

Establishing a risk reduction model for the inbound supply chain in an oil refinery

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I dedicate this dissertation to you

*“Every great dream begins with a dreamer.
Always remember, you have within you the Strength,
the Patience, and the Passion to reach
for the STARS to change the world”
Harriet Tubman*

ABSTRACT

Companies are in business to make money; money is not there just to be taken. The drive should be on Cash Focus and Project Excellence, the ultimate goal and first price is always to *grow stakeholder value sustainability*. To be able to achieve just that, the focus should be on:

- | | | |
|---------------------------|---|---|
| - Operations excellence | } | Develop and empower their people |
| - Functional excellence | | Continuously improve and grow existing asset base |
| - Capital excellence | | |
| - Value-driven leadership | | Deliver on transformation agenda |

The mission of the oil refinery is to refine crude oil utilising high conversion capability, generating sustainable financial growth and delivering a competitive return on investment, while focusing on sustainable profitability, costs, efficiency, reliability and flexibility. How does the supply chain function fit into all of this and what is their role to play?

The objective of any supply chain function should be to support the company's vision and strategic objectives and by means of risk reduction strategies ensure that the risks that the oil refinery is exposed to in the supply chain function are identified and managed to acceptable levels. Due to the major impact of supply chain activities on a business, a combined programme and project approach should be followed, which will include the understanding of the potential reward, vision clarity, management support, will grow internal ownership and accountability, training, communication and a formal change management programme.

The purpose of this study was to determine whether there is an existing risk reduction model within the inbound supply chain within the oil refining process. A literature and empirical study was conducted and the conclusion was made that although a risk management framework and processes exist within the operational and maintenance functions, it was not evident in the supply chain function. The supply chain function, together with the operations function (maintenance and plant reliability), is about understanding risk created within

equipment and supporting the maintenance strategies by implementing sourcing strategies that will contribute to ensuring the effective supply of materials and services.

During the literature study, three models were discussed, namely:

- The Deloitte Touche Tohmatsu model of Understanding Risk and the value of Flexibility;
- The KPMG Methodology for Implementing Risk Management; and
- The Supply Chain Operations Reference model for Business Process Re-engineering.

The recommendation was made that all three models are combined and proposed to implement as a supply chain risk reduction model with potential risk reduction strategies.

Why would any company want to manage and mitigate risk? It links strategic objectives to risks and controls in order to improve corporate performance, increase transparency, provide an early warning system and enhance business sustainability. Once the top risks have been selected, an appropriate risk strategy is defined to optimally manage these risks to enhance and safeguard the company's performance and value. The steps recommended to be followed by the combined and proposed risk reduction model are:

Step 1 All role-players should understand where the supply chain function fits into the business and what its reason for existence is.

Step 2 Understanding the impact of macro-environmental factors on the supply chain.

Step 3 Implementing the proposed risk management framework for supply chain

Phase 1 Planning and establishing context of risk management process

Phase 2 Risk identification and risk exploration

Phase 3 Risk assessment and risk treatment

Phase 4 Implementation, monitoring and review

Phase 5 Risk reporting and communication

- Step 4 Establishing sustainable business processes to support the supply chain strategies and the risk management framework
- Step 5 Implementing performance measurement and reporting processes
- Step 6 Proper training and awareness should be given to all parties involved

The biggest barriers for modifying a supply chain system within a company are internally and people related. Decision-making must become fact based and because companies depend on the measurement and analysis of performance, measurements must derive from the company's strategy and provide critical data and information about key processes, outputs and results. Sustainable business processes will link continuous management activities together, which will contribute to an overall outcome. Implementing a pro-active risk management system will assist in the efficient management of the business risk, which can then lead to constituting value in the business.

To be able to function within all the ongoing changes occurring all the time, it requires balancing multiple links concurrently to have an effective supply chain function as a result. With the unpredictability in the supply chain, comes increased risk, which may result in disruptions to the supply chain. These disruptions may be unexpected and statistically rare, but they must be understood, identified and managed.

For any business, it is first prize to have a risk reduction model in place that can prevent or mitigate a risk before it can actually happen.

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LIST OF ABBREVIATIONS

API	American Petroleum Institute
APT	Asset Performance Tool
ATP	Available To Promise
BBBEE	Broad Based Black Economic Empowerment
BDI	Business Development and Implementation
BOM	Bill Of Material
EE	Employment Equity
FR	Failure Rate
HAZOP	Hazardous and Operability Study
HSE	Health, Safety and Equipment
ICS	Internal Control System
JV	Joint Venture
MOC	Management of Change
MRP	Material Requirement Planner
MTBF	Mean Time Between Failure
OEM	Operations Equipment Maintenance
PHR	Process Hazard Review
PMG	Performance Measurement Group
R&D	Research & Development
RFQ	Request for Quotation
ROIC	Return on Investment Capital
RTS	Return to Store
SAMI	Strategic Asset Management Intelligence
SAP	ERP Business System
SCM	Supply Chain Management
SCOR	Supply Chain Operations Reference Model
SPIR	Spare Parts Interchangeability Record
STAR	Work Management Process
SWOT	Strengths, Weaknesses, Opportunities, Threats
TPY	Total Product Yield
WBS	Work Breakdown Structure

CHAPTER 1

NATURE AND SCOPE OF STUDY

1.1 INTRODUCTION

Effective supply chain planning is one of the critical ingredients for effective supply chain management. Jacobs (2009:358) defines supply chain management as an application of a total system's approach to managing the entire flow of information, materials and services from raw material suppliers through factories and warehouses to the end customer. Waller (2003:521) noted the concept of supply chain management as being the integrated process operations network in place to provide tangible goods or services to a client. In manufacturing, it is the linkage for the physical movement of all materials from suppliers, through transformation, to finished goods to the customers. Many companies are achieving significant competitive advantage by the way they configure and manage their supply chain operations. Supply chain planning processes translate the supply chain strategy into plans that direct the supply chain operations (to manage the flow of materials, products, information and funds). These supply chain planning processes span over long-, medium- and short-term time horizons. They balance the market demand requirements with supply resources (taking into account agreements, capacity, availability, efficiency, service level and profitability) and establish/communicate plans for the whole supply chain.

Companies with mature supply chain planning processes are far more profitable, hold much less inventory and have superior delivery performance compared to their less advanced competitors. Large-scale integrated petrochemical companies pose some very specific supply chain planning challenges and risks. This dissertation aims to address the most pertinent of these challenges and risks.

1.2 BACKGROUND

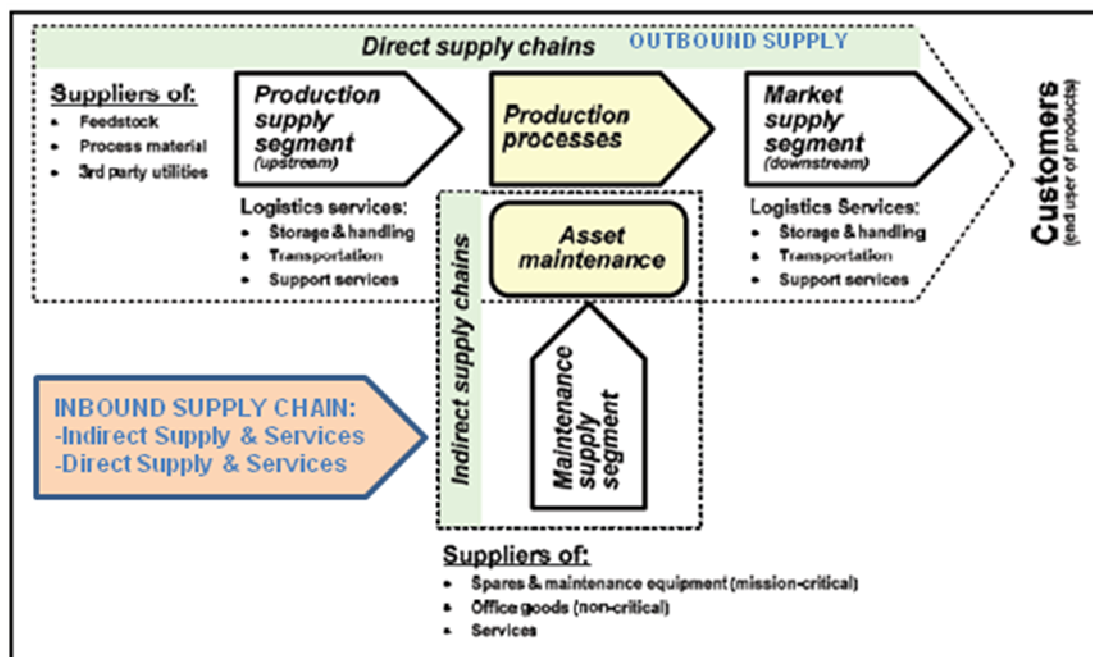
The purpose of supply chain management and planning is:

- to plan for the fulfilment of the needs of the customer along the key business processes;

- to co-ordinate the fulfilment of the needs of the customer by managing material, information and financial flows;
- to enable the supply chains to function as a single synchronised network via cross-functional integration; and
- to ultimately improve the competitiveness of the supply chain network as a whole.

For the purpose of this dissertation, the focus will be on the inbound supply chain and the ultimate support it gives to the maintenance and operations functions within the business process. The maintenance and supply chain functions form part of the inbound indirect supply chain, which provides the necessary support to the direct supply chain, which is responsible for managing manufacturing, operations and ensuring plant reliability (refer Figure 1.1).

Figure 1.1 Focus of inbound indirect and direct supply chains



Source: Adapted from i2 Technologies (2001)

Key issues influencing supply chain management and planning that will be dealt with in the dissertation, are the following:

- The impact of current and new projects;
- Supply chain infrastructure;

- Sourcing strategies and price containment;
- Supply chain responsiveness;
- Changed or new legislation; and
- Global skills shortages.

At the end of the day, the whole strategy should be about how well the risk is managed in the inbound supply chain planning and decision processes and the focus should be on quality, service and cost. Supply chain mastery will become the decisive factor in most battles for consumer market share. The most progressive companies will move from an internally focused cost reduction strategy to an externally focused revenue enhancement strategy (Taylor & Terhune, 2000:42).

1.3. PROBLEM STATEMENT

An opportunity exists to contribute to a risk reduction model in the inbound supply chain within an oil refining process. This dissertation will aim to understand how the inbound supply chain fits into the business processes and identify what the business risks are in the oil refining process. A theoretical inbound supply chain risk reduction model will be developed, if need be, that could be applied by companies in the petrochemical industry. The ultimate aim is to create a sustainable competitive advantage for the company in the market it operates in.

1.4 OBJECTIVES OF THE STUDY

1.4.1 Primary objective

The primary objective of this dissertation is to develop an inbound supply chain risk reduction model that will effectively support the maintenance and operations functions within the business process.

1.4.2 Secondary objectives

From the above primary objective, the study aims to reach certain secondary objectives, which include:

- To identify the risks and gaps within the inbound supply chain to function effectively;

- To define the inbound supply chain, maintenance and operations functions within an oil refining process;
- To gain insight into the inbound supply chain;
- To identify the key performance indicators to be able to measure the inbound supply chain effectively; and
- To identify and describe the elements required for an effective inbound supply chain.

1.5 SCOPE OF STUDY

1.5.1 Field of study

This dissertation is focused on inbound supply chain planning and risk reduction processes relevant to the petrochemical industry. Large-scale petrochemical companies in South Africa are the prime focus. The framework developed within this dissertation could also be applied to small and medium-sized chemical companies.

1.5.2 Geographical scope

The study will primarily focus on a petrochemical company in South Africa. Although the company is relatively small, their unique challenges are significant. The resulting framework for this dissertation could also be applied to small and medium-sized organisations, although they might not be faced with the same complexities than that of a large-scale petrochemical company.

1.6 RESEARCH METHODOLOGY

1.6.1 Literature study

A proper literature study will be conducted. The aim of the study is to lay the theoretical foundation and better understand inbound supply chain and supply chain risk management approaches.

1.6.2 Empirical study

An empirical study will be performed to gather data to address the problem statement and the study objectives. The following aspects will be taken into account during the empirical research:

- *Data collection and analysis*

Open-ended questions will be included in order to obtain better recommendations, and to assess the level of advancement in identifying planning processes along relevant different supply chain dimensions. These findings will be analysed and conclusions and recommendations will be made to achieve the objectives of the research.

- *Semi-structured interviews*

Interviews will be conducted with identified stakeholders to clarify the best practice, concepts and approaches.

1.7 LIMITATIONS OF THE STUDY

The following aspects have been identified as limitations to the study:

1.7.1 Limited time to complete the study

The study will be done over a period of nine months during the 2010 calendar year.

1.7.2 Limited geographical scope of the study

It would have been advantageous if the study and benchmarking could have been done against the backdrop of international petrochemical companies. Assumptions will have to be made, because we will be measured against ourselves and other petrochemical companies within South Africa.

CHAPTER 2

LITERATURE REVIEW ON EXISTING MODELS OF SUPPLY CHAIN RISK REDUCTION

2.1 INTRODUCTION

Supply chain management has always been treated as a small office, non-core function managing the logistics of supply chains. Today, environmental and social transparency across the supply chain delivers significant value to their companies. According to Business for Social Responsibility (BSR, 2007:3), a new era is unfolding in supply chain management.

The success of a business is no longer determined only by customer loyalty and shareholders' value; it is all about being shaped by external pressure from the investment community, business partners, civil society, governments, the media and consumers. To respond to stakeholder expectations and to meet the increasing regulatory requirements, companies are required to be transparent about their supply chain practices. By gaining visibility and control over their supply base, companies are in a position to align supplier performance and capabilities with their own corporate objectives (BSR, 2007:3).

The question to be asked is what makes supply chain management difficult? According to Simchi-Levi and Kaminsky (2008:2), reasons can be related to the following observations:

Supply chain strategies cannot be determined in isolation, they are directly affected by the value chain.

New products get developed every day to keep up with continuously changing environments. It is essential that all supply chain strategies should align with organisation-specific goals at all times, for example an increase in profit and market maximisation.

It is challenging to design and operate a supply chain so that total system-wide costs are minimised, and system-wide service levels are maintained.

The difficulty to operate a single facility is experienced frequently while the focus

is constantly on cost minimisation and maintaining service levels. The process to find a system-wide strategy is known as *global optimisation*.

Uncertainty and risk are inherent in every supply chain.

When developing supply chains and the management thereof, the focus must always be on eliminating as much uncertainty and risk as possible as well as dealing effectively with the uncertainty and risk that remain. Industry trends, outsourcing of functions, off-shoring and lean manufacturing that focus on reducing supply chain costs increase the level of risk in the supply chain.

For the purpose of this study, the focus will be on “*uncertainty and risk*”. This chapter focuses on literature that captures the different views on what the experts’ understanding of risk is, what possible risk reduction models and methods can be applied within the supply chain to manage uncertainties and risks, and how all of this fits into business planning and processes.

2.2 What is risk?

According to Artbrant (quoted by Kersten *et al.*, 2006:74) there is a very close relationship between all the important parties contributing to the supply chain. Any deviation, sub-standard performance or non-performance from any of the role-players will have an impact on the other role-players. For example the domino effect, where when one system fails to perform, the others will soon follow, because all of the systems are integrated and interdependent.

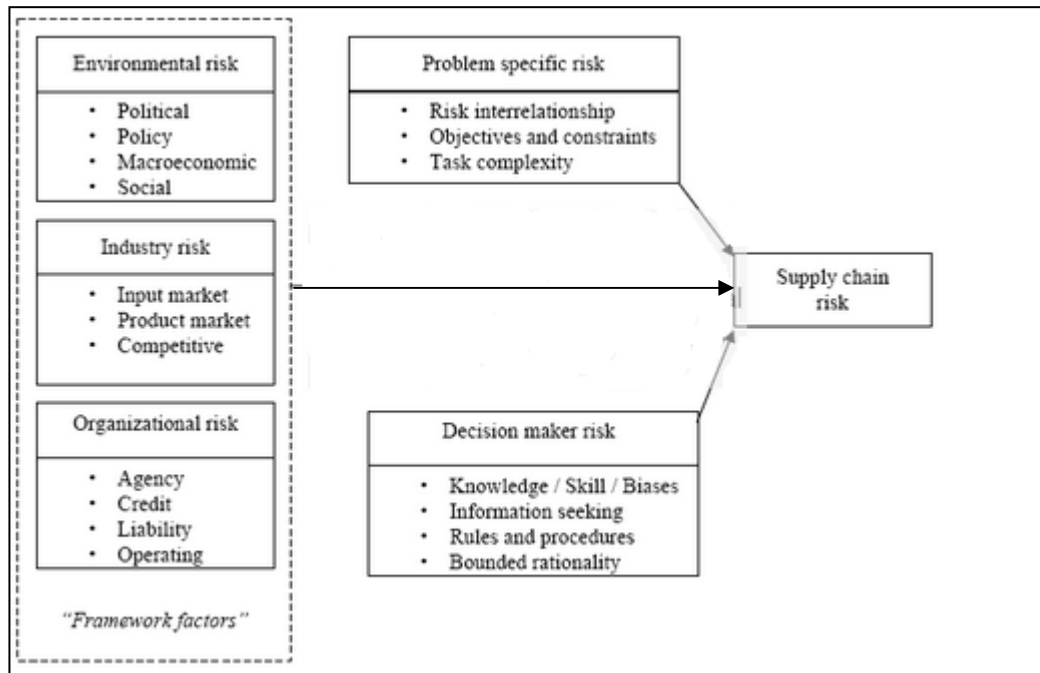
According to Holton (quoted by Rao *et al.* 2004:97-123), a situation is risky when it is opened up to two essential components: exposure to an event and the uncertainty of possible outcomes. Both the two components must be present to cause a risky situation. When you are dealing with a situation that has a certain outcome, how negative it might be, the situation is not risky. However, when you deal with a situation where the outcome is unknown, then it becomes risky.

Rao and Goldsby (2009:97-123) identified five sets of different factors with their risks that contribute towards the “overall” supply chain risk (refer Figure 2.1).

- a) Environmental risk
- b) Industry risk

- c) Company risk
- d) Problem-specific risk
- e) Decision-maker risk

Figure 2.1 Various factors contributing to overall supply chain risk



Source: Rao and Goldsby (2009:97-123)

According to Deleris and Erhun (quoted in IBM Global Business Services White Paper, 2008:6), Table 2.1 summarises supply chain risk categories and examples companies need to consider as a starting point to guide organisations in an initial assessment of their supply chain.

All of the categories mentioned in Table 2.1 can have a great impact on any supply chain function if the possible risk that might occur in each of the above mentioned categories is not properly managed, mitigated or illuminated. For the purpose of this study, possible risks in all of these areas might be identified.

Table 2.1 Supply chain risk categories, with examples

Category	Examples
Operational / Technological	Forecast errors, material shortages, capacity constraints, quality problems, machine failure / downtime, software failure, imperfect yields, efficiency, process / product changes, property losses (theft, accidents), transportation risks (delays, damage from handling), storage risks (incomplete customer order, insufficient holding space), budget overrun, contract terms (minimum and maximum limit orders, communication / IT disruptions)
Social	Labour shortages, loss of key personnel, strikes, accidents, absenteeism, human errors, company errors, union / labour relations, negative media coverage, perceived quality, coincidence of problems with holidays, fraud, sabotage, acts of terrorism, decreased labour productivity
Natural / Hazard	Fire, severe thunderstorm, flood, monsoon, blizzard, ice storm, drought, heat wave, tornado, hurricane, earthquake, tsunami, avalanche
Economy / Competition	Interest rate fluctuation, exchange rate fluctuation, commodity price, price and incentive wars, bankruptcy of partners, stock market collapse, global economic recession
Legal / Political	Liabilities, lawsuits, governmental incentives / restrictions, new regulations, lobbying from customer groups, instability overseas, war, tax structures, customer risks (inspection delay, missing data on documentation)

Source: Adapted from Deleris and Erhun (2007)

Typical examples in the market where risk had an impact on the company's supply chain:

- a) *Supplier issues* caused Boeing to lose \$2.6B in 1997 because of raw material and part shortages.

Supplier issues caused the Refinery to lose >R650k because of equipment supplied by a sub-agent who was under specification.

- b) *Transportation* plays a very critical role in any supply chain, especially if the company relies on just-in-time supply. In 2002, there was a shutdown of all the West Coast ports, most of the dockworkers striked at that stage and manufacturers had to incur high costs because a lot of material had to be flown in.

In the beginning of 2010, there was a volcano in Iceland, which had an outburst. The volcano ash covered the air in Western Europe, which delayed flights with material to be delivered to us by more than a week. Fortunately, the order was placed in advance and delivery was still in time to the refinery.

- c) When material is needed from overseas companies, cross-border problems can cause vulnerability in the supply chain. There might be delays in inspections at customs or border closure might take place. The 9/11 terrorist attack caused trucks full of parts to queue at the US-Canadian border.

A valve was ordered by the refinery from an overseas supplier in Germany. There were no direct flights and the plane had to land in Portugal, where the valve was then put on a wrong plane. The delivery had to be sent back to Germany again, after which it was delivered to South Africa. The delivery was in time, but if not, it could have been disastrous.

- d) *Supply chain visibility and non-compliance* caused a lot of problems in 2007 for the toy maker Mattel. A large number of toys had to be withdrawn from the market because of lead in the paint that was used by a sub-contractor to paint the toys.

An order was placed well in advance with a local company to build a heat exchanger. As per schedule it would have been delivered two months before the actual equipment had to be used. The supplier made use of sub-contractors to drill holes, which was wrongly done. The current situation is that it might be delivered late.

- e) A problem in Nike's *demand planning* software resulted in a \$100 million sales loss. Information technology plays a very important role in

coordinating and linking supply chain functions. IT systems are becoming the core of many companies and when they become unreliable, the consequences can be catastrophic.

The refinery's production planning system failed approximately 6 years ago. The impact of the failure was slower movement of products out of the plant, and the yield of the plant was negatively affected because of the slow reaction time. The throughput was negatively affected by 20%.

An important fact that companies must not lose sight of is that “smaller risks” can also hurt them as much as any extraordinary event. These “smaller risks” can lead to losing important customers or not having stock if they take place too regularly. The MIT research group on “Supply Chain response to Global Terrorism” (2003) has indicated that companies in most instances rather focus on the symptom than the problem, which then causes them not to be able to prepare against the risk. The research group distinguished between six different types of failure modes (refer Table 2.2) that cause risk in supply, transportation, facilities, freight breaches, communications and demand.

Table 2.2 Supply chain failure modes

Failure mode	Examples
Disruption in supply	Delay or unavailability of materials from suppliers, leading to a shortage of inputs that could paralyse the activity of the company
Disruption in transportation	Delay or unavailability of the transportation infrastructure, leading to the impossibility to move goods, either inbound or outbound
Disruption at facilities	Delay or unavailability of plants, warehouses and office buildings, hampering the ability to continue operations
Freight breaches	Violation of the integrity of cargos and products, leading to the loss or adulteration of goods (can be due to either theft or tampering with criminal intent)
Disruption in communications	Delay or unavailability of the information and communication infrastructure, either within or outside the company, leading to the inability to coordinate operations and execute transactions
Disruption in demand	Delay or disruption downstream can lead to the loss of demand, temporarily or permanently, thus affecting all the companies upstream

Source: Sheffi, Rice, Fleck and Caniato (2003)

2.3 Why risk reduction?

The ultimate reason why any company would need to reduce risk as far as possible is to limit the potential damage caused when a risk does take place. By being proactive at all times and having early warning systems installed, the company will possibly succeed in avoiding or reducing the possible risk. If the company did not succeed in avoiding the risk, the company must try to position itself in such a way that they will be able to transfer the potential impact of the risk to another company, for example to an insurance company. Strategies and processes to reduce supply chain risks must form part of any supply chain management system. The main reason for putting energy and effort into implementing effective and efficient strategies and processes is to increase resilience and efficiency.

According to Vinod Lall (2010:1), these strategies and processes can include supply management, demand management, product management, and information management. The task of managing supply chain risk is difficult because processes and strategies that mitigate one risk element can end up aggravating another.

Supply management

The main reason for focussing on supply management is because in this area risks are appearing on the inbound supply chain. By not managing this properly, disruptions in the availability of product or transportation delays from the supplier to the company may occur. Companies should have their focus on building a web of internal and external sources. It is of utmost importance for the company to be very selective in building a strong web of vendors and closely managing the vendor network. Another important aspect under supply management is the development of a profile of their suppliers as this will assist them in having a more complete picture. The profile should basically include the total number of suppliers, their BBEE status, the location and diversity of each, and the flexibility in the volume and variety of supplier capacities. All of the information will help companies to identify vulnerabilities in their supply chains so they can strategise, create contingency plans, conduct trade-off analyses of issues such as single

sourcing, and if needed, identify and line up backup sources. Holding reserves of inventory and capacity is another option to reduce risk in the supply chain. This might be a solution, but it will hurt the bottom line and increase costs if not properly analysed and managed.

Demand management

These risks are more downstream, and are on the demand outbound side of the supply chain. If there is a sudden increase in customer demand without notifying the relevant people in time, the consequence can be running out on safety and emergency stocks. The stock-outs will result in an increase in back orders and will put pressure on expediting. The opposite will also have an effect on the company. If there is a decrease in customer demand, the holding cost of inventory increases, which leads to price reductions. Strategic plans to manage demand will focus on product pricing, while tactical plans are used to shift demand across time, across markets and across products.

Product management

It is important for any company to develop profiles of their products, processes and services. This will give an idea as to whether there is a good mix of products and services and if there are risks associated with the processes.

Information management

Most companies are becoming very reliant on information technology. These tools can be used to understand what the risk is and by providing visibility into planned events and warnings for unplanned events can help to manage the risk in the entire supply chain. The use of reliable data and measures on inventory, demand, forecasts, production and shipment plans, work in process, process yields, capacities and backlogs can assist in offering the company more opportunities to all parties to respond quickly to sudden changes in the supply chain. This requires the implementation of information technology solutions that interface business data and processes end to end.

2.4 Risk models

For the purpose of this literature study, the focus will be on the following three models:

- The Deloitte Touche Tohmatsu model of Understanding Risk and the value of Flexibility;
- The KPMG Methodology for Implementing Risk Management; and
- The Supply Chain Operations Reference Model for Business Process Re-engineering.

2.4.1 Deloitte Touche Tohmatsu model of understanding Risk and the value of Flexibility. How to reduce risk and enhance flexibility in the supply chain?

Deloitte Touche Tohmatsu's (2009:5) viewpoint is on understanding how risk affects supply chain performance and how this impact can be reversed by balancing or offsetting risks with supply chain flexibility. There are two potential strategies:

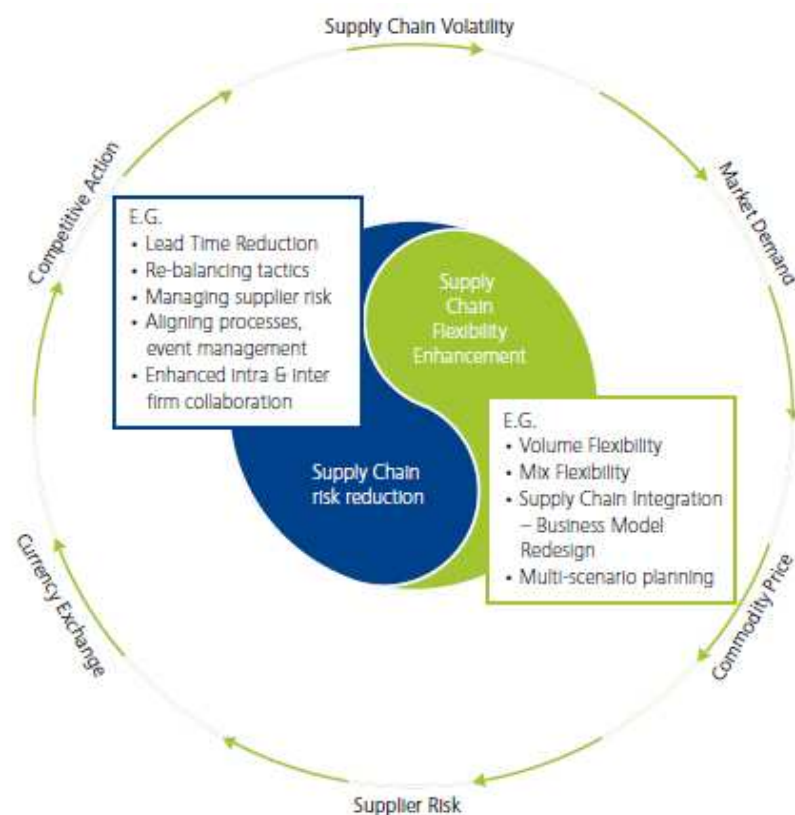
- Managing and reducing supply chain risk, e.g.
 - starting a formal supplier risk management programme
 - increasing demand planning accuracy
- Managing and enhancing supply chain flexibility, e.g.
 - investing in additional tooling and assets to enhance mix flexibility of a product line
 - fine tuning deployment tactics at a more granular level, and doing it more frequently

In the current uncertain times, managing the supply chain is all about managing the company's cash with a strong focus on inventories and cost reduction in the business. Companies should focus on increasing their levels of integration and the globalisation of the supply chain. This provides an opportunity to take advantage of consolidated services and synergies, to drive out redundancy and

increase efficiency. More integrated supply chain structures are more capable of leveraging network flexibility potential.

Supply chain volatility, market demand, fluctuations of commodity prices, supplier risk, currency exchange and competition all contribute to the daily uncertainties and create risks within the supply chain. Supply chain risk can, for example, be reduced by reducing lead times, managing supplier risk and aligning processes (refer Figure 2.2).

Figure 2.2 Risk and flexibility communicating vessels



Source: Deloitte Touche Tohmatsu (2009)

Supply chain flexibility enhancement can be achieved by multi-scenario planning and volume flexibility. The bottom line is that these practices mitigate business risk, enhance flexibility and therefore increase the value of the company. By managing risk and enhancing supply chain flexibility, there is a clear opportunity for companies to win in the current uncertain environment, and to sustain their

supply chains as a critical asset and differentiating factor for success towards the future.

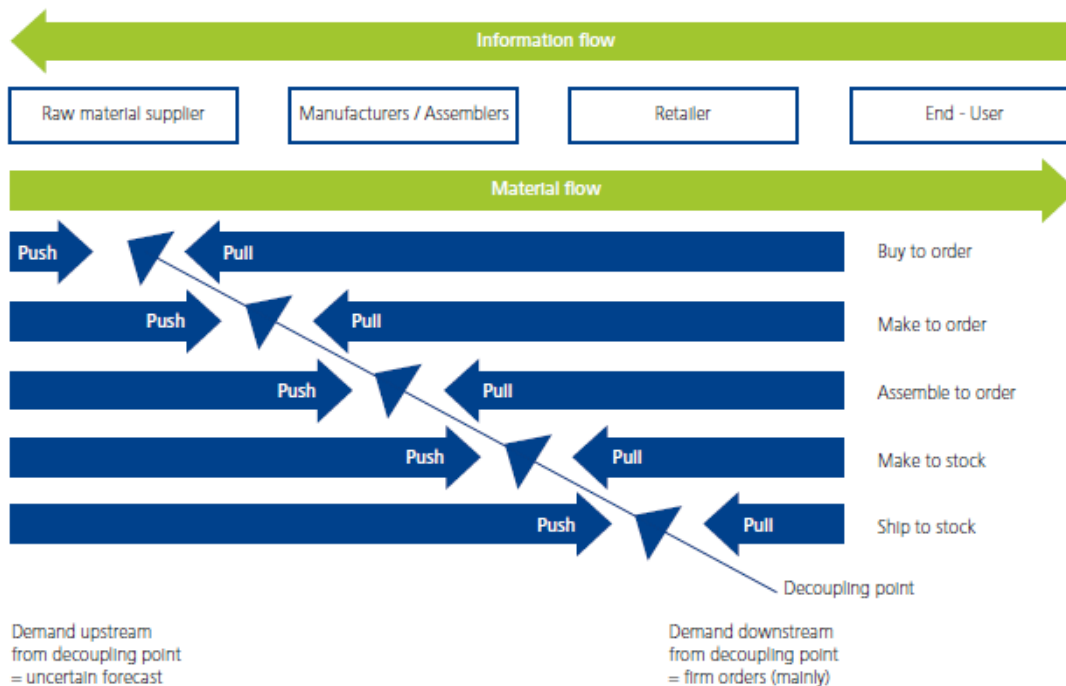
2.4.1.1 *Network flexibility*

At the level of the supply chain network, it is about making the hidden flexibility visible, which can include alternative sources of supply, alternative locations to manufacture and to deliver. Supply chain integration promotes more optimal and faster decision-making by leveraging the hidden network flexibility. This might require a redesign of the business model; it might be complex, but it is often less expensive than building additional flexibility within the walls of individual operational facilities in response to market demand, supplier risk, currency exchange and commodity price volatility.

2.4.1.2 *Reducing lead times*

Flexibility can be enhanced by investing in additional tooling or assets to enhance product mix flexibility on existing manufacturing assets, by negotiating more flexible labour or supplier agreements, or by investing in lead time reduction efforts. Reducing supply chain lead times through enterprise lean six sigma efforts for instance, very often allows moving the push-pull boundary in the supply chain, physically to more upstream levels. This typically results in a situation where a relatively larger part of the supply chain can be planned against company orders instead of uncertain forecasts. At the same time, decisions in the supply chain that need to be taken based on uncertain forecasts can be delayed to a later point in time when the quality of the forecasts is typically higher. Lead time reduction is a powerful lever to reduce risk and rigidity in supply chains and to make them more flexible and responsive.

Figure 2.3 Lead time reduction



Source: Deloitte Touche Tohmatsu (2009)

2.4.1.3 Frequently rebalancing supply chain tactics

Another way to reduce risk is to rebalance the supply chain tactics more frequently at the level of planning and portfolio policies. For example, a lot of supply chains currently have more fat built into their capacity, which can be used as a buffer for (demand or supply) uncertainty rather than using inventory for this purpose. This requires taking a more frequent view at planning and service offering policies and to rebalance them more regularly in order to trade excess inventory for slack capacity and release cash out of the supply chain. In a volatile supply chain environment, regular alignment of planning and service offering policies reduces the risk of experiencing service problems and of carrying excess inventory.

2.4.1.4 Process flexibility

Supply chain management processes also have a high potential of contributing to either risk reduction or enhancing flexibility in the business. Cash is king – the importance of an effective supply and operational process is very high. In times of uncertainty, practices that can improve the value of the supply and operational process are:

- increasing the frequency,
- doing mid-cycle sensitivity checks,
- accelerating the supply and operational process,
- developing multiple demand / supply scenarios,
- more pro-activeness and collaboration with customers and suppliers, and
- the incorporation of risk factors.

2.4.2 KPMG Methodology for Implementing Risk Management

Why would any company want to manage possible risk? It links strategic objectives to risks and controls in order to improve corporate performance, increases transparency, provides an early warning system and enhances business sustainability.

Figure 2.4 Example of a risk management framework



Strategy	Development and prioritization of risk categories from company's key strategic success factors
Risk systematization	Identification and classification of risks
Assessment & measurement	Assessment of likelihood and potential impact (risk modeling, scenario analysis) as well as continuous monitoring of the risks using key risk indicators
Mitigation	Individual mitigation measurements: acceptance/mitigation/avoidance/transfer of risks as well as tracking of the implemented measures
Reporting	Definition of reporting lines, structure and format; integration in controlling and reporting
Organization	Definition of roles and responsibilities ("three lines of defense": Risk Owner, Risk Controller, Internal Audit)
IT system	Definition of the risk management IT system requirements as well as selection and implementation
Internal control	Define and assess internal controls and integrate internal process controls into mitigation strategy

Source: KPMG Holding Ltd. (2008)

When implementing a thorough risk management framework, it would focus on the following phases:

2.4.2.1 Planning

During the planning phase, information and documentation related to risk identification are analysed, assessed and / or managed. Another aspect that needs to be identified is the desired state of the risk management in the company. Where does the company want and need to be with risk management? Prior to the planning phase, it is important to know what already exists with regard to risk management and to define the primary objectives of risk management. Aspects such as the following are discussed:

1. How is the company organised?
2. What management tools are used?
3. Has management performed a risk assessment in the past?
4. How were the most significant risks identified, managed and documented?
5. What is the IT landscape and how do IT related risks influence the risk assessment?

Based on the outcome of the analysis, the company is benchmarked against better practice and makes a preliminary decision about the **desired state** of its risk management. The high-level reporting requirements are aligned with the desired state. There is a need to develop common risk management language for the company right at the beginning. The **definitions** and **terms** used for risk management need to be defined. With regard to the **scope** of the project, it must be clear which areas, entities etc. should be covered by the risk management. It is advisable to initially focus on the most important areas. The scope is to be reviewed and updated on an annual basis.

The risk management project is dependent on the support from senior management and board members. Without such support, the project can face delays and even failure. Therefore, the project sponsor needs to be defined right at the start of the project. The project sponsor could be a member of the executive management, the steering committee or the audit committee based on the company's setup and should be in a position to promote the project against any possible impediments. **Roles** and **responsibilities** are defined and allocated to employees. One employee can take over more than one role, depending on the complexity and the size of the company. The project structure and the key team members are defined based on the roles and considering the resources available. **Planning** is set up and milestones are defined to achieve the desired state of risk management. This planning should not be seen as final, but rather as an iteration, as it will be updated and further detailed throughout the next phases.

2.4.2.2 *Risk identification and assessment*

Risks are identified and categorised. These risks are assessed and prioritised with the focus on defining the top risks the company faces. Considering the limited amount of resources available within a company, it is important to focus on the most important risks and to use the resources efficiently to manage these top risks to achieve maximum value. The risk assessment is therefore one of the most important and critical parts of the risk management process as it sets the tone and focus for the whole risk management setup in the company. The **risk identification** begins with a **SWOT analysis** (Strengths, Weaknesses, Opportunities, and Threats) in a workshop supplemented by interviews with key

members of the company. The SWOT analysis is a simple tool, but it is very beneficial in creating awareness and providing focus regarding the key issues linked to the company's strategic objectives. The aim of any SWOT analysis is to identify the key internal and external factors that affect the company's performance and value.

The information gained from workshops and interviews in combination with benchmarking analysis and other publicly and privately available data helps to create a database of all relevant risk information in the form of a master risk list generally called a risk catalogue. The risks are categorised in order to allocate the risks to the right dimension of the risk model (see Figure 2.5). Companies can create a categorisation that reflects their existing business and that is aligned to the already operational framework, for example for the internal control system (ICS).

Figure 2.5 *Example of a risk model*

EXTERNAL RISKS				
Financial market	Economy		Regulatory	...
INTERNAL RISKS				
Strategic	Operational			Financial
	Processes	Technology	Compliance	
	■ Business interruption ■ Product development ■ ...	■ Data security ■ Technological know-how ■ ...	■ Management fraud ■ Environment damages ■ ...	
	Management information	Human capital		
	■ Budgeting & forecasting ■ Investor relations ■ ...	■ Change readiness ■ Leadership ■ ...		■ Commodity prices ■ Foreign exchange rates ■ Liquidity ■ Financing ■ ...

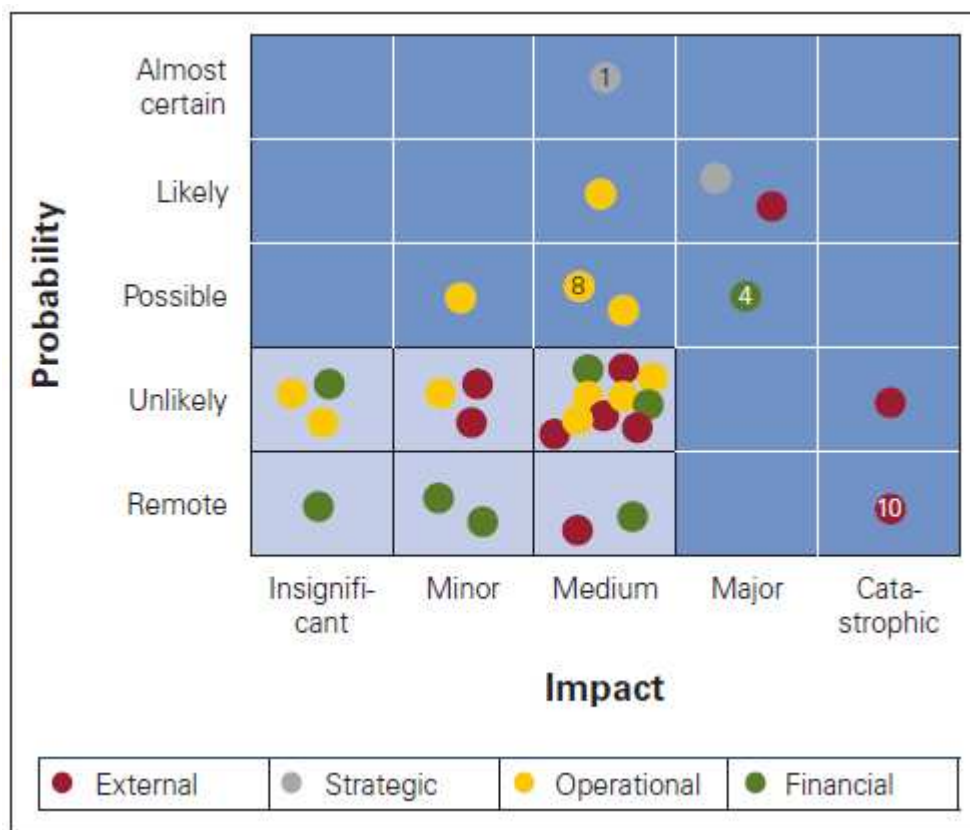
Source: KPMG Holdings Ltd. (2008)

Once the risk catalogue is defined, a high-level **risk assessment** is carried out for all risks identified. The assessment is usually done on the following two dimensions:

Probability is the likelihood of occurrence of the risk. It is common that a three-year timeframe is considered for the probability approximation. If a company has a strategic planning cycle, that timeframe is generally applied.

Impact is the effect that an event might have on the company if it occurs. Generally, a financial value of the impact is considered. Since it is not easy to quantify many of the risks only on a financial basis, risks can also be evaluated on the basis of other qualitative criteria, such as reputation damage, regulatory compliance, health and safety benchmarks or management effort required to control the situation once the risk occurs. The results of the risk assessment are illustrated in the form of a risk map (see Figure 2.6). The **top risks** are selected considering both dimensions: probability and impact. As a rule of thumb, companies often focus on approximately 10 top risks.

Figure 2.6 *Example of a risk map*



Source: KPMG Holdings Ltd. (2008)

2.4.2.3 Risk management process

The top risks identified above are analysed in more detail. Appropriate risk strategies and necessary actions are defined and agreed upon. In addition, the desired state of the risk management process is defined more precisely. Once the

top risks have been selected, an appropriate risk strategy is defined to optimally manage these risks to enhance and safeguard the company's performance and value. The **top risks** are **analysed in detail** to support the decision process and are discussed in workshops to create a dialogue among different functions leading to a common understanding of the risks. The risks are allocated to **risk owners** who need to monitor their risks. **Risk strategies** are defined for all top risks, which include "accept", "mitigate", "avoid" or "transfer" the risks and continuous monitoring. Often a combination of several risk strategies is agreed upon and transferred to **action plans**. Figure 2.7 shows an example of a risk action plan for one of the top risks.

Figure 2.7 *Example of an action plan*

Action plan				
Risk no. and name	1 Technological substitution that could make existing business redundant			
Risk owner	Jack Howard (Head Technology)			
Risk category	☐ External	☒ Strategic	☐ Operational	☐ Financial
Risk description	There have been several new technologies arriving in the market place that could prevent or even destroy the existing business model. The impact could be especially hard if the competitors are faster than ABC Tech Ltd. in the market with new products.			
Risk drivers/ main causes	■ Delay in bringing new products to market ■ Insufficient investment in R&D ■ Wrong strategy regarding product mix			
Risk strategy	☐ Acceptance	☒ Mitigation	☐ Avoidance	☐ Transfer
	■ Build an opportunity to aggressively adopt new strategies and actions to create market conducive portfolio ■ Be at the leading edge in developing substitutes and create opportunities			
Effective measures already in place	■ R&D budget increased by 250% over the last year ■ New hiring policy in place for recruiting researchers competent in the field of emerging technology			
Action	Responsible	Milestone	Deadline	Status
1. Push the prototypes to market	Mike Randy	Prototype 1	30.09.2008	Open
		Prototype 2	31.03.2009	Open
2. Acquire a substitute offering company	Christina Frey	Acquisition offer	31.07.2008	Started
3. Hire two new employees in R&D	Lee Ang	Hiring employee 1	30.06.2008	Done
		Hiring employee 2	30.09.2008	Done

Source: KPMG Holdings Ltd. (2008)

2.4.2.4 *Implementation*

Relevant policies and guidelines are set up. The risk management system is put into practice and the proper implementation is monitored. **Policies** and

guidelines are framed to summarise all key decisions and processes developed during the project period. These documents are approved by the board of directors and executive management stating the “tone at the top” and providing the members of the company with a road map supporting them in carrying out their risk management responsibilities.

The **actions** and the additional aspects of the **risk management system** as defined in phase 3 are **implemented**. One of the key elements is to ensure continuous monitoring. The risk owners are responsible for periodic reporting regarding the status of the defined actions and the development of the risks. A summary of all risks together with the status of the defined actions is periodically presented to the board of directors and executive management as outlined in Figure 2.8

Figure 2.8 Example of a reporting template

Risk reporting 2008																
Risk no.	Risk category	Risk name	Probability			Impact			Risk owner	Risk drivers/main causes	Effective measures already in place	Action plan				
			Remote Unlikely	Possible Likely	Almost certain Insightful	Minor	Medium Major	Catastrophic				Action	Responsible	Deadline	Status	Comments
1	Strategic	Technological substitution that could make existing business redundant			x		x		Jack Howard (Head Technology)	■ Delay in bringing new products to market ■ Insufficient investment in R&D ■ Wrong strategy regarding product mix	■ R&D budget increased by 250% over last year ■ New hiring policy in place for recruiting researchers competent in the field of emerging technology	1. Push the prototypes to market 2. Acquire a substitute offering company 3. Hire two new employees in R&D	Mike Randy	31.03.09	Open	...
												Christina Frey	31.07.08	Started	...	
												Lee Ang	30.09.08	Done	...	
...	...	...							...	...	...	...	...	...	...	

Source: KPMG Holdings Ltd. (2008)

Risk management should be a pivot between internal controls and other assurance functions, such as an internal audit. One of the key success factors to a sustainable risk management programme is its integration into the overall corporate governance of the company. Risks are derived from the company's strategy and linked to the internal controls that are in place or are to be implemented to manage the risks. The various assurance functions of the company are coordinated such that adequate risk monitoring can be most effectively ensured. A continuous communication and feedback loop among the

various functions closes the circle. Table 2.3 lists the principal activities, results and success factors of the individual phases of a risk management project.

Table 2.3 Summary of a list of principle activities of risk management project

	Phase	Activities	Results	Success factors
Required from a good governance perspective (e.g. "Swiss Code of Best Practice for Corporate Governance")	Minimum legal disclosure requirements relate to general information on phases 1 and 2			
	1. Planning	- Analyze the current situation - Gather information and documentation - Perform high-level review of current risk management system - Define goal of the risk management process which includes - Desired status of risk management - Reporting requirements - Agree on risk definitions and terms - Define areas, entities etc. to be in scope - Plan the project - Establish project structure - Define project plan, timeline and milestones	- Overview of existing information - Project objective and reporting plan - Definitions and terms - Scoping - Project plan	- Strong sponsoring by top management and Board of Directors - Long term perspective - Efficient resource planning - Pro-active approach - Clear allocation of roles and responsibilities
	2. Risk identification and assessment	- Perform SWOT analysis - Define assessment approach and categorization - Identify risks - Carry out interviews - Conduct workshops - Categorize risks - Assess and prioritize the identified risks	- Risk catalogue - Risk map - Top risk list	- Involvement of people across functions and hierarchy levels - Open discussions and transparency
	3. Risk management process	- Analyze top risks in detail - Perform cause-effect or other qualitative and quantitative analysis - Conduct workshops and discussions - Identify risk owners - Define appropriate risk strategies for the top risks - Identify current controls - Define new actions - Define a sustainable risk management process	- Action plan - Trained risk owners - Ongoing risk management system	- Involvement of people who have in-depth knowledge of business - Cost-benefit analysis for risk management system and actions - Strong process and risk ownership
	4. Implementation	- Develop and agree on policies and guidelines including reporting - Implement defined actions and the risk management process - Continuous reporting and monitoring	- Policies and guidelines - Regular risk reports	- Effective reporting - Continuous management sponsorship - Continuous support and training of risk owners

Source: KPMG Holdings Ltd. (2008)

2.5 Supply chain planning

Supply chain planning is becoming a key differentiator for companies in an increasingly competitive global environment (Shen, Lee & Van Buskirk, 2001:68). Koutsoukis *et al.* (2000:657) indicated that strategic planning and the operational management of supply chains are two leading decision problems in supply chain management. According to Mulani (2001:27), advanced planning has now gone well beyond the factory and into the supply chain. Companies now use integrated planning processes for the sole purpose of building a master plan for procurement and supply.

The benefits of adopting supply chain management and advanced planning cannot be achieved by one company alone, due to companies focusing on their own core competencies. This brought about new challenges for the integration of legally separate companies and the coordination of material, information and

financial flows not experienced in this magnitude before. To a large extent, this then encompasses the new supply chain management philosophy. (Stadtler & Kilger, 2000:1). The oil refinery used in this study is a good example of legally separate companies forming a joint venture (JV) with two other oil refineries, nationally and internationally based. Negotiating one group contract for specific commodities helps all parties of the JV to ensure material as and when needed at the most cost effective price. Economies of scale would play a very important role; the buying power is much more than where three companies would have tried to negotiate three different contracts.

According to the results of a supply chain benchmarking study conducted by The Performance Measurement Group (PMG), well-developed supply chain planning processes are critical for achieving a competitive advantage (Wawszczak, 2003). The study shows that companies with mature planning practices are 38% more profitable than average companies, have 22% lower levels of inventory and have 10% greater delivery performance. The companies that combine mature planning processes with advanced planning systems gain added performance improvements (including 27% greater profitability).

“Planning drives the supply chain. It orchestrates the flow of materials and resources, getting them to the right location at the right time, in the right sequence. Effective planning balances demand and supply, internal and external objectives, all in a constantly changing environment. Mastering supply chain planning can provide a major competitive advantage” (Ribbers 1994:26).

The removal of national barriers to international trade, combined with the increased sophistication of the customer, means that companies do not have a choice anymore but to integrate. The potential benefits of full integration have not yet all been achieved. The biggest barriers to modifying a company's logistics systems are internal and people related. The change process is left unmanaged ten times out of ten. The principal source of resistance to change is employee attitude (Ribbers, 1994:26).

The chemical industry is still faced with the required shift in their supply chain focus from integrating internally to integrating across overall enterprises and from

suppliers to end-customers (Boulanger & Eckstut, 2000:11). Although companies believe that SCM can help their competitive drive, they recognise the tension that exists between SCM's competitive enhancement potential and the inherent difficulty of collaboration. Establishing seamless processes that bridge company boundaries are an appropriate goal, but establishing them is anything but easy (Fawcett & Magnan, 2002:360).

2.6 Decision-making as a means to manage risk

It is no longer appropriate to base decisions and actions only on prior experiences and assumptions. Decision-making must become fact based. Measurements must be across company boundaries and should provide information on overall supply chain performance (Vakurka & Lummus, 2003:55). Because companies depend on the measurement and analysis of performance, measurements must derive from the company's strategy and provide critical data and information about key processes, outputs and results. Supply chains need to share and take action on data and information, not assumptions and emotions. Performance analysis and problem-solving must be based on reliable and relevant information.

According to Pienaar (2005:71), the decision-making process should assure that decisions reached are quantitatively sound and did consider the various tradeoffs (costs & service) and coordination involved.

King and Wright (2002:24) state that broken supply chains are cemented together with stock so that the cracks do not show. Fundamental structural problems are thus avoided. The point of fracture of most supply chains is the connection between demand management and supply management.

Long- and short-term tactical supply chain planning has thus far mainly been ignored by managers and consultants (Shapiro, 2001:43). According to Bramel and Simchi-Levis (1997:7), managers and consultants typically resort to one of the following for solutions:

- People tend to repeat what has worked in the past;
- Use the "rule of thumb"; and
- Apply the experience and intuition of logistics experts and consultants.

Sophisticated decision support systems are now available to optimise logistics and supply chain strategic decisions. These systems apply techniques that have been developed in the operations research and management science research communities. An increasing number of managers in a wide range of companies are seeking to manage their supply chains based on facts, that is, data and proper analytical methods (Shapiro, 2001:25).

As supply chains develop over time and integrating processes become prominent, decision-making and a pro-active approach with longer time horizons become the norm for excellence.

The logical steps in decision-making can also be viewed to comprise the following to summarise the interaction between information systems and decision modelling (Koutsoukis *et al.*, 2000:642):

- a) Data (-base) modelling involves defining relationships between data items leading to a relational data model, or identifying categories that are then used to define multidimensional tables, leading to a multidimensional database.
- b) Decision modelling involves the development of models that are used for decision-making (not only linear, nonlinear, or discrete optimisation models, but also simulation, cluster analysis, costing, data mining and other analytical models).
- c) Model analysis and investigation involve descriptive analysis of the results; this leads to insight and knowledge with regard to a given decision problem.

A mix of optimisation techniques, common sense, business best practices, and political savvy is required to develop and implement a workable solution. There are typically many common sense, best practices and political savvy to go around in most companies. What is often lacking, is the analytical resources required to model and solve logistical problems (Frazelle, 2002:15).

Business will not continue to succeed or prosper unless it continues to offer good customer service in the form of accurate delivery commitments and supply chain streamlining. In a complex environment, these tasks cannot be executed successfully without optimisation engines (proper analytical tools) to enable them (Peterson, 1999:2). Quantitative models provide companies with decision support

as well as insight for the better management of supply chains (Keskinocak & Tayur, 2001:70).

But how does this apply to the decisions that need to be made in the supply chain? Supply chain management is about, “Getting the right product, at the right place at the right time”. Supply chain planning decisions are about determining, “Which is the right product, where is the right place, and when is the right time?” (Stemmet, 2002:4). This will be discussed in more detail in the empirical study.

2.7 Business processes

Processes can be regarded or defined as a series of linked, continuous and managed activities that contribute to an overall outcome (Manrodt & Fitzgerald, 2001:110). Each process has a specific starting and ending point and goes beyond functional boundaries within a company. A business process can also be viewed as a series of actions directed towards a particular goal (Microsoft Encarta Reference Library, 2002). For two companies to send information back and forth and do business, they need to have a common understanding of their own and each others' processes (Hill Jr., 2000:62). This principle plays a vital role in integrating supply chains.

Francis (2004:3) indicated the following benefits when focussing on the process. It helps to:

- manage the business (*through visibility of how work actually gets done*)
- compete more effectively (*the knobs and levers are explicit*)
- create real improvements (*not just move bottlenecks around*)
- improve multiple areas (*performance measures are controlled independently*)
- improve coordination between teams (*visibility of relationships and consequences*)
- streamline and accelerate business change (*rather than silos of change with an unpredictable approach*)

2.8 Value of risk management

When a business has a proactive risk management system in place, it will assist in the efficient management of the business risk, which can then lead to the constitution of value in the following areas of the business (Smith and Merritt *et al.* 2002):

2.8.1 Compliance and prevention

- avoid crises in own organisation
- avoid crises in other organisations
- comply with corporate governance
- avoid personal liability failure

2.8.2 Operating performance

- understand full range of risks facing the organisation
- evaluate business strategy risks
- achieve best practices

2.8.3 Corporate reputation

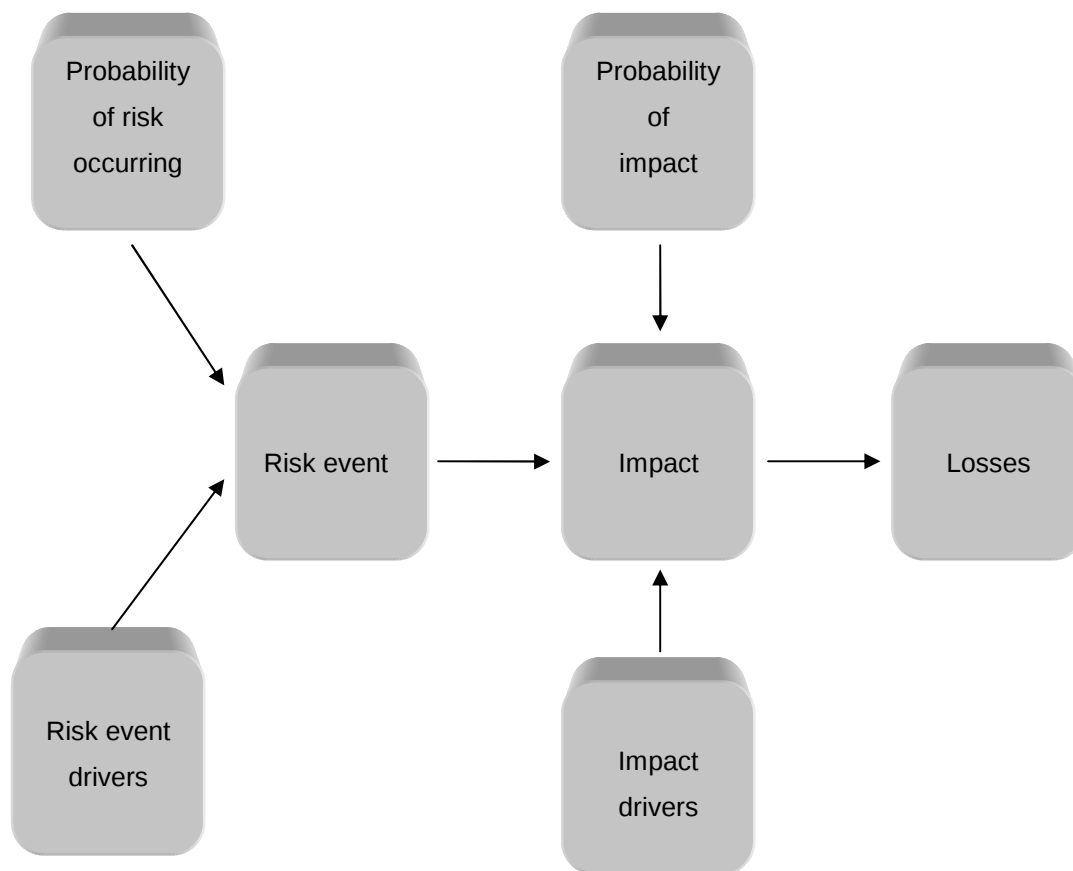
- protection of corporate reputation

2.8.4 Shareholder value enhancement

- enhance capital allocation
- improve returns through value-based management

According to Smith and Merritt (2002), proactive risk management evaluates the probability of risk occurring, risk event drivers, risk events, the probability of impact and the impact drivers prior to the risk actually taking place. For any business this is the ultimate first prize – to have a model in place that can prevent or mitigate the risk before it can actually happen

Figure 2.9 Pro-active risk management



Source: Smith and Merritt (2002)

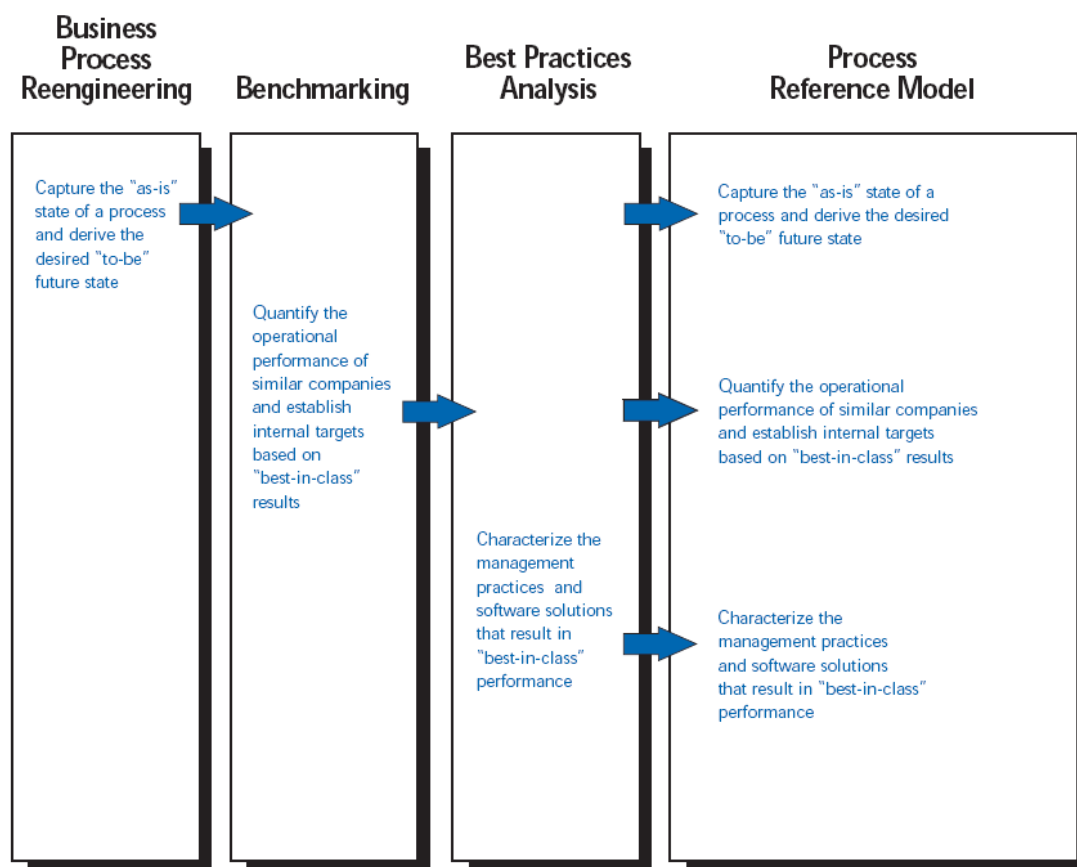
2.9 Supply Chain Operations Reference model (SCOR)

How do we put all of the above together? How do we take the current situation in the company and get to where we want to be and make sure we stay there? Such a model referred to in the literature is called the *Supply Chain Operations Reference model*, in short called *SCOR*, a registered trademark in the United States and Europe, developed and endorsed by the Supply Chain Council.

According to the Supply Chain Council (2005:1), a process reference model integrates the well-known concepts of business process reengineering, benchmarking, and process measurement into a cross-functional framework. SCOR is a process reference model designed for effective communication among supply chain partners. A standard *language* helps management to focus on management issues. As an industry *standard*, SCOR helps management focus

across inter-company supply chains. SCOR is used to **describe, measure** and **evaluate** supply chain configurations.

- **Describe:** Standard SCOR process definitions allow virtually any supply chain to be configured.
- **Measure:** Standard SCOR metrics enable the measurement and benchmarking of supply chain performance.
- **Evaluate:** Supply chain configurations may be evaluated to support continuous improvement and strategic planning.



According to the Supply Chain Council (2005:1), a process reference model contains:

- Standard descriptions of management processes;
- A framework of relationships among the standard processes;
- Standard metrics to measure process performance;
- Management practices that produce best-in-class performance; and
- Standard alignment of features and functionality.

Once a complex management process is captured in a standard process reference model form, it can be:

- Implemented purposefully to achieve competitive advantage;
- Described unambiguously and communicated;
- Measured, managed and controlled; and
- Tuned and re-tuned to a specific purpose.

The Boundaries of any model must be carefully defined. From your supplier's supplier to your customer's customer.

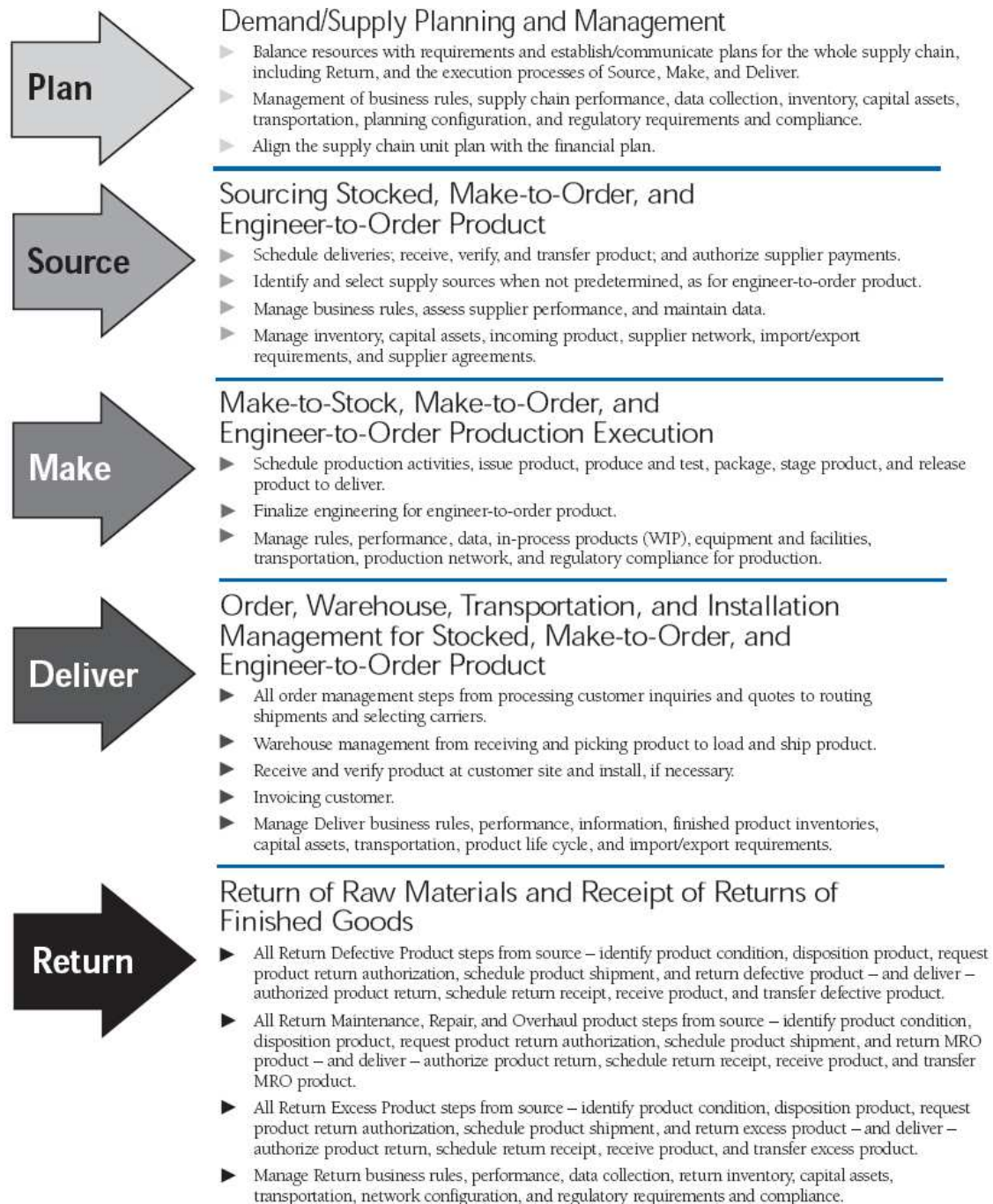
SCOR spans:

- All customer interactions, from order entry through paid invoice;
- All product (physical material and service) transactions, from your supplier's supplier to your customer's customer, including equipment, supplies, spare parts, bulk product, software, etc;
- All market interactions, from the understanding of aggregate demand to the fulfilment of each order, SCOR does not attempt to describe every business process or activity, including:
 - Sales and marketing (demand generation)
 - Research and technology development
 - Product development
 - Some elements of post-delivery customer support.

Links can be made to processes not included within the model's scope, such as product development, and some are noted in SCOR.

SCOR assumes but does not explicitly address training, quality, information technology (IT) and administration (non SCM).

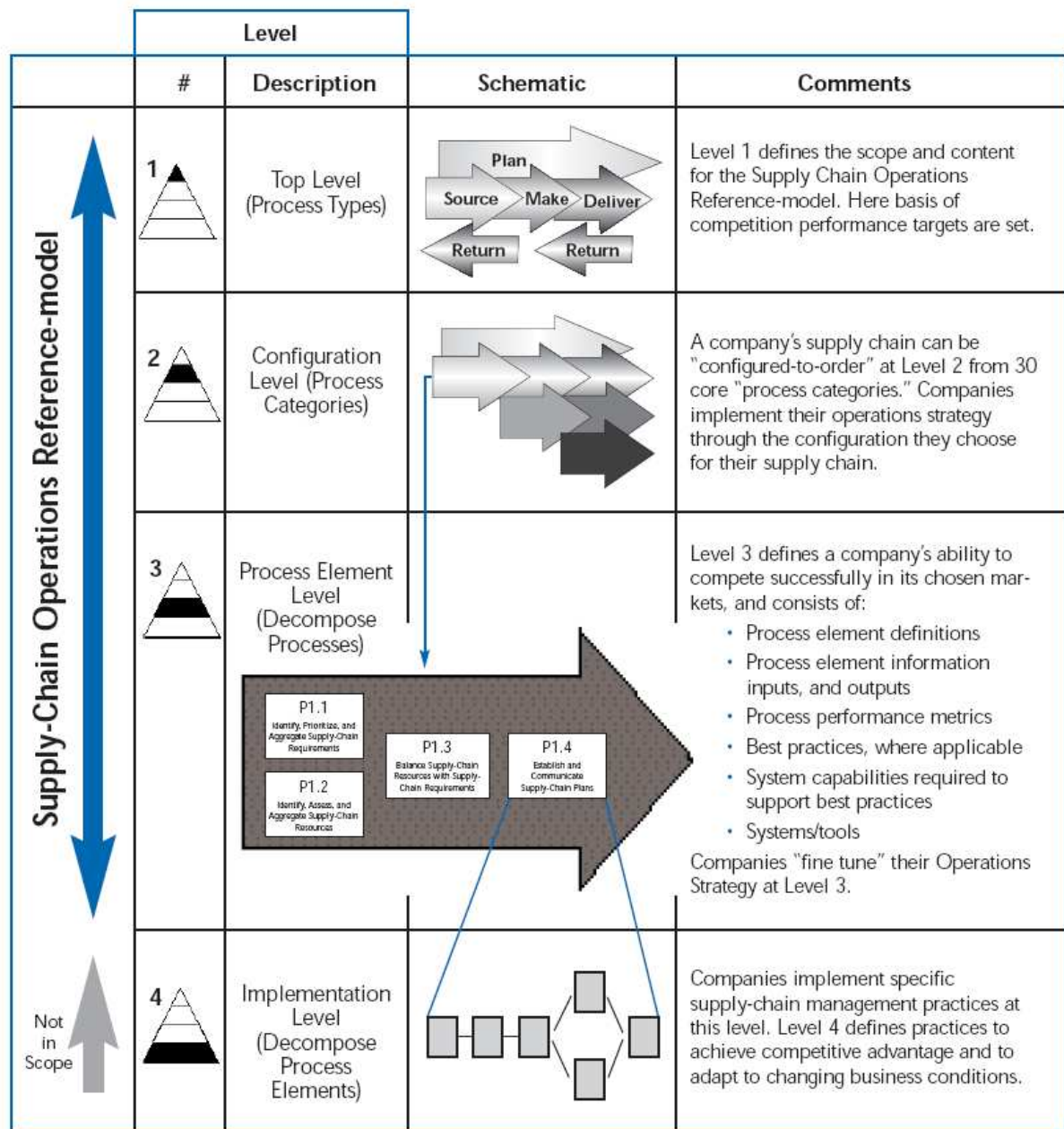
Figure 2.10 SCOR is based on five distinct management processes, namely:



Source: Supply-Chain Council, (2005)

According to the Supply Chain Council (2005:6), SCOR contains four levels of process detail (refer Figure 2.11)

Figure 2.11 Four levels of process detail



Source: Supply-Chain Council, (2005)

Level 1 entails the definitions of each of the five core management processes, on which SCOR is based, as well as Level 1, high-level measures that may cross multiple SCOR processes. Level 1 metrics do not necessarily relate to the SCOR Level 1 process (Plan, Source, Make, Deliver, Return).

Level 2 is a further description of each SCOR process by process type as well as a tool kit to enable the process.

Level 3 presents detailed process element information for each Level 2 Category, namely process flow, inputs and outputs, source of inputs, and output destination.

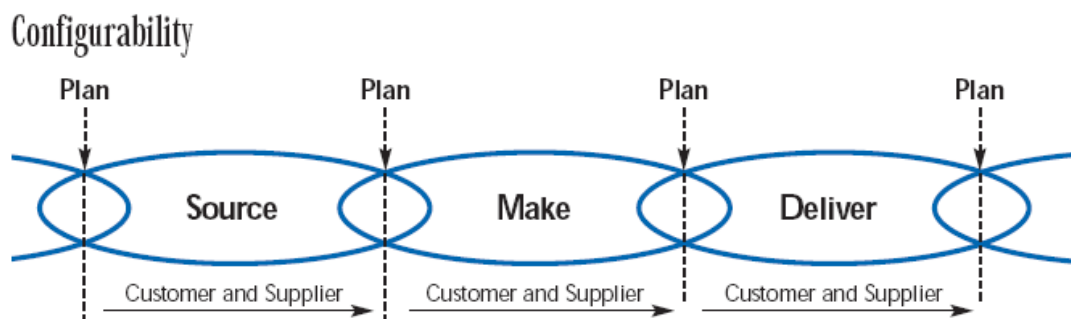
Level 4 is where the implementation of supply chain management practices within the company occurs.

According to the Supply Chain Council (2005:13), within a process reference model, the concept of “configurability” should also be understood. A supply chain configuration is driven by:

- **Plan** levels of aggregation and information sources
- **Source** locations and products
- **Make** production sites and methods
- **Deliver** channels, inventory deployment and products
- **Return** locations and methods

SCOR must accurately reflect how a supply chain’s configuration impacts management processes and practices (refer Figure 2.12).

Figure 2.12 “Chain” of Source, Make, and Deliver execution processes



Source: Supply-Chain Council, (2005)

Each intersection of two execution processes (Source-Make-Deliver) is a “link” in the supply chain (refer Figure 2.13):

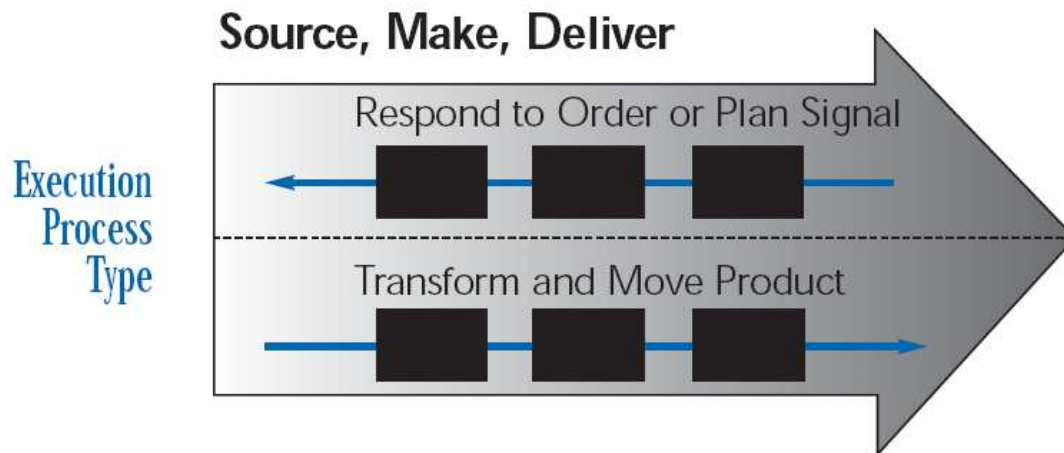
- Execution processes transform or transport materials and/or products.
- Each process is a customer of the previous process and a supplier to the next.

Planning processes manage these customer-supplier links:

- Planning processes thus “balance” the supply chain

- Every link *requires* an occurrence of a plan process category.

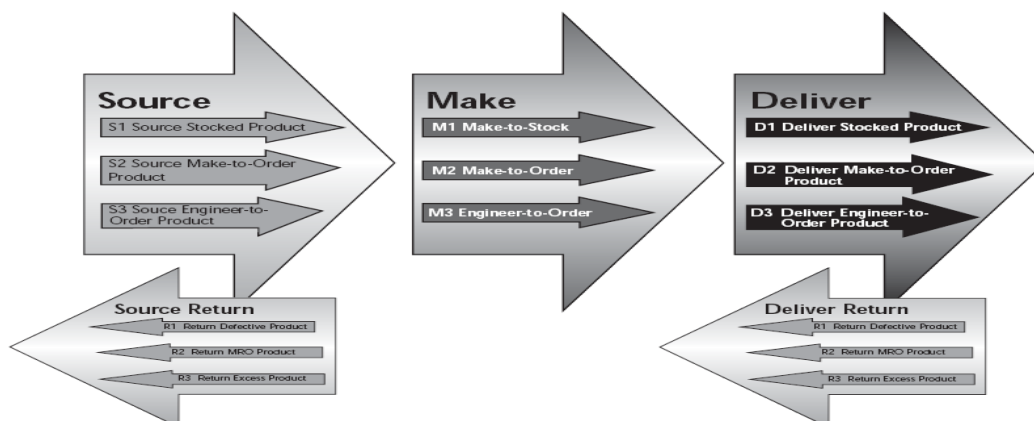
Figure 2.13 Execution process



Source: Supply-Chain Council, (2005)

Also to focus on, according to the Supply Chain Council (2005:17), is the configuration of supply chain threads. What does this mean? Configuring a supply chain "thread" illustrates how SCOR configurations are done. Each thread can be used to describe, measure and evaluate supply chain configurations (refer Figure 2.14).

Figure 2.14 Example of configuring supply chain threads



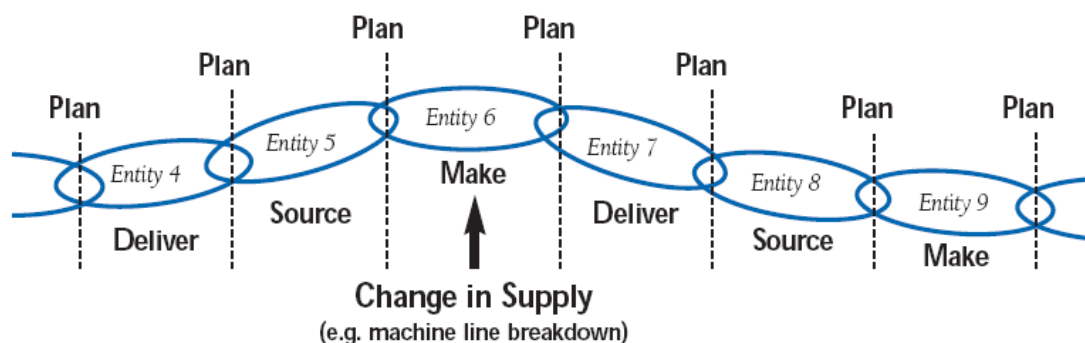
Source: Supply-Chain Council, (2005)

How would you go about configuring the supply chain threads?

- a) Select the business entity to be modelled (geography, product set, organisation).
- b) Illustrate the physical locations of:
 - Production facilities (Make)
 - Distribution activities (Deliver)
 - Sourcing activities (Source)
- c) Illustrate primary point-to-point material flows using “solid line” arrows.
- d) Place the most appropriate Level 2 execution process categories to describe activities at each location.
- e) Describe each distinct supply chain “thread”
 - A supply chain thread ties together the set of Source-Make-Deliver supply chain processes that a given product family flows through.
 - Develop each thread separately to understand common, and distinct, execution and return process categories.
 - Consider end-to-end threads in the inter-company case.
- f) Place planning process categories, using dashed lines to show links with execution processes.
- g) Place P1, if appropriate.
 - P1 – Plan supply chain aggregates outputs from P2, P3, and P4.

A change in a supply chain often “ripples” through each linkage, affecting other areas (refer Figure 2.15)

Figure 2.15 Example in a classic logistics world

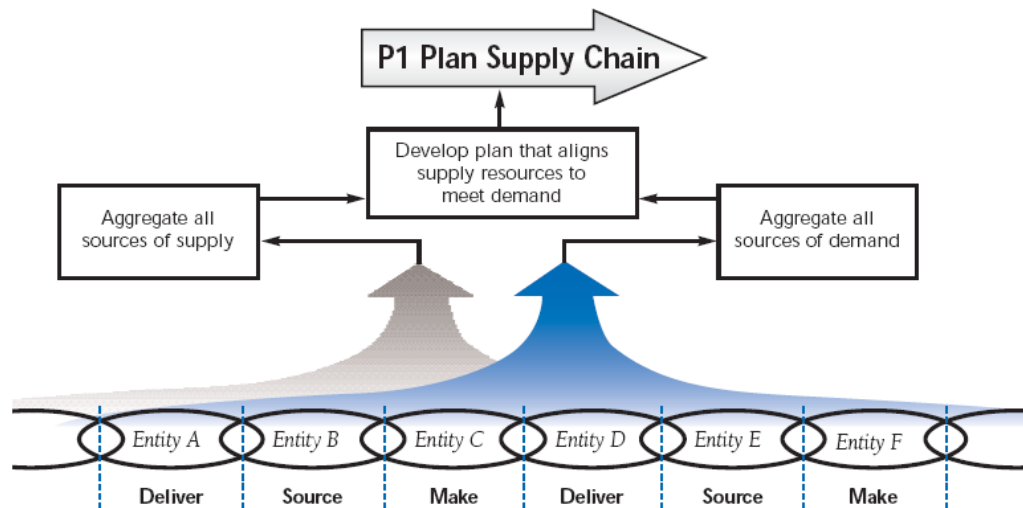


Source: Supply-Chain Council, (2005)

The impact of a change can be felt both up and down the supply chain:

- A change in supply caused by a “production planner” may affect a “materials planner” and an “inventory planner”.
- Furthermore, such a change may affect both your customer’s and supplier’s supply chain planning.

Figure 2.16 Effective supply chain management



Source: Supply-Chain Council, (2005)

It requires balancing multiple links concurrently to have an Effective Supply Chain management as a result within all the ongoing changes happening all the time (refer figure 2.16).

2.10 Conclusion

With the unpredictability in the supply chain, market demand, commodity price, supplier risk, currency exchange and competitive action comes increased risk, which may result in disruptions to the supply chain. These disruptions may be unexpected and statistically rare, but they must be understood, identified and managed.

To understand, identify and be able to manage risk, the focus in this chapter was on the Deloitte Touche Model of Understanding Risk and the value of Flexibility, the KPMG Methodology for Implementing Risk Management and the Supply

Chain Operations Reference Model (SCOR). The purpose of Chapter 3 will be to identify the risk within the supply chain in and oil refining process.

CHAPTER 3

OVERVIEW OF CHALLENGES AND RISKS WITHIN THE SUPPLY CHAIN PROCESS IN AN OIL REFINING PROCESS

3.1 INTRODUCTION

According to Johan Dique (2010:2), some of the reasons why businesses fail are because of wrong strategies, *A LACK IN RISK MANAGEMENT*, poor management, lack of leadership, etc. The list gets longer and longer. Again what is evident is that a lack in risk management is one of the main factors contributing to the failure.

The focus of this chapter is to explain what operational types and processes are used within operations and what roles the operations, maintenance and supply chain functions play within these processes. Furthermore, the focus is on understanding the purpose of the equipment used in the process and the risk identified when the equipment fails. Understanding these risks and the impact they might have on the oil refinery will assist all parties involved to be able to develop and implement sourcing and maintenance strategies to mitigate and manage the risk.

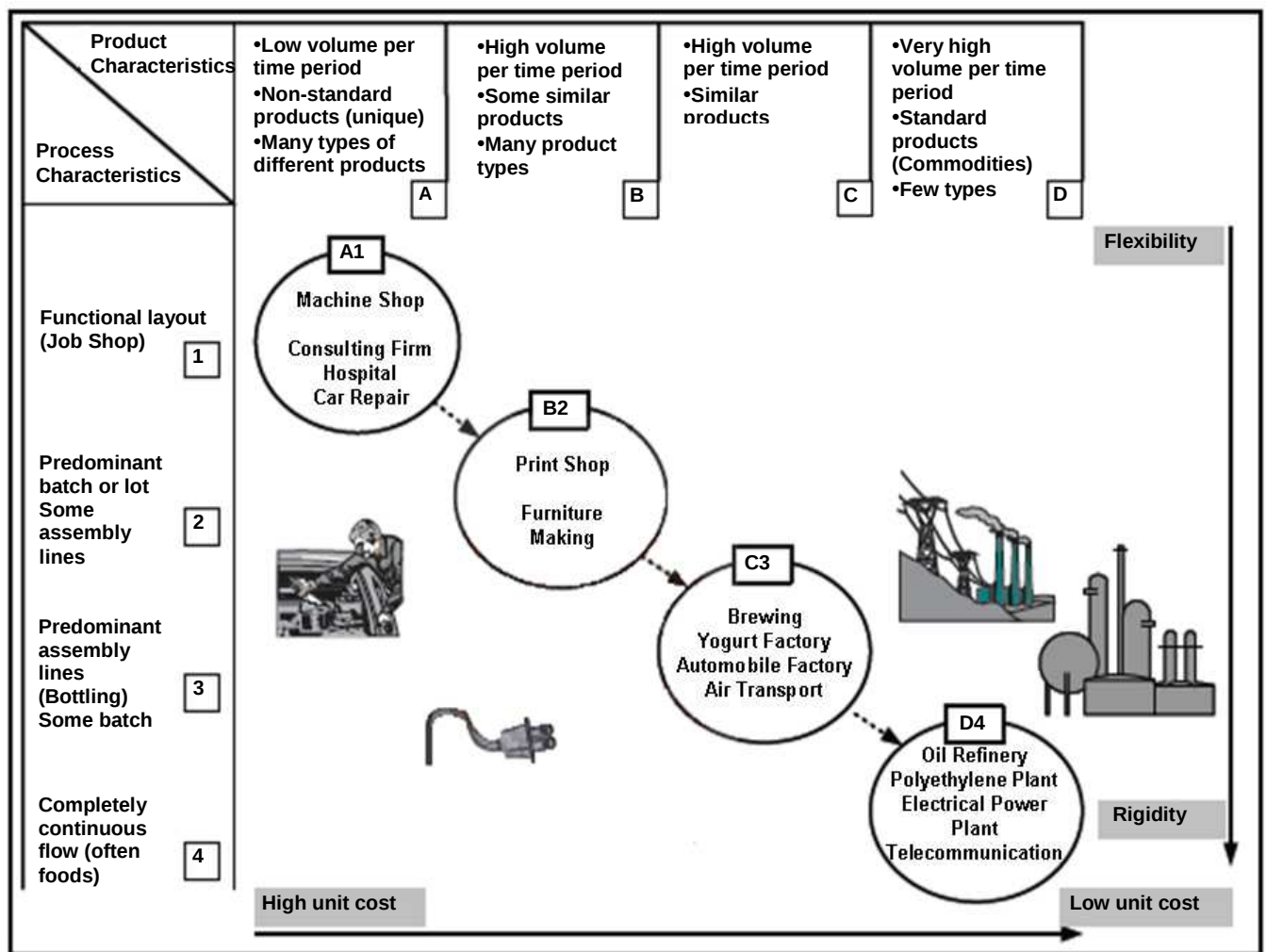
3.2 Types of manufacturing processes

Products are manufactured through a number of different manufacturing processes, as indicated in Figure 3.1 (Waller, 1999:167). These manufacturing processes differ largely due to their flexibility, product volume and unit cost. The various manufacturing processes are:

- Job shop
- Assembly line
- Batch and campaign process
- Continuous flow

An oil refinery will typically find itself in the D4 group, which is a continuous flow with very high volume per time period, standard products (commodities) and few types (indistinguishable).

Figure 3.1 Correlation of the product and the process



multi-streams, which are a whole range of individual interrelated streams, each performing a specific process. If any part fails to perform, for whatever reason, **the overall plant will fail and come to a standstill**. For a refinery, the production loss can be disastrous.

Crude Oil

Other Gases

Gas

Fuel Gas

Amine Treating

Refinery Fuel

H₂S

Claus Sulfur Plant

Sulfur

H₂S from Sour Water Stripper

Mercox Treaters

LPG Butanes

Gas

H₂

Hydrotreater

Light Naphtha

Isomerization Plant

Isomerate

Gas

H₂

Hydrotreater

Heavy Naphtha

Gas

H₂

Catalytic Reformer

Reformate

Gas

H₂

Mercox Treater

Jet Fuel and/or Kerosene

Gas

H₂

Hydrotreater

Diesel Oil

Gas

H₂

Hydrotreater

Atmospheric Gas Oil

Gas

H₂

Hydrocracker

Hydrocracked Gasoline

Gas

H₂

Alkylation

Alkylate

Gas

H₂

FCC Feed Hydrotreater

Gas

H₂

Fluid Catalytic Cracker (FCC)

Gas

H₂

Naphtha

Gas

H₂

Hydrotreater

FCC Gasoline

Gas

H₂

FCC Gas Oil

Fuel Oil

Gas

H₂

Delayed Coker

Gas

H₂

Coker Naphtha (after hydrotreating and reforming)

Coker Gas Oil

Petroleum Coke

Gas

H₂

Asphalt Blowing

Asphalt

Vacuum Distillation

Evacuated non-condensibles

Light Vacuum Gas Oil

Heavy Vacuum Gas Oil

Vacuum Residuum

Gas

H₂

Sour Waters

H₂S to Sulfur Plant

Steam

Sour Water Steam Stripper

Stripped Water

Natural Gas

Steam

Hydrogen Synthesis

CO₂

H₂

Gasoline Blending Pool

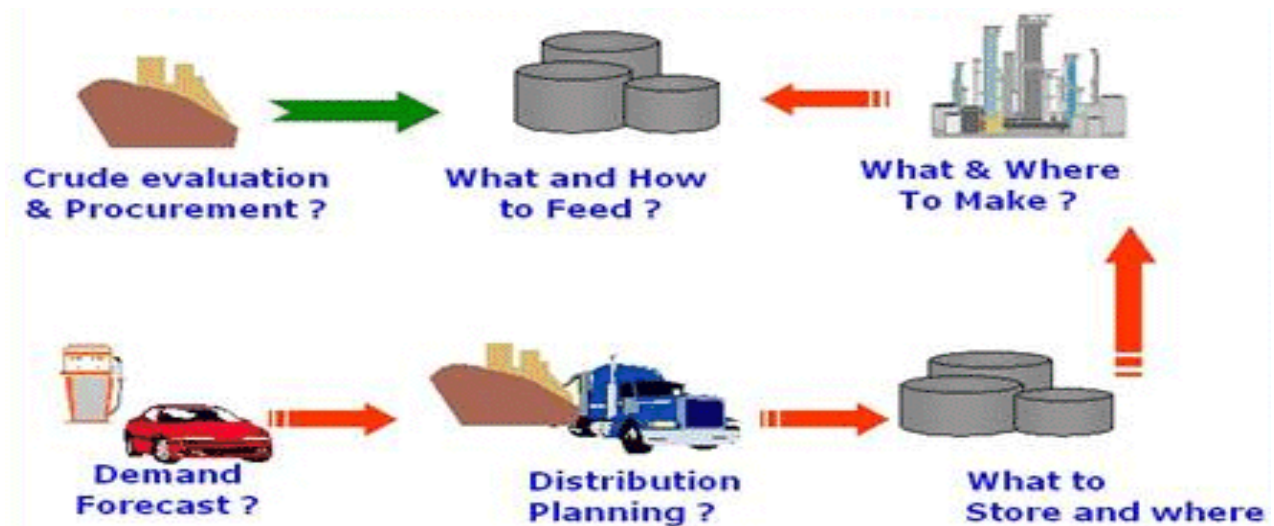
- Finished products are shown in blue.
- Sour waters are derived from various distillation tower reflux drums in the refinery.
- The "other gases" entering the gas processing unit includes all the gas streams from the various process units.

3.3 ROLES AND RESPONSIBILITIES OF OPERATIONS, MAINTENANCE AND THE SUPPLY CHAIN FUNCTIONS WITHIN THE OIL REFINING PROCESS

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materials and sells no products. Figure 3.3 is a basic example of the process flow from raw material to final product and sales to the customer.

Figure 3.3 Example of oil refinery process



3.3.1 Role of the operations function

The operations function within the oil refining process needs to understand the type of crude oil that is being used so as to create and plan the most effective throughput (Total Product Yield) to create the most value for the shareholders. The Total Product Yield (TPY) reflects the value added to each barrel of crude oil processed by the refinery and therefore plays a key role in the return on investment. A number of parameters impact on the TPY, such as reduction of fuel consumed, flare and losses, maximisation of the utilisation of conversion units and optimisation of the finished products' blending, among other parameters. The TPY is calculated by the operations function on a monthly basis using data from the refinery's material balance.

Secondly, the operations function also needs to understand the risk that exists within the different multi-streams and within the streams the risks within all of the equipment because of the different types of equipment used.

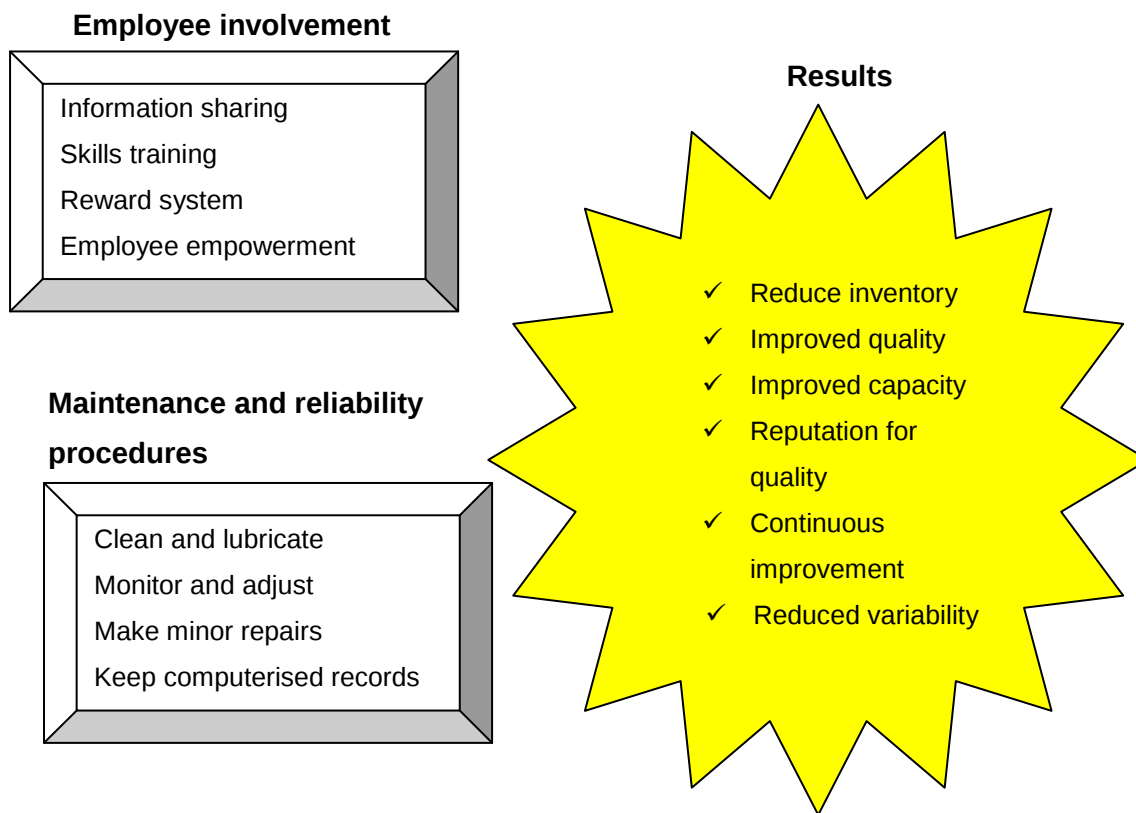
3.3.2 Role of the maintenance function

The role of the maintenance function is the understanding of the risk identified within all of the equipment and at all times the prevention and avoidance of the failure of equipment by implementing maintenance strategies to mitigate the risk. If failure cannot be prevented, it can be disruptive, inconvenient, wasteful and expensive. If failure on machines and productivity happens frequently, it would reduce the plant reliability with an effect on the business' operational throughput, reputation and profitability. The plant downtime will cause the workforce to idle, customers might want to go somewhere else because of non-delivery, and in the long run, losing customers will lead to profits being turned into losses.

"The objective of maintenance and reliability is to maintain the capability of the system." (Heizer, J. & Render, B. 2008:670).

For any piece of equipment or machine to be reliable and function properly for a specific time under certain conditions, proper maintenance must be done as planned and when needed. The planned maintenance must at all times include activities to keep the system's equipment in working order. According to Heizer *et al.* (2008:670), the interdependency of operator, machine, and mechanic is a hallmark of successful maintenance and reliability. As Figure 3.4 illustrates, it is not only good maintenance and reliability procedures that make operations successful, but also the involvement of the organisation's employees as well.

Figure 3.4 Good maintenance and reliability strategy requires employee involvement and good procedures



Source: Heizer and Render (2008)

3.3.3 Role of the supply chain function

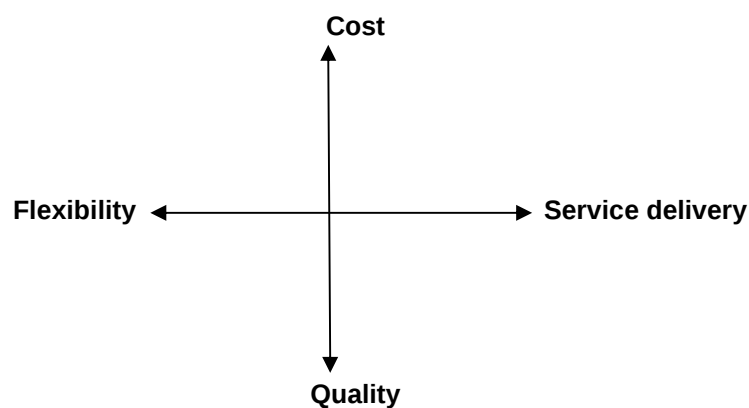
“At the most fundamental level, operations and supply management is about getting work done quickly, efficiently, without error, and at a low cost. Operations function refers to the processes that are used to transform the resources employed by a firm into products and services desired by customers. Supply refers to how materials and services are moved to and from the transformation process of a firm.” (Jacobs, et al. 2009:4).

The supply chain function, together with the operations function (maintenance and plan reliability), is about understanding the risk created within all of the equipment and supports the maintenance strategies to ensure the effective supply of material and services. Together they should focus on strategies that are developed to set broad policies and plans for using the resources of a company to best support the organisation’s long-term competitive strategy.

The supply chain function strategy to move materials and services should always focus on the following four elements in order to effectively support the maintenance strategy:

- Quality
- Service
- Cost
- Flexibility

It is always about a trade-off and / or balance between the four competitive dimensions:



According to Jacobs *et al.* (2009: 22-24), these four major competitive dimensions form the competitive position of a company.

3.3.3.1 Quality

Quality within the supply chain is about getting the right material or service as required by the end-users (plant). There are two characteristics of a product or service that define quality: design quality and process quality. Design quality relates to the set of features the product or service contains. The goal in establishing the proper level of design quality is to focus on the requirements of the customer. Process quality relates directly to the reliability of the product or service. The goal of process quality is to produce defect-free products and services.

3.3.3.2 Service delivery

Service delivery within the supply chain is all about systems being in place to be able to supply material and services “just in time”.

Delivery reliability within the operations and supply chain functions is the cornerstone of the company's strategy and success.

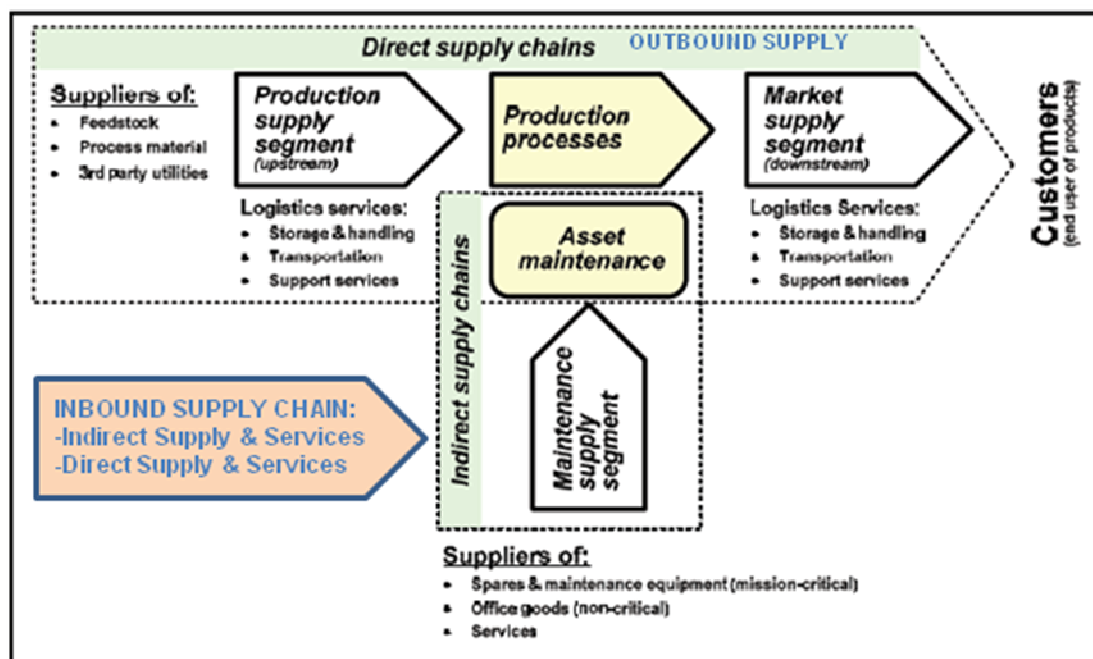
3.3.3.3 Cost or price

The focus of the supply chain is to deliver the material and services in the most cost effective way. This will include buying direct and indirect material at the approved quality, service and the best price.

3.3.3.4 Flexibility

Flexibility refers to the supply chain's ability to obtain a wide variety of products, material and services for its end users and transformation process.

Figure 3.5 Focus of indirect and direct supply chains



Source: Adapted from i2 Technologies (2001)

Within the indirect supply chain is the replenishment strategy to support the maintenance strategies. The replenishment strategy is a combination of supply (warehouses), demand (buyers) and procurement (contracts).

3.4 THE PROCESS USED BY THE OPERATIONS FUNCTION TO IDENTIFY THE RISK FOR ALL THE EQUIPMENT IN THE DIFFERENT MULTI-STREAMS

A process exists to specify steps to ensure that all foreseeable risks on the refinery site are proactively identified, mitigated and managed to acceptable levels on a continuous basis. The process focuses on:

- The methodology of performing risk assessments on identified aspects or hazards.
- The process for evaluating the refinery risk levels involved.
- The ranking of risks to establish priorities for complementing the necessary risk control measures that will prevent potential harmful occurrences.
- The means employed to set realistic and measurable objectives in respect of significant risks.

The process reviews these risks as part of a comprehensive risk management programme and, where required, establishes the required risk financing structures.

3.4.1 Plant risk impact analysis

In refineries and processing plants, the enormous amount of piping is more complex in distribution than other types of equipment. In general, compared with other types of equipment in these industries, more difficulty in inspection planning is encountered. However, under-inspection or over-inspection can occur due to the lack of jurisdictional requirements on the inspection interval and method for piping, or the inspection interval being based only on piping service classifications in the existing regulations, such as API 570. This can result in unacceptable risks, along with a costly loss in resources.

Currently, the method used by the refinery to do the necessary analysis on the plant to identify possible plant risk and the possible impact thereof is called Process Hazard Review (PHR). PHR is a hazard identification and risk assessment technique originally developed for reviewing existing operations in production, storage or transportation. The objective for PHR is to identify

significant process-related hazards and to confirm that adequate measures for prevention, control and mitigation are in place and being effectively applied.

The PHR technique was designed to be thorough while optimising the time and effort required for busy operations staff. There is considerable time, and hence cost, savings for existing processes when compared to other related techniques, such as the Hazard and Operability (HAZOP) study. The streamlined review methodology utilises the experience gained from the existing operation, rather than a new design for which the HAZOP study (Refinery PHR Report (2004:1) was developed and remains the preferred methodology.

PHR concentrates primarily on the potential for loss of containment events and subsequent hazards such as fire, explosion, toxic effects or environmental impact. The focus of PHR is on significant health, safety and environment (HSE) issues, screening out minor safety, operational, equipment damage or quality issues. However, this may be changed to focus just on both health and safety, or on major accidents to the environment.

PHR provides a structured approach making use of both 'what-if' and 'checklist' techniques for hazard identification. It has been used for a wide range of process plants, and together with other techniques such as auditing, it is effective for plants covered by major hazard legislation (e.g. the major hazards directive 'Seveso II' in Europe and OSHA 1910 Process Safety Management in USA). This is presented in the format of a risk assessment and identifies:

- a potential hazardous event associated with loss of containment;
- the causes of the hazardous event;
- the consequences of the event;
- details of any safeguards that either reduce the likelihood of the event occurring, or mitigate the consequences;
- details of any concerns/recommendations identified by the PHR team; and
- a risk ranking for any improvement actions in accordance with the refinery's risk matrix and word models.

The findings from the refinery PHR were prioritised using the refinery's PHR risk matrix (refer figure 3.6). This is a 7X7 matrix. It is frequency ranked from *highly unlikely* at 1/100,000 years (1) to *frequently* at 10/yr (7). Severity is ranked in

accordance with a series of word models covering financial impact, safety and health, environmental, or legal impact. For the purpose of this PHR, only the safety and health and environmental ranking criteria were used. Safety and health were ranked from first aid injury (1) to more than 100 fatalities (7). The risk matrix is colour coded into high, medium and low risk bands with a weighted aversion towards high consequence events.

The PHR was performed on the whole refinery, which included the Alkylation, Butamer, and LPG Merox Plants, Distillate Hydrocracker, Hydrogen Unit, Carbon Dioxide Recovery Plants, Fluidised Catalytic Cracker (FCC), Despatch Area, RCD, SRU and Sulphide Plants, Off-site Area, Unifiner and Platformer Area, PPU4, Diesel Unifiner, and Utilities.

The PHR findings were presented in the form of a risk assessment and identified:

- a potential hazardous event associated with loss of containment;
- the causes of the hazardous event;
- the consequences of the event;
- details of any safeguards that either reduce the likelihood of the event *occurring*, or mitigate the consequences;
- details of any concerns/recommendations identified by the PHR team; and
- A risk ranking in accordance with the Natred risk matrix and word models.

From the PHR performed on the whole of the refinery, the following risk matrix was compiled based on the top 20 risks of the refinery (refer Figure 3.6). For the purpose of this study, risk number 5 was identified to demonstrate the supply chain strategy supporting operations and maintenance processes (refer Table 3.1).

Although, for the purpose of this study, we will only focus on risk number 5 to explain the process, each of the specific actions listed in the PHR report should be addressed by the company.

Figure 3.6 Refinery top 20 risks

Refinery Top 20 Risks							Impact Category	Weight Number	Impact Severity	Financial Impact (R)	Safety & Health	E
8	9	10	11	12	13	14	A	7	Catastrophic	> 500 mil	More than 100 fatalities	I
7	8	9	10 3	11 1, 2	12	13	B	6	Very Critical	100 mil - 500 mil	More than 10 fatalities	
6	7	8	9 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,	10 4, 5, 6, 7	11	12	C	5	Critical	10 - 100 mil	More than one fatality	V
5	6	7	8	9 19, 20	8	11	D	4	Major	1 mil - 10 mil	One fatality	S
4	5	6	7	8	9	10	E	3	Medium	100 000 K - 1 mil	Lost workday case	I
3	4	5	6	7	8	9	F	2	Minimal	10 000 K - 100 000 K	Medical treatment/ Restricted workday case	M bo i
2	3	4	5	6	7	8	G	1	Insignificant	0 - 10 000 K	First aid/ No injury	In b
1	2	3	4	5	6	7	Weight Number					
N	M	L	K	J	I	H	Probability Category					
Highly Unlikely	Unlikely	Not during lifetime of operation (Rare)	Once in operation lifetime (Low Likelihood)	Once in ten years (Can Happen)	Once per year (Likely)	More than once a year (Frequently)	FREQUENCY INTERVALS					

Source: Refinery PHR Report (2004:1), Rev 1

Table 3.1 Risk nr. 5 PHR top 20 risks identified for refinery

5.	27. J 17010 A & B Debutaniser Product Pumps	27.1 Seal failure	Solids in the liquid being pumped, such as FeS and Hydrates.	Potential UVCE resulting in extensive damage to plant and potential fatality.	Currently only single mechanical seals in place, but project underway to replace these with double mechanical seals on pumps with high pressure alarms on seal failure. Water spray deluge system installed above pumps.	C5	J5	10	Install double mechanical seals.
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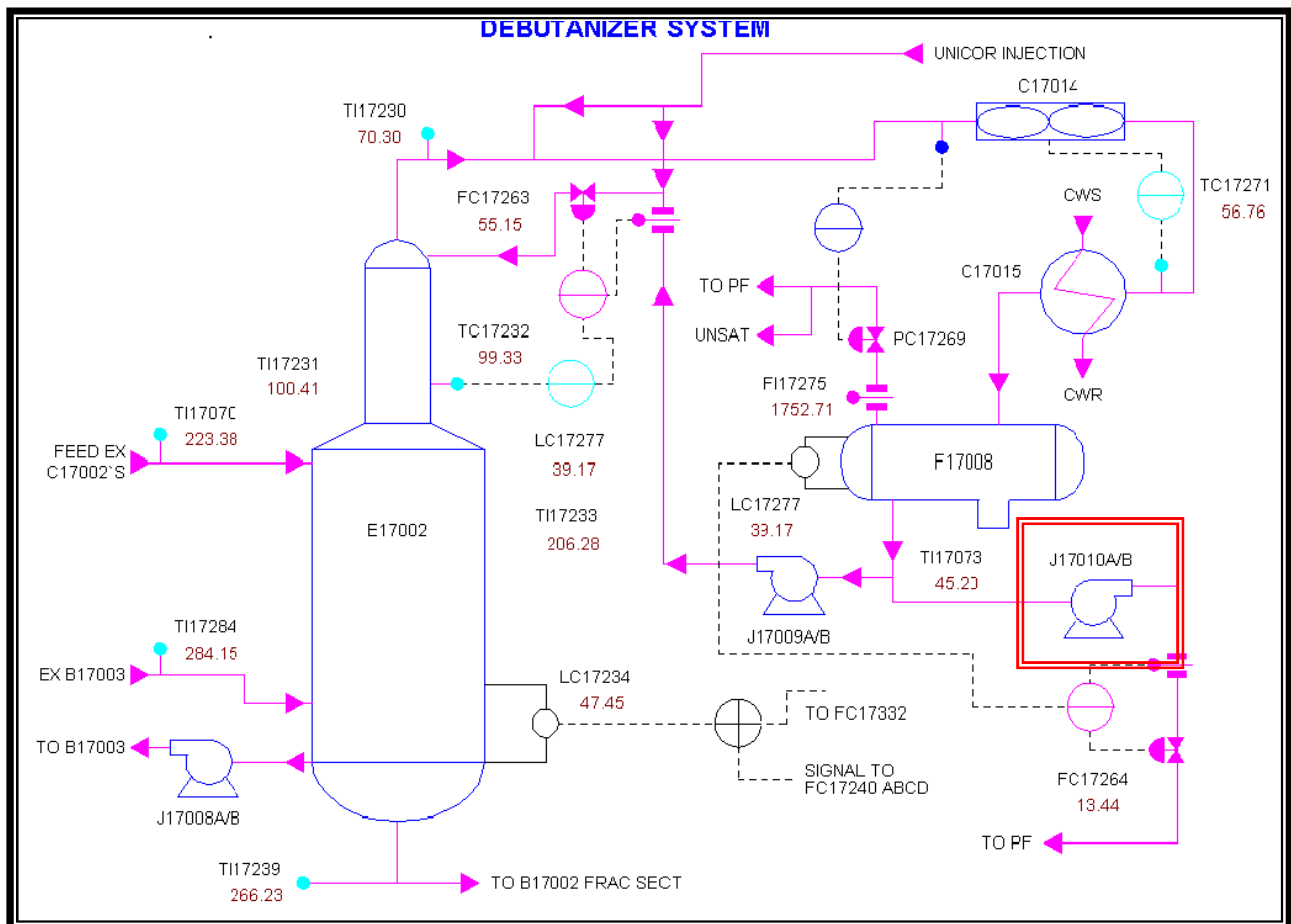
Source: Refinery PHR Report (2004:1), Rev 1

Risk number 5 from the PHR assessment was on equipment J17010 A & B, the Debutaniser Product Pumps. The purpose of this piece of equipment in the plant is to pump solids from one area of the plant to another area of the plant (refer Figure 3.7). If the equipment fails, the impact is critical and it will lead to the shutting down of the total plant and potential fatality. The risk that was identified was failure of the mechanical seals, which will lead to gas leaks in that specific area of the plant where equipment J17010 A & B had been installed.

On the risk matrix, risk number 5 was rated as follows:

Impact severity	C5	Impact critical
Frequency / Probability	J5	Once in ten years
Risk value	10	Financial impact can be between R10 million to R100 million
Health and safety		More than one fatality
Environment		Very serious long-term reversible impact on regional level
Legal		May lose plant operating permit provisionally

Figure 3.7 Debutaniser system



Source: Refinery Site Information. AspenTech (2000-2001)

The “Top 20” list approach (Refinery PHR Report (2004:1) is quite old and currently the refinery is busy reviewing its risk assessments. It was suggested that a good look should be taken at the risks with a fresh eye and to then decide what is significant. The “Top 20” philosophy is very flawed because sometimes risks that are ignored have the ability to resurface unexpectedly. A better approach is that one should look at all the risks and start to work on them on a priority basis. The further the risks are to the bottom left-hand corner on the matrix, the lower priority they are. The further to the upper right, the higher they are. This should eliminate the “Top 20” risk thinking.

3.4.2 The strategy followed by the supply chain function to understand, support and mitigate the risk created

As mentioned in section 3.2, together with the operations and maintenance functions, the supply chain function must at all times try to prevent and avoid failure of equipment. The operations function operates on designed parameters, whereas the maintenance function puts strategies in place to assist the operations function and to mitigate risks. The supply chain function's responsibility is to support and assist with the mitigation as and when risks do occur.

Whenever a problem or potential problem is detected, changes are instituted to methods, procedures, work instructions, specifications, standards, modifications to equipment or by installing equipment to prevent the recurrence of a specified deficiency in the product / service or occurrences that may affect product quality, or to correct unsafe or unhealthy conditions.

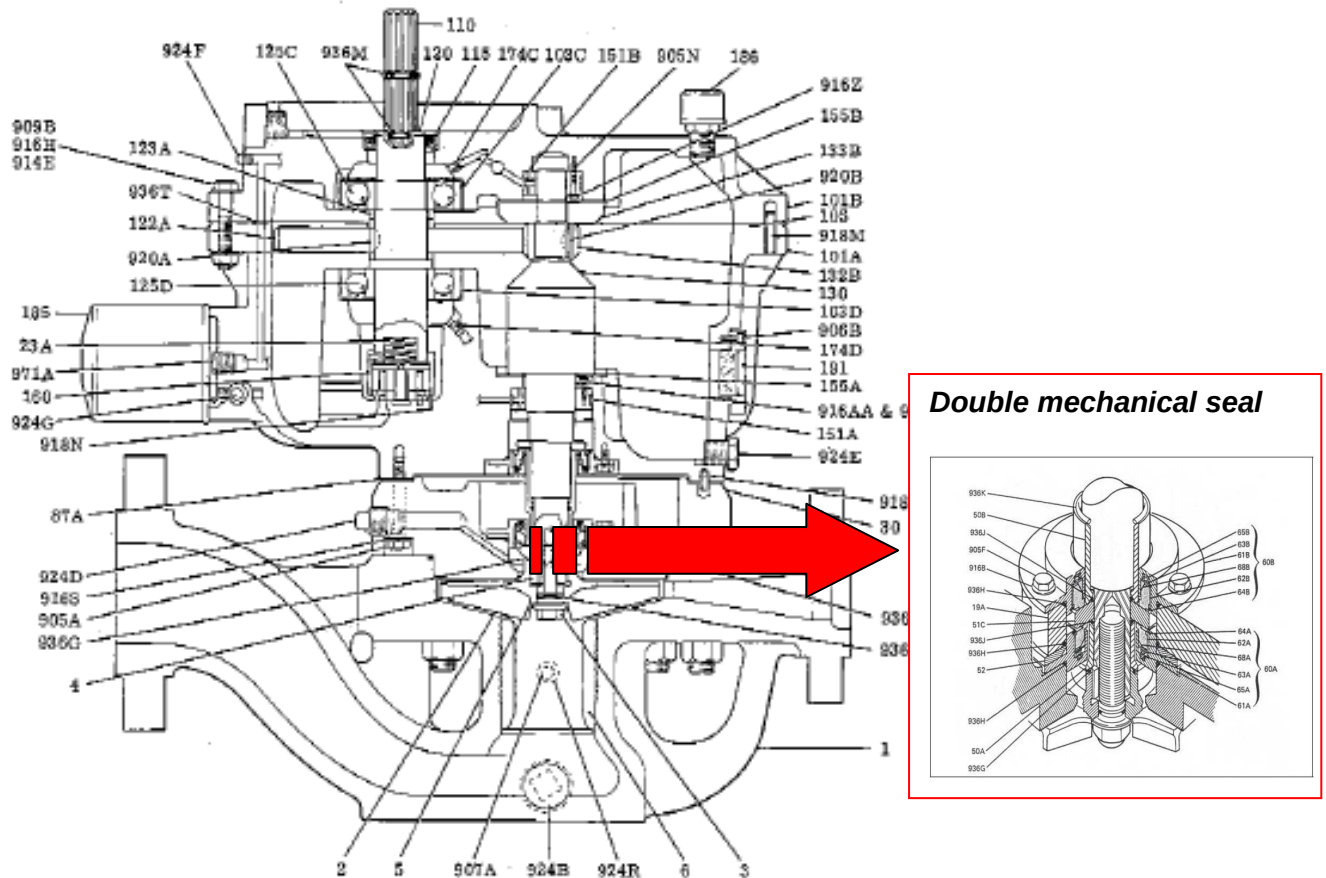
Although the PHR assessment identifies risks in all areas of safety, health, environmental, legal, financial and impact, what role should supply chain's play? As per the risk assessment (refer Table 3.1), the reason for possible failure of equipment J17010 A&B, the Debutaniser Product Pump, is that currently only single mechanical seals are in place. The recommendation made to reduce the risk is to replace these with double mechanical seals on pumps with high pressure alarms on seal failure (refer Figure 3.8). If the first mechanical seal fails, there is a second seal to prevent any leaks from happening.

What is the strategy followed by supply chain to understand, support and mitigate the risk created by the failing of the single mechanical seal?

There is an existing project spares policy (Refinery Project Spares Policy: 2005) within the refinery that provides the necessary guidelines on how to regulate all project spares that are part of a specific project and that should become part of maintenance spares where a stock evaluation process will be applied. The process must include all parties, namely the vendor, the research and development supplier, the warehouse, engineering (end user), and commercial and financial services. The main aim of the process is to prevent unnecessary

investment in stock and manage the risk created from the plant equipment to avoid duplications of materials in the material master.

Figure 3.8 Equipment J17010 A & B



ITEM NO.	DESCRIPTION	QTY.	ITEM NO.	DESCRIPTION	QTY.
1	Pump Casing	1	101B	Gearbox Housing (Input)	1
2	Impeller	1	103C	Bearing Liner	1
3	Impeller Bolt	1*	103D	Bearing Liner	1
4	Impeller Key	1	105	Housing Gasket	1
5†	Impeller Tab Washer	1*	110	Interconnecting Shaft	1
6	Inducer Housing	1	115	Shaft Seal (Gearbox)	1*
23A	Spring, Lube Pump	1	120	Low Speed Shaft	1
30	Seal Housing	1	122A	Spur Gear	1
87A	Gasket	1	123A	Shaft Spacer	3
101A	Gearbox Housing (Output)	1	125C	Bearing, Radial Ball	1

Source: Sundyne LMV-322 Pumps Instruction and Operation Manual (2009:6)

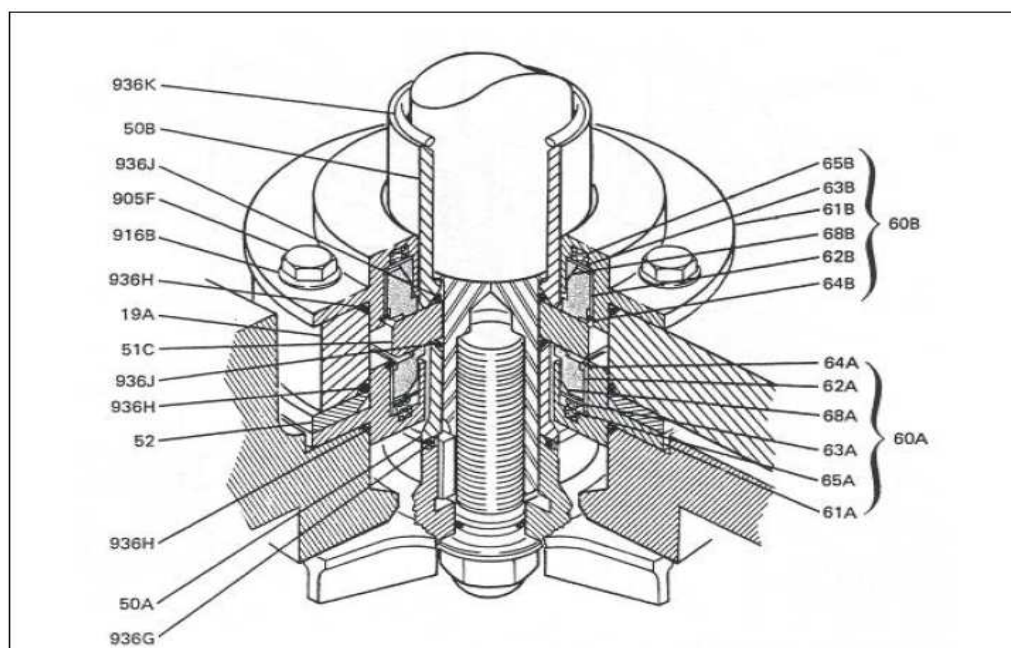
The moment the R & D supplier and the refinery decide to embark on a project, the R & D supplier starts with a “Request for Quotation” process for the project to be able to identify the two- to four-year maintenance spares and equipment needed for the project. The R & D supplier must ensure that an agreement exists with the vendor to supply maintenance spares.

As soon as an official purchase order has been created by the R&D supplier per equipment, the R & D supplier will ensure that the vendor will, within 30 days after the main order is placed, supply them with a completed *Spare Parts and Interchangeability Record (SPIR)* (refer to Annexure 1) with all relevant information regarding the recommended maintenance spares, including the following:

- Pricing (will act as an official quotation)
- Lead time for each item
- Recommended spares
- Full description of spare parts and equipment
- The same terms, conditions and clauses will be valid and applicable as for the refinery orders
- The SPIR form shall be submitted to the R & D supplier no later than 30 days after the main equipment for the project is ordered by the contractor.

As per Figures 3.8 and 3.9, the double mechanical seal was provided with a spare list from the supplier, which indicates each individual component the pump consists of. Each component is allocated with an individual spare part number for future identification, should these parts need replacement.

Figure 3.9 Double mechanical seal



Item Name	Part Name	Qty.	Item Name	Part Name	Qty.
19A	Seal Retaining Spacer	1	60B	Mechanical Seal (Upper)	1*
50A	Shaft Sleeve (Lower)	1	61B	- Retainer & Drive Sleeve Assy.	1
50B	Shaft Sleeve (Upper)	1*	62B	- Seal Face Washer	1**
51C	Seal Rotating Face	1*	63B	- Seal Spring Backup disc	1**
52	Seal Spacer	1	64B	- Seal Retaining Ring	1**
60A	Mechanical Seal (Lower)	1*	65B	- Seal Spring	6**
61A	- Retainer & Drive Sleeve Assy.	1	68B	- Seal Wedge Ring***	1**
62A	- Seal Face Washer	1**	905F	Hex Head Cap Screw	3
63A	- Seal Spring Backup Disc	1**	916B	Washer	3
64A	- Seal Retaining Ring	1**	936G	O-Ring Packing	1*
65A	- Seal Spring	6**	936H	O-Ring Packing	3*
68A	- Seal Wedge Ring***	1**	936J	O-Ring Packing	2*
			936K	O-Ring Packing	1*
* Recommended Spare Parts ** Recommended Seal Space Component Parts *** Specific to Type 9AB Seal Design					

Source: Sundyne LMV-322 Pumps Instruction and Operation Manual (2009:6-2)

The R & D supplier will register the SPIR form and forward a copy of the SPIR and the project order to the warehouse within 14 days after delivery, but a minimum of six months prior to the delivery of equipment to the site. The R & D supplier shall ensure that the SPIR is completed in full (as per procedure requirement) and correctly before sending it to the warehouse. With each specific project, the R & D supplier shall supply a *Work Breakdown Structure Element (WBS)*.

As soon as the warehouse receives all the SPIRs and a copy of project orders from the R & D supplier, the warehouse will register it in the SPIR control register to control and keep record of each SPIR. The warehouse must check for materials that already exist in the material master to prevent any doubles. The existing material number must be applied on the SPIR; these items should not be purchased if they are already a stock item.

Where no material numbers exist in the material master, the material requirement planner shall, with assistance from the MRP Evaluation Document (Annexure 2) and the area engineer, decide on what to stock and what quantities to stock. It is of critical importance to do the necessary investigations and calculations before buying and increasing your stock.

Although all new material will be coded according to a standard coding system, the MRP controller should try to code as much stock as possible as non-stock,

depending on the risk, sourcing strategy and availability. The focus once again should always be on preventing unnecessary investment in stock; the risk will determine which purchasing strategy to apply per commodity. After the warehouse has completed the SPIR list, the plant area engineer is responsible to confirm the correctness of the technical data information supplied by the warehouse. For each new material commodity, as per the SPIR list, stock requests need to be created and approved by the divisional manager.

Finally, purchase requisitions will be created by the warehouse and a copy of each SPIR and project order will be sent to demand for placing of a refinery order via the computerised system (SAP). On delivery of the goods, the normal receipt procedures will be applicable. Engineering and supplier should assist the warehouse with final inspection of the goods delivered, if possible or applicable, to prevent possible duplications and to create standardisation. Start-up spares must be part of maintenance spares and must be taken into account.

Taking all of the above into account and referring to the risk identification of the specific equipment now installed into the plant, how does supply chain on the one hand support the operations and maintenance strategy and on the other hand try to prevent unnecessary investment in stock, taking into account the risk?

3.5. REPLENISHMENT STRATEGY SET-UP IN SUPPLY CHAIN IN SUPPORT OF OPERATIONS AND MAINTENANCE FUNCTIONS

For all existing and new material created and warehouse movements, the MRP controller will apply the *MRP Evaluation Document for Existing and New Commodities* (refer Annexure 2). The main focus of the current replenishment strategy within the supply chain function is:

- To understand the risk the equipment, or any part within, creates when failing.
- The cost associated with the supply of such a part.
- The availability of the part or any alternative to support and maintain the equipment when failing.
- The usage patterns of such a part and unit of supply.

The following logic is followed and questions asked:

Question 1 Register new material commodity

Requestor	JOE SOAP	Date: 27/08/2010
Signature		
Commodity Number	10 - 02 - 171	
Full Description of Commodity		
Seal: Mech 1-1/4 x 1-1/2 T8AB Double / X51F		
☐ Exist	☒ New	☒ Link to BOM ☒ YES ☐ NO

When the stock request form is completed by the requestor, the MRP controller and the end user will complete the MRP evaluation document. This enables the MRP controller to build up a history base on all material commodities and related equipment on the plant. It is critical that a full description is provided to ensure that correct material and parts are bought in future. If drawings exist, they should also form part of the description.

In both existing and new material commodities, the next important question to ask is whether the material commodity has been linked to a Bill of Material (BOM)? All spare parts should belong to a piece of equipment in the plant. If not, the question should be asked as to whether it should be in the system. If the answer is still yes, the end user will compile a BOM from the above spare list received from the supplier and capture the information in SAP (refer Figure 3.10).

What is the purpose of a BOM?

Jacobs *et al.* (2009:593) noted that the BOM file contains the complete product descriptions, listing not only the materials, parts, and components, but also the

sequence in which the product is created. It contains all the information to identify each item and the quantities used per unit of the item of which it is a part (Jacobs, Chase, & Aquilano, 2009:593-595).

Figure 3.10 Bill of material for equipment J17010 A&B

Equipment	J17010A	Valid from
Description	DEBUTANISER OVERHEAD PUMP	
▼ J17010A	DEBUTANISER OVERHEAD PUMP	
▼ 10-P2-212	J17010A+B	
▼ 10-02-I01	FLUID SIDE	
10-02-117	GEARBOX: COMPL 8400 RPM SPLINED INPUT	
10-02-008	IMPELLER: 5,487";LMV322	
10-02-062	WASHER: TAB IMPELLER	
26-02-203	O-RING: 13/16"X1-3/16"X3/16"; BUNA	
26-02-046	O-RING: 5/8"X13/16"X3/32";BUNA;PARKER	
26-01-184	SHAFT SEAL: GEARBOX PART: 20-019	
16-05-015	FILTER: OIL FOR GEARBOX LMV322 (**KT**)	
10-02-167	BARRIER: GASKET TH;J-11020 A/B	
26-06-034	GLASS: SIGHT CIRCULAR; 44X4; PYREX	
10-02-002	SHAFT:INTERCONNECTING ITEM 110;S/NO 2520	
26-02-297	O-RING: 1-3/8"X1-9/16"X3/32" 2-126 VITON	
▼ 10-02-I02	MECHANICAL SEAL	
10-02-148	SHAFT SLEEVE UPPER TANDEM DOUBLE SEALS	
10-02-171	MECH:SEAL 1-1/4 X 1-1/2 T8AB DOUBLE/X51F	
10-02-009	BUSHING: THROTTLE LMV322/311 P/NO BU02AA	
10-02-028	SLEEVE:SHAFT LOWER TANDEM SEAL	
10-02-149	SLEEVE: SHAFT LOWER DOUBLE SEAL	
10-02-074	KIT: REPAIR O-RING	
10-02-154	GASKET: THERMAL BARRIER;P/NO GK01AA02;LM	
10-02-012	SEAL: MECH 1-1/2 T8AB XP151K1/SP-SP=F150	

Important for both warehouse and end user is to at all times keep the information on existing BOMs up to date, for the purpose of creating and maintaining a catalogue for the ordering of correct materials and quantities to apply Available to Promise (ATP) and to be able to do a proper risk assessment for the spares linked to a piece of equipment.

Currently, the risks and shortcomings identified from a supply chain point of view when the process starts, are:

- Competency of requestor for registering commodity. The descriptions forwarded to the warehouse are not 100% completed or specifications are incorrect because the requestor does not understand the material or

equipment he / she is working with. The requestor sometimes asks the suppliers to send him / her a scope of work / specification, which is then captured in the system. The supplier writes the scope of work according to his / her specifications, which causes a preferred supplier situation, making the supply chain very rigid. This makes it difficult for the supply chain function to put proper sourcing strategies in place and this might result in duplications of the same material to be kept in the warehouse.

- Another risk is that the person in the warehouse who receives the request to register new commodities does not understand the process. Incorrect information is captured, which can cause equipment failure.
- When new commodities are registered, the check is not done from the warehouse to ensure that it is linked to a BOM. After 35 years of existence, only 35% of equipment spares are linked to BOMs.

Question 2 Evaluation criteria for existing stock commodities (A)

A. EVALUATION CRITERIA FOR EXISTING STOCK COMMODITIES			
A.1	Purchase price	> R5,000	ACTUAL R 23 459
A.2	Period not being used	> 2 Years	3.5 Years
A.3	Demand patterns	From: Units / Mth To: Units / Mth	Δ = Units / Mth
A.4	Current stock levels	Max Min	

Commodity requires further investigation ☒ YES ☐ NO

Because of the large quantity of existing active material commodities (± 21000) currently in SAP, it does not make sense to evaluate each commodity every time movement takes place.

Therefore, if the MRP controller comes across a commodity where the:

- a) Price > R5,000 **or**
- b) Period not being used > 2 years **or**
- c) Change in demand patterns

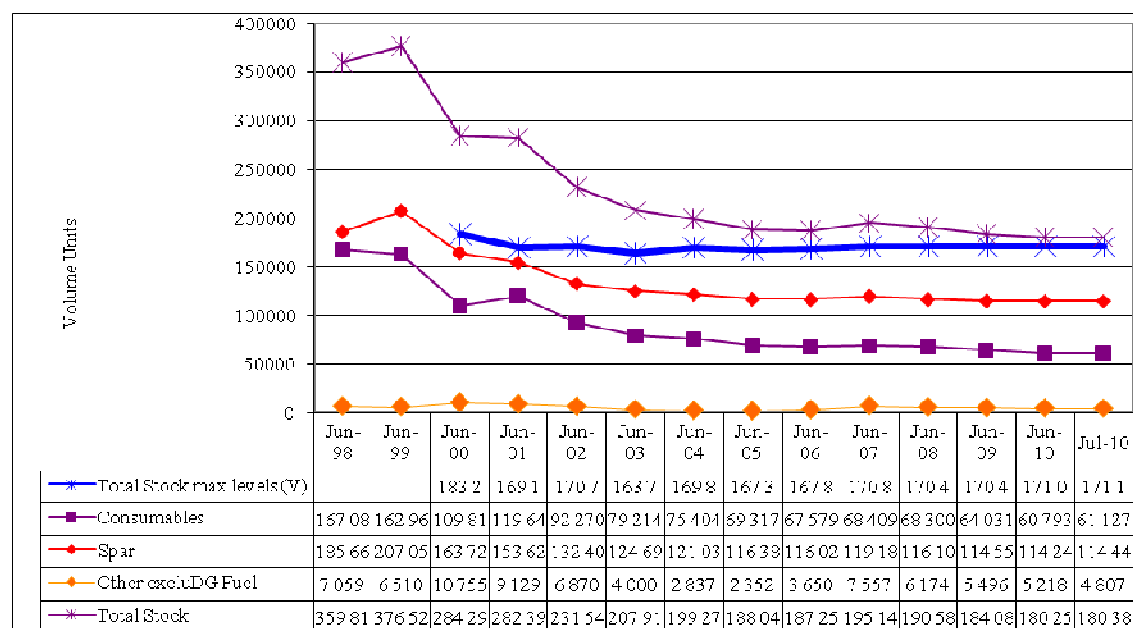
The question should be asked whether the commodity requires further investigation, and whether the current stock levels are still relevant.

The risks pertaining to this part of the evaluation are:

- The timing and reaction are too long when receiving the request; currently it is rather a reactive than a proactive process.
- The MRP controller spends too much time on non-critical material instead of focussing on maintenance and critical stock. The non-critical material should be managed through an automatic MRP system.

This should become part of the MRP controller's health checks. The evaluation process is working, but it should be streamlined again.

Figure 3.11 Stock volume trends 1999-2010



Source: Refinery Stock Maintenance Report (2010)

As per Figure 3.11 in the past 10 years, stock volumes decreased from 359 817 units to 180 380 units. This is due to the constant evaluation done when movement takes places in stock.

3.5.1 Risk profile of equipment (B)

As discussed in section 3.5.1, all spare parts with commodity numbers should be linked to a BOM, which is linked to existing equipment in the plant. For the purpose of this study, we refer back to the risk matrix (refer Figure 3.6) and risk number 5 (refer Table 3.1) to demonstrate the determination of the supply chain strategy by completing the MRP evaluation document (refer Annexure 2). The equipment number in this example is **J17010 A/B**.

The risk rating (B1) information will be obtained from the PHR assessments done on equipment and where the risk is plotted on the risk matrix (refer Figure 3.6).

Question 3 Risk Profile of Equipment

Equipment number	J17010A		
B.1 Risk rating:			
Consequence	C5	Frequency	J5
Financial impact	R10-R100m		
Notice period when needed (MTTR)	3 Days		
SHERQ impact	☒ YES		
Description	Fatality		

The importance of capturing this information on the MRP evaluation document is that anyone dealing with the commodities relating to this equipment from the supply chain will better understand the risk and impact of not having the correct

material when needed. This is currently done manually. A priority should be to implement this evaluation system electronically to ensure it is in time.

The second important aspect under the risk profile of the equipment is the availability of the equipment (B2).

Question 4 Availability of Equipment

B.2 Availability of equipment	
Equipment required for maintenance	☐ Planned / Breakdown ☒ Anytime
Number of equipment where commodity is used	2
Number required for normal operation	1
Equipment number	J17010A J17010B
Alternative equipment / standby	Yes Equipment number J17017A/B

This information will assist the supply chain to understand when equipment is available if maintenance needs to be done and on which other equipment/s the relevant material commodity is used. The criticality of the equipment in the plant will determine if maintenance can only be done on planned maintenance, i.e. every four years for shutdown or is the equipment available anytime? The equipment can be removed from the process any time of the day for maintenance purposes.

As per the example above, the information indicates that the same commodity is used on four different pieces of equipment of which only two of the four pieces of equipment are on line. This means that there are two spare pieces of equipment currently in the plant. If one of the two that are currently running needs to be stopped, there will be no impact on production, because the refinery can switch over to one of the surplus pieces of equipment to perform the necessary repairs

and then switch back to the equipment being repaired. All the equipment numbers are also provided to be able to identify immediately if and when it is necessary to stop and switch over.

The third important aspect is the maintenance strategy (B3) to ensure availability of equipment J17010A at all times.

Question 5 Maintenance Strategy

B.3 Maintenance strategy

- ☒ **Run to Failure**
- ☒ **Scheduled Maintenance**
- ☒ **Condition Monitoring**

As mentioned in section 3.2, the importance of doing maintenance and having a maintenance strategy in place, is to ensure that all activities take place as planned to keep a system's equipment in working order. If proper maintenance takes place, it is probable that a machine part or product will function properly for a specified time under stated conditions.

However, because it is the real world and failures and breakages do occur, it is important to understand why it does happen. This is a main contributor to sustainability and reliability. According to Heizer and Render (2008:672), component reliability is often a design or specification issue for which engineering design personnel may be responsible. However, supply chain personnel also have a role to play in this. Their role is to be able to improve on the quality of components of systems by staying aware of products and research in the market and doing proper supplier performance evaluations on a regular basis, especially the critical suppliers.

According to Heizer and Render (2008:672), the basic unit of measure for reliability is *the product failure rate (FR)*. For a refinery company that needs 24/7 365 days plant reliability, it is essential to often provide failure-rate data. The

failure rate measures the percentage of failures among the total amount of equipment / part failures, or a number of failures during a certain period of time, FR(N).

$$FR(\%) = \frac{\text{Numbers of failures}}{\text{Number of units tested}}$$

$$FR(N) = \frac{\text{Numbers of failures}}{\text{Number of unit-hours of operation time}}$$

The more common terminology used for reliability analysis is **mean time between failures (MTBF)**, which is the expected time between a repair and the next failure of a part, machine, process or product.

$$MTBF = \frac{\text{Numbers of failures}}{\text{Number of unit-hours of operation time}}$$

If the failure rate is too high, then the decision will have to be taken to either increase the reliability of the individual parts, or the company will have to invest in backup parts / equipment to provide redundancy.

The MTBF for equipment **J17010A** and when the mechanical seal caused the failure was calculated as follows, according to history available (refer Table 3.2):

Table 3.2 MTBF equipment J17010A

Order	Bas. start date	Description	Days
11910	1997/01/08	RECON 1002117;PM 11150;GEARBOX COMPLETE	
142321	1999/12/23	REPAIR LEAKING MECHANICAL SEAL	1079
167021	2000/07/19	REPAIR J17010A MECH SEAL	209
232666	2002/05/24	REPAIR SEAL	674
244993	2002/11/05	PLEASE REPAIR SEAL FLUSH LINE(STRAP)	165
316864	2004/11/06	DISMANTLE & OVERHAUL PUMP	732
448923	2008/11/27	REPAIR SEAL LEAK ON J17010A	1482
MTBF			723.5

There are generally two types of maintenance:

Preventative maintenance, which involves routine inspections and servicing, to keep facilities in good repair. The intention of preventative maintenance is to build a system that will identify potential failures and make changes or repairs that will prevent failure. The system should also include the design of technical and

human systems that will keep the productive process working with tolerance. How does the company get to this point? By understanding the process and keeping it working without interruption (Heizer, & Render, 2008:674).

Breakdown maintenance is when individual parts / equipment fail and must be repaired on an emergency or priority basis. This is the position that no company wants to find itself in, because it is very expensive and the response is reactive the whole time (Heizer, & Render, 2008:674).

The maintenance strategy currently applied in the refinery focuses on a planned maintenance process. Planned maintenance consists of work identification, planning and scheduling, conditioning monitoring, work execution and review, and materials management, followed by preventative maintenance. Without these very basic layers, asset management has no foundation. According to the American Petroleum Institute (API) Standard 610 2004:16, the equipment covered by this international standard shall be designed and constructed for a minimum service life of 20 years (excluding normal-wear parts) and at least three years of uninterrupted operation. It is recognised that these requirements are design criteria and that service or duty severity, misoperation or improper maintenance can result in a machine failing to meet these criteria. Operations and maintenance of the refinery take all of this into account and according to all of the information available to them, they will make decisions on what maintenance strategies should be applied to the equipment to ensure availability at all times.

According to the third important aspect of the MRP evaluation document, maintenance strategy (B3), the basic strategies followed by maintenance are:

a) Run to failure

This strategy will be applied to material that can be used until it breaks. Referring to the BOM (refer Figure 3.10), the majority of the material commodities for equipment J17010A are categorised under this strategy because of the availability of the material as well as the surplus equipment J17010B also contributes to this decision. Examples of material are the washers, gaskets, O-Rings, seals etc. There is time to replace the failed material without having any impact on the plant availability.

b) Scheduled maintenance

Some of the parts in the equipment cannot run to failure because of the importance the part plays in the equipment. Referring to the BOM (refer Figure 3.10), material commodity 10-02-117, Gearbox: Complete 8400 RPM splined input is one of the commodities where scheduled maintenance will take place on the oil and filter. According to the operations, equipment and maintenance (OEM) manual, the oil and filter need to be replaced every six months.

During the next planned turn-around and inspection (TI) shutdown (± 4 yearly), the pump will be taken out and sent for reconditioning, where the mechanical seals will be replaced.

c) Condition monitoring

Referring to the BOM (refer Figure 3.10), material commodity 10-02-117, Gearbox: Complete 8400 RPM splined input is one of the commodities where condition monitoring will be done on the bearings on a weekly basis, for example weekly monitoring where a relevant tool will be used to test the vibration of the gearbox. Depending on the results, they will be able to determine if any replacements need to be done.

The risk the supply chain function faces with the capturing of the risk profile of the equipment, is that it gets done properly the first time around, but as time goes on and changes happen, there is no proper management of change process in place to ensure from a plant point of view that all changed information is communicated to the warehouse, For example, when design and strategy changes occur, or when there is a breakdown and it happens outside of the strategy, the questions are not asked.

Question 6 Procurement strategy for material (C)

C. PROCUREMENT STRATEGY FOR MATERIAL		
Availability of stock:	☐ Off the Shelf	Lead time Days
	☐ Manufacture	Lead time Days
	☒ Recondition	Lead time 5 Days

The availability of the material in the market plays an important role in determining the strategy to procure the relevant material. Can the buyer obtain the material?

- New material off the shelf, readily available?
- Is there a drawing and can the commodity be manufactured if required?
- Can the commodity be sent for reconditioning where the current state of the commodity is taken and it is reconditioned back to its original state instead of buying new material?

As soon as the supplier(s) has/have been identified, the geographical area also plays an important role:

- Local
- Overseas
- Sole
- Preferred

Supplier	Rhine Rhure		
	☐ Local	Lead time	Days
	☒ Overseas	Lead time	35 Days
	☒ Sole	Lead time	35 Days
	☒ Preferred	Lead time	35 Days
Alternative comm available	☐ YES ☒ NO	Commodity number	

All of the above has an impact on the lead times – how long it will take the buyer to get the material delivered to the refinery. In the event of a sole or preferred supplier a departmental manager must approve the supplier.

The example used for the purpose of the study is equipment J17010, which is a Debutaniser Overhead Pump and the BOM (refer section 3.10), which is used for this study to explain the supply chain strategy and methodology being applied. The specific equipment was bought from an overseas supplier that has a branch in South Africa, basically for after service support. In most instances, material and parts needed for the pump are ordered from overseas. This supplier is also a sole supplier and therefore material and parts cannot be bought from any other supplier. The lead time for an overseas supplier to deliver is on average 4-6 weeks, therefore varying between 35 to 42 days

The risk in this area of the MRP evaluation process is that the current supply chain function infrastructure is not suitable to deal with the day-to-day workload to be able to put proper procurement strategies in place – normally this gets done by a whole project team. The impact of this is resource shortages and existing contracts not being maintained and updated.

Another short-coming is that there are no proper partnership agreements and portfolios in place, especially on critical suppliers. Some of the suppliers also find it difficult to move from a sales environment to stockholding and warehouse functions. For example, when supply chain approaches the supplier to implement consignment stock or vendor-held stock, they cannot from their side provide consumption reports or MRP reports.

Question 7 Demand for material (D)

D DEMAND FOR MATERIAL			
Unit of issue	Each	Minimum once-off usage	1
Mean time between failure commodity	24 months		
Shelf life	20 years	Criticality A/B/C	A

Because of this, in most of the material commodities, one will be kept as a spare part in the warehouse. Because of the availability of spare pumps, it is not deemed necessary to increase the stock levels. According to the American Petroleum Institute (API) Standard 610 2004:16, the equipment covered by this international standard will be designed and constructed for a minimum service life of 20 years (excluding normal-wear parts) and at least three years of uninterrupted operation. Figure 3.12 is the recommendation from API Standard 610 on how to determine stock levels.

Another option, other than the API Standard 610, that the maintenance department uses to determine stock levels is based on the history of failure of the equipment and the movement of the material.

The shortcoming in this part of the process is that the unit of issue and unit of receiving differ, causing stock differences and making reporting difficult. This could lead to the reporting of wrong figures. This should be investigated immediately by the warehouse personnel when they come across the problem.

Figure 3.12 Recommended spare parts

	Number of identical pumps (<i>n</i>)						
	1 to 3	4 to 6	≥ 7	1 to 3	4 to 6	7 to 9	≥ 10
Recommended number of spare parts							
Part	Start-up			Normal maintenance			
Cartridge ^{b, e}				1	1	1	1
Element ^{b, f}				1	1	1	1
Rotor ^{c, g}				1	1	1	1
Case ^a							1
Head (case cover and stuffing box)							1
Bearing bracket ^a							1
Shaft (with key)				1	1	2	<i>n</i> /3
Impeller				1	1	2	<i>n</i> /3
Wear rings (set) ^h	1	1	1	1	1	2	<i>n</i> /3
Bearings, complete (rolling element, radial) ^{a, i}	1	1	2	1	2	<i>n</i> /3	<i>n</i> /3
Bearings, complete (rolling element, thrust) ^{a, i}	1	1	2	1	2	<i>n</i> /3	<i>n</i> /3
Bearings, complete (hydrodynamic, radial) ^{a, i}	1	1	2	1	2	<i>n</i> /3	<i>n</i> /3
Bearing pads only (hydrodynamic, radial) ^{a, i}	1	1	2	1	2	<i>n</i> /3	<i>n</i> /3
Bearings, complete (hydrodynamic, thrust) ^{a, i}	1	1	2	1	2	<i>n</i> /3	<i>n</i> /3
Bearing pads only (hydrodynamic, thrust) ^{a, i}	1	1	2	1	2	<i>n</i> /3	<i>n</i> /3
Mechanical seal / packing ^{d, h, i}	1	2	<i>n</i> /3	1	2	<i>n</i> /3	<i>n</i> /3
Shaft sleeve ^h	1	2	<i>n</i> /3	1	2	<i>n</i> /3	<i>n</i> /3
Gaskets, shims, O-rings (set) ^h	1	2	<i>n</i> /3	1	2	<i>n</i> /3	<i>n</i> /3
Add for vertical pump:							
Bowls						<i>n</i> /3	
Spiders or spider bushings (set)			1	1	1	<i>n</i> /3	<i>n</i> /3
Bearings, bushings (set)	1	1	2	1	1	<i>n</i> /3	<i>n</i> /3
Add for high speed integral gear:							
Gear box		1	1	1	1	1	<i>n</i> /3
Diffuser and cover	1	1	1	1	1	1	<i>n</i> /3
Splined shaft	1	1	1	1	1	1	<i>n</i> /3
Gear box housing				1	1	1	<i>n</i> /3
Oil pump, internal		1	1	1	1	1	<i>n</i> /3
Oil pump, external		1	1	1	1	1	<i>n</i> /3
Oil filter	1	2	<i>n</i> /3	1	2	3	<i>n</i> /3

^a Horizontal pumps only
^b Vital-service pumps are generally unspared, partially spared or multistage. When a vital machine is down, production loss or violation of environmental permits results.
^c Essential-service pumps are required for operation and have an installed spare. A production loss occurs only if main and spare fail simultaneously.
^d Cartridge-type mechanical seals include sleeve and gland.
^e Cartridge consists of assembled element plus discharge head, seal(s) and bearing housing(s).
^f Element consist of assembled rotor plus stationary hydraulic parts [diffuser(s) or volute(s)].
^g Rotor consists of all rotating parts attached to the shaft, except the half-coupling.
^h Normal-wear parts (see 5.1.1).
ⁱ Per pump set.

Source: American Petroleum Institute (API) Standard 610 (2004:85)

Question 8 Recommendation (E)

E
RECOMMENDATION

☐ No Change
☐ Redundant
☐ No Stock

☐ Non Stock
☒ Stock
☐ New
☐ Recon
☐ Spares

☒ Complete

☐ Level Change

Max
Min

☐ Cost Impact

If an evaluation was done on an existing commodity and all aspects were re-evaluated, then the “*No Change*” option will be chosen and the MRP evaluation document will be filed. It might also be determined through the evaluation that because of no movement, the commodity actually became redundant, maybe the equipment got replaced by something else or the material and spares are no longer needed. The “*Redundant*” option will be taken and the necessary *Disposal forms* will be completed and approved via the financial department. After approval, all the relevant BOMs and Material Master also need to be changed accordingly to ensure information is always up to date. The physical material needs to be removed from the bin and sent for selling through the disposal procedure.

The question can still be asked, even if material was made stock previously, can't it be changed to non-stock. The whole situation might have changed in usage and the market and now the opportunity might exist to move it to non-stock.

As per section 3.5.2, if there was a change in the usage patterns then a re-evaluation will be done by the MRP controller as to why the situation changed. The question should be asked if this is only a once-off or was new equipment using the same commodity implemented etc. The financial impact should also be calculated in the case where the levels should be reduced or increased.

In the instance where new equipment has been installed with new commodities created, taking into account all the relevant information captured regarding the equipment, i.e. risk, what it is used for etc., a sourcing strategy needs to be developed and implemented.

The recommendation on equipment **J17010A** will therefore be as follows:

Scenario 1 Current situation

Equipment J17010A was identified as one of the top 20 risks in the refinery. The critical impact and financial impact (between R10m and R100m) can become a reality if the equipment fails. It was identified that the single mechanical seal can cause the pump to fail; therefore the recommendation is that the single mechanical seal be replaced with a double mechanical seal. Because of the

spare capacity in the plant when equipment J17010A fails, the switch-over will be to equipment J17010B.

Because of the probability of failure of 24 months (refer to Table 3.2), in the event of a failure the usage is one double mechanical seal with a cost implication of R4,500 with availability off the shelf within 24 hours. The sourcing strategy would be to put a contract in place with the local supplier to keep stock specifically for the refinery and with service delivery of 24 hours for when the commodity is needed.

Scenario 2 Demonstration of an alternative scenario

In the event where equipment J17010A was identified as one of the top 20 risks of the refinery, but no other equipment is available as spare, then the recommendation of the sourcing strategy will be different from scenario 1. The scenario will require a proper material sourcing strategy to support and mitigate the risk.

The critical impact and financial impact will be the same as Scenario 1 (R10-R100m), and because of the probability of failure of 24 months (refer to Table 3.2) and no back up pump available, the recommendation would therefore be to keep stock on site 24/7.

There is no systematic approach from the MRP controller pertaining to the recommendations section of the evaluation. Currently, decisions are based on experience of people, gut feel, and no proper facts. The risk of this is that when an individual leaves, the experience leaves with him / her. Systems are built on people and are therefore not sustainable.

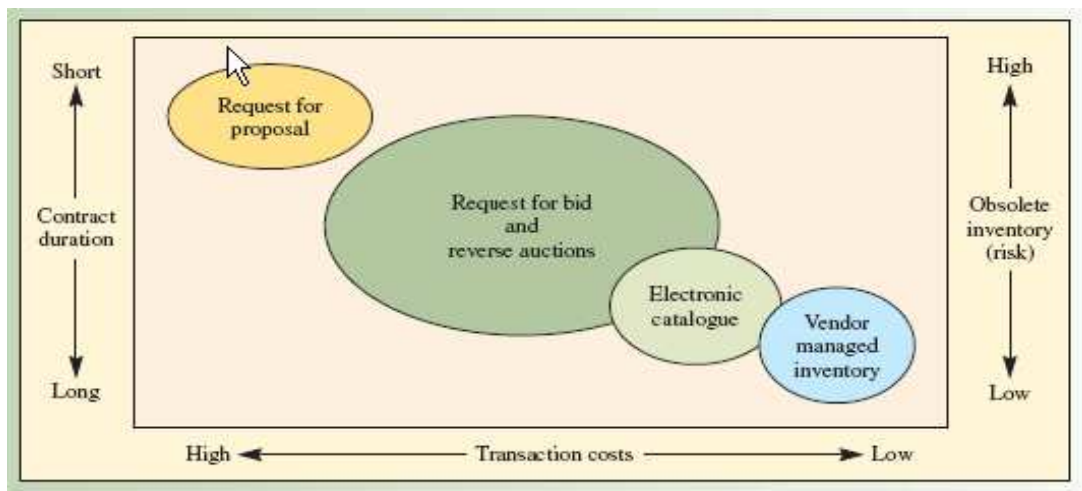
3.5.7 Sourcing strategy (F)

According to Jacobs *et al.* (2009:374), procurement is responsible for developing a strategy for procuring the items that a company needs to acquire. Depending on factors such as the cost of the item, volume required, and scarcity, many different processes can be used by the company.

Question 9 Sourcing Strategy

F SOURCING STRATEGY	
Non stock	☐ Contract ☒ Lead Time ☒ Vendor Held Stock ☒ Consignment Stock
	☐ RFQ
Stock	☐ Contract ☒ Lead Time ☒ Vendor Held Stock
	☒ RFQ

Figure 3.13 Sourcing / Purchasing – System design matrix / framework



Source: Jacobs, Chase, & Aquilano (2009)

The procurement function focuses on items where there is some type of ongoing relationship and there is usually a contract with special pricing, delivery and other arrangements designed to coordinate the interaction between the two companies. In Figure 3.13, the sourcing / purchasing system design matrix for major types of processes can be used:

a) Request for proposal

Used for significant purchases where there may be a few prospective suppliers. The proposal will list the criteria for that which the company wanted done, as well as dates for completion. Suppliers interested in performing the work would be required to respond to the proposal by a

particular date. The company would select a supplier and execute a contract to the purchase.

b) Request for bid and reverse auctions

Companies often use this approach when they have a set of similar or related items that they would like to purchase. The company would prepare a document that describes the parts, which includes engineering drawings, production schedules and other pertinent details. A site visit is arranged to meet with potential bidders and answer questions related to the purchase.

c) Electronic catalogue

This method is designed to reduce transaction costs and make the interface between the supplier and the company more efficient.

d) Vendor managed inventory

This is when the supplier takes full responsibility for a group of items needed by a customer. The supplier would monitor inventory levels of the items at the customer site and automatically replenish based on usage. The process can be very efficient and relieves the customer of the work involved in managing the items on a daily basis.

Strategic sourcing looks beyond the traditional transactional view of purchasing. Instead, strategic sourcing focuses on all strategies and objectives and translates them into actionable strategies that address all elements of the sourcing processes. When properly implemented, strategic sourcing will be effective, because the company will have:

- Company-wide purchasing power;
- Vast majority of purchasing done under contract;
- Rationalised vendor and part options, managed at a strategic level;
- Supplier partnerships that reduce inventory levels and speed products and services to the market;
- Efficient processes that reduce transactional costs; and

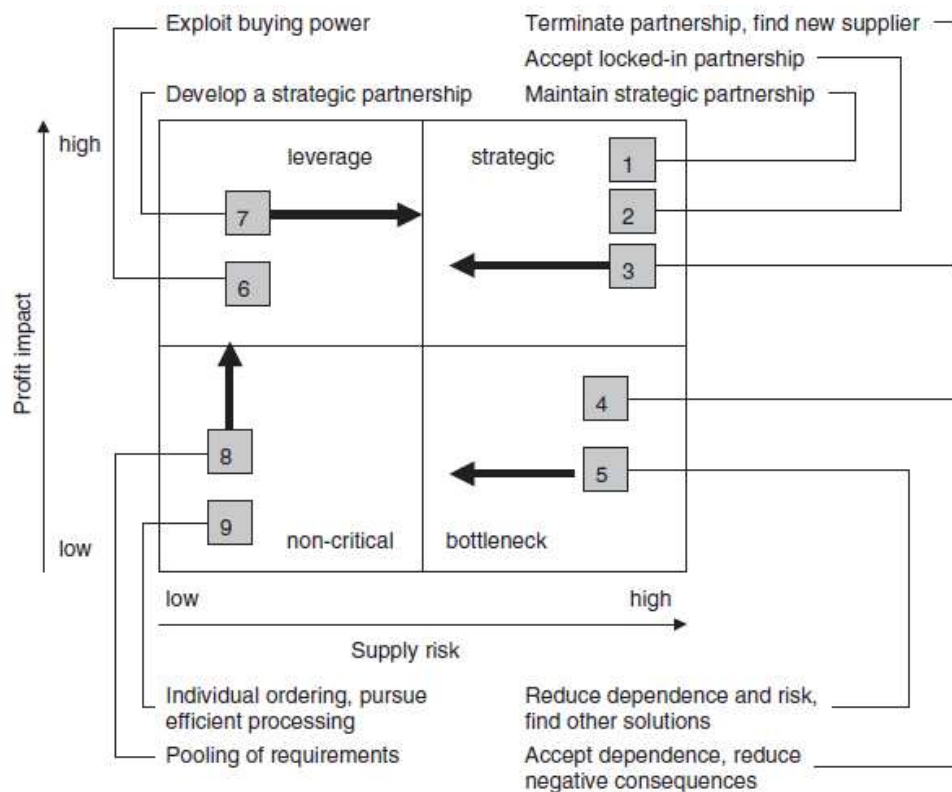
- Better configuration of the value chain with inbound and outbound suppliers.

Strategic sourcing is a business optimisation process that highlights, qualifies and quantifies the value added resulting from constantly looking for a better way of doing things. What would the typical objectives of the strategic sourcing process for the refinery be?

- Establish the refinery as the industry leader in procurement supply management practices and processes;
- Create financial advantage by delivering the lowest total cost and highest value for commodities produced;
- Fully implement financial advantage as an internal metric for commodity management;
- Optimise business, technical and commercial practices;
- Challenge existing processes continuously for ongoing improvement;
- Organisation wide networking and relationship building;
- Tracking and measurement systems with high integrity; and
- Raise the level of understanding commodities and factors influencing them.

One of the strategies the company is focussing on is the price containment strategy. This strategy depends on the volatility of the market factors influencing the commodity or service. Secondly, it will depend on the type of supplier being used or identified.

Figure 3.14 Kraljic purchasing strategy matrix



Source: Caniels and Gelderman (2005)

The four areas that the supply chain focuses on as per the above purchasing strategy are:

- Strategic suppliers – High spending / Critical to business**
The supply chain strategy that the refinery applies to this category is to focus on the top-ten suppliers, for example a supplier that is managing the shutdowns, waste management removal supplier, scaffolding suppliers etc.
- Critical suppliers / Bottleneck – Lower spending / Critical to business**
Under this category, the suppliers are still critical, but with lower spending. Typical contracts that will be put in place will be, for example, licence agreements for production-related software etc.
- Leverage suppliers – High spending / Not as critical to business**
Two strategies can be applied to leverage suppliers, namely:
 - Annual RFQ process
Only one-year contracts are awarded.
 - Term contracts

Two- to three-year contracts with spot market price checks are advisable.

Under this category, there are many suppliers available in the market and a cost containment strategy will be applied to control prices. A contract will be put in place to eliminate the RFQ process, for example bearings, gaskets etc.

d) Spot suppliers – Low spending / Not as critical to business

Spot purchases can be made via the RFQ process where three quotes have been obtained. Because of volumes, as with leverage suppliers, short-term contracts can be granted where volume allocation will be based on the most beneficial pricing structure.

Contracts will still be the advisable option because of the high volumes; it will reduce the workload on the buyer's side. Examples include stationary, cleaning services, safety equipment etc.

After the sourcing strategy has been determined, the MRP controller will recommend which strategy will be best to follow for supporting maintenance to have the material available at all times.

In this area, there are lost opportunities on small commodities, because there is no system to currently support the workload that needs to be done to perform a proper evaluation. There are still opportunities for the bigger commodities.

Question 10 Recommended warehouse

G	RECOMMENDED WAREHOUSE	
MRP Contr	John Smith	Date: 30/08/2010
Signature		

All documentation and SPIR forms will be sent back to the area manager, engineering and manager supply and demand for the necessary approval.

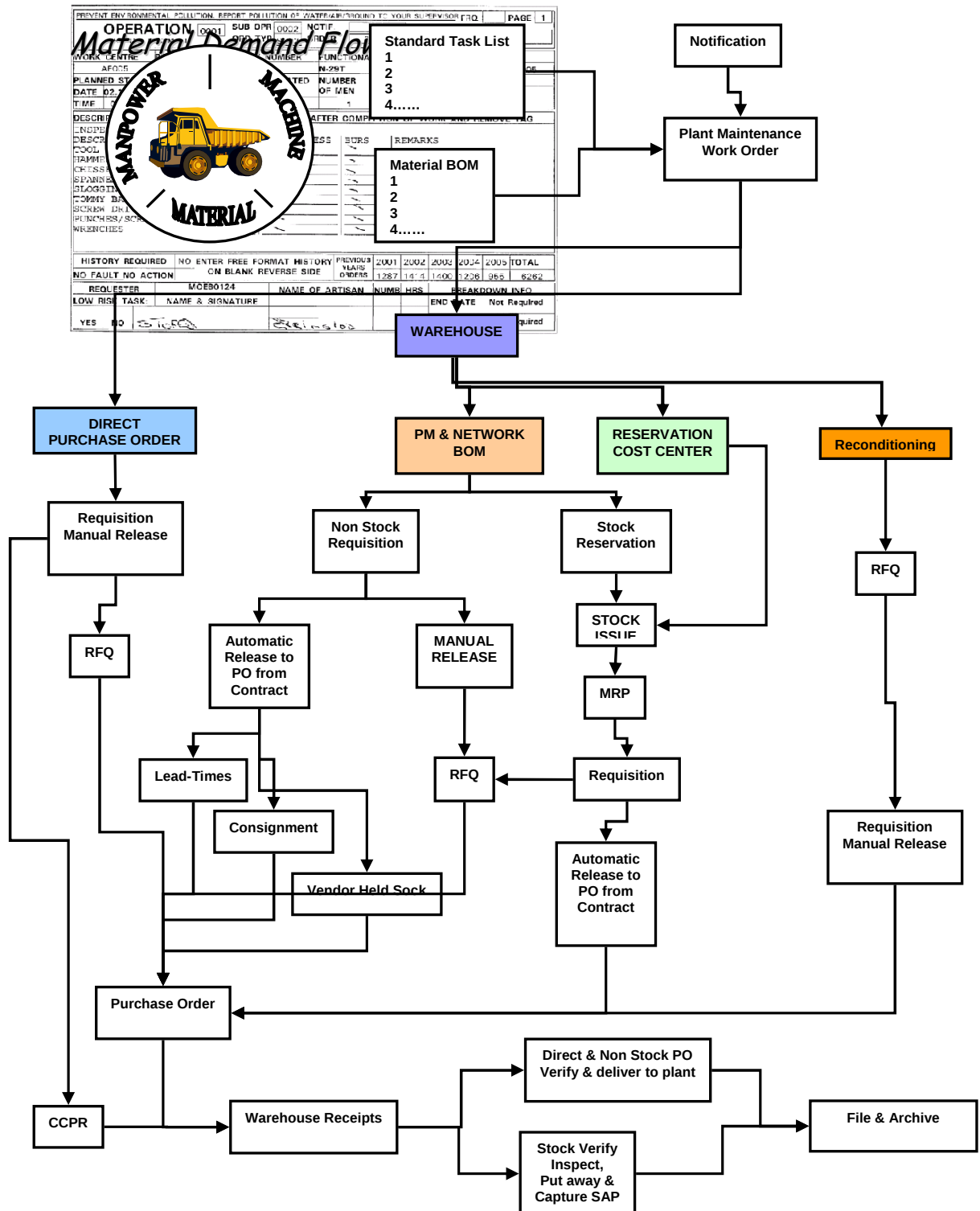
Question 11 Approval end-user

H	APPROVAL END-USER	
As per ASAM	Suzie Browny	Date: 30/08/2010
Signature		
Manager S & D	Casper Osmond	Date: 30/08/2010
Signature		

Figure 3.15 is the demand flow process currently applied by the refinery based on the information gathered through the MRP evaluation document.

Figure 3.15 Material demand flow

Source: Refinery Supply Chain Process (2009)



3.6 Supply chain and infrastructure

According to Simchi-Levi *et al.* (2008:79), the physical supply chain consists of suppliers, plants, warehouses, distribution centres, and retail outlets as well as raw materials, work-in-process inventory and finished products that flow between the facilities. For the purpose of this study, the focus is only on the inbound supply chain, which will include the suppliers, plants and warehouses.

The focus should be on the process by which the company structures and manages the supply chain in order to:

- find the right balance between inventory, transportation and manufacturing costs;
- match supply and demand under uncertainty by positioning and managing inventory effectively; and
- utilise resources effectively by sourcing products from the most appropriate manufacturing facility.

According to Simchi-Levi *et al.* (2008:79), it is useful to divide the network planning process into three steps:

a) Network design

This includes decisions pertaining to the number, locations and size of manufacturing plants and warehouses, the assignment of retail outlets to warehouses, and so forth.

b) Inventory positioning

This includes identifying stocking points as well as selecting facilities that will produce to stock and keep inventory, and facilities that will produce to order and keep inventory.

c) Resource allocation

Determine whether production and packaging of different products are performed at the correct facility. What should the plant's sourcing strategies be? How much capacity should each plant have to meet seasonal demand?

The supply chain infrastructure needs to be re-evaluated on a regular basis due to changes in demand patterns, product mix, production processes, sourcing strategies, or the cost of running facilities. The focus should be on:

- Determining the appropriate number of facilities, such as plants and warehouses;
- Determining the location of each facility;
- Determining the size of each facility;
- Allocating space for products in each facility;
- Determining sourcing requirements; and
- Determining distribution strategies – the allocation of customers to each warehouse.

The objective of the above, according to Simchi-Levi *et al.* (2008:80), is to design or reconfigure the logistics network in order to minimise annual system-wide costs, including production and purchasing costs, inventory holding costs, facility costs, and transportation costs, subject to a variety of service level requirements.

Over the past 10 years, half of the volume of all material was reduced. The important focus should be on critical and insurance material and your infrastructure strategy should be aligned with that. The reason for having warehouses is to have the critical and insurance stock readily available to the plant.

Currently, some of the warehouses are full, which can cause a safety risk as well as making it difficult to get to the stock when needed to be issued to the plant. The reason for shortage of space is because of non-stock items being kept for the plant, which was not planned for. Non-stock items have been put there without the involvement of the warehouse. This happened because of poor access control. In the past, one store master was situated at the bottom warehouses, but because of the slow movement of the material and the shortage of resources at the main warehouse, the store master was moved back to the main warehouse. Because the warehouse is not situated at the entrance gate, it poses another risk. When deliveries take place, they should go to the main warehouse. In many instances, the supplier delivers directly to the plant, which then results in

deliveries not being captured into the system, material not being inspected and delivery notes and invoices getting lost, which delays payment to suppliers. Another safety risk is that hazard identification in the warehouse environment is only performed every three years. If a proper MOC system is not in place when new equipment is installed or changes are made to infrastructure, the risk exists that the hazard identification list is not updated, which can lead to serious accidents or incidents. Another risk currently is that warehouse personnel do not completely understand the total business and the impact of their actions on the business. Not all of them understand the importance of each part kept as stock and the role it plays in the plant.

3.5 Governance / Legislation

“Corporate Governance is concerned with holding the balance between economic and social goals and between individual and communal goals...the aim is to align as nearly as possible the interest of individuals, corporations and society.”
Cadbury (1999)

Corporate Governance in South Africa was implemented by the publication of the King Report on Corporate Governance in November 1994 (Executive summary of the King Report: 2002). The purpose of the document is:

- to establish a comprehensive supply chain policy that will promote effective and efficient practices and systems;
- to support the refinery's vision;
- to comply with the seven characteristics of corporate governance as determined by the King Commission on Governance in South Africa; and
- to implement, monitor and integrate the day-to-day supply chain activities.

The seven characteristics of good corporate governance as per the King Report are:

Discipline

Corporate discipline is a commitment by a company's senior management to adhere to behaviour that is universally recognised and accepted to be correct and

proper. This encompasses a company's awareness of, and commitment to, the underlying principles of good governance, particularly at senior management level.

Transparency

Transparency is the ease with which an outsider is able to make a meaningful analysis of a company's actions, its economic fundamentals and the non-financial aspects pertinent to that business. This is a measure of how good management is at making necessary information available in a candid, accurate and timely manner – not only the audit data, but also general reports and press releases. It reflects on whether or not investors obtain a true picture of what is happening inside the company.

Independence

Independence is the extent to which mechanisms have been put in place to minimise or avoid potential conflicts of interest that may exist, such as dominance by a strong chief executive or large shareowner. These mechanisms range from the composition of the board, to appointments to committees of the board, and external parties such as the auditors. The decisions made, and internal processes established, should be objective and not allow for undue influences.

Accountability

Individuals or groups in a company, who make decisions and take actions on specific issues, need to be accountable for their decisions and actions. Mechanisms must exist and be effective to allow for accountability. These provide investors with the means to query and assess the actions of the board and its committees.

Responsibility

With regard to management, responsibility pertains to behaviour that allows for corrective action and for penalising mismanagement. Responsible management would, when necessary, put in place what it would take to set the company on the right path. While the board is accountable to the company, it must act responsively to and with responsibility towards all stakeholders of the company.

Fairness

The systems that exist within the company must be balanced in taking into account all those that have an interest in the company and its future. The rights of various groups have to be acknowledged and respected. For example, minority shareowner interests must receive equal consideration to those of the dominant shareowner(s).

Social responsibility

A well-managed company will be aware of, and respond to, social issues, placing a high priority on ethical standards. A good corporate citizen is increasingly seen as one that is non-discriminatory, non-exploitative, and responsible with regard to environmental and human rights issues. A company is likely to experience indirect economic benefits such as improved productivity and corporate reputation by taking those factors into consideration.

Supply chain risk management and complying with governance mean taking deliberate actions to shift the odds in the refinery's favour, increasing the odds of good outcomes, and reducing the odds of bad outcomes. The focus should always firstly be to eliminate risk. If the risk cannot be eliminated it must be mitigated. If the risk cannot be eliminated or mitigated, a procedure must be put in place to manage the risk. Continuous review should always be done on the procedures.

The challenge is the understanding of all the risks within the supply chain function.

3.8 Conclusion

The aim of this empirical research chapter was to determine what risks exist in the supply chain function within the oil refining process. To come to a conclusion, it was necessary to look at possible risks within the operations and maintenance functions, and the supply chain function strategies must be in line with the maintenance function strategies.

Conclusions and recommendations will be discussed in Chapter 4.

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

4.1 INTRODUCTION

This chapter will:

- provide conclusions from the research; and
- make recommendations concerning the research.

The aim of this study was to understand how the inbound supply chain fits into the business processes and to identify what the business risks are within the operational, maintenance and supply chain functions. Furthermore, the aim was to determine if there was a proper risk reduction model in place to mitigate risk in the inbound supply chain within an oil refining process. To achieve this aim, the following objectives were set and met:

- Firstly, an overview of supply chain management was provided and the purpose of the research was established. This was done in Chapter 1 by means of a problem statement questioning the opportunity that might exist to contribute to a risk reduction model in the inbound supply chain within an oil refining process.
- Secondly, a literature study was done in Chapter 2 where three different risk management systems were discussed as well as how risk management fits in with the supply chain. The Deloitte Touche Tohmatsu, KPMG Holdings Ltd as well as the Supply Chain Operations Reference Model Strategies and Methodologies were discussed in detail.
- Thirdly, in Chapter 3 the results of the empirical research were reflected upon in order to determine what the risks are and if risk management does take place in the supply chain environment. Operational, maintenance and supply chain function processes were interpreted and possible risk factors that were regarded as important were identified.

4.2 CONCLUSIONS FROM LITERATURE AND EMPIRICAL STUDIES

The following conclusions regarding the research can be drawn:

- Conclusions with regards to the importance of a Risk Reduction Model for risk management and strategies within Supply Chain from the literature study.
- Conclusions with regards to challenges and risks within the Supply Chain process within an Oil Refining Process.

4.2.1 The importance of a risk reduction model for risk management and strategies within the supply chain

The following is regarded as the main conclusions with regard to research objective 1:

- Supply chain strategies cannot be determined in isolation; they are directly affected by the value chain. All supply chain strategies should align with organisation-specific goals at all times (ch.2.1).
- It is challenging to design and operate a supply chain so that total system-wide costs are minimised, and system-wide service levels are maintained. The process to find a system-wide strategy is known as *global optimisation* (ch.2.1).
- Uncertainty and risk are inherent in every supply chain. The focus must always be on the elimination of as much uncertainty and risk as possible as well as dealing effectively with the uncertainty and risk that remain (ch.2.1).
- A situation is risky when it is opened up to two essential components: exposure to an event and the uncertainty of possible outcomes. When you are dealing with a situation that has a certain outcome, the situation is not risky, but when you deal with a situation where the outcome is unknown, then it becomes risky (ch.2.2).
- Factors contributing to supply chain risk are environmental, industry, organisational, problem-specific and decision-maker risks (ch.2.2).
- Six different types of failure modes that cause risk in supply chains are supply, transportation, facilities, freight breaches, communications and demand (ch.2.2).

- The main reason for putting energy and effort into implementing effective and efficient strategies and processes is to increase resilience and efficiency (ch.2.3).

The following conclusions are made from the Deloitte Touche Tohmatsu model of understanding Risk and the value of Flexibility:

- Companies should focus on increasing their levels of integration and globalisation of the supply chain (ch.2.2.1).
- More integrated supply chain structures are more capable to drive out redundancy and leverage network flexibility potential (ch.2.2.1).
- There are two potential strategies, namely managing and reducing supply chain risk, and managing and enhancing supply chain flexibility (ch.2.2.1).
- By managing risk and enhancing supply chain flexibility, there is a clear opportunity for organisations to win in the current uncertain environment, and sustain their supply chains as a critical asset and differentiating factor for success towards the future (ch.2.2.1).
- Network flexibility is about making the hidden flexibility visible, which can include alternative sources of supply, as well as alternative locations to manufacture and to deliver (ch.2.2.1).
- Supply chain integration promotes more optimal and faster decision-making by leveraging the hidden network flexibility (ch.2.2.1).
- Flexibility can be enhanced by investing in additional tooling or assets to enhance product mix flexibility on existing manufacturing assets, by negotiating more flexible labour or supplier agreements, or by investing in lead time reduction efforts (ch.2.2.2).
- Lead time reduction is a powerful lever to reduce risk and rigidity in supply chains and to make them more flexible and responsive (ch.2.2.2).
- In a volatile supply chain environment, regular alignment of planning and service offering policies reduces the risk of experiencing service problems and of carrying excess inventory (ch.2.2.3).
- Supply chain processes have a high potential of contributing to either reducing risk or enhancing flexibility in the business (ch.2.2.4).
- Practices that can improve the value of supply and operational processes are accelerating the supply and operational process, developing multiple demand / supply scenarios, more pro-activeness and collaboration with

customers and suppliers, as well as the incorporation of risk factors (ch.2.2.4).

The following conclusions are made from the KPMG Methodology for Implementing Risk Management:

- Risk management links strategic objectives to risks and controls in order to improve corporate performance, increase transparency, provide an early warning system and enhance business sustainability (ch.2.5).
- The KPMG Risk Management Framework includes strategy, development and prioritisation of risk categories from company's key strategic success factors (ch.2.5).
- The KPMG Risk Management Framework includes risk systematisation, and the identification and classification of risks (ch.2.5).
- The KPMG Risk Management Framework includes assessment and measurement, assessment of likelihood and potential impact as well as continuous monitoring of the risks using key risk indicators (ch.2.5).
- The KPMG Risk Management Framework includes reporting, definition of reporting lines, structure and format, integration in controlling and reporting (ch.2.5).
- The KPMG Risk Management Framework includes mitigation, as well as individual mitigation measurements (ch.2.5).
- The KPMG Risk Management Framework includes roles and responsibilities within the organisation, risk owner, risk controller, and internal audit (ch.2.5).
- The KPMG Risk Management Framework includes internal control, defines and assesses internal controls and integrates internal process controls into mitigation strategies (ch.2.5).
- The KPMG Risk Management Framework includes IT systems, the definition of IT requirements as well as selection and implementation (ch.2.5).
- When implementing a thorough risk management framework, it would focus on planning, risk identification and assessment, the risk management process, and implementation (ch.2.5).
- Risk owners are responsible for periodic reporting (ch.2.5).

- Risk management should be a pivot between internal controls and other assurance functions, such as internal audit (ch.2.5).
- Effective supply chain planning balances demand and supply, and internal and external objectives, all in a constantly changing environment (ch.2.6).
- Decision-making must become fact based. It is no longer appropriate to base decisions and actions only on prior experiences and assumptions (ch.2.7).
- Supply chain decisions are about determining which the right product is, where the right place is and when the right time is (ch.2.7).
- Benefits when focussing on a process is it helps to manage the business compete more effectively, create real improvements, improve multiple areas, improve coordination between teams and it streamline and accelerate business change (ch.2.8).
- A business that has a proactive risk management system in place, efficiently manage business risk, which can then lead to the constitution of value in various areas of business (ch.2.9).
- Any business should first and foremost have a model in place that can prevent or mitigate a risk before it can actually happen (ch.2.9).

The following conclusions are made from the Supply Chain Operations Reference Model:

- SCOR is a process reference model designed for effective communication among supply chain partners. A standard language helps management to focus on management issues (ch.2.10).
- SCOR as an industry standard helps management to focus across inter-company supply chains (ch.2.10).
- SCOR is used to describe (standard SCOR process definitions allow any supply chain to be configured), measure (standard SCOR metrics enable measurement and benchmarking of supply chain performance) and evaluate (supply chain configurations may be evaluated to support continuous improvement and strategic planning) supply chain configurations (ch.2.10).
- SCOR is based on five distinct management processes, namely plan, source, make, deliver, and return (ch.2.10.1).

- Once a complex management process is captured in a standard process reference model form, it can be implemented purposefully to achieve competitive advantage; describe clearly and communicated; measured, managed and controlled; tuned and re-tuned to a specific purpose (ch.2.10).

4.2.2 Challenges and risks within the operational, maintenance and supply chain function within an oil refining process

The following are regarded as the main conclusions with regard to research objective 2:

- Understanding the purpose of the equipment used in the refining processes and the risks identified when the equipment fails by all parties involved, will assist them to be able to develop and implement maintenance and sourcing strategies to mitigate and manage the risks (ch.3.1).
- The plant is made up of multi-streams with a range of individual interrelated streams, each performing a specific process (ch.3.2.1).
- If any part fails to perform, the overall plant will fail and will come to a standstill. The production loss can be disastrous for the plant (ch.3.2.1).

4.2.2.1 The main purpose of the operational function within the oil refining process and possible risks it may encounter

- The operations function within the oil refining process needs to understand the type of crude oil that is being used in order to create and plan the most effective throughput (Total Product Yield) to create the most value for the shareholders (ch.3.3.1).
- The operations function also needs to understand the risk that exists within the different multi-streams and within the streams the risks within all of the equipment because of the different types of equipment used (ch.3.3.1).
- The operations function identifies the possible risks within each piece of equipment. Failure to do so will lead to no transformation of resources into products and services as desired by the customers (ch.3.3.1).

- Currently, the method used to do the necessary analysis on the plant to identify possible plant risk and the possible impact thereof, is called Process Hazard Review (PHR) (ch.3.4.1).
- PHR is a hazard identification and risk assessment technique originally developed for reviewing existing operations in production, storage or transportation (ch.3.4.1).
- The objective of PHR is to identify significant process-related hazards and to confirm that adequate measures for prevention, control and mitigation are in place and are being effectively applied (ch.3.4.1).
- The shortfall of the current method being used is that it is a manual process that is outdated and not in time (ch.3.4.1).
- If the risks are not identified and strategies are not in place, the impact will be a failure to transform resources into products and services desired by customers (ch.3.4.1).
- The “Top 20” list approach is something quite old and currently the refinery is busy reviewing the risk assessments. It was also the risks are re-evaluated closely in order to ascertain their significance (ch.3.4.1).
- The “Top 20” philosophy is very flawed because sometimes risks that are ignored can have disastrous results in the future. A better approach is that one should look at all the risks and start to work on them on a priority basis (ch.3.4.1).

4.2.2.2 The main purpose of the maintenance function within the oil refining process and the possible risks it may encounter

- The role of the maintenance function in support of the operations function, is the understanding of the risks identified within each piece of equipment as well as the prevention and avoidance of the failure of equipment by implementing maintenance strategies to manage and mitigate the risks (ch.3.3.2).
- The objective of maintenance and reliability is to maintain the capability of the system (ch.3.3.2).

- If failure cannot be prevented, it can be disruptive, inconvenient, wasteful and expensive. If failure on machines and productivity happens frequently, it would reduce the plant reliability with an effect on the business' operational throughput, reputation and profitability (ch.3.3.2).
- For any piece of equipment or machine to be reliable and to function properly for a specific time under certain conditions, proper maintenance must be performed as planned and when needed (ch.3.3.2).
- A possible risk if proper maintenance strategies are not in place is failure of equipment, which can cause plant instability, which will affect operational throughput (ch.3.3.2).

4.2.2.3 The main purpose of the supply chain function within the oil refining process and possible risks it may encounter

- Supply chain management implies getting work done quickly, efficiently, without error, and at a low cost (ch.3.3.3).
- The supply chain function, together with the operations function (maintenance and plant reliability), is about understanding risk created within each piece of equipment and supports the maintenance strategies to ensure the effective supply of material and services (ch.3.3.3).
- The supply chain function strategy to move materials and services should always focus on quality, service, cost and flexibility, in order to effectively support the maintenance strategy (ch.3.3.3).
- Quality within the supply chain is about getting the right material or service as required by the end-users (plant) (ch.3.3.3.1).
- Service delivery within the supply chain is all about systems being in place to be able to supply material and services "just in time" (ch.3.3.3.2).
- The focus of the supply chain is to deliver the material and services in the most cost effective way (ch.3.3.3.3).
- Flexibility refers to the supply chain's ability to supply a wide variety of products, material and services to its end-users and also refers to

a transformation process as and when the need changes (ch.3.3.3.4).

- Within the indirect supply chain is the replenishment strategy to support the maintenance strategies. The replenishment strategy is a combination of supply (warehouses), demand (buyers) and procurement (contracts) (ch.3.3.3.4).
- The main risk that can occur if the replenishment strategy is not aligned with the maintenance and operation function strategies, will be failure to deliver on time, sub-standard service delivery, poor quality and not at the most cost effective price, unnecessary investment in stock, and duplications of material (ch.3.4.2).

4.2.2.4 The impact of new and current projects on the replenishment strategy within the supply chain and the oil refining process

- Proper project / spares policy. Although there is a policy in place, it is out-dated and needs to be revised (ch.3.4.2).
- All parties involved do not understand the content of the policy. The APT system is mentioned as a tool that is used to determine stock levels to be kept in the warehouse, but the APT system does not even currently exist (ch.3.4.2).
- All parties involved are uncertain as to what the roles and responsibilities are as stipulated in the policy. From the first planning phase, there should be involvement from the supplier, R&D supplier, warehouse, engineering, commercial and financial (ch.3.4.2).
- Agreement with the supplier regarding pricing, lead times, spares, terms and conditions. There is no consistency and clarity when it comes to supplier selection, evaluation and required induction needed when the supplier needs to come to the site (ch.3.4.2).
- Individual equipment numbers are allocated, but when the start-up spares that need to become part of the stock get delivered to the warehouse, no proper tagging is done. A tag should be put on each piece of material with the project number, equipment number,

individual commodity number and the purchase price must be captured in the SAP system (ch.3.4.2).

4.2.2.5 The replenishment strategy within the supply chain in support of the operational and maintenance strategy and the oil refining process

- The main focus of the current replenishment strategy within the supply chain function is understanding the risk the equipment, or any part therein, creates when failing; the cost of the supply of such a part; the availability of the part or any alternative to support and maintain the equipment when failing; and the usage patterns of such a part and unit of supply (ch.3.5).
- For all existing and new material created and warehouse movements, the MRP controller applies the *MRP evaluation document for existing and new commodities* (ch.3.5)
- When the stock request form is completed by the requestor, the MRP controller, together with the end-user, completes the MRP evaluation document to build up a history base on all material commodities and related equipment on the plant. It is critical that a full description is provided to ensure that correct material and parts are bought in future (ch.3.5.1).
- The end-user will compile a BOM from the spare list received from the supplier and capture the information in SAP (ch.3.5.1).
- The BOM file contains the complete product descriptions, listing not only the materials, parts and components, but also the sequence in which the product is created (ch.3.5.1).
- Shortcomings that exist when registering new equipment can include the requestor registering the commodity not being competent, and the warehouse person receiving the request does not understand the process. The descriptions forwarded to the warehouse are not 100% completed, wrong specifications are provided, or incorrect information gets captured in the system. The risk is that in future when the part needs to be replaced, a wrong

part will be replenished, which can cause equipment and plant failure (ch.3.5.1).

- The requestor sometimes asks the Suppliers to send them a scope of work / specification, which is then captured in the system. The supplier writes the scope of work according to his / her specification, which causes a preferred supplier situation, making the supply chain very rigid (ch.3.5.1).
- Another shortcoming is that currently only 35% of all equipment spares are linked to a BOM. The risk is that wrong parts are drawn from the warehouse when maintenance needs to be done, which results in delays and an increase in Return to Stores (RTS). In the event of the wrong material being drawn and not returned within a couple of days and new material being ordered, surplus stock can be created when the material is RTS. (ch.3.5.1).
- When material is reviewed for reordering along with the large quantity of ($\pm$ 21000) active commodities, a process of re-evaluation is put in place to identify which material could have potential risks within the supply chain. The criterion of review is: Price > R5,000 **or** Period not being used > 2 years **or** Change in demand patterns (ch.3.5.2).
- The shortcoming is the timing and the reaction is too long when receiving the request. Currently it is rather a reactive than a proactive process. The risk is that not enough stock will be available when needed or surplus stock will be in the system, which is money going to waste. (ch.3.5.2).
- The MRP controller spends too much time on non-critical material (95%) in stead of focussing on maintenance and critical stock (5%). The non-critical material should be managed through an automatic MRP system with conditions and health checks in place. (ch.3.5.3).
- The importance of capturing the risk profile of the equipment on the MRP evaluation document is that anyone dealing with the commodities relating to this equipment from the supply chain will better understand the risk and impact of not having the correct material when needed. This is currently done manually. A focus

should be to implement this evaluation system electronically to ensure it is in time (ch.3.5.3).

- The second important aspect under the risk profile of the equipment, is the availability of the equipment. This information will assist the supply chain to understand when equipment is available, if maintenance needs to be done and on which other equipment/s the relevant material commodity is used (ch.3.5.3).
- The third important aspect under the risk profile of the equipment is the maintenance strategy that is followed to ensure the availability of equipment at all times. The importance of doing maintenance and having a maintenance strategy in place is to ensure that all activities take place as planned to keep a system's equipment in working order (ch.3.5.3).
- The risk the supply chain function is facing with the capturing of the risk profile of the equipment is that when time goes on and changes happen, there is no proper management of change process in place, which ensures from a plant point of view that all changed information is communicated to the warehouse. For example, the design and strategies changed or when there is a breakdown and it happened outside of the strategy, the questions are not asked. This can again result in the buying of wrong parts, which can lead to equipment and plant failure and could result in surplus stock (ch.3.5.3).
- The availability of the material in the market plays an important role in determining the strategy to procure the relevant material. Is the material directly available off the shelf; is it a part that needs manufacturing or can it be reconditioned back to its original state? Is the supplier local or overseas, is it a sole or preferred supplier or can the market be sourced? This also plays an important role on the lead times (ch.3.5.4).
- The first shortcoming is that there are no supplier profiles available on any of the material kept as stock, especially on the critical suppliers. Each buyer has information in his / her own files or computers.

- A second shortcoming in this area of the MRP evaluation process is that the current supply chain function infrastructure is not suitable to deal with the day-to-day workload to be able to put proper procurement strategies in place. Normally this is performed by a whole project team. The impact of this is a resource shortage and existing contracts not being maintained and updated (ch.3.5.4).
- A third shortcoming is that there are no proper partnership agreements and portfolios in place, especially on critical suppliers. Some of the suppliers also find it difficult to move from a sales environment to stockholding and warehouse functions.
- The risk is that when there are unplanned maintenance jobs to be done or breakdowns, whoever needs to deal with the situation runs around trying to find the relevant information to solve the problem as quick as possible to prevent equipment or plant down time (ch.3.5.4).
- Demand of material and how much must be kept in stock are based on minimum once-off usage, the Mean Time Between Failure (MTBF), the shelf life and the criticality of the material (A,B,C) (ch.3.5.5).
- The shortcoming in this part of the process is that the unit of issue and unit of receiving differ; this causes stock differences making reporting difficult. This could cause the reporting of incorrect figures (ch.3.5.5).
- Secondly, if the information is incorrect, it will impact on the stock levels – either surplus or shortage (ch.3.5.5).
- There is no systematic approach by the MRP controller when it comes to the recommendations portion of the evaluation. Currently, decisions are based on the experience of people, gut feel, and no proper facts. The risk of this is that when the individual leaves, the experience leaves with him / her. Systems are built on people and are therefore not sustainable (ch.3.5.6).
- The procurement function is responsible for developing a sourcing strategy for procuring the items that a company needs to acquire. Depending on such factors as the cost of the item, volume required,

and scarcity, many different processes can be used by the company (ch.3.5.7).

- The procurement function focuses on items where there is some type of ongoing relationship and there is usually a contract with special pricing, delivery and other arrangements designed to coordinate the interaction between the two companies (ch.3.5.7.1).
- One of the strategies the company is focussing on is price containment strategy. This strategy depends on the volatility of the market factors influencing the commodity or service. Secondly, it will depend on the type of supplier being used or identified (3.5.7.2).
- After the sourcing strategy has been determined, the MRP controller will recommend which strategy will be best to follow to support maintenance in having the material available at all times (ch.3.5.7.2).
- In this area, there are lost opportunities on small commodities because there is no current system to support the workload that needs to be done in order to perform proper evaluation. There are still opportunities for the bigger commodities (ch.3.5.7.2).

4.2.2.6 The infrastructure within the supply chain in support of the operational and maintenance strategy and the oil refining process

- The focus should be on the process by which the company structures and manages the supply chain in order to find the right balance between inventory, transportation and manufacturing costs; matches supply and demand under uncertainty by positioning and managing inventory effectively; utilises resources effectively by sourcing products from the most appropriate manufacturing facility (ch.3.6).
- It is useful to divide the network planning process into network design, inventory positioning and resource allocation (ch.3.6).
- The objective of is to design or reconfigure the logistics network in order to minimise annual system-wide cost, including production and purchasing costs, inventory holding costs, facility costs, and transportation costs, subject to a variety of service-level requirements (ch.3.6).

- Issues to be dealt with currently are: 1) although stock levels have been reduced over the past 10 years, there are still some of the warehouses that are full because of non-stock items that are being kept; 2) shortage on resources causes non-availability of store masters at all times at all the warehouses; 3) warehouse personnel do not always understand the impact of their actions on the business as well as not fully understanding the importance of each of the parts being kept as stock in the warehouse (ch.3.6).

4.2.2.7 The impact of governance and legislation within the supply chain in the oil refining process

- Corporate governance is a document that establishes a comprehensive supply chain policy, which will promote effective and efficient practices and systems; which will support the refinery's vision; which will comply with the seven characteristics of corporate governance as determined by the King Commission on Governance in South Africa and which will implement, monitor and integrate the day-to-day supply chain activities (ch.3.7).
- The focus should always firstly be to eliminate risk, and if the risk cannot be eliminated illuminated, it must be mitigated. If the risk cannot be eliminated or mitigated, a procedure must be put in place to manage the risk. Continuous review should always be done on the procedures (ch.3.7).
- The challenge is the understanding of all the risks within the supply chain function (ch.3.7).

4.3 Recommendations with regard to the importance of having a risk reduction model in place within the operations function to mitigate risks

As determined in the empirical study, the operations function within the oil refining process identifies the possible risks within each piece of equipment. Failure to do so will lead to no transformation of resources into products and services taking place as desired by the customers. When

new projects have been executed, the Business Development and Implementation model (BDI) forms the framework where the business focus, idea generations, business definitions, implementations and continuous improvement activities are captured into one. The BDI model's relevance to risk can be described as a systematic process consisting of seven stages (gates) within a project management model where, during each stage, appropriate risk reviews and impact assessment methodologies are applied to assess risks.

Before Gate 3 (feasibility) and Gate 4 (basic development), risk assessments such as PHA and Hazop are conducted. The purpose is to ensure that the design will be within the safety risk parameters for both the risks to persons on site as well as any exposure to the community.

Table 4.1 Example of a business development implementation model

Focus:	Business Definition			Business Establishment		Operate Business	
Idea Generation	Front End Loading			Implementation		Continuous Improvement	
	1	2	3	4	5	6	7
Idea Packaging	Pre-feasibility	Feasibility	Basic Development	Execution	Start-up	Evaluation	Operation
Strategic Alignment	Business Planning	Facility Planning	Project Planning	Provide assets according to Plan	Safe Start-up assets and systems	Evaluation to ensure project meets objectives	Optimise by guiding improvement sustainability

The risk management system currently used includes:

- Phase 1 Establishing the context and planning
- Phase 2 Risk identification
- Phase 3 Risk exploration
- Phase 4 Risk assessment
- Phase 5 Risk treatment
- Phase 6 Monitor and review risks
- Phase 7 Risk reporting

The shortfall of the current method is that it is a manual process, which is outdated and not in time. The “Top 20” list approach is quite antiquated and currently the refinery is busy reviewing the risk assessments. It was suggested that a proper evaluation of the risks should be performed so that their significance can be determined. The “Top 20” philosophy is very flawed, because sometimes risks that are ignored can cause grave problems in future. A better approach is that one should evaluate all risks and start to work on them on a priority basis.

A second shortfall is that there is no real system in place where existing equipment’s risks get evaluated / re-evaluated. The plant is 35 years old and the BDI model was not in place then.

The recommendation therefore is that the models and systems in place are sufficient, but the required review cycles should be more regular. This should be considered and decided upon by management.

4.4 Recommendations with regard to the importance of having a risk reduction model in place within the maintenance function to mitigate risks

As determined in the empirical study, the maintenance function within the oil refining process in support of the operations function, needs to understand the risk within each piece of equipment identified by the operations function. The maintenance function must at all times prevent and avoid the failure of equipment by implementing maintenance strategies to remove and mitigate the risk. Failure to do so can cause plant instability and / or shutdown, which will affect operational throughput.

The current process used by the maintenance function to base their strategies on, is Reliability Availability Maintainability (RAM). When new projects are executed and spares need to be ordered and decisions need to be made as to which of the spares must become part of the stock, the interpretation differs from person to person, because this is not a standardised systematic approach that is followed. It is a manual process

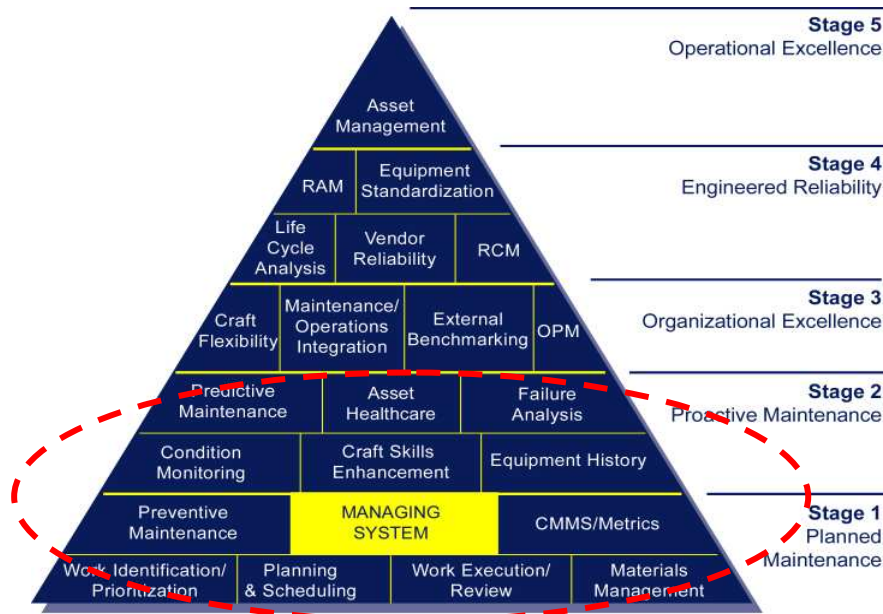
where each person's view is based on experience and others just on a guess. The second shortcoming is that there is no proper MOC in place for when new equipment gets installed in the plant or is being removed from the plant. When implementing new equipment from projects, the supply function only gets involved close to the end, and this has an impact on stock holding.

The recommendation is that the task team that has already started benchmarking with other oil refineries to investigate the utilisation of Strategic Asset Management Intelligence (SAMI) and Work Management Process (also referred to as STAR), to complete the benchmarking as soon as possible and to get the work teams started in the implementation of changes as and where required. A proper MOC process should be followed for each and every change to all parties involved and affected by the changes.

What are the benefits of strategic asset management and why SAMI?

According to Samicorp (2008:1), SAMI is a process to systematically derive the highest value from facility assets, through a consistent philosophy, plans and objectives, and cooperative involvement by everyone in the plant. Asset management ties business objectives, operational readiness and resources to a single view (refer Annexure 3). The system must completely align the business plan with plant realities, identifying specific equipment conditions and performance gaps to overcome in order to achieve the plan. All measures from a corporate Return on Invested Capital (ROIC), to plant contribution, to unit production rates, to specific equipment's health requirements, to the supporting maintenance strategy, all cascade in alignment (refer Figure 4.1).

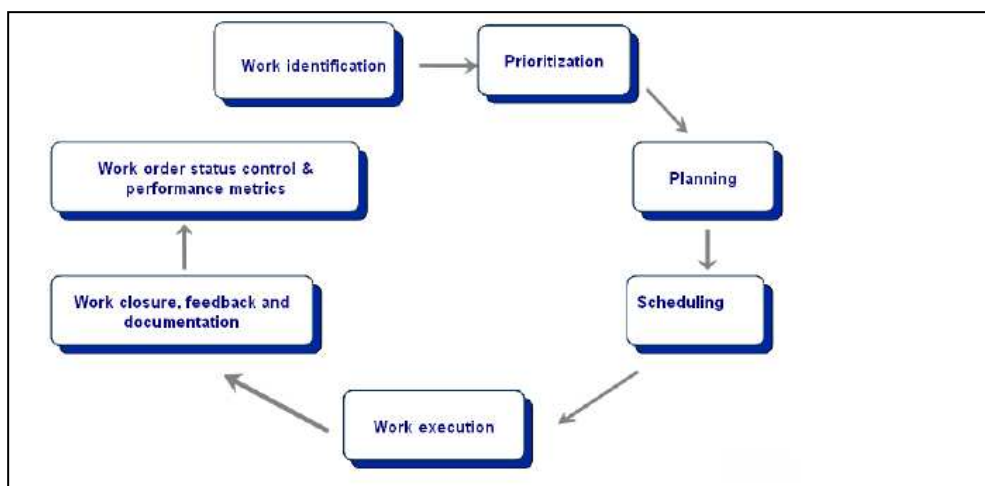
Figure 4.1 SAMI asset health care triangle



Source: Strategic Asset Management Corporation (2008)

The second process currently being investigated is the Work Management Process (STAR), which consists of an integrated set of tools and procedures designed to assist maintenance leaders in the management of work. STAR is used as a vehicle to identify, prioritise, plan, schedule and execute work and then give feedback and have work status control. This process can assist in the increase of equipment reliability and utilisation of maintenance personnel (refer Figure 4.2).

Figure 4.2 Example of STAR work management process



The above processes will assist the maintenance function to be able to do proper planning and assisting them with putting proper maintenance strategies in place to mitigate the risks identified.

4.5 Recommendations with regard to the importance of having a risk reduction model in place within the supply chain function to mitigate risks

It was determined in the empirical study that the main purpose of the supply chain function is to have a replenishment strategy in place to support the maintenance strategies in managing and mitigating the identified risks. If the supply chain function is not aligned with the maintenance and operation functions, then it will lead to failure to deliver on time, sub-standard service delivery, poor quality and not at the most cost effective price, unnecessary stock investment and the duplication of material.

Key issues identified in Chapter 1, which would have been dealt with in this study influencing supply chain management and planning, were the following:

- The impact of current and new projects;
- Supply chain infrastructure;
- Sourcing strategies and price containment;
- Supply chain responsiveness;
- Changed or new legislation;
- Global skills shortages.

4.5.1 The impact of current and new projects

As per the empirical study and conclusions that were made regarding the impact of new and current projects, the first problem is a timing issue. The supply chain function only becomes part of the process at the end where parts are delivered and need to become stock. The importance for the supply chain to be involved from the beginning of new projects is that the supply chain will understand what the project is about, as well as who is responsible for what. Secondly, an important contribution of the Supply

Chain to new projects, is not only assisting with the management of stock, but also giving advice during the process to standardise equipment and parts. For example, the plant might want to bring in Rockwell parts of which no stock is kept in the warehouse. At this early stage, the supply chain can advise that they have Siemens stock in the warehouse – why not rather implement Siemens equipment?

The problem that is experienced with current projects is that when equipment is taken out of the process or when risk assessments are performed and there are changes to the risks of a specific piece of equipment or part, there is no proper MOC performed to notify the warehouse that certain spares won't be used anymore. The end result is redundant material being kept in stock holding, which should rather be scrapped and sold. This action contributes to stock level optimisation.

The recommendation to manage new and current projects sufficiently by everybody involved is to implement the asset performance tool system (refer Annexure 4), which will assist the maintenance function in deciding on which spares to hold in what numbers, and secondly, it will assist the supply chain function in the evaluation and optimisation of inventory and purchasing decisions. This is an in-time systematic approach that is referred to in the spares policy.

A second recommendation is that all parties involved in projects get proper training on the policies and procedures for new and current projects.

Thirdly, there should be a proper MOC process in place for when changes take place within the plant or operations.

4.5.2 Supply chain infrastructure

As per the empirical study and conclusions made, the main risk is access control. Because of the shortage of resources and warehouse personnel not being situated at each warehouse, unauthorised people access the warehouses to dump unwanted material, which causes a safety risk

because of untidiness and the warehouses being full. The unauthorised access also causes a security risk as material gets removed without proper processes being followed, which then leads to a cost to the supply chain because of stock not balancing.

The recommendation therefore is that a proper access control system gets implemented at all the warehouses. Secondly, a bar coding system that will assist with the resource shortage and that will ensure that all transactions are done electronically, making the material in time and improving the ATP, and not out of time and manually as it is currently done, needs to be implemented.

4.5.3 Sourcing strategies and price containment

The sourcing strategy is captured in the replenishment strategy of the supply chain. As per the empirical study and conclusions made, the main focus of the supply chain function should be the understanding of the risk the equipment and parts creates when failing, the cost of the supply of such a part, the availability of the part or any alternative to support and maintain the equipment when failing and the usage patterns of such parts.

The equipment risk is not known or understood by the supply chain. Not all relevant information on suppliers is available relating to these parts, as well as where and when they are available in the market. Because of resource shortages in many instances, the process followed by the supply chain is more re-active than pro-active. The supply chain infrastructure is not suitable to deal with the day-to-day workload to be able to put proper sourcing strategies in place, and existing contracts are not maintained and updated. Normally this gets done by a whole project team.

The recommendation therefore is that a proper supplier portfolio management system is implemented. By standardising all the activities within the procure-to-pay process for all the buyers, it will be easier for anyone when information is needed and the buyer is not available. The risk matrix should be discussed with all supply chain personnel for them to understand what they need to focus on and why. Regular service level

agreement sessions should be held with especially critical suppliers, as this will help with the building of ongoing relationships with these suppliers. Lastly, as part of a joint venture, the oil refinery should look at getting involved and being part of shared services, especially focusing on getting as much as 80% of stock on contracts. This will assist with the sourcing strategies to be part of group contracts.

4.5.4 Supply chain responsiveness

The importance of the supply chain function is to focus on quality, service and cost. The supply chain function should also focus on getting the right material or service delivered at the right time, place and cost. During the empirical study and conclusions that were made, it is obvious that the supply chain function in many cases reacts on a reactive basis rather than being proactive. This is because of resource shortages and people not always understanding their environment, the risks they are dealing with and the impact of their actions and decisions on the business and what risks they need to focus on.

The recommendation is that all critical and project spares are identified and categorised according to A, B or C; A being the most critical to C less critical. The benefit from implementing this is that anyone who deals with a part categorised as A will know that immediate action should be taken and that relevant feedback should be given to all parties involved. The situation must be dealt with as soon as possible.

4.5.5 Changed or new legislation

From the empirical study and conclusions made, governance and legislation are important and critical because it assists and guides the supply chain function to have effective and efficient practices and systems in place to eliminate, mitigate or manage risks. The challenge the supply chain function has is that not everybody understands all of the risks.

The recommendation is that sessions should be arranged on a regular basis with the group where certain areas of governance and legislation are discussed. Secondly, an external expert should come and update the

group on changed and new legislation and what the impact thereof is on the function.

4.5.6 Global skills shortages

Sourcing material and services from Europe to other countries are a fundamental component in a networked and globalised economy. In the empirical study and the conclusions made from the study, it is evident that not everybody within the supply chain function has the necessary skills to perform to the full. One influencing factor is Employment Equity (EE) and the fact that companies have targets to meet every year, and therefore sometimes employees get promoted to quickly to achieve these EE targets. The impact of this is that the individual never gets the opportunity to really grow to his / her full potential within a certain job. This job hopping catches up eventually when he / she arrives in a management position where he / she cannot cope. Another factor can be that when the interviews were held, a wrong candidate for the position was employed, trying to fit a square peg into a round circle. The candidate performed very well, but without practical testing done it is sometimes possible that the person gets appointed because he / she might be well spoken. Another factor that can contribute to this is that the individual in the position does not really want to be in this field of expertise and therefore the effort put into really getting to know the job, and performing well, the right attitude, drive and energy are not there. People also leave a company because of the way the company manages the employees. Employers might say they do talent planning, talent acquisition and talent development, but they are not good in managing and developing talent.

A global skills shortage does not necessarily mean that there are large numbers of unfilled positions in a particular field. It can mean there is a rapid increase in demand for experienced workers with highly specialised skills and new workers cannot be trained or up-skilled in time to meet the demand before it drops.

So what can companies do to deal with this world-wide dilemma? According to Moad (2010:7), companies need to increase attention to clarify business and people strategies, communications and performance measurements, as well as employee development with particular focus on the latest technologies, problem-solving skills, and change readiness. The recommendation is that there is a need currently within the supply chain function within the oil refinery to identify coaches and mentors to help the employees to move onto the next level, not necessarily the supervisor or somebody from the same environment. Secondly, for all the positions within the supply chain function, profiles should be written for all the critical jobs, do a comparison against the profile of the people currently employed and should then determine the gaps. They should draw up and implement a development plan with the employee and agree to the time slots of when what needs to be achieved. Regular one-on-one meetings should then take place between the line and the individual to assist him / her to achieve the goal.

Sirota *et al.* (2005:4-8) noted that it is up to the employer to develop and nurture the company's relationship with its employees, as well as to keep it positive. To maintain the enthusiasm employees initially bring to their jobs, management must understand three sets of goals that the great majority of workers seek from their work, and then satisfy those goals. If just one of the three goals is missing, then it creates less enthusiasm. The three goals are:

- **Equity:** To be respected and to be treated fairly in areas such as pay, benefits and job security.
- **Achievement:** To be proud of one's job, accomplishments and employer.
- **Camaraderie:** To have good, productive relationships with fellow employees.

Finally, employers have to create a workplace where their people feel good about where they are and what they do; they will have to share information about the business and offer forms of recognition and remuneration that

motivate employees and reward them for the part they play in the organisation's growth and achievements.

4.6 Discussion of the proposed risk reduction model within the inbound supply chain to manage and mitigate risk within the oil refining process

It could not be determined during the empirical study whether there is a proper risk reduction model or risk framework implemented within the supply chain function. There is evidence of a proper framework in place within the operational function where risk identification was done on equipment and parts within the multi-streams within the oil refining process.

As previously discussed, it was determined during the empirical study that the main purpose of the supply chain function within the oil refining process is to put sourcing strategies in place to support the maintenance function to manage and mitigate the risks on the equipment and parts identified by the operational function. If the supply chain function does not have a proper risk reduction model or risk framework in place, how can they successfully provide support to the rest of the company?

Why would the supply chain want to manage their risk?

Supply chain risk management means taking deliberate actions to shift the odds in their favour, increasing the odds of good outcomes, and reducing the odds of bad outcomes.

What are the risks the supply chain will encounter if not properly managed?

There is a possibility that internal and external events will negatively affect their ability to achieve their supply chain risk management objectives. It may be that something good will not happen, or that something bad will happen.

How would the supply chain go about to manage their risk in such a way that they and all others get what they want?

They need to implement risk reduction strategies and a risk management process that entails the planning, arranging and controlling of activities and resources to minimise the impact of all risks to levels that can be tolerated by internal and external shareholders and stakeholders.

The objective of any supply chain management framework should be to support the company's vision and strategic objectives and by means of risk reduction strategies ensure that the risks that the oil refinery is exposed to in the supply chain are identified and managed to acceptable levels. To be able to put risk reduction strategies in place, everybody within the supply chain function should understand where they fit into the business; what the purpose of the supply chain function is; what strategies and processes they must follow to align with the company's vision and strategic objectives; what the internal and external factors that can have an influence on the supply chain function are; what the things that can go wrong are and what risk reduction strategies must be in place to proactively eliminate, mitigate or manage these risks.

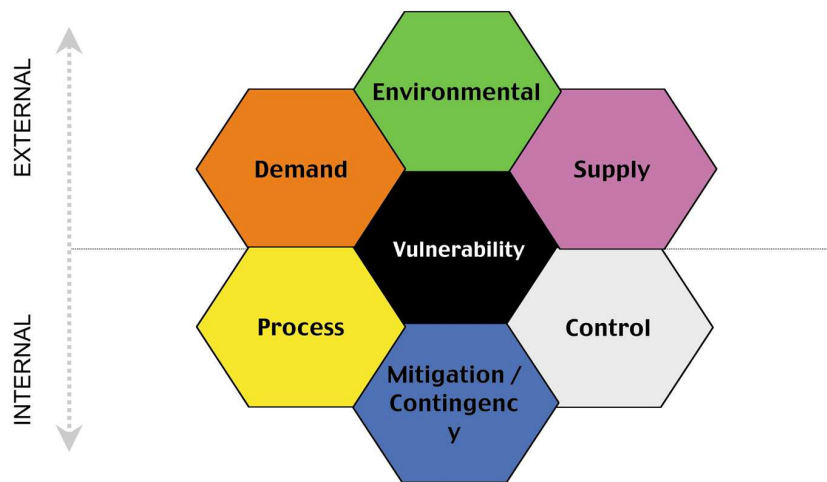
During the literature study in Chapter 2, three models were briefly discussed:

- The Deloitte Touche Tohmatsu model of Understanding Risk and the value of Flexibility;
- The KPMG Methodology for Implementing Risk Management; and
- The Supply Chain Operations Reference Model for Business Process Re-engineering.

The recommendation therefore is to combine all three models into one (refer Figure 4.4), which will cover risk understanding and the impact of internal and external influences; how to re-engineer business processes; the implementation of a proper risk management framework; and finally the identification of key strategic focus areas with key performance indicators for performance to be measured against.

Supply chain planning processes balance the market demand requirements with supply resources and establish / communicate plans for the whole supply chain function, keeping in mind the vulnerability of internal and external factors (refer Figure 4.3).

Figure 4.3 External and internal vulnerability drivers

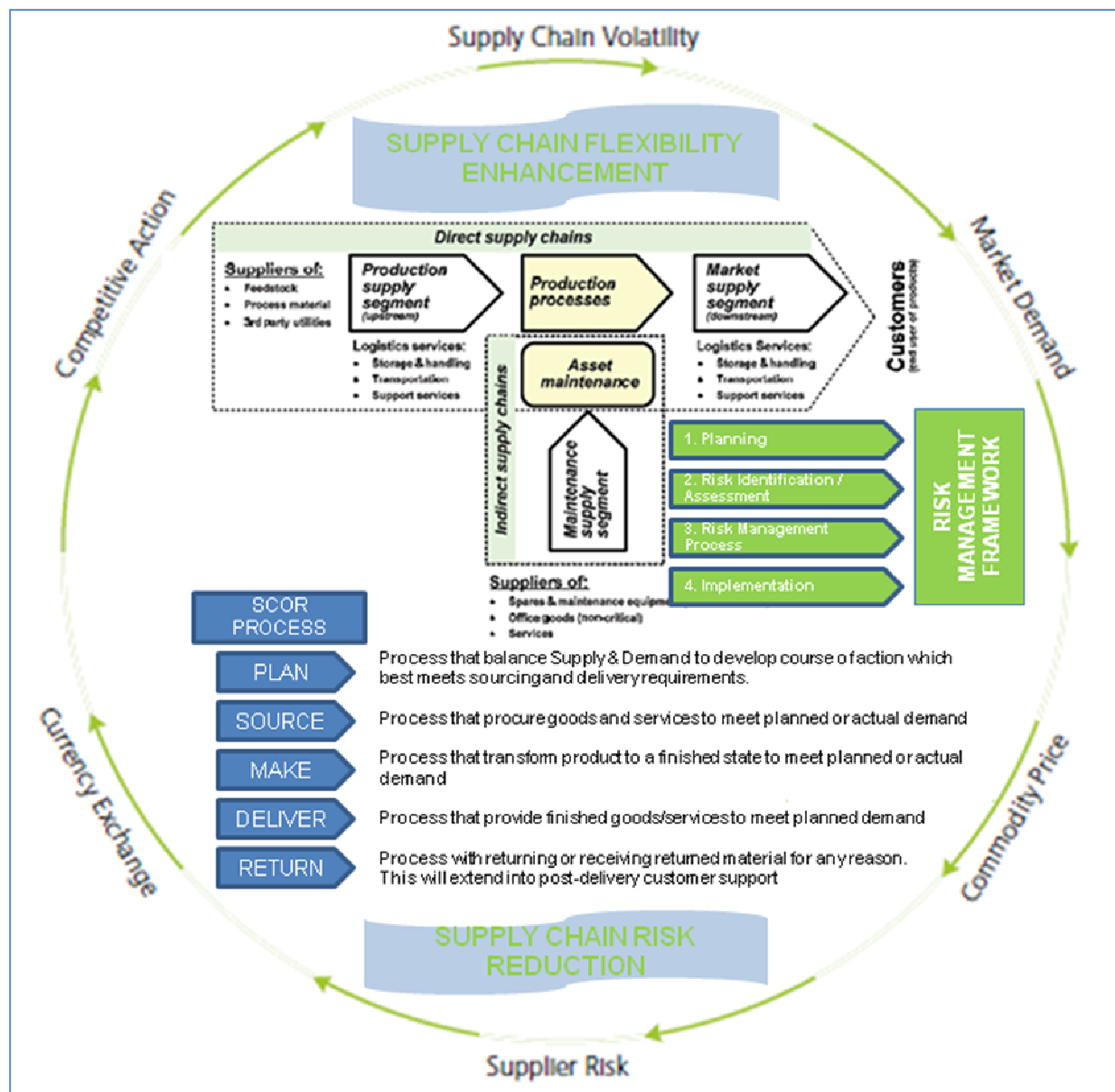


Source: Cranfield School of Management (2003)

To be able to function within all the ongoing changes happening all the time within these processes, requires balancing multiple links simultaneously to have an effective supply chain management as a result. The unpredictability in the supply chain leads to increased risk, which may result in disruptions to the supply chain. These disruptions may be unexpected and rare, but they must be understood, identified and managed. For any business it is most important to have a model in place that can prevent or mitigate a risk before it can actually happen.

The proposed supply chain risk reduction model will now be discussed in detail.

Figure 4.4 Proposed supply chain risk reduction model

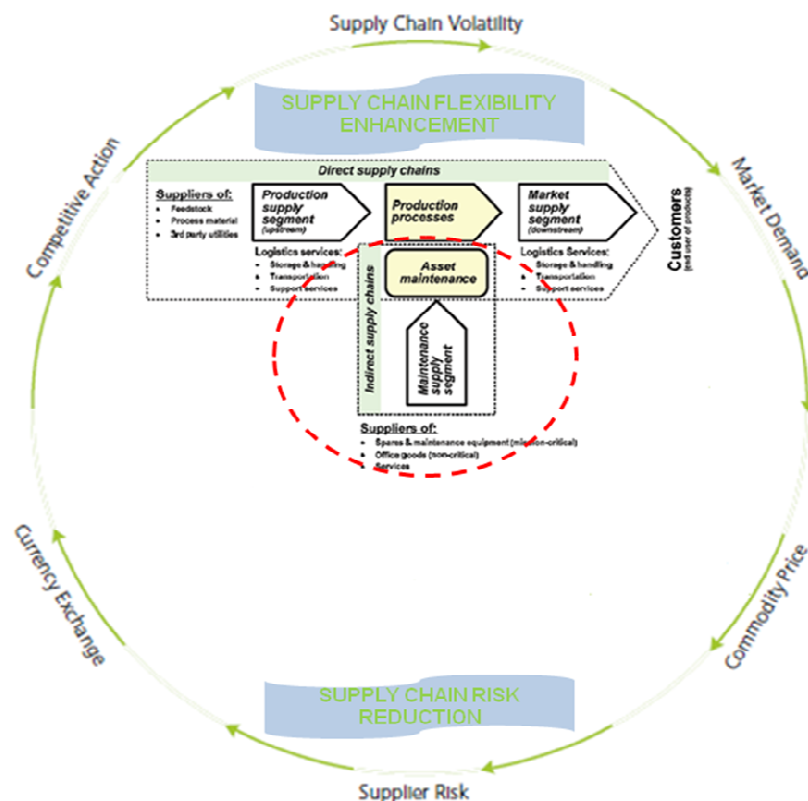


The objective of any supply chain management framework should be to support the company's vision and strategic objectives and by means of risk reduction strategies ensure that the risks that the oil refinery is exposed to in the supply chain are identified and managed to acceptable levels. Due to the major impact of supply chain initiatives on a business, a combined programme and project approach should be followed, which will include an understanding of the potential reward (business case); vision clarity; management support; internal ownership

and accountability; training; communication; and a formal change management programme.

As recommended in Chapter 4, the following discussion and model are based on the combination of the Deloitte Touche Tohmatsu model of Understanding Risk and the value of Flexibility; the KPMG Methodology for Implementing Risk Management, and the Supply Chain Operations Reference Model for Business Process Re-engineering.

Step 1 **Understanding by all role-players of where the supply chain function fits into the business and what is its reason for existence?**



It is important that all role-players, especially the people who form part of the supply chain function, understand where they fit into the business and the reason why such a function is needed. In so many companies, it is the norm that when, for example, a person is in charge of purchasing, it is the only role that the person will focus on, it does not matter what the person in the office next to him / her

does and why. In many instances this is a reason for many problems and causes the shortages within the supply chain functions and processes (silo effect). Times have changed and the time has come where role-players must understand the impact of each of their actions on the business and what the risk will be if they do or do not do what they are supposed to do – from the cleaner to the manager.

Throughout the study, it was concluded that the main purpose of the supply chain function is to support the maintenance strategies through effective sourcing strategies to mitigate the risks identified by the operations function. All processes and functions that are part of a company's value chain contribute to its success or failure. These processes and functions do not operate in isolation; no one process or function can ensure the supply chain's success, it must be done together. Therefore, the design of the overall supply chain and the role of each stage must be aligned with all other functions to be able to support all strategies to ensure a strategic fit.

Step 2 Understanding what the impact of macro-environmental factors on the supply chain is

According to LCP Consulting, Cranfield School of Management (2003:9), there are many types of risks that can threaten business continuity and organisations must have built-in resilience to these at different levels. This means that executives planning for and managing vulnerability face a difficult task, since problems can appear from many different directions. There are many forms of risk, and many theories, too, but only one overriding principle. A risk that is visible may (not necessarily can) be managed, minimised and perhaps even eliminated; an unseen risk is far more dangerous. External risks are, by definition, potentially greater than internal ones – they are not within the focal company's direct control.

According to Deloitte Touche Tohmatsu (2009:1), the mindset in many businesses has changed on very short notice from a quest for growth to a quest for cash, operating margin and asset efficiency, in an environment that is exposed to significantly higher levels of risk and uncertainty than ever before. The Deloitte Touche Tohmatsu Model (refer Figure 2.2) Risk and Flexibility: Communicating

Vessels indicated that macro-environmental factors that can have an impact on the supply chain are:

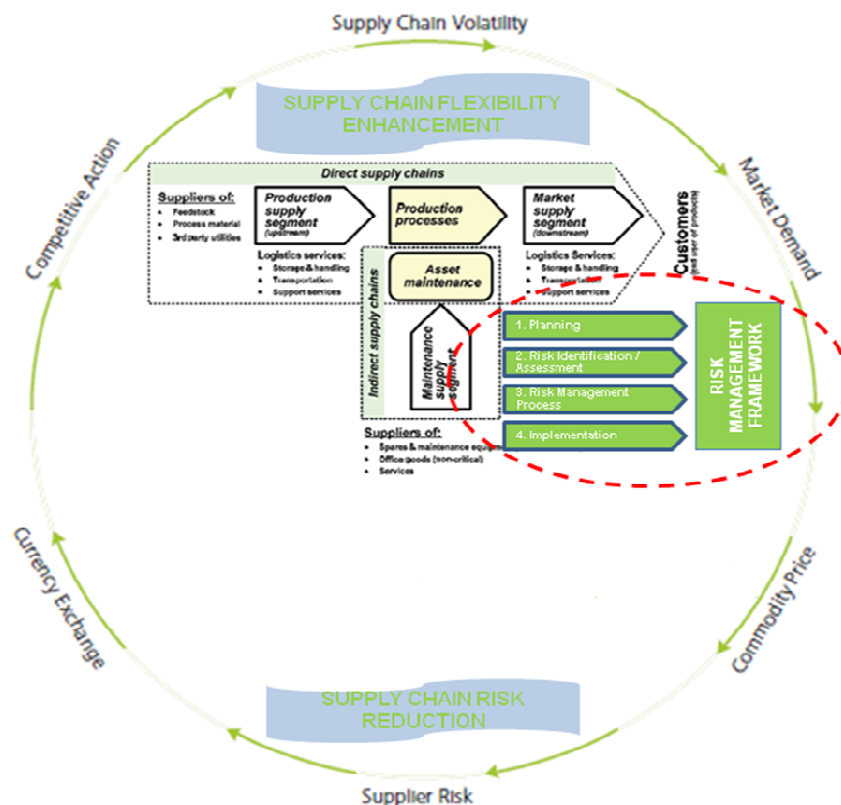
- Supply chain volatility;
- Market demand;
- Commodity price;
- Supplier risk;
- Currency exchange; and
- Competitive action.

These are the types of factors that need to be identified and understood by the supply chain to be able to put strategies in place that will pro-actively help to mitigate risks. With uncertainty and volatility to stay, using the analogy of the communication vessels (refer figure 2.2), the two strategies to use are:

- Managing and reducing supply chain risk by starting a formal supplier risk management programme and increasing demand planning accuracy; and
- Managing and enhancing supply chain flexibility by enhancing network flexibility, reducing lead times, and frequently rebalancing supply chain tactics and process flexibility.

There will be more detailed focus later on in this discussion. By managing risk and enhancing supply chain flexibility, there is a clear opportunity for businesses to win in the current uncertain environment, and to sustain their supply chains as a critical asset and differentiating factor for success towards the future.

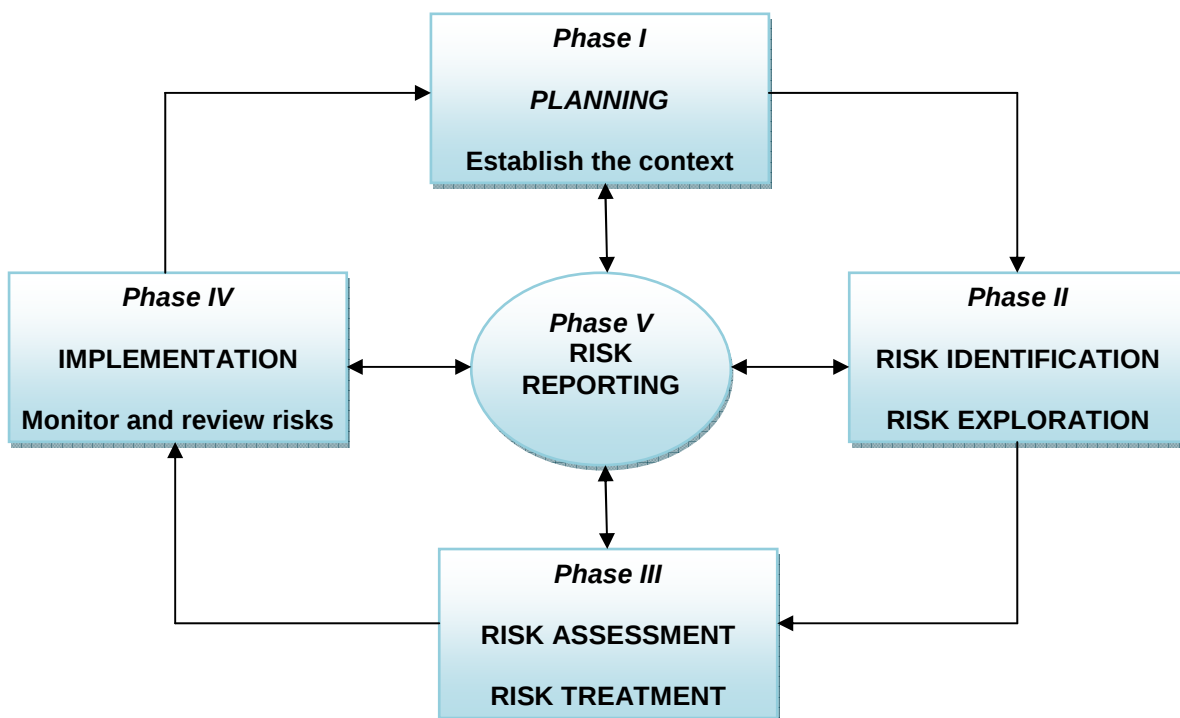
Step 3 Proposed risk management framework for the supply chain



As previously determined in this study, there is no proper risk management system within the supply chain function with strategies to manage and mitigate these risks. Therefore, deliberate actions need to be taken to put a supply chain risk management system in place with an integrated risk management process to ensure that all risks that the supply chain function is exposed to are proactively identified and managed to acceptable levels on a continuous basis.

According to KPMG Holdings Ltd (2008:2), risk management is a process for managing the risks an organisation face; it is not a stand alone function. It is an integrated system that links the management of strategic objectives to risks and controls in order to improve corporate performance, increase transparency, provide an early warning system and enhance business sustainability. This system should be integrated down to individual functions such as the supply chain. By applying the same model right through, the business will enhance consistency and standardisation.

Figure 4.5 Proposed risk management phases



PHASE 1 Planning – establishing the context

The planning phase deals with the analysis of the information and documentation related to risk identification, assessment and / or management. In setting the context, thought must be given to the business objectives, the scope and depth of the risk management process, and the time horizon to be covered. Objectives for the supply chain function can typically be:

- To consider the consequences of foreseeable significant risky events and opportunities on the performance of the company (the Top 20 risks identified);
- To respond appropriately to internal and external changes in risk perception and information;
- To develop strategic options for eliminating or controlling significant risks and their consequences (for example sourcing strategies); and
- To link these options to the general decision and control framework used by the company.

Based on the insights gained from the analysis, the supply chain function is benchmarked against better practice and makes a preliminary decision about the **desired state** of its risk management. With regard to the **scope** of the project, it must be clear which areas should be covered –the most important areas must be

clearly identified. **Roles and Responsibilities** are defined and allocated to employees. It is always very important that everybody knows exactly what they are responsible and accountable for. For example, allocating the risk owner, who will be involved from the management side, etc.

PHASE 2 Risk identification and risk exploration

Because of the shortage of the amount of resources available within the supply chain function, it is important to focus on the most important risks and use the resources efficiently to manage these top risks to achieve maximum value. **Risk identification** is an essential part of the process. Risks that are not identified in this phase will be executed from the other phases or process, resulting in these risks taking us by surprise and having dire consequences on financial results. **Risk identification** starts with a **SWOT analysis** (Strengths, Weaknesses, Opportunities, Threats), i.e. interviews to be held with key members of the organisation. The aim of any SWOT analysis is to identify the key internal and external factors that affect the supply chain function's performance and value.

Table 4.2 Example of a supply chain SWOT analysis

Strengths Highly trained and motivated staff Established operating procedures Stable demand pattern	Weaknesses Large number of suppliers to manage Poor use of technology High labour cost
Opportunities Deploy commodity plans Outsourcing Partnering with key suppliers	Threats Large fluctuations in material cost Lack of competition between suppliers Material obsolescence

A generic list must be drawn up that will act as a checklist to ensure that all possible risks are addressed (refer Table 4.3).

People's behaviour should be challenged to continuously identify risks and act on them immediately.

Table 4.3 Example generic list of possible risks within supply chain

No	Risk description
	INBOUND RISKS
	Sourcing
1.	Failure to meet legislative and environmental requirements and standards.
2.	Purchasing - Impact of supply failure on cost - Impact of supply failure on SHERQ - Impact of supply failure on plant efficiencies - Impact of supply and market characteristics
3.	Lack in experience leads to unawareness of commercial risks and exposure.
4.	Failure in quality control systems
5.	Scarcity of supply
6.	Failure to supply on time
7.	Wrong specifications specified
8.	Exposure through contract terms
	Supplier relationship
1.	Ensure continuity of supply and sustainable value to minimise exposure before entering into contracts - Inability to deal with confidentiality agreements - Inability to supply maintenance equipment - Inability to supply technical support - Lack of supplier innovation - Limited number of suppliers (sole, monopoly) - Political pressure - Unreliable supply - Failure to maintain quality and quantity levels - Inflexible supply - Non-conformance to safety standards
	Demand
1.	Ignorance of demand forecasting and planning: - Failure to identify end-user needs timeously - Governance structure ignored in procure of material and services - Incorrect handling of invoices and initialising of payments for materials and services rendered - Inability to understand and meet business requirements
	Materials management
1.	No storage and handling procedures in place for all goods and materials
2.	No loss of control measures in place
3.	Failure to meet legislative and environmental requirements
4.	Failure in quality control systems
5.	Failure in SHERQ systems
6.	Lack of risk management
7.	Poor facility design and construction
8.	Lack of proper governance
	Inventory management
1.	Wrong quality and quantity control system
2.	Monetary loss due to failure to determine quantity and value of inventory
3.	Lack of proper management practices
4.	Lack in supply chain visibility results in stock shortages / over-stocking
5.	Product shelf life
6.	Needs analysis, time and place maintenance material

The purpose of **risk exploration** is to explore the causes and consequences of the identified risks. In the absence of a precise understanding of the cause of a

risk, one is unable to implement effective preventative control measures to manage the cause. Similarly, in the absence of a precise understanding of the nature of the consequences of a risk, one could be unable to accurately measure the impact that the risk may have or to implement effective corrective control measures to manage the impact.

After all the necessary information has been gained from interviews, in combination with benchmarking analysis, a database can be created with all the relevant risk information in the form of a master risk catalogue. The risks are categorised in order to allocate the risks to the right dimension of the risk model (refer Figure 4.6).

Figure 4.6 Example of a risk model

EXTERNAL RISKS					
Supply chain volatility	Market demand	Commodity price	Supplier risk	Currency exchange	Competitive action
INTERNAL RISKS					
STRATEGIC ▪ Business objectives	OPERATIONAL				FINANCIAL ▪ Commodity prices
	Processes	Technology	Compliance		
	▪ Business interruption	▪ Technological know-how	▪ Supplier fraud		
		Management information		Human Capital	
		▪ Budgeting and forecasting		▪ Leadership ▪ Skills shortage	

Once the risk catalogue is defined, a high-level risk assessment is carried out for all risks identified.

PHASE 3 Risk assessment and risk treatment

This phase of the process involves an informed view taken on the likelihood / probability of each of the risks occurring within the timeframe, as determined in phase 1; and secondly, what impact the risks could have on the company in terms of earnings, project schedule and costs, fatalities, reputation, impact on the environment and communities, non-compliance with laws and regulations, etc. It is important that both quantitative and qualitative factors are considered in

assessing the impact of a risk. Appropriate tools and techniques must be used to accurately measure the impact of a risk. The deliverable from this phase is the plotting of the risks on the risk matrix (refer Figure 4.7).

Figure 4.7 Example of a risk matrix

Level 3 Risk	Level 3 Risk	Level 3 Risk	Level 1 Risk	Level 1 Risk	Level 1 Risk	Level 1 Risk
Level 3 Risk	Level 3 Risk	Level 3 Risk	Level 2 Risk	Level 2 Risk	Level 2 Risk	Level 1 Risk
Level 4 Risk	Level 4 Risk	Level 4 Risk	Level 3 Risk	Level 2 Risk	Level 2 Risk	Level 2 Risk
Level 5 Risk	Level 5 Risk	Level 5 Risk	Level 3 Risk	Level 3 Risk	Level 3 Risk	Level 3 Risk
Level 6 Risk	Level 6 Risk	Level 6 Risk	Level 5 Risk	Level 5 Risk	Level 5 Risk	Level 4 Risk
Level 6 Risk	Level 6 Risk	Level 6 Risk	Level 6 Risk	Level 6 Risk	Level 6 Risk	Level 5 Risk
Level 6 Risk	Level 6 Risk	Level 6 Risk	Level 6 Risk	Level 6 Risk	Level 6 Risk	Level 6 Risk
1	2	3	4	5	6	7
P7 Remote	P6 Highly unlikely	P5 Not during lifetime of operation (Very Unlikely)	P4 Once in operation lifetime (Low)	P3 Once in ten years (Possible)	P2 Once per year (Likely)	P1 More than once per year (Almost certain)
0,0005%	0,005%	0,05%	0,05-10%	10-68%	68-90%	90-100%

Source: Oil refinery HIRA risk impact template

The risk matrix is simply a tool that depicts the risks that have been identified and how they have been assessed. It should be used for the following purposes:

- To rank the risks relative to one another for purposes of deciding which risks should take priority for further action;
- To report risks at different levels within the supply chain function;
- As an aid to track progress being made to reduce a risk to an acceptable level; and

- To ensure a high degree of consistency in the assessing and reporting of risks within the business.

Figure 4.8 should be used as a guideline in determining where a risk should be plotted on the impact scale of the matrix.

Figure 4.8 Risk matrix impact scales

Weight Number	Impact Severity	Financial Impact (Rand) Earnings Before Interest and Tax - EBIT	Safety & Health	Community & customers	Environment
7	•1	> 500 m	More than 1 fatality	More than 1 fatalities	Irreversible impact on pristine environment
6	•2	100 m – 500 m	One fatalities	One fatality	Serious national environmental impact
5	•3	10m – 100 m	One fatality	Hospitalisation or multiple press articles regarding complaints eg. smell	Very serious long term environmental impact at regional level
4	•4	1m - 10 m	Hospitalisation	Press articles regarding complaints eg. smell	Serious but reversible short term impact at regional level
3	•5	100 000 – 1m	Lost workday case	Complaints regarding e.g. smell	Moderate reversible short term impact at local level
2	•6	10 000 - 100 000	Medical treatment/ Restricted workday case	None	Minor effects extending beyond boundaries of installation
1	•7	<10 000	First aid/ No injury	None	Limited impact within plant boundaries

Source: Oil refinery HIRA risk impact template

Each consequence on the scale must be considered in isolation when plotting the impact. It is incorrect to compare one scale with another. Where a risk has more

than one consequence type, the consequence type with the highest impact should dictate where the risk is plotted on the matrix. It is recommended that two types of risk assessments should be performed on each risk, namely an inherent risk assessment and a residual risk assessment.

The **inherent risk assessment** is an assessment of the level of risk before treatment measures have been taken or the effectiveness of existing controls has been considered. In other words, this could be considered as the worst case scenario. **The residual risk assessment** is an assessment of the level of risk after risk treatment measures have been taken or existing controls were considered.

The reasons for assessing each risk at both the inherent and residual levels are as follows:

- It assists in ensuring the integrity of the risk assessment process, for example that all risks with high inherent risk levels are adequately considered;
- To measure the effectiveness of existing and new controls in mitigating the risk; and
- To ensure that resources are first deployed to address those risks with the highest value at risk.

After the risk assessment's **top risks** are analysed in detail and plotted, an appropriate risk strategy is defined to optimally manage these risks to enhance and safeguard the company's performance and value. As a rule of thumb, companies often focus on approximately 10 top risks.

The **risk treatment** phase also addresses those risks that are considered to be at an unacceptably high level and that require additional treatment. In determining whether a risk is at an acceptable level or not, consideration must also be given to whether the risk could potentially be in violation of the code of ethics and values of the oil refinery. For those risks that require additional treatment, there are three primary risk treatment options, namely risk avoidance, risk reduction and risk transfer:

- **Avoidance** implies that a risk is undesirable if, for example, it is off-strategy, offers unattractive rewards or the company does not have the capability to manage the risk.
- **Reduction** is putting in place risk control measures that reduce the likelihood and / or the consequences of the risk to acceptable levels. The vast majority of the risk treatment options will fall within this category.
- **Transfer** includes insurance, contractual or hedging arrangements, or transferring the cost of risk to a third party.

After identifying the risks and analysing them in detail, it is advisable to hold workshops among different functions that will help to create a dialogue to assist people to come to a common understanding of the risks. The risks are allocated to **risk owners** who need to monitor their risks. Often, a combination of several risk strategies is agreed and transferred to action plans (refer Figure 4.9).

Figure 4.9 Example of an action plan

Action Plan				
Risk no. and name	1 Commodity not available in the market			
Risk owner	Joe Soap			
Risk category	☐ External	☒ Strategic	☐ Operational	☐ Financial
Risk description	Commodity of critical pump not available in market anymore			
Risk drivers/main causes	▪ OEM, no alternative suppliers ▪ Plant shutdown			
Risk strategy	☐ Acceptance	☒ Mitigation	☐ Avoidance	☐ Transfer
	▪ Build an opportunity to aggressively adopt new strategies and actions to create market conducive portfolio ▪ Be at the leading edge in developing substitutes and create opportunities			
Effective measures already in place				
Action	Responsible	Milestone	Deadline	Status
Find alternative supplier	Suzi Kline	Portfolio supplier	30.04.2011	Open
				Started
				Done

The requirements for establishing a sustainable risk management process are defined at the end of this phase. The main aspects include how the implementation of the actions should be monitored and what the periodically

recurring risk identification and assessment – risk management process – should look like in the future.

PHASE 4 Implementation – monitoring and review

Policies and **guidelines** are written to summarise all the key decisions and processes developed during the project period. The **actions** and any additional aspects are **implemented**. One of the key elements is to ensure continuous monitoring. The risk owners are responsible for periodic reporting regarding the status of the defined actions and the development of the risks.

Any risk profile changes over time. Risk treatment plans that were once effective may become irrelevant; control activities may become less effective or are no longer performed; business objectives may change; or regulatory requirements may change. This can be due to the arrival of new personnel, changes in business direction, and the introduction of new systems. The following monitoring mechanisms should be implemented:

- **Monitoring of implementation of risk treatment plans**

Action plans to develop and implement risk treatment plans need to be monitored to ensure that the necessary plans are implemented on schedule and as intended. This monitoring process should be embedded within the normal day-to-day monitoring processes already in place within the business, for example departmental meetings. Internal audits should regularly evaluate the progress of these action plans as part of their routine audits.

- **Ongoing effectiveness of risk treatment plans**

The effective operation of risk treatment plans must be evaluated on an ongoing basis. Each functional area within the business will need to develop its own plans as the frequency and scope of these reviews take account of legal and regulatory requirements. These will include management reviews, and self assessments, etc.

- **Identification and assessment of new emerging risks**

There is a need to regularly review risk profiles to ensure that they remain relevant and complete. Each functional area will need to determine the

frequency with which the entire risk profile is reviewed to ensure that new emerging risks are identified and assessed.

PHASE 5 Risk reporting and communication

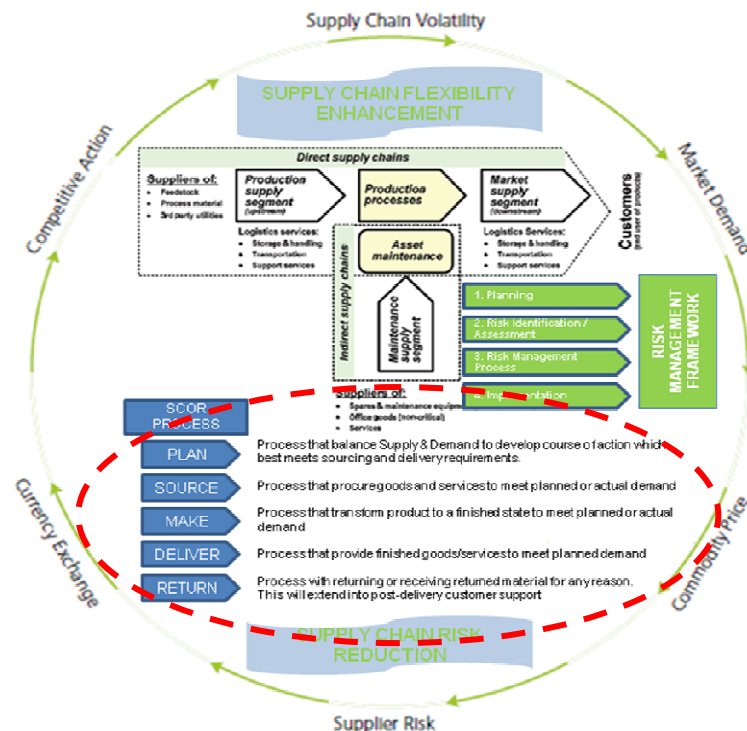
The essence of **internal risk reporting and communication** is that the right people should become aware of risks at the right time. This helps to ensure that risk treatment plans are timeously implemented.

Risks at all six levels must be reported internally (formally and informally) at different levels within the business. Each business will have to develop its own reporting framework, taking into account existing management processes and legal and regulatory requirements.

- Risk & SHE Committee: consider level 1 risks and related risk treatment plans;
- Risk Management Forum: consider level 1, 2 & 3 risks for his / her business;
- MD: approve the tolerability or otherwise of all level 1, 2 & 3 risks for his / her business; and
- For risk levels 4, 5 & 6, each business will need to develop its own risk reporting and governance structures.

Developing standard templates will enable an effective and efficient risk reporting process.

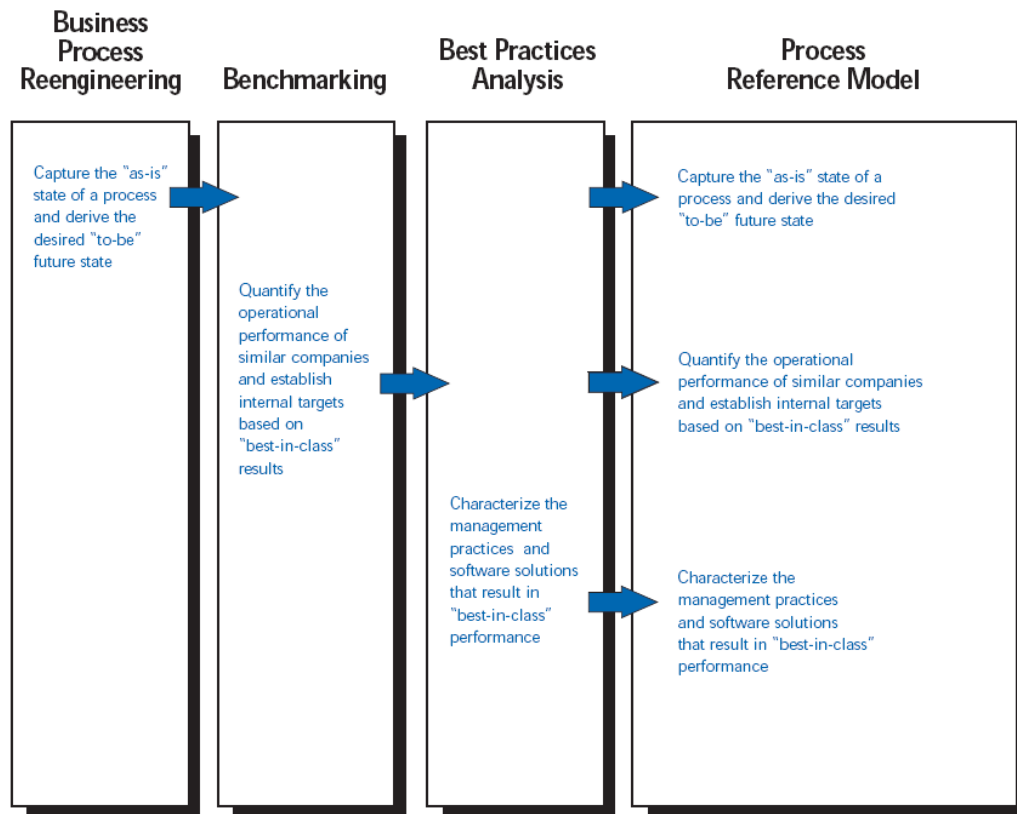
Step 4 Business process supporting the supply chain strategies and risk management framework



As discussed during the literature review in Chapter 2, a process reference model integrates the well-known concepts of business process re-engineering, benchmarking, and process measurement into a cross-functional framework. SCOR is a process reference model designed for effective communication among supply chain partners, and a standard *language* helps management to focus on management issues. As an industry *standard*, SCOR helps management focus across inter-company supply chains. SCOR is used to **describe, measure** and **evaluate** supply chain configurations;

- **Describe:** Standard SCOR process definitions allow virtually any supply chain to be configured.
- **Measure:** Standard SCOR metrics enable measurement and benchmarking of supply chain performance.
- **Evaluate:** Supply chain configurations may be evaluated to support continuous improvement and strategic planning.

Figure 4.10 SCOR Process Reference Model



Source: Supply-Chain Council, (2005)

According to the Supply Chain Council (2005:1), a process reference model contains:

- standard descriptions of management processes;
- a framework of relationships among the standard processes;
- standard metrics to measure process performance;
- management practices that produce best-in-class performance; and
- standard alignment to features and functionality.

Once a complex management process is captured in a standard process reference model form, it can be:

- Implemented purposefully to achieve competitive advantage;
- Described unambiguously and communicated;
- Measured, managed and controlled; and
- Tuned and re-tuned to a specific purpose.

After revising all the processes and writing them into the “to be” processes, proper systems should be put in place to do performance management.

Step 5 Performance measurement and reporting process

After finalisation and approval of processes and procedures, a proper performance management framework should be in place to track the progress that is made towards the achievement of the supply chain function’s balance score card. Through a process of dialogue and discussion the key strategic focus areas must be identified and key performance indicators for each focus area with targets for the balance score card must be set and agreed upon.

Typical key strategic focus areas that could be measured against within the supply chain function are:

- Risk management;
- Stakeholder relationships;
- Organisation design;
- People strategies;
- Supply chain business planning;
- Operational effectiveness & efficiency;
- Supply chain design & infrastructure;
- Sourcing;
- Inventory;
- Information and technology management; and
- Supply chain value proposition.

Figure 9 Example of a template to summarise the key focus area, strategy, strategy actions, tools and KPIs

Key focus area 1: Risk management & governance

Strategic Objective: To ensure that the risks the supply chain function is exposed to are managed at acceptable levels	
<i>Strategy</i>	<i>Strategic actions</i>
<i>Tools</i>	<i>Key performance indicators and targets</i>

Finally, proper training should be given to all involved within the supply chain function to ensure that everybody understands and agrees to the document. Monthly feedback sessions should be arranged to give feedback and decide on the way forward.

4.7 VALUE ADDING ROLE OF PROPOSED MODEL

Companies are in business to make money; it is all about cash focus and project excellence. Why do we need to manage and mitigate risks? It links strategic objectives to risks and internal controls to improve corporate performance, increase transparency, provide an early warning system and enhance business sustainability. This can be achieved by:

- having proper governance to ensure effective control over companies' assets and resources;
- through the above principal, stakeholder value can be maximised, resulting in the generation of cash through effective business strategies that cover good internal controls to manage and mitigate risk or prevent or detect possible system failures.

The proposed risk reduction model for the inbound supply chain function is a model based on a summary of the understanding of risk and the impact of the ongoing changes happening all the time within the internal and external environment; effective risk management framework to ensure good controls are in place to be able to proactively detect possible risks; and sustainable business processes and business strategies defined, understood and implemented, which support the business to be able to manage and mitigate risks before they can actually happen.

4.8 RECOMMENDATIONS FOR FUTURE RESEARCH

More detailed research can still be performed related to the following focus areas:

- Defining appropriate supply chain enabling technologies that can enable standardisation, and ERP (Enterprise Resource Planning) consolidation in a sheared services environment;

- Research and develop possibilities to establish, within the project execution model, actions and holdings points where supply chain involvement is required and needs signoff before the next step in the project may continue. These actions and holding points can ensure that standardisation and correct procedures are followed, controlled outcome is created and effective sourcing strategies are put in place.
- Research and identify material clusters in the business that are in the 95% group that have a low risk if the material is not available and have a high turn around in usage, which could make a business case to:
 - develop a system that can allow electronic trading with high response and support and service direct to the end-user as and when required; and
 - Outsource the warehousing function for non-critical materials that are $\pm 65\%$ of the materials in the warehouse.

This would allow the supply chain the capacity to focus on the high risk materials and ensure value adding to its stakeholders.

- Research the operation and maintenance structures, and working processes, and develop a point-of-entry system in the supply chain to create, align, understand and allow interaction with all stakeholders.

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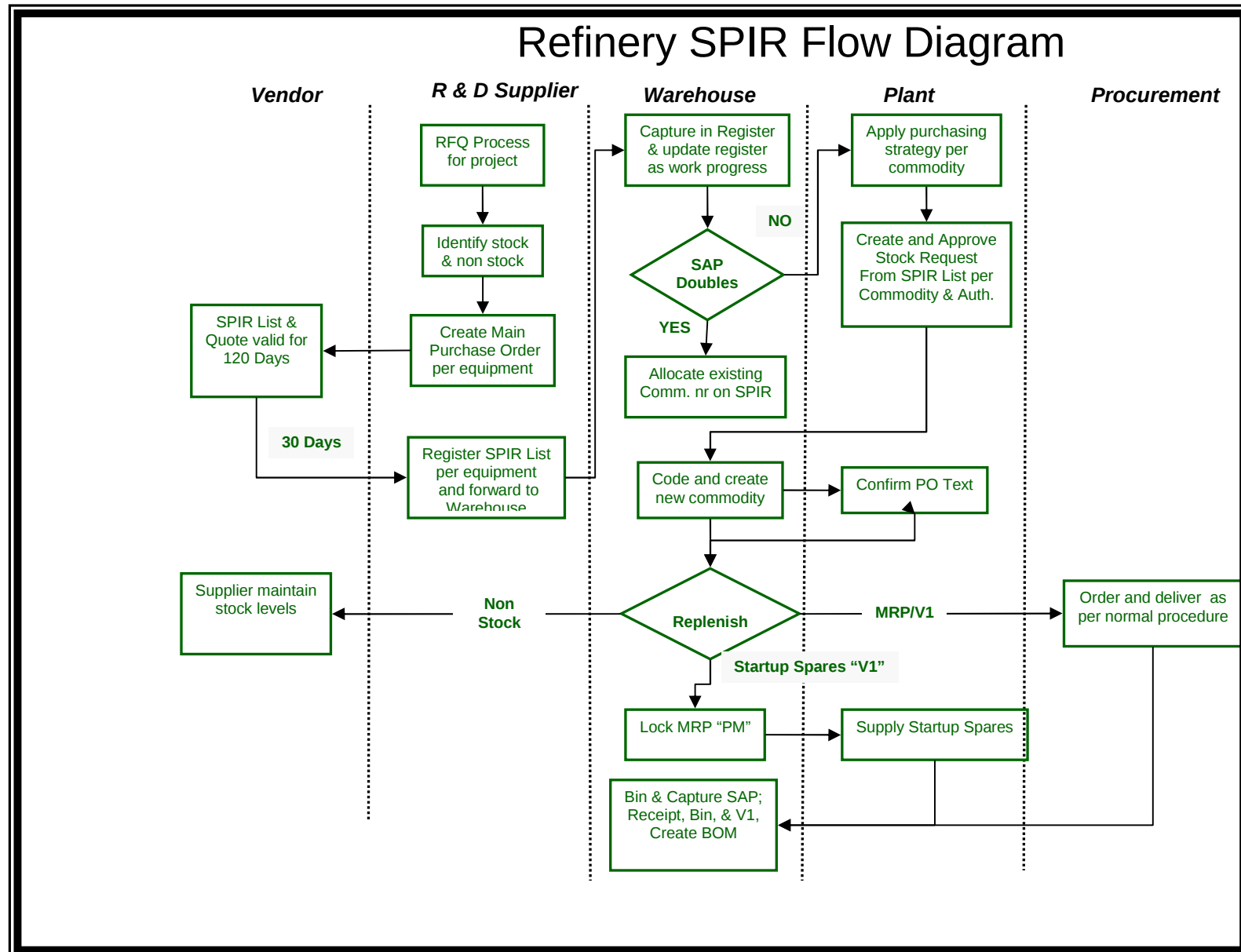
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ANNEXURE 1 REFINERY SPIR FLOW DIAGRAM AND SPIR FORM



[illegible]

ANNEXURE 2 MRP EVALUATION DOCUMENT FOR EXISTING AND NEW COMMODITIES

Requestor Date: ____/____/____

Signature _____

Commodity number Date: ____/____/____

Full description of commodity

☐ Exist ☐ New ☐ Link to BOM ☐ YES ☐ NO

A. EVALUATION CRITERIA FOR EXISTING STOCK COMMODITIES

			ACTUAL
A.1	Purchase price	> R5,000	
A.2	Period not being used	> 2 Years	
A.3	Demand patterns	From: Units / Mth	} $\Delta =$ Units / Mth
		To: Units / Mth	
A.4	Current stock levels	Max Min	

Commodity requires further investigation ☐ YES ☐ NO

B. RISK PROFILE OF EQUIPMENT

Equipment number

B.1 Risk rating:

Consequence

Frequency

Financial impact

Notice period when needed (MTTR)

SHERQ impact

☐ YES

Description

B.2 Availability of equipment

Equipment required for maintenance

☐ Planned / Breakdown

☐ Anytime

Number of equipment where commodity is used

Number required for normal operations

Equipment number

Alternative equipment / standby

Equipment number

B.3 Maintenance strategy

☐ Run to Failure

☐ Scheduled Maintenance

☐ Condition Monitoring

C. PROCUREMENT STRATEGY FOR MATERIAL

Availability of stock: ☐ Off the Shelf Lead time Days

☐ Manufacture Lead time Days

☐ Recondition Lead time Days

Supplier

☐ Local Lead time Days

☐ Overseas Lead time Days

☐ Sole Lead time Days

Alternative commodity available ☐ YES ☐ NO Commodity number

D DEMAND FOR MATERIAL

Unit of issue Minimum once-off usage

Mean time between failure commodity

Shelf life Criticality A/B/C

E RECOMMENDATION

☐ No Change ☐ Redundant ☐ No Stock

☐ Non Stock ☐ Stock ☒ New ☒ Recon ☒ Spares

☒ Complete

☐ Level Change Max Min

☐ Cost Impact

F SOURCING STRATEGY

Non Stock ☐ **Contract** ☒ **Lead Time** ☒ **Vendor Held Stock** ☒ **Consignment Stock**

☐ **RFQ**

Stock ☐ **Contract** ☒ **Lead Time** ☒ **Vendor Held Stock**

☐ **RFQ**

G RECOMMENDED WAREHOUSE

MRP Contr

Date: ____/____/____

Signature

H APPROVAL END USER

As per ASAM

Date: ____/____/____

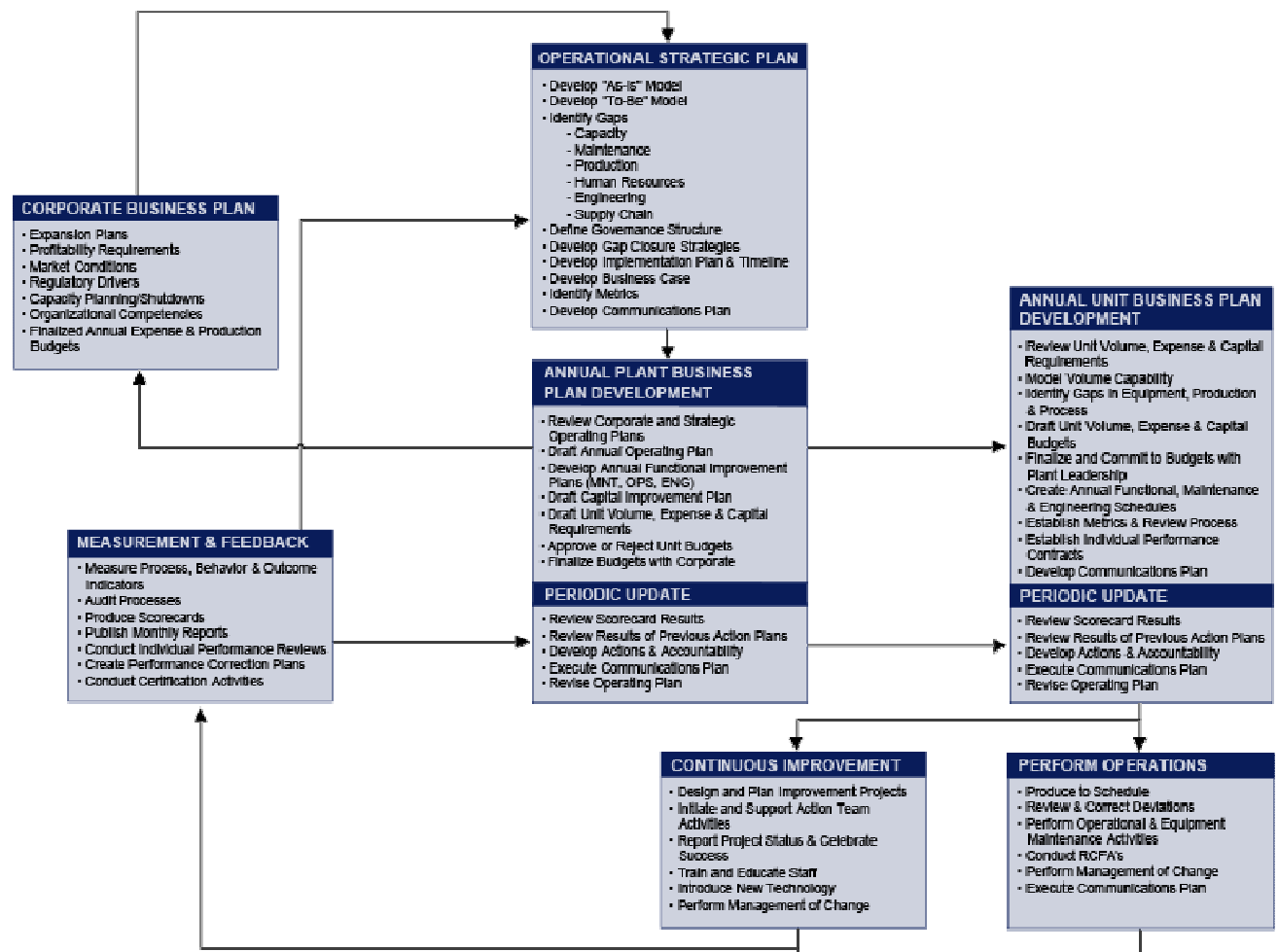
Signature

Manager S & D

Date: ____/____/____

Signature

ANNEXURE 3 SAMI MANAGING SYSTEM MODEL



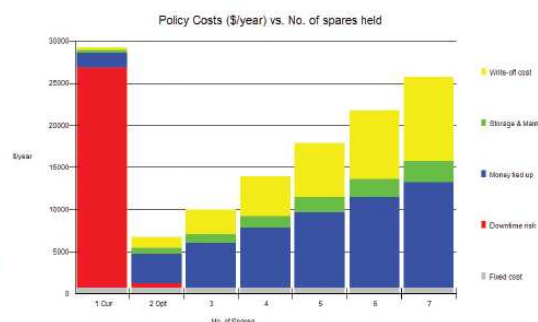


The decision-support tool for critical & slow-moving spares

APT-SPARES models

APT-SPARES is the most comprehensive analysis tool available. It performs instant 'what if?' calculations and uses advanced probability distribution analysis and queuing theory mathematics to identify the risks and consequences of alternative spares holding strategies.

- Installed population of equipment and redundancy or stand-by units, operating regime, reliability, demand rates and reparability.
- Unavailability consequences, criticality and escalating impact of failures.
- Normal, emergency and repair lead-times
- Capital costs, ownership, storage and maintenance costs.
- Shelf life, technology overtake, finite useful life horizons and obsolescence.
- Range-estimates and uncertain data or assumptions, with instant sensitivity testing and identification of 'tipping points'.
- Data import/export and batch review/update of data and assumptions.
- Graphical and tabular outputs, including all cost, risk, availability and service level implications of different inventory strategies.
- Comprehensive guidance, tips, configurable fields and defaults.



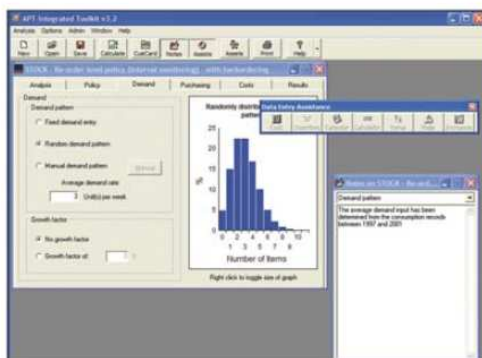
Source: Asset Performance Tools (APT). Decision Support Tools (2007)

EVALUATION & OPTIMISATION OF INVENTORY AND PURCHASING DECISIONS

- How do you determine the re-order stock levels?
- How do you determine the optimum re-order quantity?
- What is the optimum stock holding and how do you determine this?
- What is the optimum purchasing policy?
- What is the right blend of Just-In-Time and risk exposure?

APT-STOCK finds opportunities to save money, improve service levels, rationalise inventory and choose the best value supply chain options.

All materials and spare parts tie up working capital, and there is constant pressure to reduce inventory and obtain materials Just-In-Time. On the other hand, supply chain unreliability, quantity discounts, unpredictable demand and the operational impact if vital items are not available, all call for some buffer stock. APT-STOCK is the world-leading cost/risk evaluation method to determine the best compromise. In contrast to Economic Order Quantity and min/max stock algorithms, which only tackle part of the problem, APT-STOCK determines the right amount of risk to take, the optimal inventory and service level, reorder points, strategic inventory, spares 'pooling' options, storage requirements and a whole lot more.



A wide variety of purchasing policies can be easily modelled with intuitive user interface. The illustration shows entry of a random (Poisson distribution) demand rate.

APT-STOCK allows a wide range of min/max, reviews cycles and other inventory strategies to be applied. The conflicting pressures of variable demand patterns, replacement leadtimes, purchase quantity discounts, warehousing constraints and cost, stockout consequences and many other factors require sophisticated risk assessment to determine the best compromise decisions.

APT-STOCK identifies the right reorder level, purchase quantity, min/max thresholds and space requirements. A number of additional items of valuable information are made available for each purchasing policy.

- Total impact cost per item purchased
- Direct cost (excluding penalty costs)
- Average stock levels
- Annual turnover
- Service level (% of occasions a demand is met from stock)
- Number of containers required in warehouse
- Storage space required in warehouse

APT-STOCK uses powerful Monte-Carlo simulation techniques to calculate the optimum (lowest cost) purchasing policy. In order to obtain fast and accurate results a large number of simulations are carried out, capable of addressing different purchasing policies.

FUNCTIONAL SPECIFICATIONS

APT-STOCK performs a range of risk analysis functions, using sophisticated risk distribution analysis and dynamic simulation to determine the best way forward. It is a comprehensive tool for inventory/purchasing decisions taking into consideration:

- Multiple inventory management policies (reordercycles, reorder levels, min/max, fixed/variable reorder quantities, backordering options etc).

Source: Asset Performance Tools (APT). Decision Support Tools (2007)

ANNEXURE 5

EXISTING RISK MANAGEMENT PROCESS OPERATIONAL FUNCTION

