraces strategic, technological and organisational perspectives.
- **Local Site Perspective:** They had a holistic perspective and a vision which led to setting up a series of successful teams. Maintaining business imperatives and using technology to the team and the organisation’s advantage.

- They use **systematic processes and frameworks** (the power of visualisation).

- **Local Site Perspective:** An infrastructure of clear business tools, clear expectations and an understanding of the linkages supports the Alliance and Association Method of knowledge sharing.

- They "bet on knowledge", even when the cost-benefits cannot easily be measured.
- **Local Site Perspective:** The knowledge leaders have trust in each other and the process. On occasion ‘gut feel’ or ‘instinct’ is used.

- They use **effective communications**, using all the tricks of marketing and PR.
- **Local Site Perspective:** Communications is critical to the knowledge leaders’ success. They believe in leading from the front and on data driven communications. They do not however appear to use marketing or PR ploys.

- There is **effective interaction** at all levels with their customers and external experts. Human networking takes place internally and externally on a broad front.
- **Local Site Perspective:** A series of meetings are scheduled which captures all appropriate site professionals and managers. Informal meetings also take place.

- They demonstrate **good teamwork**, with team members drawn from many disciplines.
- **Local Site Perspective:** Team members are drawn from many disciplines. Effectiveness of these members is as discussed in the main body of the research.

- They have a **culture of openness** and inquisitiveness that stimulates **innovation and learning**.
- **Local Site Perspective:** They are a data driven team who want to understand the full nature and detail of a problem or initiative. They like to educate others and bring everyone up to the same level as them.

- They develop **incentives**, sanctions and personal development programmes to change behaviours.

- **Local Site Perspective:** there are examples of incentives (permanent position for agency workers who demonstrate knowledge and flexibility), sanctions (no support on capital requests if failure to comply with system) and development programmes (individual development programme for manufacturing technicians who are not at desired training level).

Ten characteristics of the knowledge laggards with a local site perspective were:

- They simplify knowledge to information or database model, often applying the 'knowledge' label without a comprehensive understanding of what knowledge is about.
- **Local Perspective:** This type of behaviour was demonstrated by departments which operate under the “broken” or “bypass” approach (Figure 8-1). Knowledge to them is simply a table of data. Knowledge leaders put context behind the data and turn it into a language other departments can understand.

- They package and disseminate knowledge that is most readily available (vs. that which is the most useful).
- **Local Perspective:** Knowledge leaders work with other departments to come up with creative ways of ‘moving to the next level’. Knowledge laggards simply regurgitate data.

- They work in isolated pockets without strong senior management support. Thus, they may hand over responsibility for knowledge systems to one department, such as MIS, without engaging the whole organisation.
- **Local Perspective**: Data from semi-structured interviews support the observation about working in isolation. However, this can be with senior management support.

- They focus on a narrow aspect of knowledge, such as knowledge sharing rather than all processes including new knowledge creation and innovation.

- **Local Perspective:** It is knowledge creation and innovation which sets the departments apart. Those who have been creative and innovative appear to recognise this is the case. They feel good about success breeding success. Other departments do not appear to have the ability to be creative or innovative.

- They blindly follow a change process e.g.. BPR, without understanding the associated knowledge dimension.
- **Local Perspective:** The site relies on departmental ability to generate and interpret data. This data is then used to make key equipment or process decisions. Knowledge leaders appear to excel in this task. Knowledge laggards do not understand the full context of the data.

- They downsize or outsource without appreciating what vital knowledge might be lost.
- **Local Perspective:** This was not demonstrated at the site.

- They think that technology (alone) is the answer. For example, that expert systems by themselves are the way to organise and use knowledge.
- **Local Perspective:** This was a fundamental finding in the research. There can be an over reliance on technology.

- They have a major cultural blockage, perhaps caused by a climate of "knowledge is power".
- **Local Perspective:** This was demonstrated by departments who operate on the "broken approach" per figure 8-1.

- They "know all the answers" i.e.. they are not open to new ideas.
- **Local Perspective:** A number of departments demonstrate this characteristic. They tend to be comfortable within their own business boundary. As long as their

own departmental metrics are in order they will contently maintain what could be viewed as a “polarised” view.

- They get impatient. They think knowledge management is simply another short-term project or programme. They do not allow time for new systems and behaviours to become embedded.

- **Local Perspective:** This was another fundamental finding. Likeminded knowledge leaders understood the potential benefit of new systems and "stayed the course" managing multiple hurdles to embed these improvement systems. Knowledge laggards would either not recognise the value of the system or be too impatient to support the implementation of the system.

The characteristics suggested by Entovation (undated) appear to be reasonably consistent with those demonstrated at the local site. There are certainly characteristics which differentiate knowledge leaders from knowledge laggards.

Appendix F Site Teams

The Productivity Team

Four to five years ago during a formal operations review at the local site, the financial controller was presenting on cost data when the senior operations managers suggested the finance group should be doing more to support operations. They were completely unaware of the attempts the finance group had previously made to become part of the site's operational strategy team. It was this faux pas however which transformed the local site's fortunes. Following this meeting the finance controller and senior operations manager defined a new knowledge-based way of making manufacturing decisions. It would involve all relevant department heads and completely move away from silo-based decision making. It was the advent of the Productivity Team. The operations and finance managers agreed both departments could have done more to help initiate the knowledge-led cross functional team earlier.

The company began its knowledge journey almost by accident. Had it not been for the exchange in the operations review triggering this new knowledge approach it may never have realised the consequent leap in performance.

Establishing and embedding a knowledge-based productivity team took approximately two years. Some problems existed from the outset:

- Manufacturing representatives at the meetings did not appreciate being questioned by non-manufacturing team members. It took time for this to change. Some remain slightly uncomfortable with it;
- It was very difficult to convince senior management the productivity team would perform whilst results were not competitive;
- Some departments thought they were present just to share data;
- Some departments thought they were there to observe;
- Some departments were very good at critiquing others.

From a knowledge perspective, there was relative unease about sharing in an open forum. Once performance began to improve considerably knowledge sharing became less conditional.

The success of the productivity team and the way it achieved this success was recognised across the site but not necessarily by every department head. It was the first time two departments had set out to work together to achieve a common goal which was traditionally considered to be purely an operational responsibility. There was not universal acceptance to this style of working. Ostensibly, not every department was receptive to knowledge sharing in this way.

The Site Absence team

This team was set up to address attendance issues within the direct labour population. Through various channels of feedback it was clear there was an opportunity to improve the consistency of decision making relating to sickness absence.

As with all other knowledge-based teams, the team was selected and responsibilities discussed at the outset. The team decided to present a summary of team members and objectives to the direct labour workforce. Prior to this it presented to senior staff to ask all department managers to follow the same principles and guidelines. Both presentations were very well received. Within the direct labour workforce feedback was particularly supportive of the process and the consistency it promised.

All decisions made were recorded for the record and feedback from employees was solicited at regular intervals. The site absence team became respected and it was deemed to be doing a good and consistent job with site absence levels moving to world class levels.

There were some departments throughout the process which were not comfortable with the team and what it was doing. This ultimately thwarted the team. In some instances knowledge cannot be fully shared for confidentiality purposes. This restricts knowledge sharing.

Fortunately the management team have retained the essence of what the site absence team was trying to do.

The Capital Review Team

The leaders of the productivity team consciously decided to establish a team in a similar knowledge-based vein to review the local site's capital spend. Investment in capital equipment is significant. There was no dedicated team. It was normally reviewed through rolling up individual department requests and seeking approval by senior staff.

The capital review team was established and became finance centric. The finance controller created the necessary templates and databases and took on the responsibility for maintaining these. As a knowledge advocate the controller accepted the extra burden of responsibility.

The productivity team engaged all levels of management, the capital review team engaged management and engineers. The capital review team became proactive where before it was considered reactive.

The capital review team has also proved to be very successful. For the first time the local site was managing significant investment, on time, on budget and with equipment specified to a local site standard. It was now the second demonstration of managing knowledge in an efficient way which would give a significant bottom line investment.

Engineers in particular acknowledged the success and importance of the capital review team. This was an important milestone in engaging the technical community from a knowledge sharing perspective. The knowledge leaders felt this was a further endorsement of how teams should be managed on site. There was an acceptance of the process and it naturally expanded as engineers and managers became familiar with its success. Members became proponents of knowledge sharing.

The Consumable and Project Spend Team

The knowledge leaders wanted to build even further on the success of the knowledge meetings established to-date. Focus on site spend can be intense. The knowledge leaders spent considerable time analysing site spend data to decide if setting up a knowledge-based team would be effective. Not only was it worth establishing, it would involve all levels of the organisation. The knowledge leaders felt this would be the springboard to establishing a truly knowledge-led operating method. They termed this the ‘Alliance and Association’ method of knowledge sharing.

The consumable and project spend team was established and a number of review meetings were scheduled. Senior managers, technical staff and finance were represented at all meetings.

Encouragingly most meetings ran particularly well with most representatives feeling comfortable with what they were presenting on their part of the business and what they were accepting as actions to improve. The early days of managers or staff being guarded and uncomfortable with knowledge sharing had for the most part subsided.

There was occasionally however situations where presenters did not feel the burden of responsibility around the room were equal. In my experience there is never an equally shared burden of workload across departments. It would appear on this occasion a knowledge sharer wants to receive an equal amount of knowledge in return for sharing. This cannot always be accommodated. Case study observations supported this request for equal sharing. During one of the interviews a manager referred to the benchmark visit as a “*burden, preparing for something where there would not be equal payback*”. This is a direct obstacle to knowledge sharing.

The Shift Review Team

The shift review team consisted of members of the productivity team. Shift patterns were a contentious issue. It was decided to ask a team who had already had an established trust with the shift workforce to review shift patterns which would suit both site and employee, if possible. The leader of the productivity team assumed leadership of this team. Using experiences from the productivity team the team leader ensured:

- Face to face meeting with every employee would take place
- A sub-team involving representatives from all shifts and disciplines would be set up
- Regular presentations to the shift workforce would be made
- Regular email updates on progress would be sent
- The leader would attend every meeting and presentation

These are all examples of knowledge sharing across the site.

The organisation was not looking for an approach which would be so time intensive. The leader of the team chose an intense method which would require a fully committed team for the best part of one year. A lot of personal time on the project would be required. Anything less than this was deemed to result in failure.
Initially the productivity team found it difficult to gain support until the results started to come through. In the case of the shift review team, the result would only happen approximately one year from project start. If the shift employees taking part in the exercise displayed patience through-out then the team assumed, correctly, they would be given the time required. Planning this up front and using accumulated knowledge resulted in a successful conclusion to the shift review process. Knowledge sharing is worth the effort. It can require a lot of persistence and is not necessarily two-way. During the shift

review exercise knowledge sharing was more about the why’ behind the ‘what’ to keep everyone on board.

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