The impact of the Bullwhip Effect on throughput in an Electrical Utility in Pietermaritzburg

by

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Declaration

The work presented herein is my own and has not been submitted before for any degree or examination in any other University.

Where use has been made of the work of others, it has been duly acknowledged in the text.

Dhunraj Anirudh Dukhan
12 May 2006

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Executive Summary

In a rapidly-changing globalised economy, companies need to become more competitive to stay ahead of the competition and sustain the advantage of being on the top. Supply chain efficiency and lean production are familiar in supply chain management. However, there are impediments to the extent of success that companies wish to achieve. One such impediment is demand amplification (or the bullwhip effect) through the supply chain.

This study investigated the impact of human behaviour on the bullwhip effect, the impact of variability in materials and information flow, and the relationship between the impact of human behaviour and that of materials and information flow on the bullwhip. The research included a case study to validate the findings of the former investigations.

A questionnaire survey was conducted using a sample of supply chain role-players for the investigation of human behaviour of the bullwhip. A separate study was conducted on a sample of real-time projects for the investigation of materials and information flow on the bullwhip. A comparison was drawn between the two independent studies. A case study was presented, based on a power-lines refurbishment project, currently in the construction phase.

The results on human behaviour revealed that the types of "disabling" behaviour, namely "panic" or "safe harbour" exist amongst supply chain role-players. The findings of the study on real-time projects showed chronic variability in materials and information flow. Similar results have been reported from the findings of the case study.

The key conclusion is that there is a relationship between people and processes and both have an impact on the bullwhip.

The recommendations made are applicable to a generic company as well as Eskom. An action plan for a way forward for Eskom is included in this study. The key elements of the action plan include revision of the current policy document with suppliers, prioritization of customer projects and optimal use of the warehousing function.

Further research is proposed to extend the investigation to other regions and divisions within Eskom and to probe into the suppliers' supply chain to promote efficiency.

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Glossary of Terms

ABC	Activity-based Costing	A method of dividing on-hand inventory into unit-based measures using annual rand volumes.
BEE	Black Economic Empowerment	Companies with at least 51% black-ownership
	Bullwhip Effect	This effect is similar to a whiplash. It can move from one extreme value to another. Distortions in information flow from one end of the supply chain to the other can lead to a fluctuation in demand. This variability in demand is referred to as the "Bullwhip Effect".
CAO	Computer-assisted orders	Computerized standard ordering system that promotes information sharing between companies like Nabisco
COW	Clerk-of-Works	Project member who oversees quality on and off site.
CRP	Continuous Replenishment Program	Paperless inventory program in consumer products. Used by Nabiso, Nestle, Campbell Soup.
EDI	Electronic Data Interchange	A standard data-transmittal format for computerized communications between companies like Nabisco.
EDLC	Everyday Low Cost	Uniform pricing policy to eliminate price promotion. Used by Kraft, Pillsbury, P&G
EDLP	Everyday Low Price	Uniform pricing policy to eliminate price promotion. Used by Kraft, Pillsbury, P&G
KPI	Key Performance Indicator	Metrics instrument used to measure any performance-based activity.
MRP	Materials Requirements Planning	A dependant demand technique that uses the BOM, master schedules to determine materials requirements.
PC	Project Coordinator	Delegated by a Project Manager to administer the project in terms of scope, time and cost.
POS (or EPOS)	Point of Sale or Electronic Point of Sale	Point where product is purchased. EPOS uses computerized systems to enable transactions to be made.
RED	Regional Electricity Distributor	Restructuring of the Eskom Distribution business into Regional Electricity Distributors that will incorporate the electrical function of municipalities.
RPC	Regional Performance Compact	A set of standard Key Performance Areas encompassing KPI's used to measure regional based performance
SCM	Supply Chain Management	It is the integration of business processes from end-user through original suppliers that provide products, services and information that add value for customers.
	Throughput	Focuses on what the overall outputs are of a system. Overall throughput may be constrained by bottlenecks, which makes the system counter-productive and wasteful.
VMI	Vendor Managed Inventory	A supply chain in which the supplier manages the inventory. Inventory is delivered directly where needed instead of warehousing.
VSM	Value Stream Management	Improvement of designs and specifications at research and development stage of product development

Chapter One: Introduction

1.1. BACKGROUND AND MOTIVATION

Supply Chain Management is certainly one of the familiar "buzz-words" in modern production-related industries. While the concept is one of integrating business processes from the end-user to original equipment manufacturers, the process is not without glitches.

Research conducted on variability (later known as the bullwhip effect) within the supply chain had been conducted in industries other than the electricity distribution industry, which forms the basis for this dissertation. The company focus is on Eskom, which supplies 95% of South Africa's electricity. Within this large parastatal, there are three divisions, namely Generation, Transmission and Distribution. This dissertation is based on the Distribution division and more specifically on the Eastern Region.

A Regional Performance Compact (RPC) had been devised for the six regions within the Eskom Distribution Group with the main objective of creating inter-regional competitiveness by means of a set of common KPI's. The variance between forecasted and actual information was measured and weighted. The summation of the various measures translates to a percentage of bonuses that is awarded to a specific region from the bonus pool as illustrated in Table 1.1. The comparative ranking of the Eskom regions is shown at the bottom of the table. Of the six regions, the Eastern Region has come in last position. The major contributing factors to the poor performance were the variability in the supply chain which has resulted in the inability in meeting the needs of customers. Electricity connections to customers were under target, that is 18000 connections per household compared to a target of 35 000. This has a cascading effect of being under-spent on Capital expenditure targets and not meeting or exceeding customer expectations. It is therefore consistent with the poor performance illustrated by the Customer Index: the Eastern Region score was 10.42. The target score was 12.00. The customer connection rating was 4.68 which was below the target score of 7.20.

The results of 2005 and the interim results of 2006 have followed a similar trend. For clarity an extract of the 2006 interim results for stock is included in Table 1.2.

Table 1.1 : Eskom Regional Performance Summary Report for 2004

	Relative Weights	Score Min	Score OT	Score Max	Western	Southern	Northern	Central & N/West	Eastern
A. **Bonus Pool:**									
1. Revenue	4%	2.40	4.00	4.80	3.74	3.40	4.80	4.80	4.80
2. Operating Cost	14%	8.40	14.00	16.80	16.80	16.80	16.55	16.80	16.80
3. Working Capital	2%	1.20	2.00	2.40	2.01	2.40	2.27	1.20	1.64
	20%	12.00	20.00	24.00	22.55	22.60	23.62	22.80	23.24
B. **Eskom Modifiers:**									
1. Capital Expenditure	6.0%	3.60	6.00	7.20	7.20	5.71	7.20	7.20	4.32
2. Customer Index	12.0%	7.20	12.00	14.40	13.81	12.02	14.40	12.01	10.42
3. Electrification Connections *(incl FWH)*	7.8%	4.68	7.80	9.36	9.36	9.36	9.36	8.55	4.68
4. Technical - Dips	4.5%	2.70	4.50	5.40	5.40	5.23	5.06	5.40	5.31
5. Technical - Waveform	6.0%	3.60	6.00	7.20	7.06	6.41	7.20	7.20	7.20
6. DIIR	4.5%	2.70	4.50	5.40	5.40	5.40	4.05	5.40	5.40
7. BEE Payments	4.2%	2.52	4.20	5.04	4.33	4.72	4.51	4.70	4.64
5. BWO Payments	3.0%	1.80	3.00	3.60	3.50	3.07	3.60	3.60	3.60
8. Gender Equity	4.8%	2.88	4.80	5.76	5.76	5.76	5.76	5.76	4.39
10. Racial Equity	4.8%	2.88	4.80	5.76	5.76	5.76	5.76	3.49	5.76
11. Disability Equity	2.4%	1.44	2.40	2.88	2.88	2.86	2.88	2.16	2.72
	60%	36.00	60.00	72.00	70.46	66.30	69.78	65.47	58.45
Eskom Pool & Modifiers	80%	48.00	80.00	96.00	93.01	88.89	93.40	88.27	81.69
C. **Divisional Modifiers:**									
1. EDI Restructuring	4%	2.40	4.00	4.80	4.00	4.00	4.00	4.00	4.00
2. Forcasting Accuracy	1%	0.60	1.00	1.20	1.00	1.00	1.00	1.00	1.00
3. Inter Divisional Service (Other Eskom Groups)	1%	0.60	1.00	1.20	1.00	1.00	1.00	1.00	1.00
4. Refurbishment Cost	1%	0.60	1.00	1.20	1.20	0.60	1.20	0.60	0.60
5. HR Sustainability Index	3%	1.80	3.00	3.60	3.60	3.60	3.60	3.60	3.16
6. Operational Sustainability Index	4%	2.40	4.00	4.80	4.52	3.56	4.20	4.52	4.49
7. Enviromental:	1%	0.60	1.10	1.20	1.20	1.18	0.72	1.18	1.20
Legal contraventions affecting SI	1%	0.30	0.60	0.60	0.60	0.60	0.30	0.60	0.60
Enviromental Index	1%	0.30	0.50	0.60	0.60	0.58	0.42	0.58	0.60
8. Audit:	2%	1.20	2.20	2.40	2.38	1.80	2.24	2.28	2.26
Audit Index	1.0%	0.60	1.00	1.20	1.18	0.60	1.04	1.08	1.06
Significant Findings Overdue	1.0%	0.60	1.20	1.20	1.20	1.20	1.20	1.20	1.20
9. Credit Management:	1%	0.60	1.00	1.20	1.20	1.18	1.11	0.98	1.09
LPU >90days (Total)	0.1%	0.06	0.10	0.12	0.12	0.12	0.12	0.12	0.12
SPU >90days (Live Accounts)	0.4%	0.24	0.40	0.48	0.48	0.48	0.42	0.40	0.40
LPU Days (Total)	0.2%	0.12	0.20	0.24	0.24	0.22	0.21	0.12	0.22
SPU Days (Live Accounts)	0.3%	0.18	0.30	0.36	0.36	0.36	0.36	0.34	0.36
10. Residential Losses	2%	1.20	2.00	2.40	2.40	2.40	2.28	2.01	2.40
	20%	12.00	20.30	24.00	22.49	20.32	21.34	21.17	21.20
TOTAL	100%	60.00	100.30	120.00	115.50	109.22	114.73	109.44	102.89

Bonus Pool: Comparative Ranking:		% of on Target Bonus pool:
1. Western	115.50	104.7
2. Northern	114.73	104.0
3. C&NW Combined	109.44	99.2
4. Southern	109.22	99.0
5. Eastern	102.89	95.0
average	110.36	

(Eskom, 2004:54)

From Table 1.2 it can be observed that the Eastern Region has come last for Stock measured as a 12 month moving average and has scored half of the points (0.60) of the other regions that scored maximum points (1.20).

Table 1.2: <u>Extract from the Interim Eskom Regional Performance Summary Report for 2006</u>

	Unit	Relative weight	Score Min	OT	Max		West	South	North	Central	North West	East
A. Bonus Pool:												
4. Stock [12mma]	R'000	1.0%	0.60	1.00	1.20		1.20	1.20	1.20	1.20	1.20	0.60

(Eskom, 2006:2)

In terms of the allocation of the bonus pool, the region that has come in last must donate 20% of their allocated pool to the region that has come first. Hence the penalty for being last is severe. The employee morale of the Region is affected by these low scores.

There is a need for improving supply chain efficiency to prevent a recurrence of the above performance in future. This dissertation aims at addressing the bottlenecks and proposes a way forward so that the company can continue to be competitive as a global player.

1.2. OBJECTIVES OF THE RESEARCH

The research objectives were three-fold as follows:

1.2.1. Research Objective One

To determine the impact of human behaviour on the bullwhip effect.

1.2.2. Research Objective Two

To determine the impact of fluctuation in materials and information flow on the bullwhip

1.2.3. Research Objective Three

To investigate the relationship between research objectives one and two and validating by means of a case study.

1.3. RESEARCH METHODOLOGY (SUMMARY)

The research methodology used to achieve the first objective was through a questionnaire survey. A sample of real-time projects was used for the accomplishment of the second objective A comparison was drawn for both findings to achieve objective three and a random project currently in the construction phase was chosen for the case study to validate the findings.

1.4 OVERVIEW OF THE RESEARCH

This research is divided into eight chapters.

Chapter Two: This chapter presents a historical background of key developments regarding the bullwhip effect . Examples of the bullwhip effect in various industries are illustrated and its causal factors and mitigating measure discussed.

Chapter Three: This chapter focuses on Eskom's company background, its supply chain, and Regional processes.

Chapter Four : This is the methodology chapter. It focuses on the problem statement, objectives of the research and research design.

Chapter Five: This chapter focuses on the research findings

Chapter Six: draws conclusion of this research

Chapter Seven : provides recommendations based on this research

Chapter Eight: proposes further research and limitations of this research

Chapter Two: The Bullwhip Effect

2.1. INTRODUCTION

According to Donovan (2004:1), the objective of supply chain management is to provide a consistent flow of accurate relevant information that will enable suppliers to provide timeous, uninterrupted flow of materials to customers. When SCM is well executed, Hugo *et al* (2004:66) are of the view that suppliers, manufacturers, warehouses and intermediaries are integrated to the extent that "production and distribution is synchronized with customer demand". This in effect reduces system costs and fulfills the needs of service level agreements.

According to Lee *et al* (1997:93), distorted information flow can lead to variability throughout the supply chain. Nienhaus *et al* (2003:5), Simchi-Levi *et al* (2000:82) and Hugo *et al* (2004:66) share the view that variability in demand increases as one moves up the supply chain. Geary *et al* (2005:2), refer to the variability in demand as demand amplification. This phenomenon is known as the "bullwhip effect" and is described in more detail in the next section.

2.2. THE BULLWHIP EFFECT-TOWARDS A DEFINITION

2.2.1. Historical Overview

Jay Forrester (1958:38) is regarded as the pioneer of supply chain management based on his studies on demand amplification through System Dynamics simulation. System Dynamics deals with how things change through time and can be simulated by computer models. Forrester (1958: 47) simulated the propagation of demand waveforms upstream in the supply chain and introduced the concept of "rogue seasonality" to show the order patterns of promotions and discounts. According to Fisher (1997:107), the concept of the bullwhip is not new and dates back to the twentieth century.

Most studies of the bullwhip effect (also known as the "whiplash" or "whipsaw" effect) converge towards the emphasis of variability in demand across the supply chain (Hayes and Wheelwright, 1984:20). According to Holmstrom (1997:108), the amplification of the bullwhip can be as much as 20:1. This may lead to stock-outs and severe losses for the industry. Consequently, when demand is reduced, then stock-on-hand and obsolete stock increases (Metters, 1997:91). The bullwhip effect is described as a consequence of unplanned demand oscillations, which may be a minor blip for one customer but may often result in "huge and costly disturbances at the supplier end of the chain"(Donavan, 2004:1). Lee *et al* (1997:93) definition of the bullwhip effect is the amplification of demand variability as a result of information distortion in a supply chain where companies upstream do not have information on actual consumer demand. According to Burt *et al* (2003:628), the bullwhip effect is a "fictional or phantom demand" and originates from the "failure to accurately estimate demand". The cumulative effect of the bullwhip is observed when inaccurate information cascades up the supply chain (Burt *et al* 2003:627). Leenders *et al* (2002:211) describes the bullwhip effect as "a large fluctuation in demand" due to for example, poor order policies that are based on lot sizes like full truckloads to minimize shipping costs. A more comprehensive definition of the bullwhip effect is that it is a phenomenon that "describes how inaccurate information, a lack of transparency throughout the supply chain, and a disconnect between production and real-time supply chain information result in lost revenue, bad customer service, high inventory levels and unrealized profits" (Factory Logic Whitepaper, 2003:2).

2.2.2 . Supply Chain Efficiency

Schmenner (2001:87) is of the view that for supply chain management to be effective; there must be a swift and even material flow. Burbidge (1981:88) made great strides in efficiency in the supply chain by advocating the use of smaller batches to reduce set up times of manufacturing lines. Forrester and Burbidge invented the FORRIDGE approach which is a set of streamlined material flow principles to reduce the effect of the bullwhip. In an effort to improve on the FORRIDGE approach, various theories emerged but converged towards supply chain efficiency. The theories were operational research (Lee *et al,*1997:101), Control Theory (Disney and Towill, 2002:180) and filter theory (Dejonckheere *et al,* 2002:135). These studies provided the basis for imperical studies of the bullwhip using simulation (Forrester, 1958:38; van Ackere *et al*,1993:413). Other studies included business process re-engineering, especially in global supply chains. (Towill and McCullen, 1999:84; Miragliotta, 2004; Watson, 1994:262).

2.2.3. Historical Best Practices in the Supply Chain

The development of smooth material flows was documented in the design and construction of the Crystal Palace in London in 1851(Towill *et al*, 2002:80). The construction led to the concept of Just-in Time (Wilkinson, 2000:51). Drucker (1995:56) used Japanese methods of value stream management (VSM) which was practiced at General Motors. Lean production was practiced at Toyota in 1970's and used to develop metrics for benchmarking (Womack *et al.*, 1990:62). The bullwhip effect was historically known, but not defined. Hence there were not many solutions available. Mitchell (1923:633), Sterman (1986:88) and Zymelman (1965:589) had knowledge of this effect in the textile and cotton industry. Other studies in a similar industry were undertaken by Stalk and Hout (1990). In the mid 1990's, Joseph Andraski (1994:2), estimated that only 7% of supply chains in the US retail industry are effective.

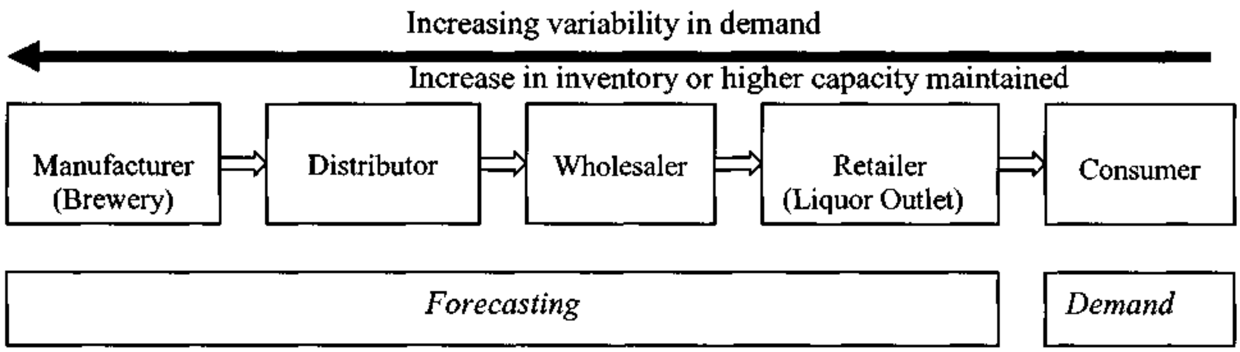
2.3. EXAMPLES OF THE BULLWHIP EFFECT

A number of industries such as the beer, diaper, tobacco, printing and soup industry is considered in the discussion of the bullwhip effect.

2.3.1. The Beer Industry

In Figure 2.3.1, a four-stage beer supply chain may be observed which has a retailer (liquor outlet), a wholesaler, a distributor and a manufacturer (brewery).

Figure 2.3.1. Illustration of the Bullwhip Effect



(Hugo, Badenhorst-Weiss and Biljon, 2004:67)

The retailer obtains demand data from the consumer and based on this demand, the retailer places orders to the wholesaler. The wholesaler uses the retailer's demand information and places orders with the distributor who in turn places orders with the manufacturer, who in this instance is the brewery.

In order to describe the variability in demand, the second stage of the supply chain, namely the wholesaler, is considered. Beer quantities that the wholesaler needs are dependent upon the retailer's demand. Assuming that the wholesaler does not have access to the retailer's demand information such as weekly beer sales, or that the data is not accurate, and then the wholesaler will forecast the retailer's demand based on orders placed by the retailer. These orders are variable on a daily or weekly basis. In the interest of customer satisfaction, the wholesaler is obliged to carry more safety stock or maintain higher capacity than the retailer.

The phenomenon of carrying more inventory or maintaining higher capacity increases as one moves up the supply chain (Hugo *et al*, 2004:67). The implications are that an even higher inventory level that is higher carrying costs, are incurred by the distributor and manufacturer. These inefficiencies may be reduced or eliminated by using various techniques described in section 2.7. under " Mitigating the Bullwhip Effect".

2.3.2. The Diaper Industry

At Proctor and Gamble, logistics executives discovered that one of their products, "Pampers", displayed an interesting phenomenon [Lee *et al* (1997:93), Simchi-Levi *et al* (2000:82)]. While the retail sales of the product were fairly uniform, it was observed that the distributor's orders placed to the manufacturer fluctuated much more than retail sales. This is similar to the beer industry described earlier in the text. According to Lee *et al* (1997:93), one would expect that babies consumed diapers at a constant rate but the variability in the supply chain amplified as one moved up the supply chain; a typical display of the bullwhip effect.

2.3.3. The Tobacco Industry

The example of how the behaviour of a sales representative of a tobacco company in Richmond, Virginia influenced the bullwhip effect in the industry is cited in Burt *et al* (2003:628). The sales representative would frequently enquire about the stock levels of the retailers. The retailers believed that there was an increased demand for the product and in turn increased orders from the manufacturer. The manufacturer reacted to the retail demand by hiring additional resources, adding a new shift and paying overtime. The tobacco suppliers increased agricultural operations and hired more workers.

However at retail level, sales were slow and declining due to increased stock levels and anti-smoking lobby-groups. The retailers then cancelled future orders from the manufacturer. The manufacturer reacted by eliminating shift work and retrenched newly hired workers. The suppliers' orders were subsequently reduced and newly hired resources on farmlands were cancelled.

2.3.4. <u>The Printing Industry</u>

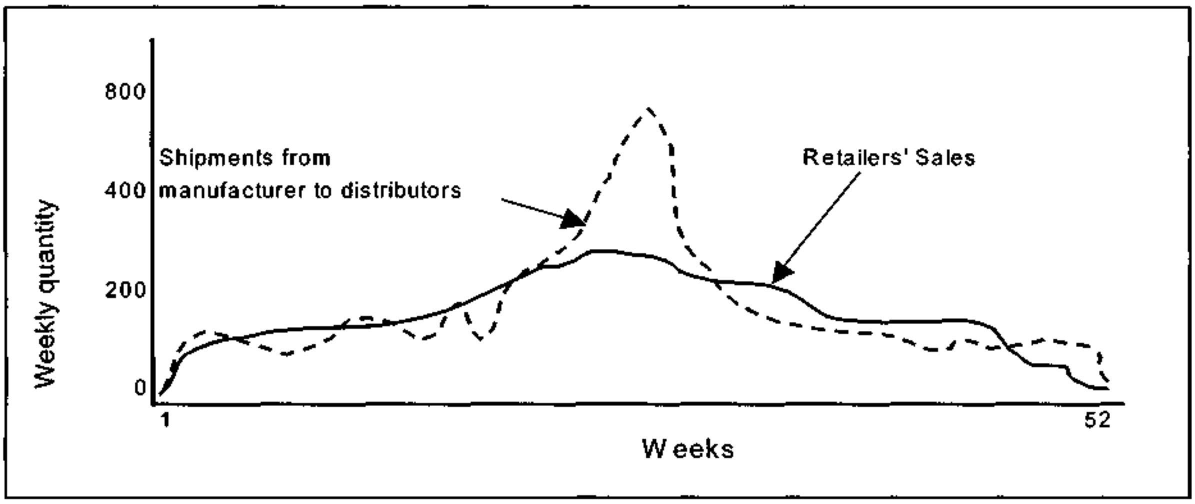
The sales of one of Hewlett-Packard (HP) best-selling printers, were examined by the company's executives due to fluctuations in orders at the retailers (Lee *et al* ,1997:93). It has since been observed that the orders placed by the retailer to the factory had even greater swings. The fluctuation in orders increased from the printer division to the integrated circuit division.

The company attributed the inefficiency of its supply chain to the bullwhip effect, where distorted information was transmitted up the chain by retailers exaggerating sales figures. One of the main reasons for the fluctuations, according to Lee *et al* (1997:93), is poor product forecasting . Each level in the supply chain depended on demand data from the previous level. The consequences were crippling, for instance, poor customer service prevailed due to stock-outs and high corrective costs such as expedited shipping and overtime costs negatively influenced the company's bottom-line profitability.

2.3.5. <u>The Soup Industry</u>

The soup industry is an example of seasonal sales fluctuation with higher winter sales as shown in Figure 2.3.5. Companies in this industry have to often run overtime for a short period and stay idle at other periods due to these fluctuations in demand (Lee *et al*, 2004:97). Another strategy that companies implement is to stock-pile in anticipation of future demand. This type of practice may lead to damage of inventory in transit due to the handling of large volumes. Furthermore, the cost of shipment increases due to the payment of premium rates for transporting the product.

Figure 2.3.5. Bullwhip Effect due to seasonal sales of soup

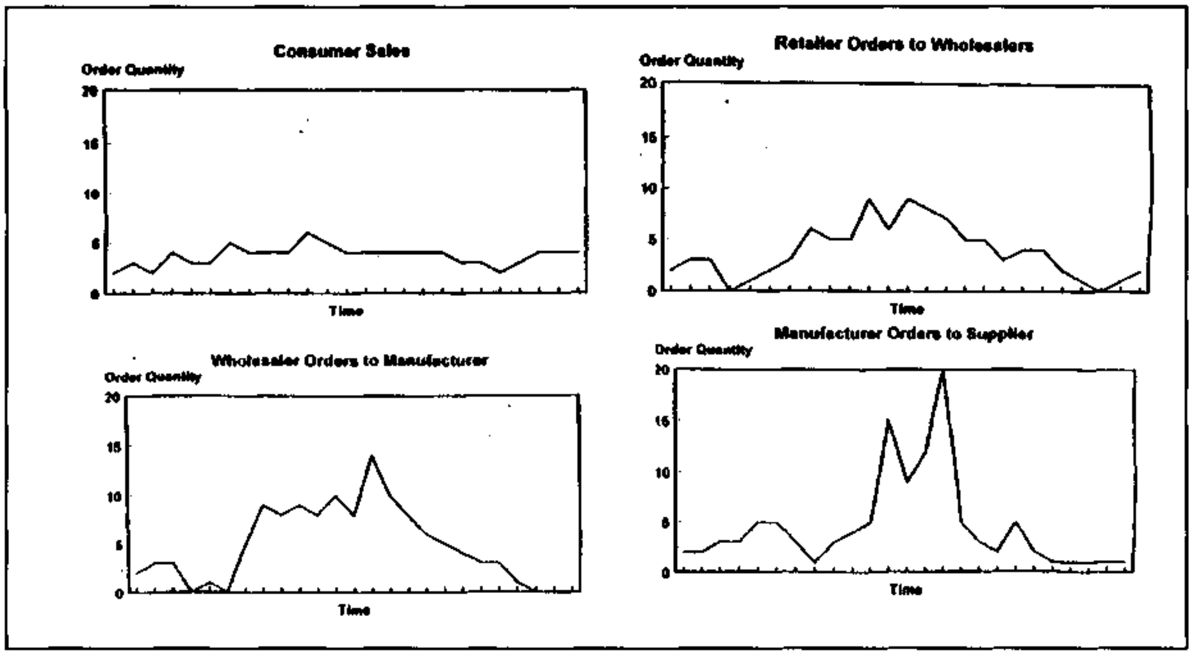


(Lee, Padmanabhan and Whang,1997:97)

2.4. COMPARISON OF THE BULLWHIP EFFECT IN VARIOUS INDUSTRIES

The bullwhip effect has a common pattern of occurrence through many industries described earlier in the text.

Figure 2.4. Increasing variability of orders up the supply chain



(Lee, Padmanabhan, and Whang, 1997:94)

It may be illustrated in a typical consumer product where consumer sales vary marginally, but the variability in orders is greater from retailer to wholesaler and in turn from wholesaler to manufacturer and so on.

For instance, in the computer and pharmaceutical industry, information distortions may cause inventory on hand to exceed 100 days (Lee *et al*, 1997:94). When the shelf life of these products is considered to be around a few days to about three months, the decision to stock up is an extremely costly one.

2.5. THE IMPACT OF HUMAN BEHAVIOUR ON THE BULLWHIP EFFECT AND SUPPLY CHAIN PERFORMANCE

2.5.1. Beer game simulation

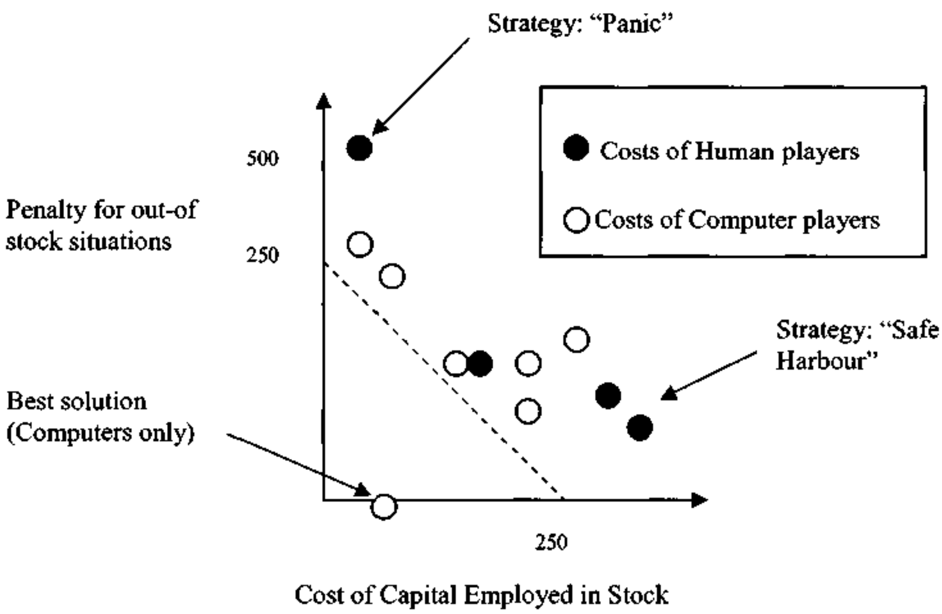
Studies reported by Nienhaus *et al* (2003:7) on the beer distribution game played online, with more than 400 participants, show how humans perform as co-makers in the supply chain as compared to simple agency-based strategies such as "moving average" or "keep level of stock". The simulation is based on a four-stage supply chain similar to that illustrated in Figure 2.3.1. Orders flow from the customer to the retailers and up the chain while the material flows from the manufacturer downwards to the customer. Decisions are executed by co-makers based on current stock levels, the time to transport stocks and time to order stock from suppliers with lead times of one period between each stage in the supply chain. The goal of the exercise was to minimize the overall cost of the supply chain by finding the balance between minimizing the cost of capital employed in stocks and avoiding stock out situations.

According to Nienhaus *et al* (2003:5), the optimum solution is when the co-maker passes onto the supplier the customer's order after refilling customer stock levels. In this way the initial stock levels would be sufficient to cover an unexpected higher demand during information and material lead times. For example, if at each stage in the supply chain, it takes one period of time to inform suppliers of a change in demand and two periods to replenish customer stock from the supplier, then the reaction time to the change in demand is a total of three periods. Suppose unexpected demand is four units, then the stock required to meet this change in demand is twelve units, that is, the unexpected usage multiplied by the total lead time. At period one the stock level will be eight (12-4), period two will be four (8-4) and period zero (4-4). The supply chain is then adjusted to the new order filling which, in this instance, is eight instead of four units.

2.5.2. Human Strategies

Figure 2.5.2. illustrates the types of human strategies namely "safe harbour" or "panic". Dots depict the typical action of a co-maker .On the horizontal axis is the cost of capital employed and the vertical axis is the penalty for out-of stock situations. The further along the horizontal a co-maker is, the higher will be the cost of capital employed. The further up the vertical axis a co-maker is located, the greater the penalty for out of stock. According to the simulation, the best solution for humans was according to the "keep level of stock" strategy resulting in a total cost of 228 for four co-makers combined. For the computer, the best solution was no costs for out-of stock situations. It was reported that the average total costs for humans was about 800-900 units with an extreme case of 4000 unit costs incurred by the worst-performing group.

Figure 2.5.2. Performance of human co-makers vs. agent-based strategies



(Nienhaus, Ziegenbein, and Duijts, 2003:7)

2.5.3. Reasons for poor performance by human co-makers

According to Nienhaus *et al* (2003:5), human co-makers act as "safe harbours" in the supply chain. This implies that this group of co-makers order more than is required thereby increasing safety stock. The supplier reacts by increasing his orders and pay for out-of-stock situations. Only one co-maker displaying the "safe-harbour" strategy can negatively impact on the entire supply chain.

The other extremity in strategy is "panic". Typical reaction of co-makers in this category is to get rid of stock before demand increases by the end customer. When there is an increase in demand from the end customer, the co-maker orders more than one who has safety stock left. The outcome of employing a "panic" strategy is the same as that of the "safe harbour" strategy; both have the same negative impact on the supply chain.

The conclusions from the simulations were that the greater the deviation from the best solution as shown in Figure 2.5.2, the higher will be the cost incurred due to the tendency to adopt either the "panic" or "safe harbour" strategy.

2.5.4. Changing supply chain process versus changing role-players behaviour

Lee *et al* (1997:95) argue that companies wanting to control the bullwhip effect should focus on "modifying the chain's infrastructure and related processes rather than the decision makers' behaviour." Nienhaus *et al* (2003:7) on the other hand, demonstrates that human behaviour does influence the efficiency of a supply chain. The reasons put forward on the impact of human behaviour on the bullwhip effect are in addition to other reasons influencing this phenomenon.(Niehaus *et al* ,2003:8).

According to Matta and Ashkenas (2003:111), the key to the completion of successful projects is to set up results-orientated integrated teams. An example cited in the text is the increase in milk production in Nicaragua from 600 gallons to 1600 gallons in 120 days. Parmalat, the largest milk producer in Nicaragua, set up a milk productivity team to meet the aforementioned objective. The team discovered that more than half of all milk purchased by distributors was being dumped due to contamination and spoilage. The solution was to test the milk at source using a centrifuge that would expedite testing. Furthermore, to limit fluctuation in demand, the milk was collected daily rather than twice weekly. This solution has also reduced operating costs by not investing in expensive refrigeration equipment.

The team leader assigned to the milk production project had discovered that role-players preferred to work on projects that are results-orientated , despite the risks involved in such projects, rather than opt for implementing a set of predefined tasks without risks (Matta and Ashkenas , 2003:112).

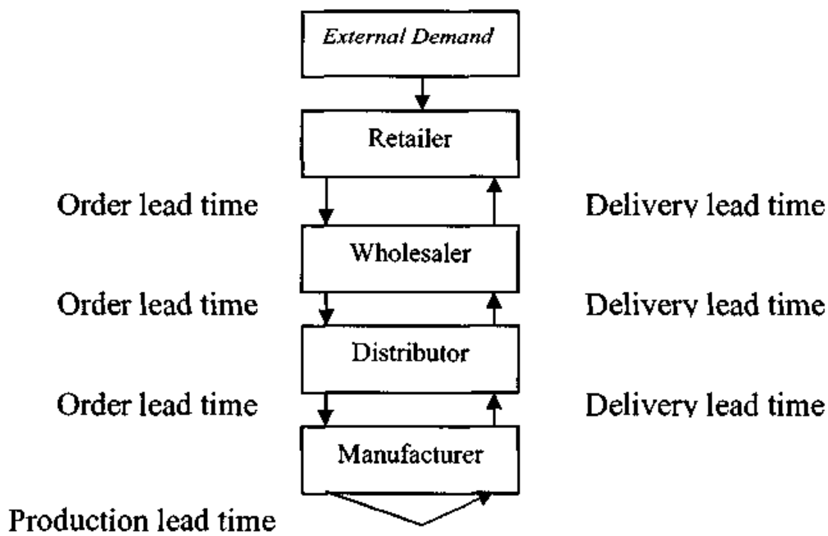
2.6. CAUSAL FACTORS OF THE BULLWHIP EFFECT AND ITS IMPACT ON SUPPLY CHAIN PERFORMANCE

Much has been discussed on the human behavioural impact on the bullwhip in the previous section. The bullwhip effect has been illustrated in section 2.3 by way of examples. However, there are other factors that contribute to this phenomenon and hence the need for further discussions on the subject at hand.

2.6.1. Lead time of information and materials

Lead time of information and material lead times is reported to be one of the primary reasons for the bullwhip effect (Niehaus *et al* ,2003:5). The supply chain in Figure 2.6.1. illustrates the components of total lead time in a supply chain.

Figure 2.6.1. A simple supply chain showing lead time elements



(Simchi-Levi, Kaminsky and Simchi-Levi, 2000:83)

According to Hugo *et al*, (2004:156), each stage of the supply chain as illustrated in Figure 2.6.1., must establish demand from its customers. For instance, the wholesaler accepts orders from the retailer and places orders with the distributor. To expedite delivery of an order, the wholesaler forecasts order quantities received from the retailer and other retailers in the supply chain. The only source of information that the wholesaler has at his or her disposal, is the order quantity placed by the retailer and not the external demand data from the retailer's customers. The wholesaler would then add safety stock to the orders placed to the distributor. However, this practice of adding safety stock is repeated for the other retailers. The wholesaler may batch all retailer orders as a single order to the distributor and consequently amplify the demand, as there is an element of safety stock in each of the retailers' orders.

The amplified demand, or bullwhip effect, increases with an increase in lead times as more provision is made for safety stock. It is thus important for inventory planners to monitor the accuracy of lead times and safety stock and make every effort in reducing these elements (Ross, D.F.,1996:303).

According to Niehaus *et al* ,(2003:2), the value of information is often under-estimated. Research conducted among operational managers from 200 companies has shown that the more important the information from customers is, the more frequently it is available to the company. However, it was discovered that operational managers would pass on the same information less frequently to their suppliers. By not passing on customer information to suppliers when it is available, the operational manager then becomes a hindrance to the flow of information throughout the supply chain, causing the bullwhip effect to be amplified by the increase in information lead times.

2.6.2. <u>Centralized versus Decentralized Information</u>

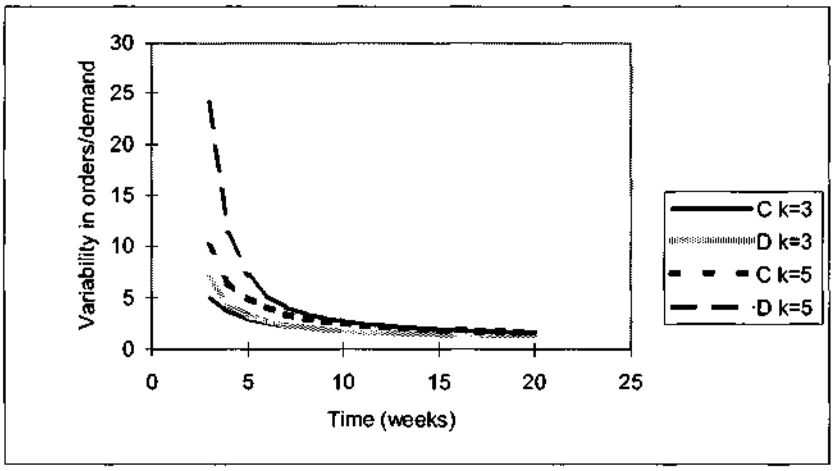
Irrespective of whether the supply chain is centralized or decentralized, the variance in order quantities increases when one moves up the supply chain. The difference between the two types of supply chains is the extent of variability as one moves from one stage to the next.

In a decentralized supply chain, customer demand is known only to the retailer, whereas in a centralized supply chain customer demand data is available at each stage of the supply chain (Simchi-Levi *et al*, 2000:90).

According to Chen *et al,* (2000:437), efforts to quantify the bullwhip effect has led to two mathematical inequality models which quantify the impact of lead time on the bullwhip effect. The application of the model has shown that variance in orders increase additively in total lead time of a centralized supply chain. However, the variance in orders increases multiplicatively in a decentralized supply chain.

The conclusion derived by Simchi-Levi *et al,* (2000:90), is that by centralizing demand data, the bullwhip effect can be significantly reduced. The differences between the two systems are illustrated in Figure 2.6.2, where "C" and "D" refer to centralized and decentralized supply chains in a particular stage "k" for lead time of 1 week between each stage.

Figure 2.6.2. Increase in variability for centralized and decentralized systems



(Simchi-Levi, Kaminsky and Simchi-Levi, 2000:87)

2.6.3. Demand forecast updating

According to Geary *et al* (2005:10) forecasts are rarely accurate. However in-built safety factors and trend detection makes forecasting more accurate. Lee *et al* (1997:93) are of the view that forecasting is based more frequently on historic order data from the company's immediate customers. When downstream role-players place an order, upstream managers process the information as a signal about future demand for a particular product. The upstream manager's reaction is to modify the demand forecast based on the signal received from downstream role-players and pass it onto upstream suppliers.

According to Simchi-Levi *et al*, (2000:85), managers use forecast smoothing techniques to forecast demand. For example, using exponential smoothing, future demand data is updated continuously when daily demand data become available. Orders sent to suppliers will have an element of replenishment stock and safety stock levels required.

As discussed in section 2.6.1, the fluctuation in order quantity is due to the level of safety stock and the lead times. For instance, long lead time material orders may have weeks of safety stock. This in effect increases the variability in order quantity compared to the demand data (Lee *et al* 1997:95).

The choice of forecasting systems, according to Simchi-Levi *et al*, (2000:99), may vary from one stage of the supply chain to another. As different techniques are employed by different role-players in the supply chain, the integrity of demand data may not be as accurate for effective forecasting of future demand. For example, future customer demand is dependent on variables such as pricing, promotions and launch of new products. Some of these variables are within the control of the retailer, while others are within the control of the wholesaler or distributor. For instance, suppose the retailer decides to introduce the launch of new products to customers and/or have a price promotion. This would change the demand patterns up the supply chain.

However, suppose all role-players in the supply chain collaborated with the retailer, for example the wholesaler and distributor offered more information of the product (as they have few products to consider) to the retailer, the retailer would then be in a position to take advantage of the situation by increasing inventories or increase the price of the product. This demand pattern is then shared with all role-players in the supply chain with a common forecasting technique.

2.6.4. <u>Batch Ordering</u>

As inventory demand increases in the supply chain, orders are not placed timeously with upstream suppliers. The common practice that a company may follow is to batch the demand before placing orders. This practice, according to Lee *et al* (1997:96), may be in the form of periodic ordering or push ordering.

Companies usually order weekly, biweekly or monthly. According to Simchi-Levi *et al*, (2000:85), if a retailer orders in batches from a wholesaler using a usual min-max inventory policy, then the wholesaler observes erratic streams of orders such as large orders followed by periods of no orders, large orders again and the pattern may repeat itself. This time-phased aggregation of orders leads to the bullwhip (Geary *et* al, 2005:10). Saunders, M.(1997:210), is of the view that lead times are an integral component of order batching. The effort spent on waiting to fill large batches, is inefficient as it ties up capacity to produce goods that are not needed immediately. According to Saunders, M.(1997:210), the longer the lead times, the greater the capacity and time period held up in stock.

Simchi-Levi *et al*, (2000:85) offers reasons as to why companies may order in batches. The first reason is that companies incur high costs in filling orders. Proctor and Gamble is one of the examples cited by Lee *et al* (1997:96), of the cost to process an order to its customers: between $35 to $75 . The company places orders with its suppliers when they run their MRP system, which is normally run monthly. The supplier may be subject to variability in demand greater than the company itself. According to Lee *et al* (1997:96), periodic ordering does amplify variability and contributes to the bullwhip effect. The second reason why companies batch orders is to save on transportation costs. Lee *et al* (1997:97) suggests that there are incentives in ordering full truckloads as compared to less than a full truckload of materials. However, the lead times and order cycles increase as Saunders, M.(1997:210), has highlighted earlier in the text. According to Saunders, M.(1997:211), by batching large orders, the need for more storage facilities will arise, hence increase in "wasteful costs".

When quarterly or yearly sales quotas need to be met, salespersons may "borrow" ahead or sign orders in advance. This causes the company to experience surges in demand, due to orders being "pushed" by salespersons wanting to meet incentive-driven sales targets. This phenomenon is what Lee *et al* (1997:97) refers to as push ordering.

The ideal scenario would be one in which all customers' order cycles are evenly spread in a given period. However, as Lee *et al* (1997:97) points out that orders may be randomly spread or overlap with customers ordering periodically. The problem arises when random orders and periodic orders coincide. This surge in demand is most pronounced and influences variability from the bullwhip effect the most.

According to Lee *et al* (1997:97), companies that generate purchase orders either at the beginning or end of the month, are subjected to order cycle overlapping. Hence, the periodic running of MRP systems contributes to the bullwhip effect.

Shapiro *et al* (2004:164), are of the view that companies should staple themselves to orders; implying that if customer orders are handled quickly, accurately and effectively, then the variability and hence the bullwhip effect is reduced.

2.6.5. Price Fluctuation

Research has shown , according to Lee *et al* (1997:97), that 80 percent of transactions concluded during the manufacturer and distributor stage of the supply chain, were items purchased in a "forward buying" way. This implies that the distributors made use of manufacturers' discount structure. Promotions in the form of price discounts, quantity discounts, coupons and rebates are carried out periodically by manufacturers and distributors.

Lee *et al* (1997:97) reports that all forms of promotions result in price fluctuation. Manufacturers may also offer other incentives to distributors and wholesalers in the form of special pricing and payment terms, which are indirectly, price discounts. The outcome of this practice is that customers purchase in quantities that are not reflective of their immediate needs. Customers will purchase in large quantities and stock up for future demand. This phenomenon was demonstrated by Fisher (1997:105-109).

When the price is low through discounts or promotions, Lee *et al* (1997:97) suggests that customers engage in forward buying, that is buying more than what is needed. When the purchase price returns to normal, the customer will not purchase until inventory in hand is depleted. As the buying pattern does not correlate with the consumption pattern, the variation due to purchasing is higher than the variation in consumption. This is indicative of the bullwhip effect.

A company's decision to implement forward buying may only be viable if the holding cost of inventory is less than the price differential, that is the difference between the normal and discounted price. A high-low buying practice does not work well in some industries such as the soup industry as illustrated in Figure 2.3.5 in section 2.3.5. As seasonal sales are higher in winter, factories may run overtime on some occasions and remain idle during other times. Some companies may opt to stockpile to meet anticipated demand. The costs associated with storage and handling of high volume inventory may be substantial. Lee *et al* (1997:97) are of the view that companies may have to pay premium-shipping rates for large volume inventory. Furthermore, damage of inventory may occur from the handling of abnormal volumes of inventory. Lee *et al* (1997:97) reports that trade promotions may have a negative impact on the stock performance of manufacturers. The example cited by Lee *et al* (1997:97), is the Bristol-Myers Squibb incident where shares dropped from $74 per share to $67 per share during a quarterly assessment. The sales volumes dropped from an expected 13% to an actual 5%. The poor performance was attributed to previous quarter sales promotions that saturated the company's distribution channel with forward buying of the company's products.

2.6.6. Rationing and Shortage Gaming

According to Lee *et al* (1997:97) rationing occurs when demand exceeds supply. For instance, a manufacturer may ration its products to its customers by a proportion of their total order. For example if the manufacturer rations the total supply to be 50% of total demand, then all customer orders will be filled by 50% of their demand. According to Mitchell (1923:632), orders are placed to "hedge" against unpredictable supply.

Customer reaction to rationing may lead to inflated orders to the manufacturer, in view of the anticipated short supply. However, when the demand reduces, customers may cancel orders, hence "game" the rationing. Lee *et al* (1997:97) are of the view that customer orders in this instance, give scarce data to the supplier. An example cited by Lee *et al* (1997:98), is the perceived shortage of computer chips. Customers placed duplicate orders with multiple suppliers and purchased only from the supplier that delivered the product first. The other orders were subsequently cancelled.

Ottesen and Gronhaug (2002:216) report that for example, in the fishing industry, when raw materials are scarce, companies build a buffer zone of stock. Companies may use incentives to fishing vessels to meet targets of buffer stocks and consequently reduce fluctuation in demand for seafood products.

2.6.7. Supplier Selection and Evaluation

The choice of suppliers is critical to the success of the supply chain. According to Burt *et al* (2003:332), potential suppliers must be evaluated individually based on their capability in terms of capacity to deliver products on time according to the right quality and quantity. The ability to be flexible is also taken into consideration in the evaluation process.

2.6.8. Strategic Partnerships and Supplier Integration

Simchi-Levi *et al*, (2000:91) is of the view that lack of strategic partnerships and supplier integration is a major cause of the bullwhip effect.

According to Wagner (2003::11), there is a high degree of supplier integration within the electrical and electronic industry but a low degree of supplier integration in the pulp and paper and oil refining industry in both the manufacturing and new product development phase. This conclusion was derived from an analysis of responses from 173 companies. The benefits of supplier integration are improved logistics, lower costs and lower stock levels for the manufacturing companies. From a customer perspective, suppliers achieving reliability in delivery times and order filling, providing spare parts and frequent information updates will reach a higher level of customer satisfaction.

2.7. MITIGATING THE BULLWHIP EFFECT

Lee *et al* (1997:99) are of the view that managers can reduce the effect of the bullwhip by developing strategies to counteract the causes of the phenomenon as shown in Table 2.7.

According to Lee *et al* (1997:99), the interventions required to mitigate the bullwhip may fall within the ambit of three broad categories namely, information sharing, channel alignment or operational efficiency which is part of the framework for supply chain co-ordination initiatives in reducing the bullwhip effect as depicted in Table 2.7.

A discussion of the framework is necessary to explain the mitigating measures to be undertaken. However there are other mitigating measures to consider in view of the additional causal factors identified in the previous section.

Table 2.7. Framework for Supply Chain Coordination Initiatives

Causes of the Bullwhip	Information Sharing	Channel Alignment	Operational Efficiency
Demand Forecast Update	• Understanding system dynamics • Use of point-of-sale (POS) data • Electronic Data Interchange (EDI) • Internet • Computer-assisted ordering (CAO)	• Vender-managed inventory (VMI) • Discount for information sharing • Consumer direct	• Lead-time reduction • Echelon-based inventory control
Batch Ordering	• EDI • Internet Ordering	• Discount for truck-load assortment • Delivery appointments • Consolidation • Logistics out-sourcing	• Reduction in fixed cost of ordering by EDI or electronic commerce • CAO
Price Fluctuation		• Continuous replenishment program (CRP) • Everyday low costs (EDLC)	• Everyday low price (EDLP) • Activity-based costing (ABC)
Shortage Gaming	• Sharing sales capacity and inventory data	• Allocation based on past sales	

(Lee, Padmanabhan,Whang,1997:99)

2.7.1. Reducing lead times

According to Simchi-Levi *et al* (2000:92), lead times magnify the increase in variability due to forecasting. The effects of lead times have been demonstrated in section 2.5.1. in the "beer simulation game" and section 2.6.1. on "lead times of information and materials". It is therefore noted by Simchi-Levi *et al* (2000:92), that reduction of lead times reduces the bullwhip effect in the supply chain.

By advocating the reduction of order lead-times and information lead-times, Simchi-Levi *et al* (2000:91) is of the view that the bullwhip effect can be reduced. The solution offered by Simchi-Levi *et al*, (2000:91) is two-fold; firstly to promote cross docking to reduce order lead times and secondly to use EDI to reduce information lead times.

2.7.2. Sharing Information through a Centralized Supply Chain

According to Simchi-Levi *et al*, (2000:90), in a centralized supply chain; actual customer demand data is used at each stage to forecast average demand. However in a decentralized system, each stage uses orders placed from the previous stage to forecast average demand, as demand information is not shared. Forecasts obtained in this way are more variable than actual customer demand information, hence more variability in orders placed.
Truong and Azadivar (2005:469) have conducted numerous simulations of information flow in supply chains and the simulation confirms that the bullwhip effect is damped by centralized information sharing.

2.7.2. Prevention of Multiple Demand Forecast Updates

The bullwhip effect is amplified when each stage of the supply chain forecasts demand based on data obtained from the immediate downstream stage. The solution to the problem, according to Lee *et al* (1997:99), is to make the data from the downstream stage available to the upstream stage. In this way, both stages will make use of the same data to update their forecasts. Centralized demand information reduces uncertainty throughout the supply chain (Simchi-Levi *et al*, 2000:91).

An example cited by Lee *et al* (1997:99) is that of computer manufacturers such as IBM, HP and Apple who mandate their distributors for point –of –sale (POS) data in order to update the manufacturer's forecast accurately. The sell-through data requested by the computer manufacturers form part of the contract with distributors and retailers.

Dobler and Burt, (1996:103) are of the view that companies operating an electronic data interchange (EDI) system will eliminate the need for generating hard copies of purchase orders, shipping notices, invoices between organizations. By using EDI, both buyer and supplier are operating in a real-time environment, hence material delays are reduced or eliminated and procurement lead-times are shortened. Lee *et al* (1997:99) highlights the growing trend that companies are adopting towards EDI; in 1992 only 20% of orders placed by retailers were transmitted by EDI. In 1995, this figure rose to about 60%, which has facilitated data sharing amongst supply chain role-players.

Another innovation in ensuring accurate timely forecasts is through vendor-managed inventory (VMI) or continuous replenishment program (CRP). In this practice, the upstream stage may control re-supply from upstream to downstream. The upstream stage accesses information with regards to inventory and demand from the downstream stage and updates the required forecasts and re-supply for the downstream stage. Lee *et al* (1997:99) refers to the downstream stage as being a "passive partner" in the supply chain. Some of the companies cited by Lee *et al* (1997:99) that practice CRP are Campbell Soup, Nestle, Nabisco and P&G. Inventory reductions of up to 25 percent have been reported by the VMI or CRP alliance. P&G makes use of VMI in the diaper supply chain beginning with its supplier, 3M and ending with its customer, Wal-Mart. Other examples of such alliances include HP, Motorola and Apple (Lee *et al*, 1997:99).

According to Lee *et al* (1997:99), research has shown that multi-echelon inventory systems can operate efficiently if downstream information is timeously available upstream. A strategy to ensure that this type of inventory system works, is to ensure that control of total inventory at upstream as well as downstream stages of the supply chain is optimized.

Another strategy that companies may adopt is to bypass the downstream stage of the supply chain and supply directly to the consumer. Examples of such "consumer direct" programs are being used by companies like Dell and Apple Computers who supply the consumer without going through the distribution channels (Lee *et al*, 1997:99).

As has been described previously in the text, re-supply lead times amplify the bullwhip effect. According to Lee *et al* (1997:99), reduction in variability in demand is achievable through operational efficiency, by for example using a just-in-time stock replenishment strategy.

2.7.4. Reducing order batches

As described earlier in the text in the section on causal factors of the bullwhip, companies need to reduce the batch size and increase the frequency of re-supply. According to Lee *et al* (1997:100), one of the reasons for increasing batch size is the high costs of generating orders for placing and replenishing inventory. One of the solutions offered by Lee *et al* (1997:99), is to use EDI. For example, companies like Nabisco perform paperless, computer-assisted orders (CAO) and customer orders more frequently. Transactional costs are reduced substantially, for instance, at General Electric, by using EDI, purchase order costs reduced from $50 to $5.

The high cost of transportation of materials was cited previously as being another reason for the large order batches. As the difference between full and less-than-full truckloads are substantial, most companies will opt for the more economical, full-truckload to order materials. On occasions, the truckload may contain a variety of different products from the same manufacturer. According to Lee *et al* (1997:100), the order frequency of such products is higher, while the frequency of deliveries to distributors remains unchanged. P&G offers discounts to distributors who accept a variety of the company's products. One solution is for manufacturers to prepare and ship the variety of products in such a way that the products are ready to deliver to the stores (Lee *et al,* 1997:100).

Another solution offered by Lee *et al* (1997:101), is to use third party logistics companies. These companies achieve economies of scale by supplying materials from multiple suppliers. In this way companies can incur reduced transportation costs due to full-truckloads. Lee *et al* (1997:101), points out that the savings achieved from consolidating orders or multiple pick-ups far outweighs the additional handling and administration costs associated with such operations. In some instances, third party logistics companies may supply truckloads of materials to customers who are competitors, such as neighbouring supermarket chains. Small volume customers will benefit from this strategy, as discounted transportation costs will be passed onto them.

The reduction of the bullwhip due to order batching is achieved when customers spread their periodic orders evenly over time (Lee *et al,* 1997:101). Manufacturers like P&G co-ordinate re-supply with their customers through regular delivery appointments. By these efforts, P&G is able to evenly spread replenishment stocks to retailers.

2.7.5. Stabilizing Prices

One of the ways of reducing the bullwhip effect caused by forward buying is to reduce both the frequency and level of wholesale price discounting (Lee *et al,* 1997:101). A solution proposed by Lee *et al* (1997:101), is to reduce incentives for retailers by adopting a uniform wholesale pricing policy. For instance, large manufacturers in the grocery industry like

Pillsbury, P&G and Kraft, have moved to an "everyday low price" (EDLP) as part of their pricing strategy. On a similar note, Lee *et al* (1997:101) are of the view that retailers and distributors can negotiate with their suppliers to take advantage of "everyday low cost"(EDLC).

A further solution offered by Lee *et al* (1997:101) to stabilize prices, is the use of CRP systems in conjunction with a "rationalized wholesale pricing policy" to control retailers' employing tactics such as diversion. The use of CAO by manufacturers also reduces the risk of undesired practice by retailers.

Another solution proposed by Lee *et al* (1997:101) is to promote EDLP by the use of activity-based costing (ABC) systems. Such a system provides a trigger for companies to detect excessive costs associated with forward buying and diversions. Companies that buy in bulk and divert their products to other regions do not quantify the total cost of consumption as they make use of conventional accounting systems. An ABC system will expose the costs of inventory, storage, premium transportation and special handling that were previously hidden. According to Lee *et al* (1997:101), these costs may outweigh the benefit of promotions.

2.7.6. Prevention of Gaming in shortage situations

Lee *et al* (1997:101) are of the view that suppliers allocate products in proportion with past sales records and not according to orders placed, during a product shortage situation. Some of the major companies that implement this strategy include General Motors, Texas Instruments and Hewlett-Packard.

According to Lee *et al* (1997:101), in the gaming during shortages, customers have no incentives to over-order. As manufacturers disseminate little information to their customers, customers have no choice but to accept the supply terms of the manufacturer. The solution according to Lee *et al* (1997:101) is one of co-operation between the manufacturer and its customers. Manufacturers may proactively inform customers to place orders in advance of their peak sales period to reduce spikes in demand.

Another solution offered by Lee *et al* (1997:101), is to place penalties on retailers in returning products to manufacturers. The return policies without penalties encourage retailers to exaggerate orders to manufacturers and consequently aggravate the bullwhip effect.

2.7.7. Good Supplier Selection and Evaluation Processes

A distinction in low value and high value purchasing is made by Burt *et al* (2003:332); in low value purchases, the evaluation is not as stringent as in high value purchasing. For purchases of low value, the evaluation is made by looking at information from websites, or mail. For high value purchases, the procedures may involve conducting supplier surveys, conducting financial analyses, carrying out site visits to plants, conducting quality, capacity and service checking.

The evaluation process may be based on a set of selection criteria and corresponding rating based on its weighting. According to Burt *et al* (2003:336), an assessment is based on the numerical ratings as well as site investigations. As Preis (2003:36) points out, that the evaluation process and rating system must be objective by choosing criteria such as price, performance and quality rather than just interpersonal satisfaction to ensure an effective evaluation.

Suppliers are selected from those that passed the evaluation process. Sourcing criteria by bidding or negotiation or both provides a basis for choosing the successful supplier. The importance of a good supplier is highlighted in the next section on strategic partnerships and supplier integration.

2.7.8. Formation of Strategic Partnerships and Supplier Integration

According to Simchi-Levi *et al*, (2000:91), the bullwhip effect can be eliminated through the constructive use of strategic partnerships. For example, in VMI as described in section 2.7.1, the manufacturer does not rely on the retailer's orders and consequently eliminates the bullwhip effect as the management of the inventory at the retailer's outlet, is the responsibility of the manufacturer.

As has been discussed earlier in section 2.6.2 , centralized demand information reduces the variability and hence the bullwhip effect as experienced by the upstream stages of the supply chain. As Simchi-Levi *et al*, (2000:93) points out, by encouraging retailers to make their real-time data available to the supply chain, the upstream stage derives tangible benefits through reduction in variability.

2.8. CONCLUSION

The bullwhip effect is an aged concept that has been investigated as early as the mid 1950's (Forrester, 1958:38). There are numerous causal factors identified in this chapter with different arguments presented in mitigating the effect.

The argument put forward by Lee *et al* (1997:95) that companies wanting to control the bullwhip effect should focus on "modifying the chain's infrastructure and related processes rather than the decision makers' behaviour" contradicted that of Nienhaus *et al* (2003:7) where it was demonstrated that human behaviour does influence the efficiency of a supply chain. These two arguments are pivotal in the discussion of findings from independent studies relating to human behaviour and supply chain processes presented in Chapters 6 and 7.

The next chapter has a company focus, namely the Eskom supply chain and processes which forms the basis for discussion of the arguments presented in this chapter.

Chapter Three: Eskom's Supply Chain

3.1. INTRODUCTION

Eskom is the only company that produces more than 90% of South Africa's electricity and is in existence for the past 83 years (Eskom, 2004b:5). An overview of the company's history is highlighted under the section below. The Eskom Supply Chain, as illustrated in Figure 3.3. is explained under the relevant sequential stages of the supply chain.

3.2. COMPANY BACKGROUND

According to Eskom (2004b:1), after the discovery of gold in 1886, there was a demand for electricity supply for mining operations. Small power utilities emerged to supply electricity to mining houses. In 1899, the first powerstation was built in Germiston by the General Electric Company. In 1906, businessmen, engineers and other stakeholders formed the Victoria Falls Power Company. However, through legislation in 1923, the Electricity Supply Commission (Escom) was established and became the sole supplier of electricity. In 1929, the Sabie River Gorge hydro station became the first station to be designed and commissioned by Eskom engineers. Activities in Kwazulu Natal commenced in 1927 with the construction of the Colenso power station which was commissioned in 1929. The power-station at Congella was built in 1951 mainly to serve the South African Railways and Harbours (Eskom, 2004b:3).

The national control centre for electricity was established in the 1960's at Simmerpan, Johannesburg, which today controls Eskom's entire transmission network. The control centre for the distribution network is located at Mkondeni, Pietermaritzburg. The company supplies 90% of South Africa's electricity through the efficient use of hydroelectric schemes and pulverised coal-fired and nuclear power stations (Eskom, 2004b:5).

Eskom's core business is split into three entities; Generation, Transmission and Distribution. Each entity has an executive director who reports to Eskom's Chief Executive Director (CEO), Mr Thulani Gcabashe (Eskom, 2004a:3).

Eskom has received an award "in recognition of the company's success in providing the world's lowest cost electricity while at the same time making superior technological innovations, increasing transmission systems reliability and developing economical, efficient and safe methods for combustion of low grade coal." (Eskom , 2004a:2).

3.3. ESKOM'S SUPPLY CHAIN

Eskom's supply chain as illustrated in Figure 3.3. begins at the power-station, with coal as the primary source for electricity generation. The electricity is transmitted through a network of powerlines and interconnected substations. The function of substations is to step down the electricity to the voltage required by the customer.

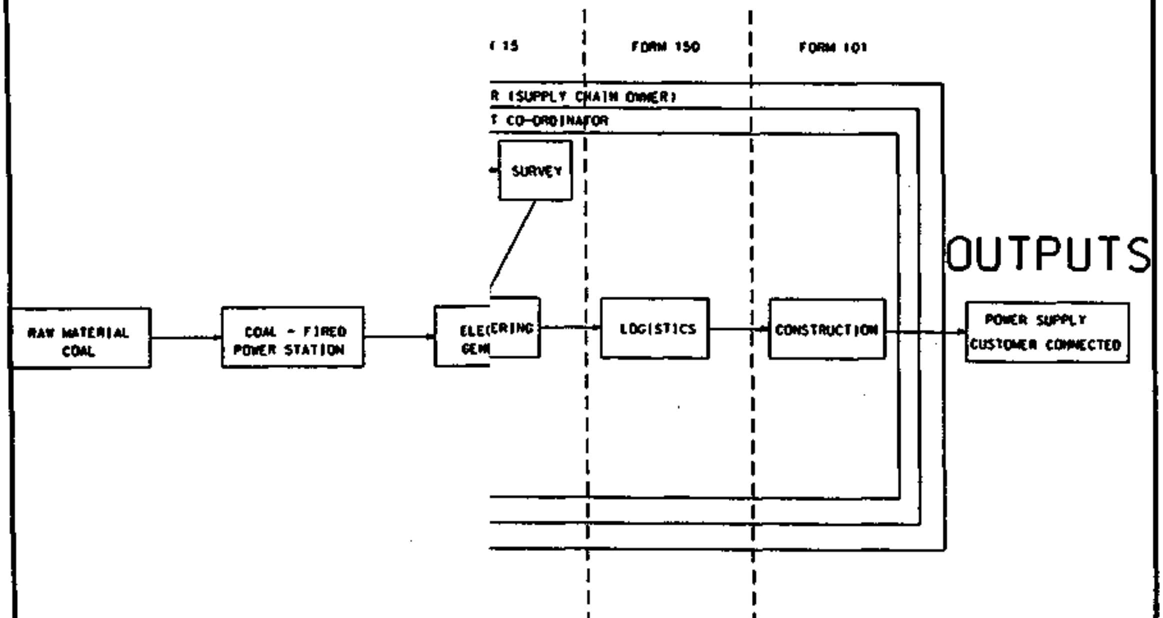
The process of acquiring the various inputs or materials for the construction of electrical infrastructure follows both global and local sourcing strategies. For example, as illustrated in Figure 3.3, bauxite, the raw material for the production of aluminum hardware for powerlines, is sourced from Australia, while the insulators for the powerline is sourced from France. Transformer hardware components are sourced from Brazil and the assembly is done locally by ABB.

The demand for electricity is driven by customer needs. These needs differ from one customer to the next; for example if a customer requires a firm uninterrupted quality of supply, then the customer is billed at a premium rate compared to a customer who can tolerate an occasional outage (Eskom, 2005:5-16).

3.4. THE REGIONAL DISTRIBUTION DIVISION SUPPLY CHAIN

In the Eastern Region, the supply chain begins with the customer. The customer makes an application for the supply of electricity through the Eskom Customer Executive. The customer application is the trigger for the various "forms" to be generated. Each "form" represents the the stages a project is at. For example Form 10 represents the feasibility stage or planning phase of the project, Form 15, the detailed stage , Form 150 the pre-construction stage of the project and F101 the completion of the project (Eskom, 2005:10). An overview of each stage is explained in the discussions that follow.

Figure 3.3. Eskom



(Eskom, 2005:6)

3.4.1. The Form 10 (feasibility) stage

According to Eskom (2005:12), the time frame mandated to produce a feasibility quote is 30 days. At this stage the electrical network planners determine whether there is sufficient capacity on the network to supply the customer. If the capacity is adequate for a period of 15 to 20 years, then the customer will be connected from the existing grid from overhead powerlines. However, should the capacity be inadequate, then a network consisting of a substation and powerline may be necessary to meet customer demand.

Once the type of infrastructure is determined, the planner will conduct a site visit and prepare the Form 10. The planner or design engineer is tasked to compile the feasibility quote, which is forwarded to the customer through the customer executive. The feasibility quote is valid for a period of 60 days.

There is no capital recovery for quoting at Form 10 stage. If the customer rejects the feasibility quote, then all costs incurred up to the Form 10 stage are written off.

If the customer accepts the feasibility quote, then the budget quote or Form 15 is prepared.

3.4.2. The Form 15 (budget) stage

At Form15 stage, a multi-disciplinary team consisting of the area planner, the design engineer, the environmental practitioner, the land surveyor and the customer executive conduct a site visit to validate the network plan. The design engineer is responsible for compiling the budget quote, which is forwarded to the customer through the customer executive. The budget quote is valid for a period of 90 days (Eskom, 2005:14).

The Form 15 is vetted at a Technical Evaluation Forum where a project proposal is appraised by senior management from a technical as well as a financial perspective. On acceptance of the project proposal by the Forum, the customer is issued with a budget quote. The long lead-time materials and other materials on the critical path of the schedule are ordered on acceptance of the budget quote by the customer. However, where materials have lead times of more than 3 months, such materials are ordered in the feasibility of Form10 stage.

Should the customer accept the budget quote and subsequently decline, then the customer is liable for all costs incurred up to the budget stage.
The quote at budget stage is binding and the company is liable for any losses incurred should the quote be less then the actual project cost.

The next phase is the constructability or "Form 150" phase.

3.4.3. <u>The Form 150 (Pre-constructability) stage</u>

On acceptance of the budget quote, a detailed project package is compiled which includes the detailed scope of work and tender documents, detailed survey of the infrastructure, environmental reports and risk analysis of the project. The Form 150 is prepared on actual tendered rates by the successful contractor based on the bills of quantity from Form 15 stage (Eskom, 2005:21). Material orders are received on site and construction commences. The project manager delegates authority to the project co-ordinator. All role-players such as the project engineer, the surveyor, the clerk-of-works and the contractor report to the project co-ordinator. The project co-ordinator is responsible for the facilitation of material delivery to site.

The final stage is the constructability, commissioning and handover, also referred to as the "Form 101" stage.

3.4.4. <u>The Form 101 (Constructability) stage</u>

At this stage the project is constructed and ready for commissioning and handover to the customer. The actual project costs are documented and as-built information is uploaded on a GIS database for easy referencing of the newly built asset (Eskom, 2005:58).

Information storage using the GIS database system is necessary for executing maintenance and refurbishment work. However, the system does not have warning systems that trigger such types of activities(Eskom, 2005:61).

3.5. CONCLUSION

The Eskom supply chain consists of numerous sequential stages. The output of each stage is necessary for the input of the next stage (Eskom,2005:55). It is therefore imperative that the efficiency of the supply chain is dependent on the efficiency of each stage of the supply chain (Eskom, 2005:63). These efficiencies is achievable by managing the variances between stages with emphasis on materials and information flow (Hugo *et al*, 2004:157).

A study on materials and information flow within the Eskom Supply Chain from two independent investigations, namely the exploratory study on human behaviour and that of real-time project is discussed in Chapter 5.

The next Chapter explains the methodology used to gather the data for the afore-mentioned investigations.

Chapter Four: Methodology of the Research

4.1. INTRODUCTION

The purpose of the research, the objectives set in achieving this purpose and the design of the exploratory study on human behaviour and interaction as well as that of the real-time projects and the case study, is explained under the relevant sections.

4.2. STATEMENT OF THE PROBLEM

The problem statement is "the impact of the bullwhip effect on throughput in Eskom's supply chain". To effectively address the problem statement, a two-prong approach was adopted. Firstly, the bullwhip as a consequence of human behaviour was researched and secondly, a study into Eskom's real-time projects was investigated.

4.3. PURPOSE OF THE RESEARCH

The purpose of this research was to investigate the extent and impact of the bullwhip effect on throughput in Eskom through research into the company's supply chain using the two-pronged approach outlined in the problem statement.

4.4. OBJECTIVES OF THE RESEARCH

The research objectives were three-fold as follows:

4.4.1. Research Objective One

To determine the impact of human behaviour on the bullwhip effect.

4.4.2. Research Objective Two

To determine the impact of fluctuation in materials and information flow on the bullwhip.

4.4.3. Research Objective Three

To investigate the relationship between research objectives one and two and validating by means of a case study.

4.5. ASSUMPTIONS OF THE RESEARCH

The competency levels and skills base of Eskom employees is high.

4.6. DESIGN OF THE EXPLORATORY STUDY ON HUMAN BEHAVIOUR AND INTERACTION

The design of the study was carried out to effectively address research objective one.

4.6.1 . The Research Population

The research population for the purposes of this research was targeted towards individuals within Eskom's network asset creation supply chain in the Eastern Region.

The composition of the population included project co-coordinators, project engineers, project planners, project schedulers, project controllers, project surveyors, construction supervisors and procurement officers.

4.6.2 . The Research Sample

The sample composition and size consisted of randomly chosen individuals as follows:

Table 4.6.2: Sample Composition and Size

Job Description	**Number of individuals in sample**	**Percentage of Population**
project co-coordinators	5	62
project engineers	5	62
project planners	4	66
project schedulers	3	60
project controllers	3	66
project surveyors	4	67
construction supervisors	4	63
procurement officers	2	67
Total	**30**	

From Table 4.6.2, the sample size consists of at least 60% of the population size within each job profile and is representative of the population size.

4.6.3. Questionnaire Design

The questionnaire design for behavioural and attitudinal responses was based on Hague (1993:118). A series of statements (illustrated in Appendix 1) were designed in accordance with simulations from the beer game as has been discussed in Chapter Two of the text as well as recommendations made by Lee *et al.* Statements 14 to 17 were specifically targeted towards the behavioural aspect of role-players in the supply chain. The questionnaire was distributed to supply chain role-players at random. The respondents had to agree, remain neutral or disagree with the statements. The statements were mixed with positive and negative statements to avoid "respondents getting into a groove and giving the same answer consistently" (Hague 1993:118).

4.6.4. Response Rate

A total of 30 questionnaires were distributed and duly completed by 28 respondents, yielding a 93% response rate.

4.6.5. Analysis

The data from each questionnaire was tallied under the relevant responses. The responses were then converted to percentages for ease of discussion.

4.7. DESIGN OF THE INVESTIGATION ON REAL-TIME PROJECTS

The design of the study was carried out to effectively address research objective two.

4.7.1. The Research Population

The research population for the purposes of this research was chosen as projects completed within Eskom in the Eastern Region within the past two years.

The population includes power-lines and substation works, refurbishment and new works.

4.7.2. The Research Sample

The sample composition and size consisted of randomly chosen projects as follows:

Table 4.7.2: Sample Composition and Size

Asset Description	Number of projects	Sample as Percentage of Population
Substation –new works	12	80%
Substation-refurbishment	4	82%
Line-new works	4	80%
Line-refurbishment	5	79%
Total	**25**	

From the above table, the sample size consists of at least 79% of the population size within each asset description and is representative of the population size.

4.7.3. Design format

The design format chosen was an "Excel "spreadsheet (Table 5.4) for a compatible platform to report on time data from "Microsoft Projects" and project status and financial data from the "Capital Assistant" database.

4.7 4. Analysis

Having extracted project materials cost data from Form10 through to Form 101, the project variance between each project phase was calculated.

Form 10 to Form 15 variance is attributed to Long-lead time materials placed and received respectively. A similar exercise was done for the cost component of long-lead time materials.

The time variance was calculated from the project schedules. Materials were expressed as a function of cost and time variance between scheduled and actual orders placed. A similar exercise was done for material orders received.

The cost component for long-lead time materials was extracted and expressed as a percentage of total materials.

Materials return-to-stores was captured for each project and expressed as a percentage. The materials returns are as a result of surplus over-orders.

Defective materials that are materials that do not meet with Eskom's specifications and standards have been captured in the table. The ratios of defective to total materials have been expressed as a percentage.

The BEE component for each project was extracted due to the increasing demand for emerging contractors and in line with Eskom's pact with suppliers (Eskom, 2004c:5). This was expressed as a percentage of total materials per project.

4.7.5. Relationship between the study on human behaviour and the study on real-time projects

A comparison was drawn between research objectives one and two and reported in the study of real-time projects. The discussion was structured under the main headings of the causal factors of the bullwhip to provide a basis for comparison.

4.8. DESIGN OF THE CASE STUDY

The design of the case study (in Chapter 5 Section.5.7.) was carried out to provide validation of the findings obtained from the study of human behaviour and interaction and the study of real-time projects.

4.8.1. The Research Population

The research population consisted of four projects within Eskom in the Eastern Region currently in the construction phase.

The research population included two power-lines and two substation projects

4.8.2 . The Research Sample

The random sample of a refurbishment project was chosen as a case study for discussion.

4.8.3. Design Data and format

The design data was in the form of project minutes of the meeting, project forms, bills of materials, the scope of work, project and materials costs located in

4.8.4. Analysis

The analysis of the case study was in the form of a discussion under the headings of the causal factors of the bullwhip.

4.9. CONCLUSION

The three objectives of this research, namely to determine the impact of human behaviour on the bullwhip effect, to determine the impact of fluctuation in materials and information flow on the bullwhip and to investigate the relationship between the afore-mentioned objectives by validating by means of a case study was achieved through the relevant research designs.

The research findings and discussion will follow in Chapter 5.

Chapter Five: Research Findings

5.1. INTRODUCTION

This chapter focuses on the discussion from the results obtained from the exploratory study on human behaviour and interaction, the investigation of real-time projects and that of the case study that was used to achieve the three objectives of this research, namely to determine the impact of human behaviour on the bullwhip effect, to determine the impact of fluctuation in materials and information flow on the bullwhip and to investigate the relationship between research objectives one and two and validating by means of a case study.

5.2. RESULTS OF THE EXPLORATORY STUDY ON HUMAN BEHAVIOUR AND INTERACTION

The sample profile of the participants of the survey is shown in Table. 5.2. The sample consisted of randomly selected supply chain role-players namely project coordinators, project engineers, project planners, project schedulers, project controllers, project surveyors, construction supervisors and procurement officers within Eskom Eastern Region.

Table 5.2. Sample Profile

Job Description	Number of individuals in sample	Number of Responses	Percentage of Population
Project coordinators	5	4	62
project engineers	5	5	62
project planners	4	4	66
project schedulers	3	3	60
project controllers	3	3	66
project surveyors	4	4	67
construction supervisors	4	3	63
procurement officers	2	2	67
Total	**30**	**28**	

The participants filled in hardcopies of questionnaires as per sample in Appendix 1. All participants were based in Pietermaritzburg. The questionnaire consisted of thirty statements. The respondents had to agree, remain neutral or disagree with the statements. The statements were mixed with positive and negative statements to avoid "respondents getting into a groove and giving the same answer consistently" (Hague 1993:118).

A total of 30 questionnaires were distributed and duly completed by 28 respondents (as shown in Table 5.2), yielding a 93% response rate.

The results of the exploratory study from the questionnaire survey are given in Table 5.3. The various responses corresponding to each statement was tallied. The tallied responses were then expressed as a percentage to be used in the discussions that follow under section 5.3.

Table 5.3. Results of the exploratory study

Statement	1-Strongly Agree		2-Agree		3-Neither Agree nor Disagree		4-Disagree		5-Strongly Disagree	
	28	%	28	%	28	%	28	%	28	%
1 There are too many project schedules for the same project	14	50	10	36	0	0	2	7	2	7
2 Project information is not centrally available and shared by all parties	14	50	12	43	2	7	0	0	0	0
3 Fast -tracked projects are given priority in material orders placed	0	0	2	7	2	7	7	25	17	61
4 Long lead time materials orders are placed on time as scheduled	1	4	1	4	0	0	11	39	15	54
5 Reducing material lead times will ensure timely completion of projects	21	75	5	18	2	7	0	0	0	0
6 It is preferable to supply materials direct to site than warehouse in New Germany	14	50	11	39	3	11	0	0	0	0
7 Materials are received timeously on site.	0	0	0	0	0	0	8	29	20	71
8 Ordering materials in batches such as concrete and paint saves on transportation	18	64	10	36	0	0	0	0	0	0
9 It is cheaper to order materials in batches as one can make use of discount structures	18	64	8	29	2	7	0	0	0	0
10 The information available at Form 10 stage is sufficient to do a feasibility quote	0	0	0	0	2	7	6	21	20	71
11 Customers have sufficient time to respond to the feasibility quote	3	11	22	79	3	11	0	0	0	0
12 The information available at Form 15 stage is adequate to do a budget quote	1	4	9	32	0	0	18	64	0	0
13 Customers have sufficient time to respond to the budget quote	2	7	24	86	2	7	0	0	0	0
14 When the supply of a type of material is scarce, then one may place orders with several sup	17	61	9	32	2	7	0	0	0	0
15 It is easy to place and then cancel orders with suppliers	18	64	6	21	4	14	0	0	0	0
16 It is better to over-order materials to ensure that at least the right quantity arrives to site	16	57	12	43	0	0	0	0	0	0
17 Materials not used are easy to get rid off by returning the materials to stores	15	54	11	39	2	7	0	0	0	0
18 During Form 150 stage, BEE companies are given preference to supply materials	15	54	13	46	0	0	0	0	0	0
19 Suppliers are chosen based on the lowest tendered price	20	71	8	29	0	0	0	0	0	0
20 The choice of material suppliers can determine the success of a project	22	79	6	21	0	0	0	0	0	0
21 Supplier selection and evaluation is done objectively and openly	0	0	0	0	0	0	5	18	23	82
22 All project roleplayers have an opportunity to evaluate suppliers	0	0	0	0	0	0	6	21	22	79
23 Material quality is often compromised resulting in rework on site	21	75	6	21	1	4	0	0	0	0
24 Project delays are attributed to poor quality of materials supplied	20	71	8	29	0	0	0	0	0	0
25 Project delays are attributed to materials arriving late to site	20	71	8	29	0	0	0	0	0	0
26 Project delays are attributed to incorrect materials arriving to site	20	71	7	25	1	4	0	0	0	0
27 Project delays are attributed to incorrect batching of materials to site	19	68	7	25	1	4	1	4	0	0
28 There are no penalties imposed on suppliers for causing project delays	21	75	7	25	0	0	0	0	0	0
29 There are no long term partnerships with good suppliers	17	61	9	32	0	0	2	7	0	0
30 Once a project is commissioned, projects are evaluated objectively	0	0	0	0	1	4	4	14	23	82

5.3. DISCUSSION ON THE FINDINGS OF THE EXPLORATORY STUDY ON HUMAN BEHAVIOUR AND INTERACTION

5.3.1. OVERVIEW

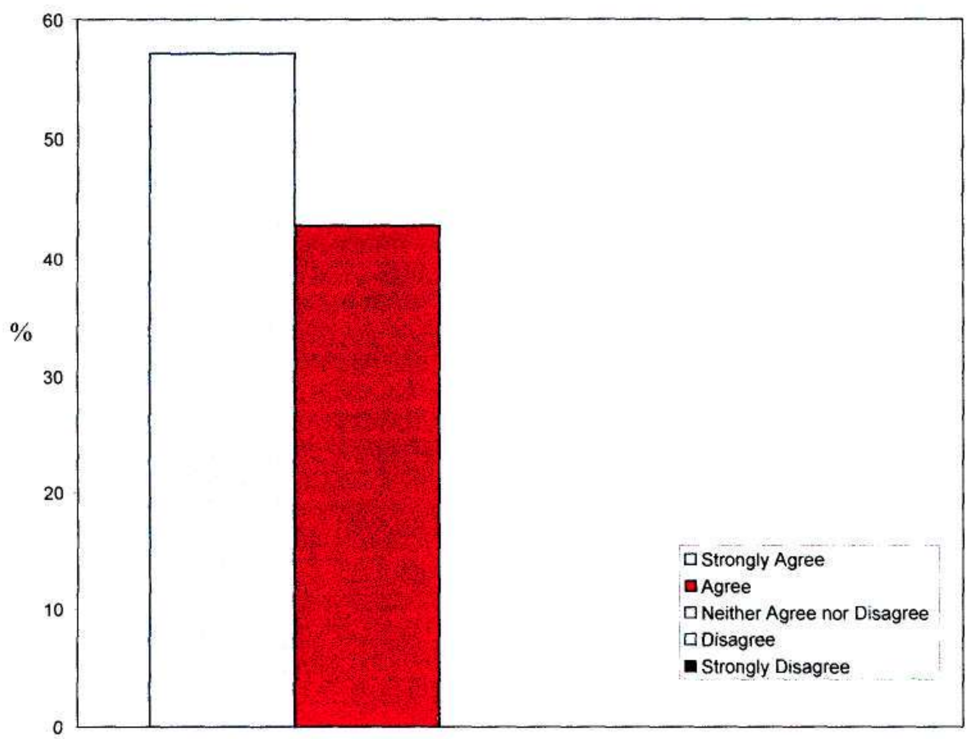
This section provides an in-depth discussion of the findings from the sample of the population of role-players as stipulated in Table 5.2 and the results of Table 5.3.

In Chapter 2, it was demonstrated that the human behaviour displayed by role-players of the beer game simulation were either "safe harbour" or "panic".

5.3.2. SAFE HARBOUR BEHAVIOUR

This type of behaviour is illustrated in *Statement 16 "It is better to over-order materials to ensure that at least the right quantity arrives on site"*.

Figure 5.3.2. It is better to over-order materials to ensure that at least the right quantity arrives to site (Statement 16)



As shown in Figure 5.3.2, 57% of the respondents strongly-agreed to the statement while 43% agreed, hence a 100% of respondents were in support of Statement 16.

5.3.2.1. Business Implication of Surplus Materials

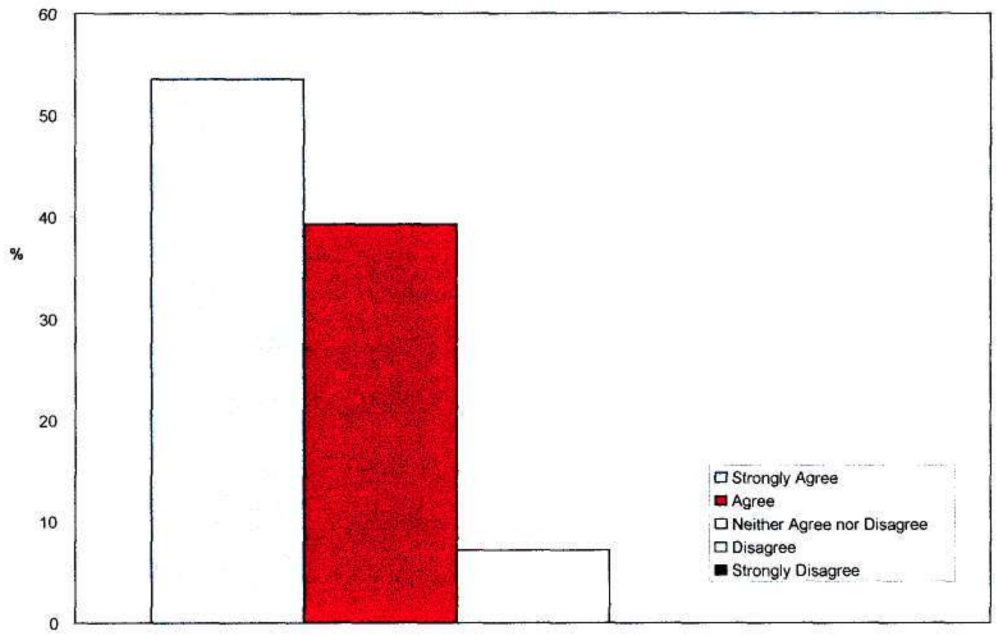
There are a total of 25 completed sub-transmission projects in Eskom over the past two years totaling R78,6 million. (The discussions on a quantitative approach pertaining to these projects will be discussed in Section 5.5.). Considering that on average, the actual cost of material was R2,62 million, a 2% over-order in materials would translate to a total of R1,57million. The funds tied up in stock may have been freed up for the completion of other critical projects.

Another disadvantage of the practice of over-ordering is the carrying costs of the materials at Eskom stores situated in New Germany, Pinetown. Surplus materials are stored in anticipation for use in other projects. The caution associated with storage is having redundant or obsolete stock. According to (Rajkarran, 2006), obsolete stock costs the business in the region of R1,2 million to R1,5 million per annum .

The extent of the issue with returning materials to stores is summed up by discussing respondents' behaviour to *Statement 17 "Materials not used are easy to get rid of by returning the materials to stores"*. About 54% of respondents strongly- agreed and 39% agreed to the afore-mentioned statement. Approximately 7% of respondents were undecided.

The business implications of having 93% of respondents in support of Statement 17 are increasing stock levels of materials that may or may not be utilized. According to (Young, 2005), the net revenue generated from the sale of redundant or obsolete stock is only 5% of original purchase price.

Figure 5.3.2.1. Materials not used are easy to get rid of by returning the materials to stores (Statement 17)



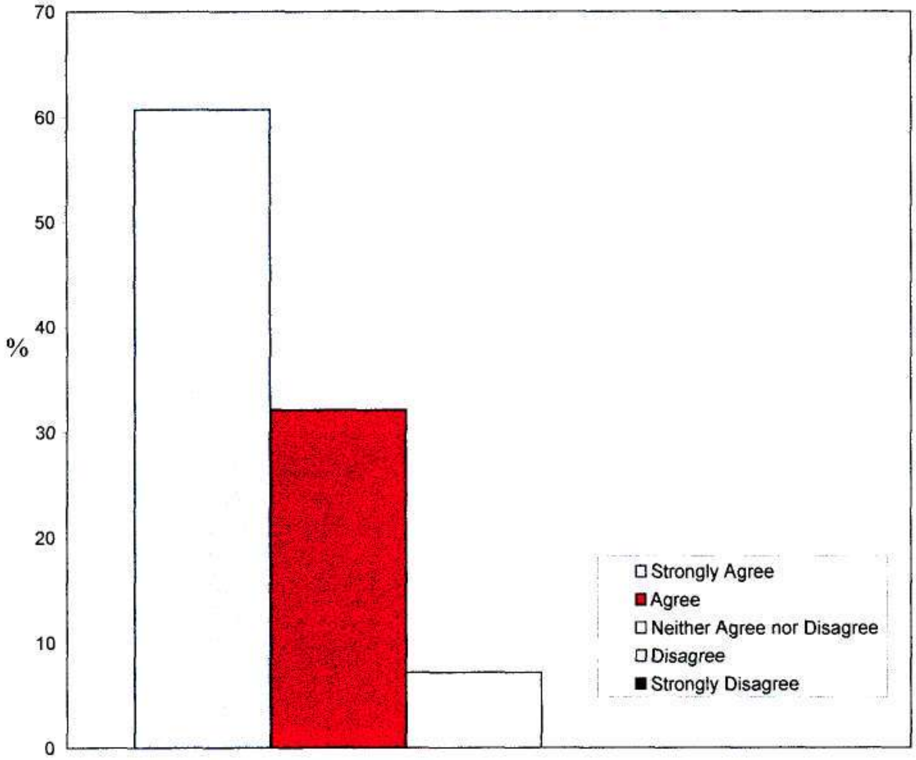
The business implications of having 93% of respondents in support of Statement 17 are increasing stock levels of materials that may or may not be utilized. According to (Young, 2005), the net revenue generated from the sale of redundant or obsolete stock is only 5% of original purchase price.

5.3.3. PANIC BEHAVIOUR

The impact on the supply chain from "panic" behaviour is similar to that of "safe harbour". Both types of behaviour negatively influence the supply chain as was demonstrated in the beer simulation.

Statement 14, "When the supply of a type of material is scarce, then one may place orders with several suppliers" is indicative of "panic" behaviour. From the graph below, 61% of respondents strongly agreed to the above-mentioned statement while 32% agreed. 7% were undecided.

Figure 5.3.3. When the supply of a type of material is scarce, then one may place orders with several suppliers (Statement 14)



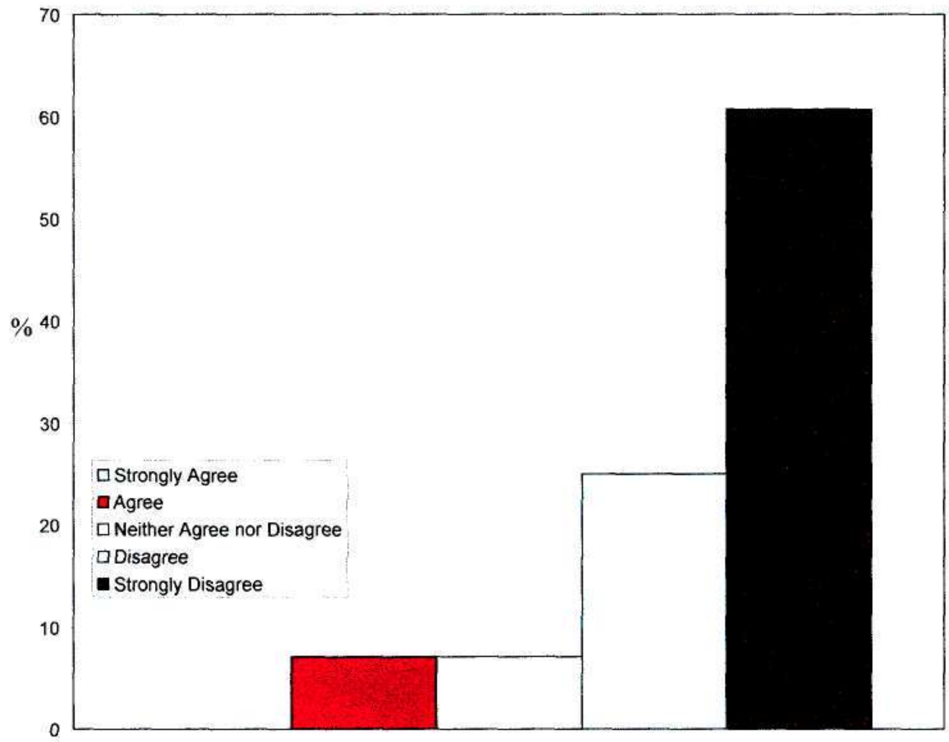
5.3.3.1. Business Implication of "panic" behaviour

The problem associated with several orders is redundant stock. Furthermore, the levels of safety or buffer stock will increase. If this practice continues across projects, then the effect is cumulative. The consequences are similar to that discussed under 5.3.2.1. "Business implications of surplus materials".

Another pertinent point to note is that when there are time constraints, for examples in projects that are fast-tracked, then role-players are prone to display "panic" behaviour.

The results of the findings of *Statement 3 "Fast-tracked projects are given priority in materials orders placed"* is illustrated in the graph overleaf.

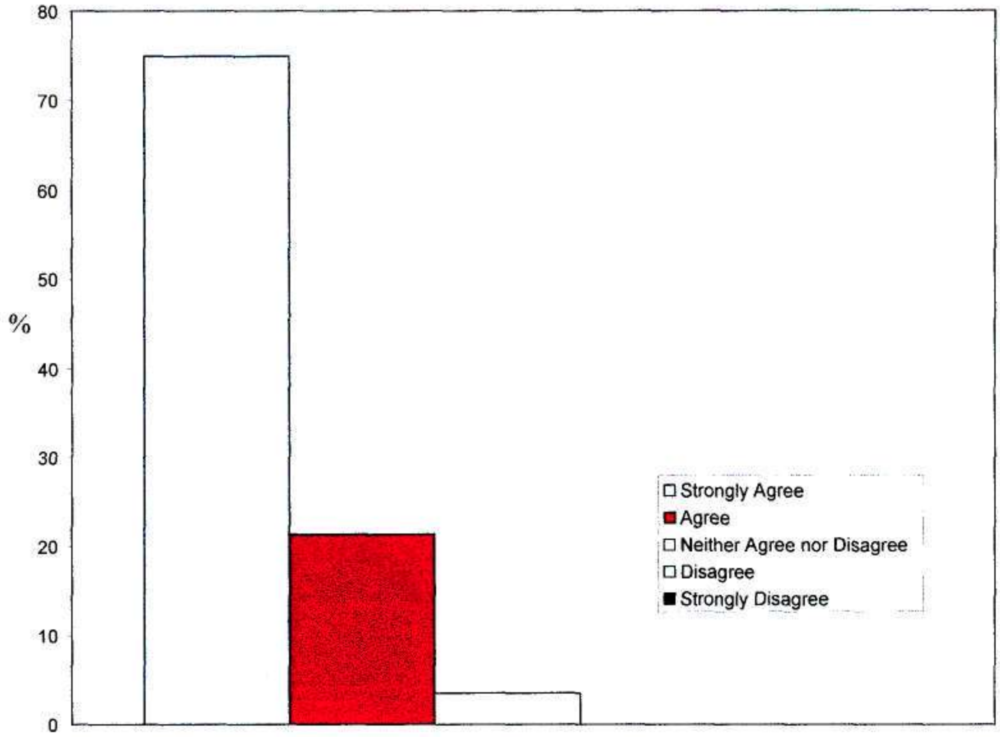
Figure 5.3.3.1(a) Fast-tracked projects are given priority in material orders placed (Statement 3)



The outcomes of the findings were as follows: 7% of respondents agreed to statement 3 while 25% disagreed and 61% strongly disagreed. 7% of respondents remained undecided.
Given that projects are not prioritized according to being fast-tracked (from graph of statement 3), role-players may incur penalties in the form of premium costs for materials from suppliers to fit fast-tracked deadlines.

Another consequence of "panic" behaviour is the issue of compromised material quality. This issue was addressed in *Statement 23: "Material quality is often compromised resulting in rework on site"*. The results of the findings to statement 23 (as shown in the graph overleaf) were as follows: 75% and 21% strongly-agree and agree respectively while 4% remained undecided. Majority (96%) of role-players are in support of statement 23. According to (Rajkarran, 2006), reworked materials are accepted due to tight project schedules without slack components.

Figure 5.3.3.1(b) Material quality is often compromised resulting in rework on site (Statement 23)



Furthermore, there is no safety stock to replace the particular component in the interim while the inferior component is replaced by the supplier. There is cause for concern as the expected material life-cycle is reduced by carrying out rework, for example, on newly galvanized steelwork, especially in coastal applications.

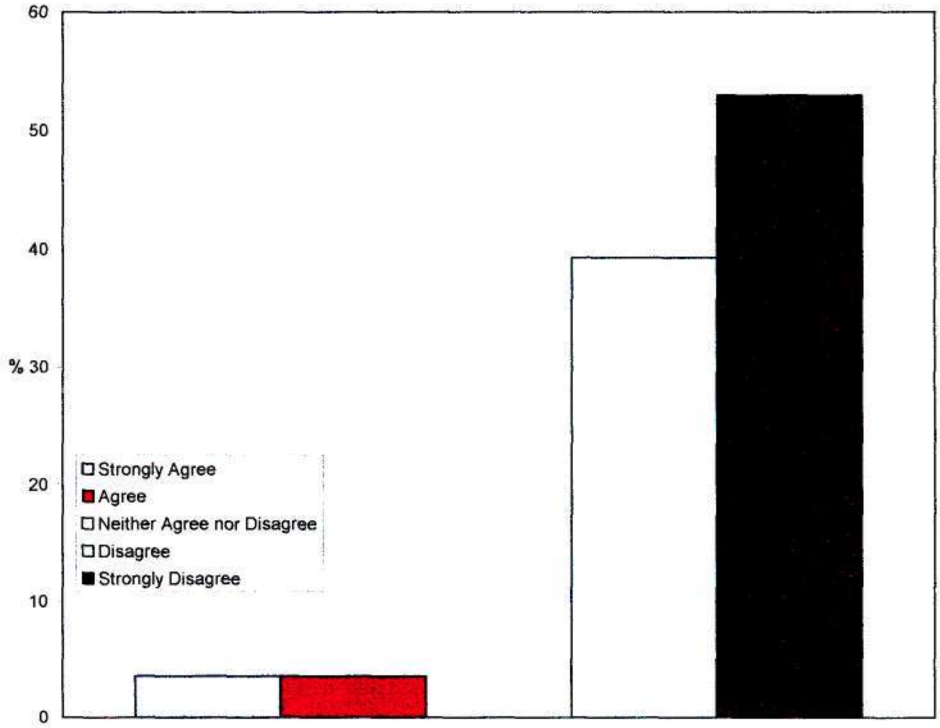
5.3.4. CAUSAL FACTORS OF THE BULLWHIP AND THE INFLUENCE OF HUMAN BEHAVIOUR

The causal factors of the bullwhip effect have been discussed in Chapter Two. However the discussions focused on the modification to supply chain processes rather than role-players behaviour. The same factors will be the focal point in the discussions to follow but from a behavioural perspective. The causal factors were lead time of information and materials, centralized versus decentralized information, multiple demand forecasting updating, batch ordering, price fluctuation and rationing and shortage gaming.

5.3.4.1. Lead time of information and materials

It was noted in section 2.7.1.that the reduction of lead times reduces the bullwhip effect in the supply chain. The negative effects of increasing lead times of information and material flow were demonstrated in the beer game simulation in section 2.5.1. The research findings based on statements 4, 5, 6 and 7 are relevant to the issue on lead times of information and material flow. The results of *Statement 4: "Long lead time materials orders are placed on time as scheduled"* were as follows: 4% of respondents strongly agreed and 4% agreed to the statement. However, 53% strongly disagreed while 39% disagreed to the statement. The graph below illustrates the results of the findings.

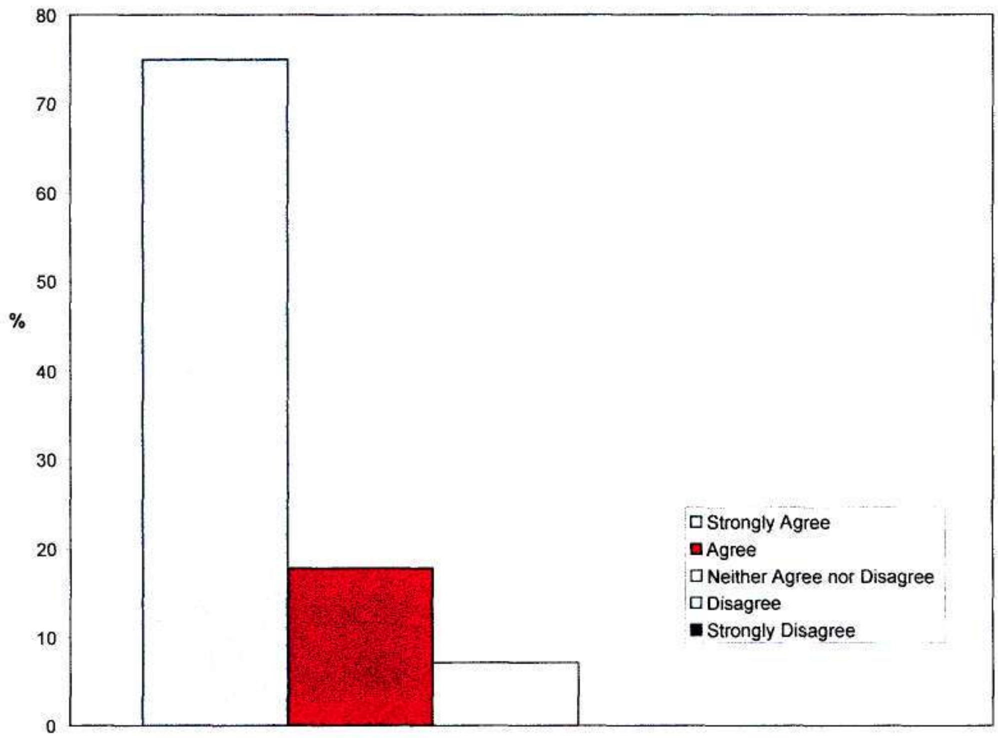
Figure 5.3.4.1(a) Long-lead time materials orders are placed on time as scheduled (Statement 4)



From the graph, a total of 92% of respondents were not in support of the statement 4. This is cause for concern as delays in ordering lead time materials places projects at risk of being late. The cumulative effect of such delays is substantive such as loss of revenue by not connecting customers on time.

Statement 5 "reducing material lead times will ensure timely completion of projects" is in line with the theory as mentioned earlier regarding the beer game simulation. Feedback from the survey regarding the afore-mentioned statement was as follows: 75% of respondents strongly agreed to statement 5 while 18% were in agreement to the statement. 7% of respondents were undecided. The results are graphically displayed below.

Figure 5.3.4.1(b) Reducing material lead times will ensure timely completion of projects (Statement 5)

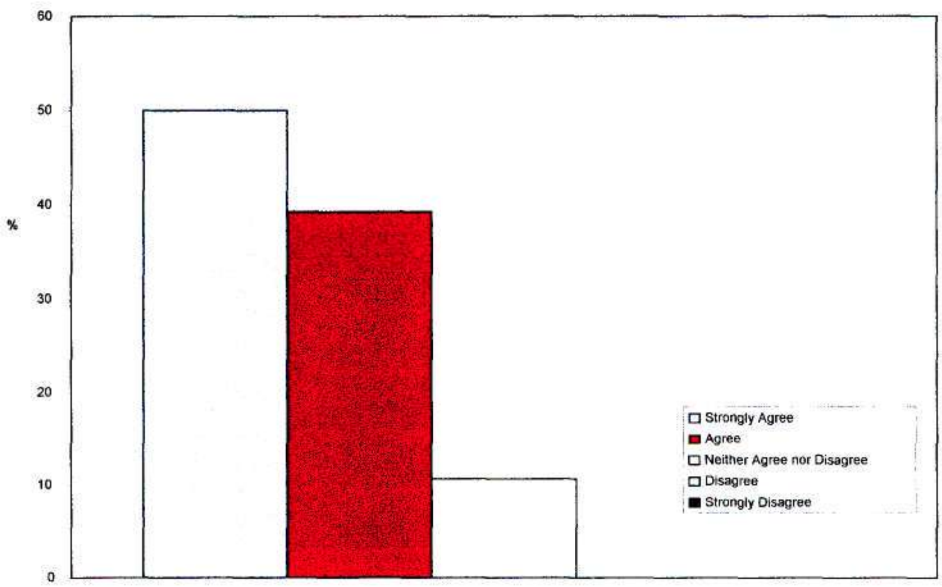


Statement 5 is strongly supported (93%) by respondents within the supply chain. While this is the appropriate response, the way forward in implementing this mitigating measure in counteracting the bullwhip effect requires discipline. All role-players in the supply chain must ensure that there is no variance in the order lead times by adhering to the time-frames stipulated on the project schedules.

The response to *Statement 6 "It is preferable to supply materials direct to site than warehouse in New Germany"* was as follows (as illustrated in the graph overleaf): 50%

strongly-agreed while 39% agreed to the statement. 11% of respondents were undecided. The inefficiencies of warehousing at New Germany are indicative of the response of a majority (89%) of respondents in support of statement 6. According to (van Greneun, 2005), materials are often stored in incorrect bins. This causes project delays and additional costs are incurred from returning materials back to stores. (van Greneun, 2005) is of the view that materials from Johannesburg and destined for Newcastle for example, arrive at New Germany and then are transported by Rotran, a transport subsidiary of Eskom back to Newcastle. There is double-accounting of transport costs incurred and the problem is compounded as this practice occurs over several projects. Rotran costs are about 30% more than the industry average. However, Eskom Distribution is obligated by Eskom Corporate to make use of Rotran in the first instance before choosing another transport company for the delivery of materials from New Germany to site.

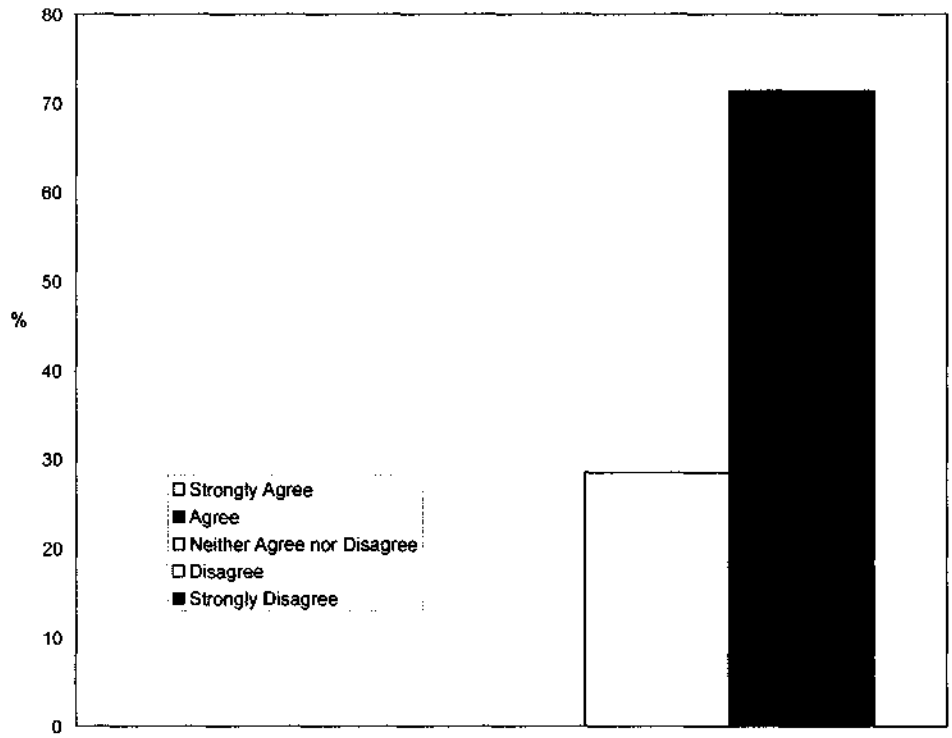
Figure 5.3.4.1(c) It is preferable to supply materials direct to site than warehouse in New Germany (Statement 6)



On average, the cost of transporting materials is 5% of the total materials cost. In section 5.1.1, the average materials cost was calculated to be R2.62 million. The transport cost would then be approximately R131 000. However by using Rotran, the premium of 30% translates to R39 000 per project. The cumulative savings that would have been realized may contribute to the funding of other much-needed projects.

The extent of turnaround time from ordering materials to receiving it is depicted in *Statement 7: "Materials are received timeously on site"*. Results of the survey were as follows: 29% disagreed while 71% of respondents strongly disagreed to the statement. The results are graphically illustrated below. It is deduced that 100% of respondents were not in favour of statement 7. According to construction supervisor, (van Rooyen, 2005), at least 90% of projects are late due to the late delivery of materials.

Figure 5.3.4.1(d) Materials are received timeously on site (Statement 7)



There are no consequence to suppliers or Eskom supply chain role-players for materials arriving late on site. The opportunity costs of late material deliveries are not easily quantifiable. Apart from losing revenue that would have been generated by the infrastructure, the loss of goodwill may be substantial. The Eskom brand may be less favoured by communities that are still without electricity due to project delays. A ripple effect is the risk associated with lack of co-operation from communities, for example when negotiating servitudes for future powerlines in the same community.

5.3.4.2. Centralized versus Decentralized Information

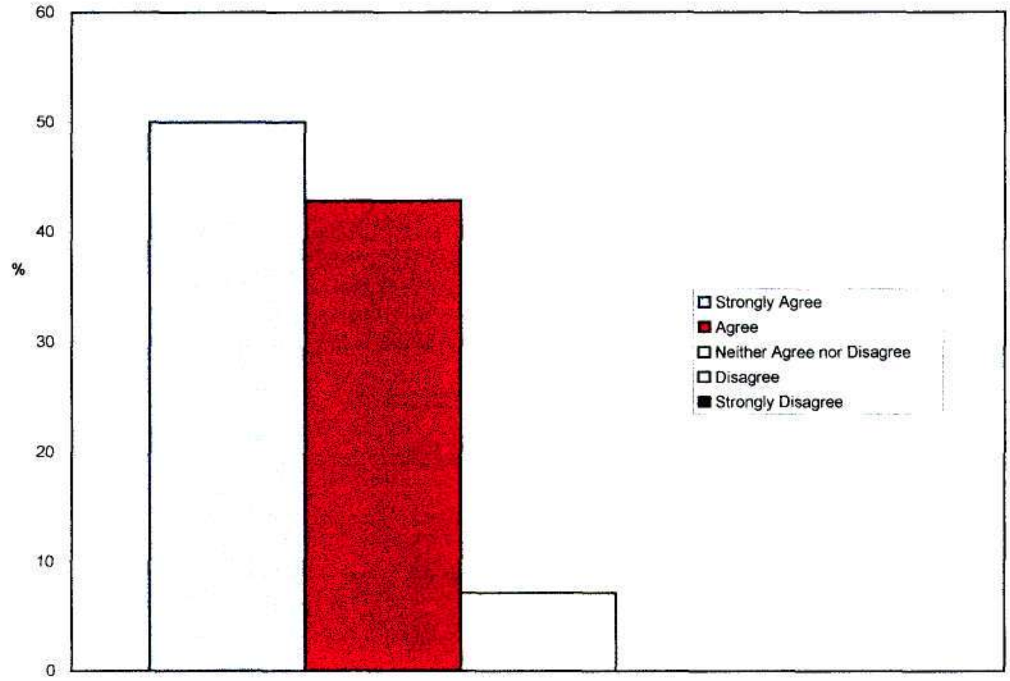
When customers apply to Eskom for a supply point, the information flow should be shared with all stakeholders in the supply chain. As shown in Figure 3.3, planning, engineering, environmental, survey, logistics and construction activities form an integral part of the Eskom supply chain and information sharing is key to its success. For example, an additional supply point for Dunlop Tyres in Howick would require that the planning department determine the need and capacity and type of supply required including future demand and other potential customers that may require supply from the newly established electrical grid. This information is required by the Engineering, Survey and Environmental departments to determine the feasibility of the supply and future supply points. The Logistics department requires the customer information to determine inventory demand and the construction department needs to establish the labour and tooling requirements for the project.

However when respondents were probed about the extent of information sharing by the use of *Statement 2: "Project information is not centrally available and shared by all parties"*, the results were as follows: 50% strongly-agreed, 43% agreed and 7% of respondents were undecided. The results are graphically displayed in Figure 6.4.2 (a).

It is alarming to note that 93% of respondents are of the view that project information is not centrally available and shared by all role-players.

When a customer applies for a point of supply, the customer is initially given a feasibility quote and thereafter a budget quote, upon acceptance of the terms and conditions of the feasibility quote. The quotation process is integrated in the supply chain as described previously in Chapter 3.

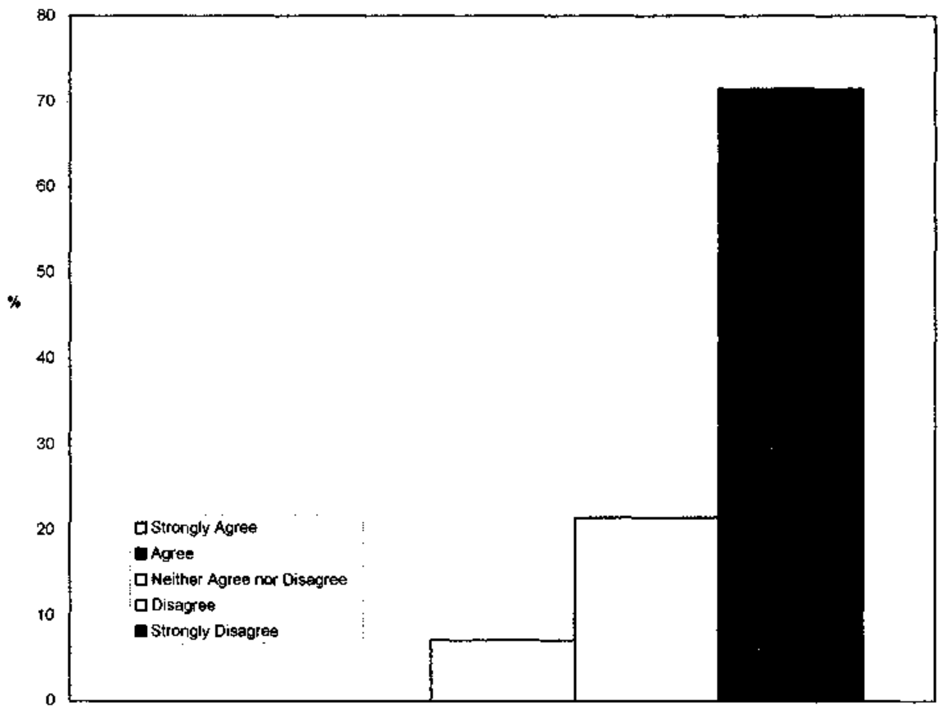
Figure 5.3.4.2.(a) Project information is not centrally available and shared by all parties (Statement 2)



When probed using *Statement 10: "The information available at Form10 stage is sufficient to do a feasibility quote"*, the response was as follows: 71% of respondents strongly-disagreed to the statement while 21% disagreed. 7% of respondents were undecided. A total of 92% are of the view that information is inadequate to complete the feasibility quote. The results of Statement 10, as shown below, are consistent with the results derived from Statement 2.

The results of Statements 2 and 10 were checked for consistency by probing at the budget stage of the quotation process by way of *Statement 12: "The information available at Form15 stage is adequate to do a budget quote"*. The response, as graphically displayed overleaf, was as follows: 82% of respondents strongly-disagreed to the statement while 14% disagreed. 4% of respondents were undecided. A total of 96% are of the view that information is inadequate to complete the budget quote.

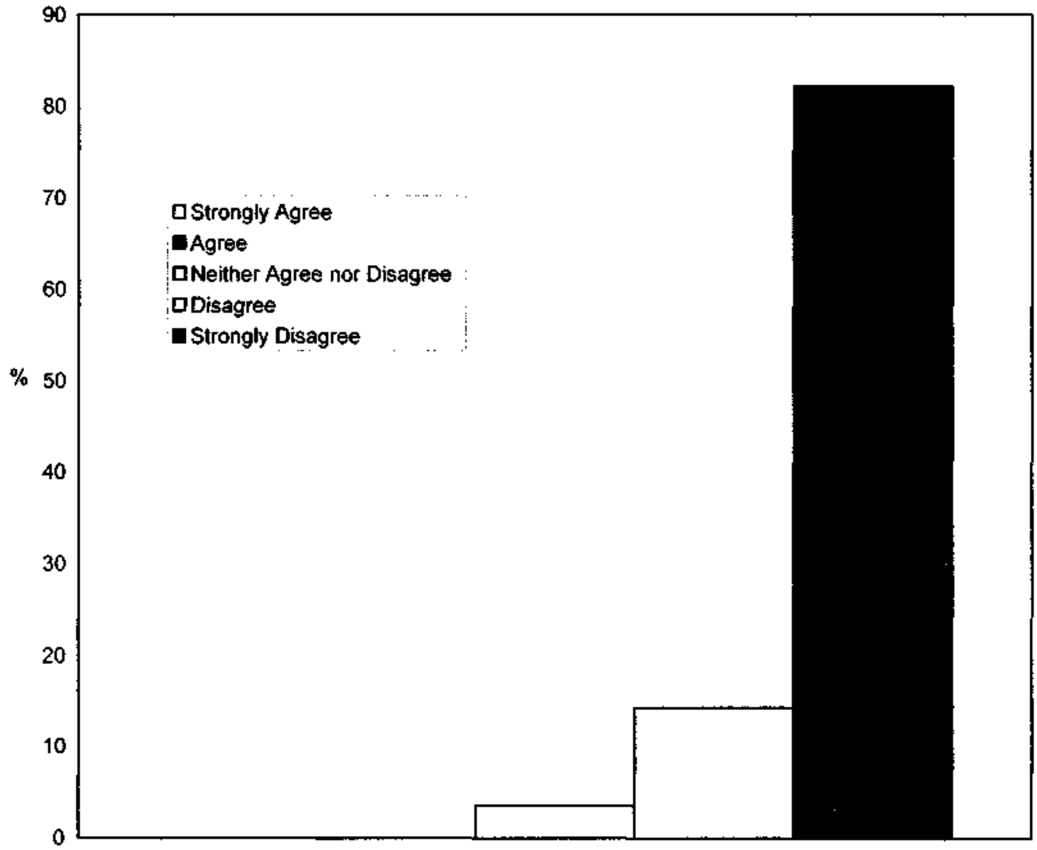
Figure 5.3.4.2.(b) The information available at Form 10 stage is sufficient to do a feasibility quote (Statement 10)



The results of Statements 2 and 10 were checked for consistency by probing at the budget stage of the quotation process by way of *Statement 12: "The information available at Form15 stage is adequate to do a budget quote"*. The response, as graphically displayed overleaf, was as follows: 82% of respondents strongly-disagreed to the statement while 14% disagreed. 4% of respondents were undecided. A total of 96% are of the view that information is inadequate to complete the budget quote.

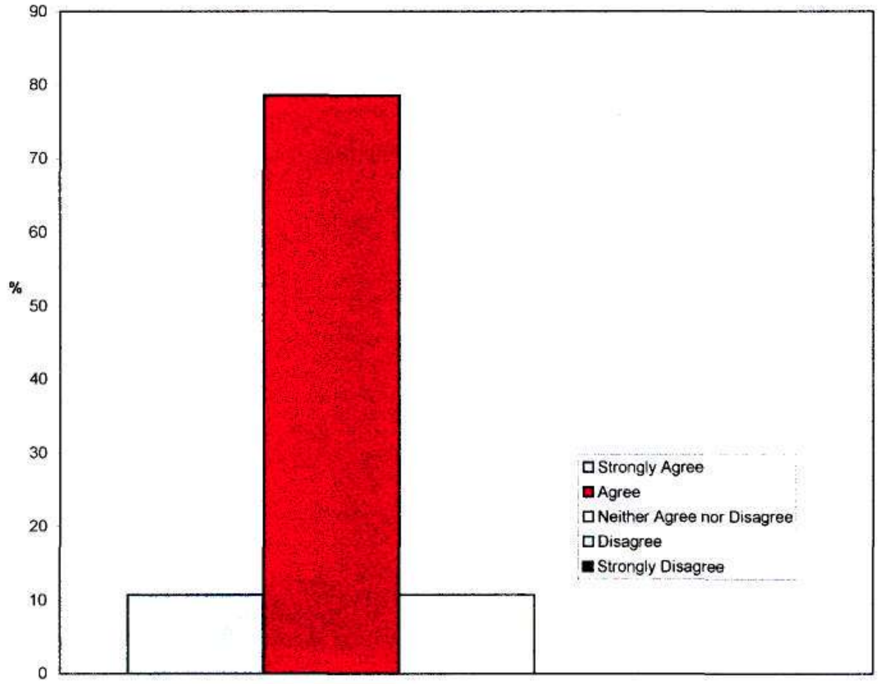
In summary, over 90% of respondents are not sharing project information from a centralized source. Furthermore, feasibility and budget quotes are estimated without the availability of complete information. The findings are consistent with the process, where the engineering department prepares the quotes. The quotation is done in isolation from the role-players in the supply chain.

Figure 5.3.4.2.(c) The information available at Form 15 stage is adequate to do a budget quote (Statement 12)



The time-frame for obtaining a response from the customer at the feasibility quote stage was investigated using *Statement 11: "Customers have sufficient time to respond to a feasibility quote"*.

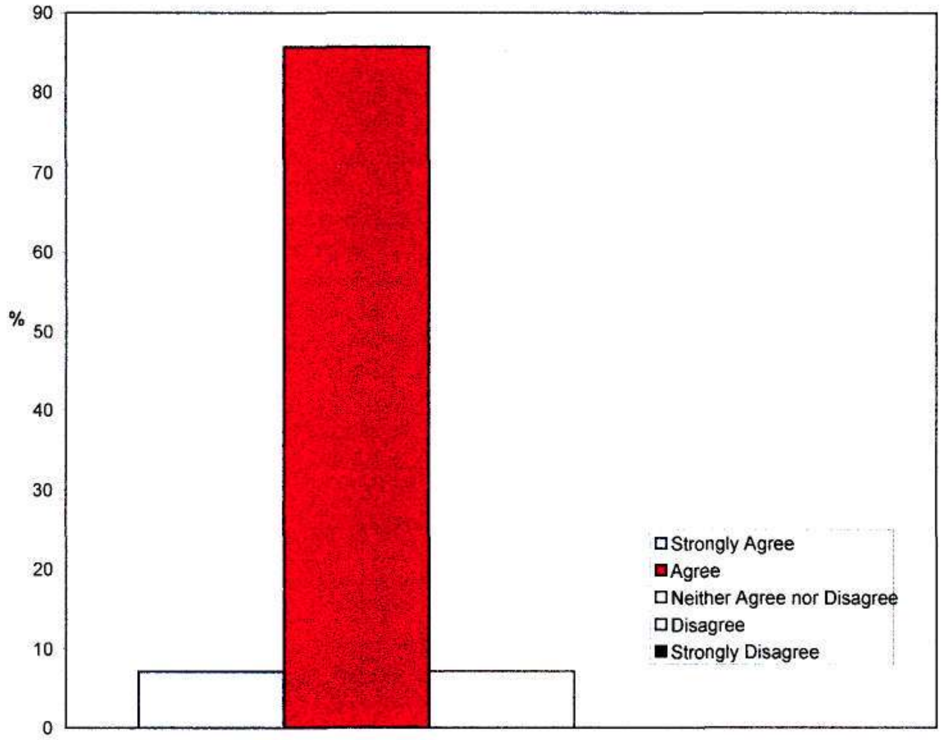
Figure 5.3.4.2.(d) Customers have sufficient time to respond to the feasibility quote (Statement 11)



The response, as shown graphically, was as follows: 11% of respondents strongly-agreed to the statement while 79% disagreed. 11% of respondents were undecided. A total of 90% of respondents are of the view that customers are given too much time to make a decision regarding the quote. The findings are consistent with the Eskom process as discussed in Chapter 3, where the customer is given 60 days to respond to the quote. According to (Pieterse, 2005), this time-frame is not strictly adhered to and projects are accepted with up to 120 days without revising the quote and re-quoting the customer.

At the budget stage, a similar response was noted. The probe using *Statement 13: "Customers have sufficient time to respond to a budget quote"* yielded the following results: 7 % of respondents strongly-agreed to the statement while 86% disagreed. 7% of respondents were undecided. The results are shown graphically in Figure 6.4.2.(e).

Figure 5.3.4.2.(e) Customers have sufficient time to respond to the budget quote (Statement 13)



A total 93% of respondents maintain that customers are given too much time to make a decision regarding the budget quote. The findings are consistent with the Eskom process as discussed in Chapter 3, where the customer is given 90 days to respond to the quote.

Eskom's Customer Executive Officer, (Pieterse, 2005), is of the view that the customers take up to 200 days to respond to the budget quote. The budget quote is no longer valid, but it is accepted because of the lengthy paperwork to re-vise and re-approve the Form 15 and prepare another quote.

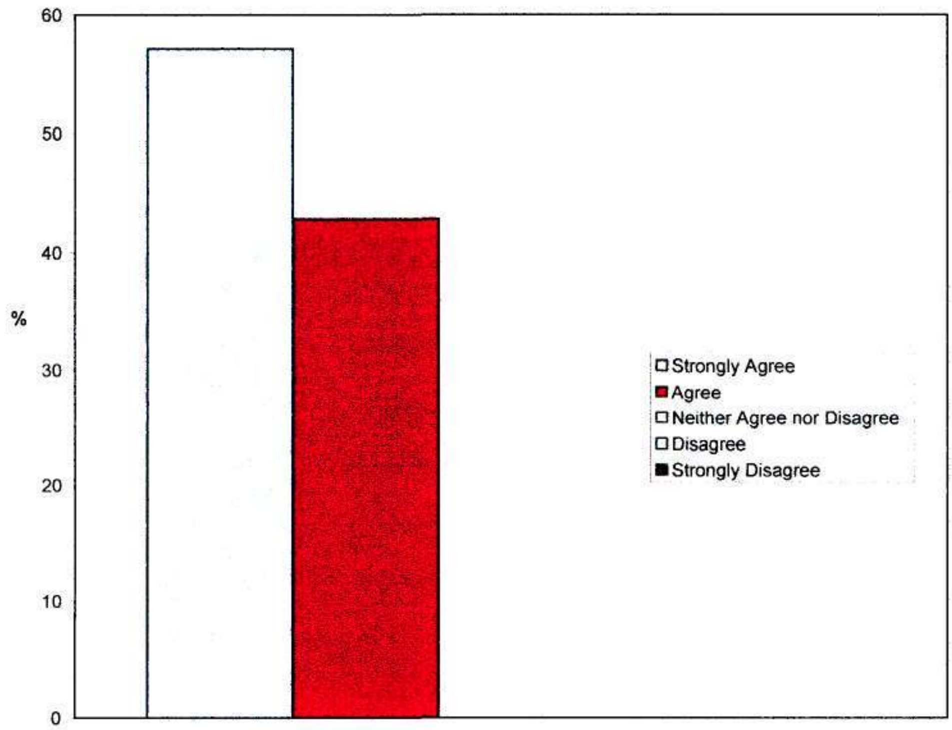
5.3.4.3. Demand forecast updating

The advantages of using and sharing centralized information flow have been demonstrated in the previous section. It is logical to have one demand schedule from which all role-players can peg crucial need dates for various activities.

However, in Eskom, multiple demand schedules are set in isolation of the supply chain role-players. A priority schedule (updated once a year) has been drawn up by the Network Services Manager (NSM) with the primary objective of optimizing cash flow, independent of customer need dates and resource constraints. The Project Engineering Manager (PEM) has set up demand schedules (updated every 6 months) with his staff to distribute the work load equitably, independent of the priority list. The Project Manager has drawn up demand schedules (updated every 2 weeks) without any liaison with both the NSM and PEM. The demand forecast is then not a true reflection of the actual customer plan.

When respondents were probed using *Statement 1: "There are too many project schedules for the same project"*, the response (shown graphically below) was as follows: 57% of respondents strongly-agreed while 43% agreed to the statement. All respondents are in agreement of statement 1.

Figure 5.3.4.3. There are too many project schedules for the same project (Statement 1)



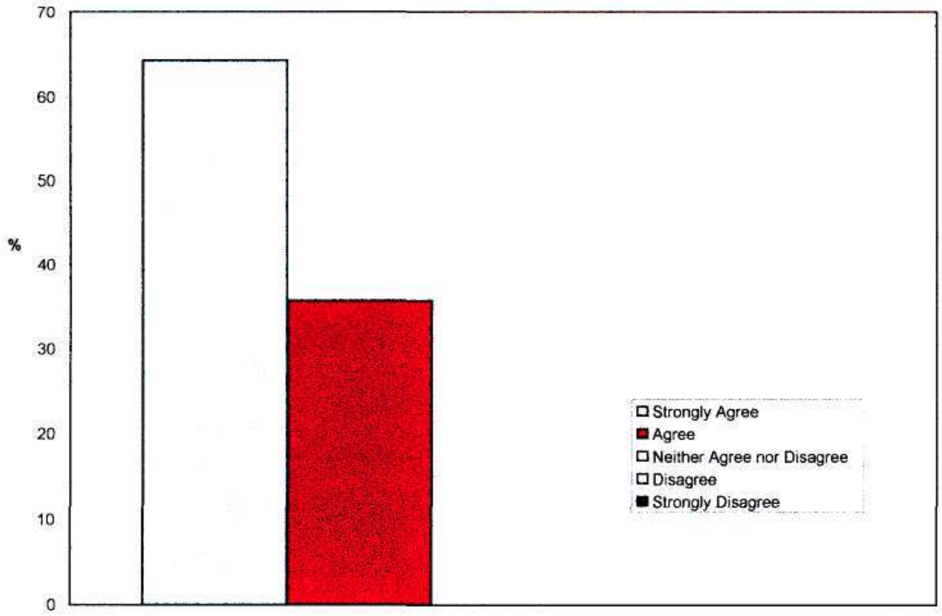
5.3.4.4. Batch Ordering

While it makes economic sense to order materials in batches as discussed in Lee *et al* (1997:96), Saunders, M. (1997:210) differs by arguing that it is inefficient in waiting to fill large batch orders, as resources are employed to produce the materials that are not required immediately.

According to (Ferns, 2005), when orders are placed in batches, such as paint and concrete, the suppliers send the entire quantity ordered instead of receiving the materials when required. The Georgedale Northdene 88kV line refurbishment project is a typical example of the problems experienced due to incorrect batching and will be discussed at length in section 5.6.of the case study.

The probe using *Statement 8: "Ordering materials in batches such as concrete and paint saves on transportation"* yielded the following results: 64 % of respondents strongly-agreed to the statement while 36% agreed to the statement. All respondents are in agreement with Statement 8.

Figure 5.3.4.4.(a) Ordering materials in batches such as concrete and paint saves on transportation (Statement 8)



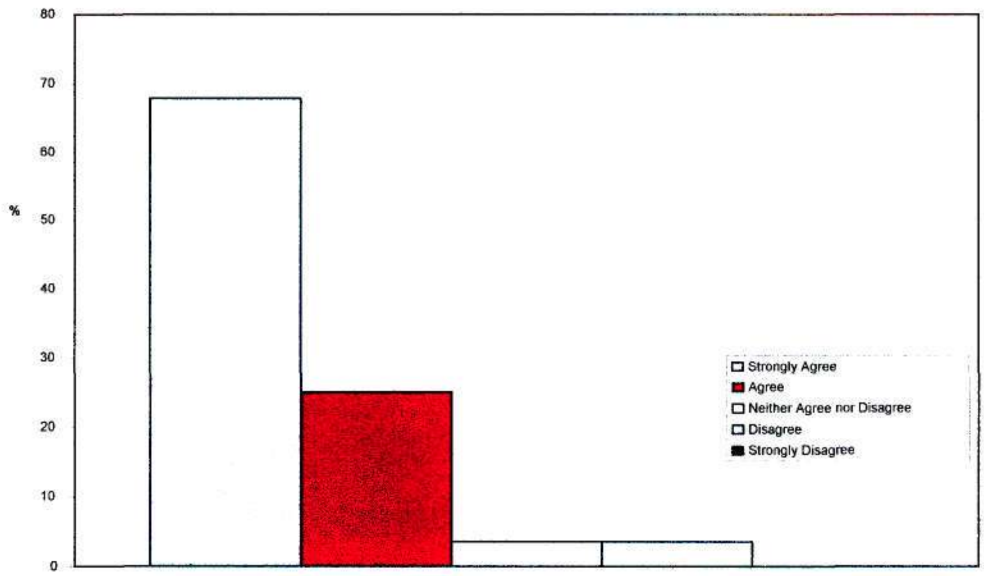
As has been discussed in the literature review, orders are required to be spread evenly to reduce the bullwhip effect due to batch ordering.

Incorrect batching, for example, increasing batch size to reduce transportation costs, aggravates the bullwhip where lead times of materials are extended to fill truckloads. The time slippage has a direct impact on project delays.

When respondents were probed about delays caused by incorrect batching of materials to site, by the use of *Statement 27: "Project delays are attributed to incorrect batching of materials to site"*, the results were as follows: 68% strongly-agreed, 24% agreed, 4% were undecided and 4% of respondents disagreed with the statement. Majority (92%) of respondents are in support of Statement 27.

According to construction supervisor, Jacobus van Rooyen, about 95% of high voltage line projects are delayed due to incorrect batches of steelwork, reinforcing bars, concrete and paint arriving to site.

Figure 5.3.4.4.(b) Project delays are attributed to incorrect batching of materials to site (Statement 27)



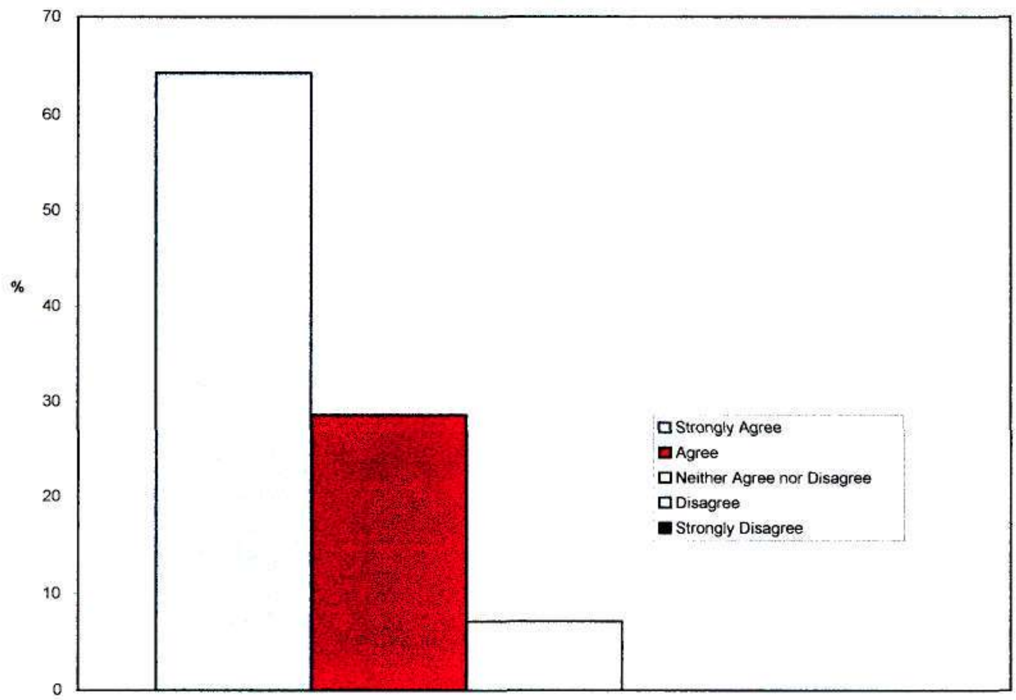
5.3.4.5 Price Fluctuation

Suppliers of products such as paint or powerline hardware, offer a tiered discount structure linked to the number of items purchased. The larger the volumes purchased, the greater is the discount.

According to Director, Tim Krishna from paint supplier, Optima Coatings, the company's discount structure is as follows: purchase orders of 10-50 units -5% discount, 51-100 units-10% discount and greater than 200 units qualify for 30% discount of the purchase price.

When respondents were probed about the use of discount structures in *Statement 9: "It is cheaper to order materials in batches as one can make use of discount structures"*, the outcome was as follows: 64% strongly-agreed, 29% agreed and 7% were undecided. Majority (93%) of respondents agreed to Statement 27. The findings are consistent with the literature review and research by Lee *et al* (1997:97). The Case Study in Chapter 8 will give further impetus on the subject.

Figure 5.3.4.5. It is cheaper to order materials in batches as one can make use of discount structures (Statement 9)



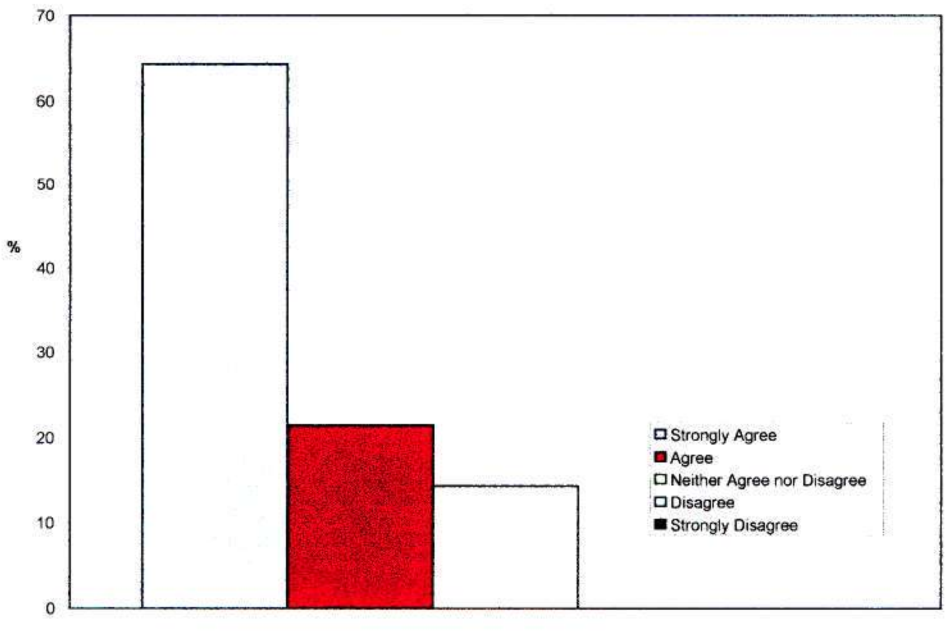
5.3.4.6. Rationing and Shortage Gaming

The concept of rationing and gaming has been dealt with in Section 2.6.6. of the literature review. An example of the concept was cited by Project Co-ordinator, Dave Barrowman during the refurbishment of the Colenso Gowrie 88kV powerline. Additional cables referred to as "Hare conductor" were ordered for the project due to a countrywide shortage of this particular cable. The cables were used to replace temporary cables which were installed after the theft of the copper cabling. The additional orders had been requisitioned due to the anticipation of future theft.

Additional orders are returned to New Germany stores rather than the materials suppliers. The materials are stored in anticipation for use in future projects. The discussion on materials returns will be addressed in section 5.5.

The research finding of the questionnaire survey on the above-mentioned concept was explored through two statements, namely statements 9 and 14. *Statement 9: "It is easy to place and then cancel orders with suppliers".* The results were as follows: 64% strongly-agreed, 21% agreed and 14% were undecided. Majority (85%) of respondents were in agreement with the statement.

Figure 5.3.4.6. It is easy to place and then cancel orders with suppliers(Statement 15)



Statement 9 has been analysed and discussed under Section 5.3.4.5. and will not be repeated here.

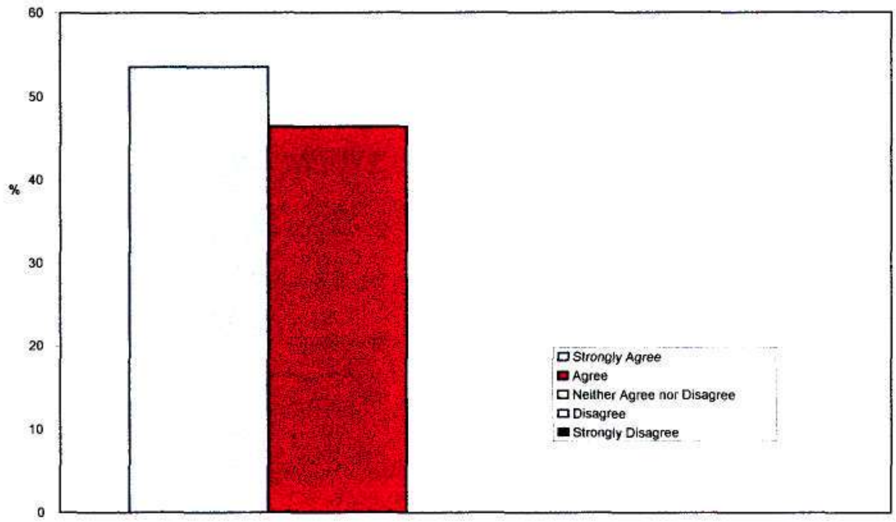
5.3.4.7. Supplier Selection and Evaluation

A distinction in low value and high value purchasing is made by Burt *et al* (2003:332); in low value purchases, the evaluation is not as stringent as in high value purchasing. For purchases of low value, the evaluation is made by looking at information from websites, or mail. For high value purchases, the procedures may involve conducting supplier surveys, conducting financial analyses, carrying out site visits to plants, conducting quality, capacity and service checking.

The evaluation process may be based on a set of selection criteria and corresponding rating based on its weighting. According to Burt *et al* (2003:336), an assessment is based on the numerical ratings as well as site investigations. As Preis (2003:36) points out, that the evaluation process and rating system must be objective by choosing criteria such as price, performance and quality rather than just interpersonal satisfaction to ensure an effective evaluation.

Suppliers are selected from those that passed the evaluation process. Sourcing criteria by bidding or negotiation or both provides a basis for choosing the successful supplier. The importance of a good supplier is highlighted in the next section on strategic partnerships and supplier integration.

Figure 5.3.4.7.(a) During the Form 150 stage, BEE companies are given preference to supply materials (Statement 18)

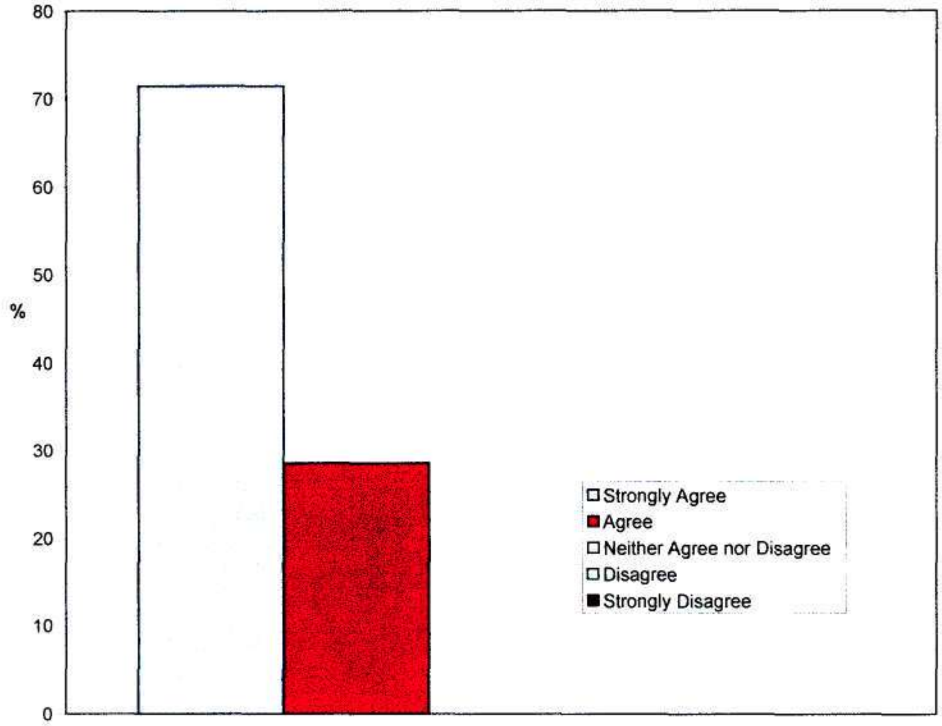


The research finding on supplier selection and evaluation was explored through Statements 18, 19, 20 21, 22, 28 and 30.

Statement 18: "During Form150 stage, BEE companies are given preference to supply materials". The results were as follows: 54% strongly-agreed and 46% agreed to the statement. The findings (100% of respondents) are in agreement with ESKADAAX7, Eskom's purchasing pact with suppliers, which is available online.

According to the document, tenders are awarded on lowest price only, or on a set of criteria such as technical merit, quality and BEE contractor and subcontractor status.

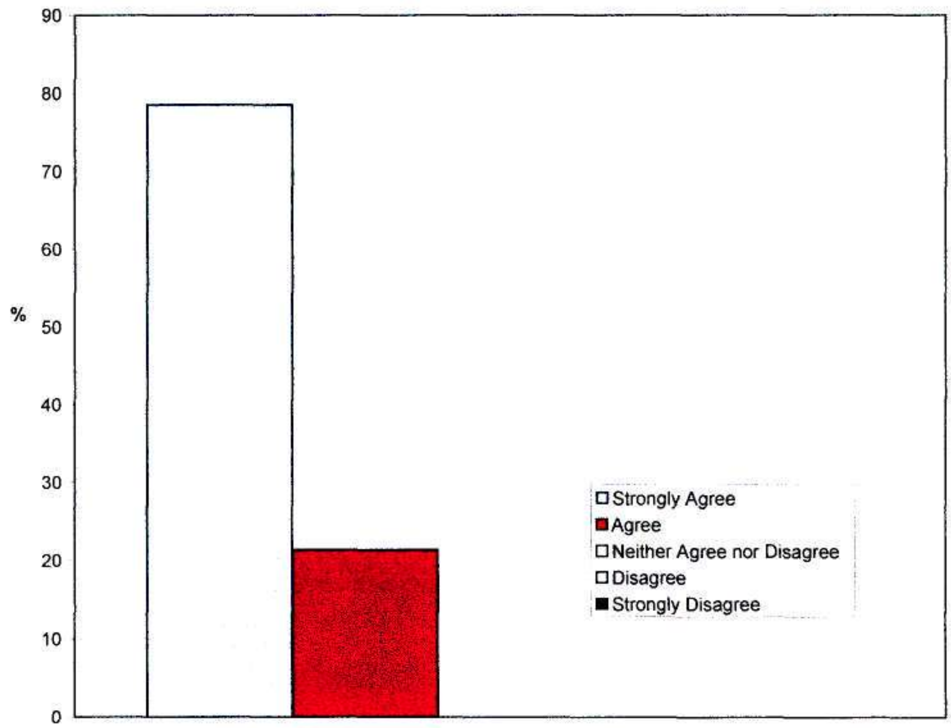
Figure 5.3.4.7.(b) Suppliers are chosen based on the lowest tendered price (Statement 19)



An analysis of the results obtained from *Statement 19: "Suppliers are chosen based on lowest tendered price"*. The results from respondents were as follows: 71% strongly-agreed and 29% agreed to the statement. The result (100% of respondents agreeing to Statement 19) is cause for concern as the lowest tenderer is not necessarily the most suitable in terms of rendering a product or service that complies with stringent specifications and standards. According to *Tucker (2005)*, no company should be competing on price alone but rather by the value it is offering.

When respondents were probed about materials suppliers in *Statement 20: "The choice of materials suppliers can determine the success of a project"*, the outcome was as follows: 79% strongly-agreed and 21% agreed to Statement 20. According to ESKADAAX7, Eskom's purchasing pact with suppliers, the responsibilities of both parties form part of the pact. A suspension procedure for suppliers that are repeat offenders or unscrupulous, is included in the document. Further documentation developed regionally; include the issuing of a non-conformance report for any aspect pertaining to materials for example poor quality or damage in transit. Any supplier that has a total of three or more non-conformance reports is suspended from the vendor list.

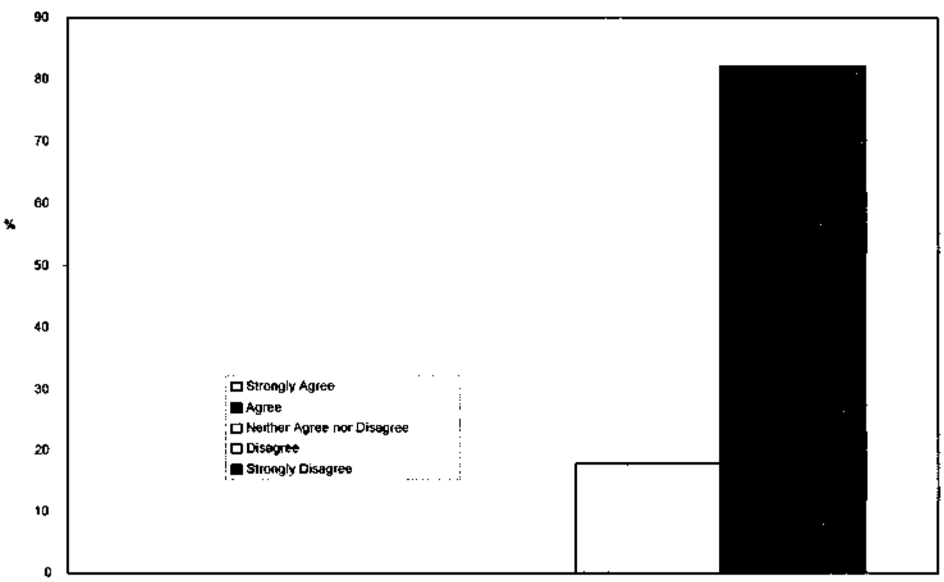
Figure 5.3.4.7.(c) The choice of material suppliers can determine the success of a project (Statement 20)



The problem is in the implementation phase. Site-personnel are reluctant to fill in the report as it requires reams of paperwork and a follow-up procedure. It then becomes challenging to successfully discipline suppliers when the information obtained by site personnel is not a true reflection of actual events.

The selection and evaluation of suppliers were investigated by the use of Statement *21: "Supplier selection and evaluation is done objectively and openly"*. The results of the findings were as follows: 82% of respondents strongly-disagreed and 18% disagreed to Statement 21. Some of the reasons expressed by supply chain role-players were that not all stake-holders are consulted during the tender and adjudication process. For instance, technical staff were omitted from the adjudication and tenders have been awarded from an economic perspective (Eskom 2003:320). This practice is not feasible as in some instances; the successful tenderer was awarded the contract based on a scope of work that could not be executed practically. One such example was the construction of 60km of 132kV powerline from Vergenoeg to Pongola in 2001. There were 2 pylons that could not be conventionally installed in an environmentally-sensitive area consisting of aloes and proteas. The solution was to use a 10 ton capacity helicopter at a cost of approximately R100 000. The contractor costs for labour trebled as this was a variation order (Eskom 2003:321). Had the environmentalists and engineers been party to the contract documentation, this compensation event would have been avoided.

Figure 5.3.4.7.(d) Supplier selection and evaluation is done objectively (Statement 21)

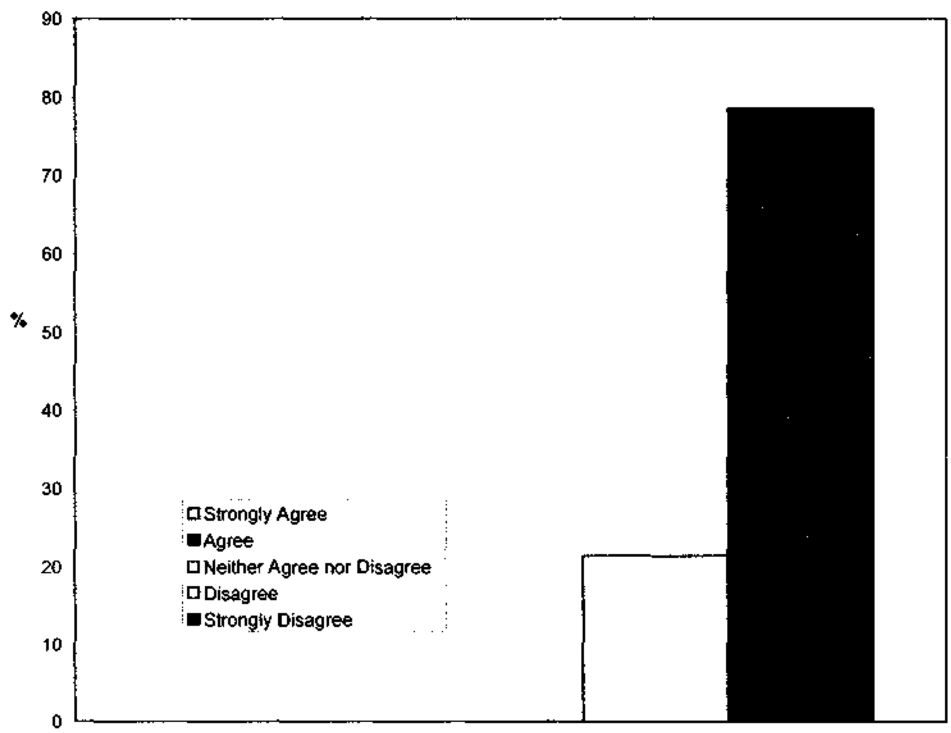


The participation of role-players in decision making is probed using *Statement 22: "All project role-players have an opportunity to evaluate suppliers"*. The outcome of the probe was as follows: 79% of respondents strongly-disagreed and 21% disagreed to Statement 22.

The findings are aligned with that of Statement 21 where role-players are not consulted in the decision-making process.

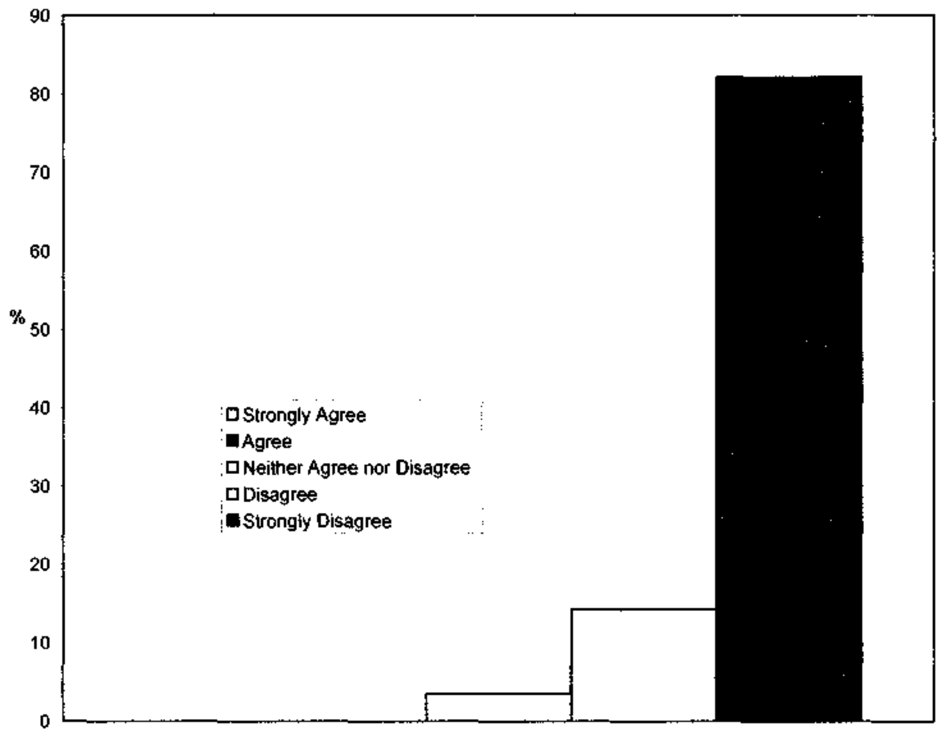
Another cross-check for consistency in the results is through the use of *Statement 30: "Once a project is commissioned, projects are evaluated objectively"*. The results of the findings were as follows: 82% of respondents strongly-disagreed, 14% disagreed and 4% were undecided to Statement 30. Hence the findings are consistent with that obtained from Statements 21 and 22. This gives further impetus to the fact that there is no consultation with an all-inclusive team of project role-players during the project life-cycle.

Figure 5.3.4.7.(e) All project role-players have an opportunity to evaluate suppliers (Statement 22)



One of the main activities within the supply chain is information flow. From the findings it is evident that information flow has been restricted.

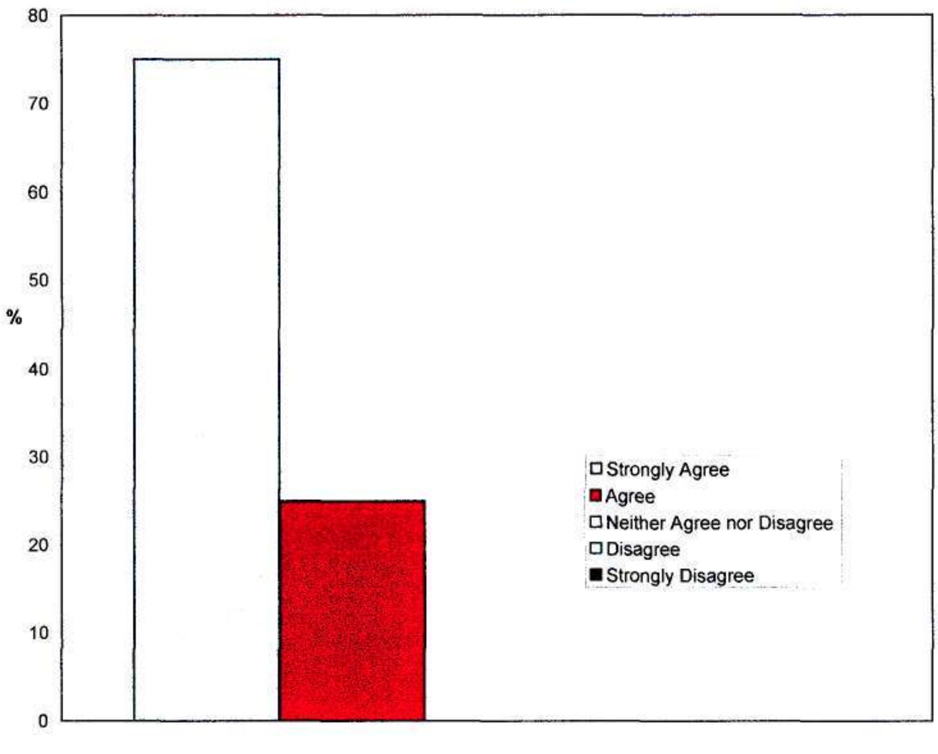
Figure 5.3.4.7.(f) Once a project is commissioned, projects are evaluated objectively (Statement 30)



From an Eskom point of view, the question one may ask is what recourse is there for poor-performing suppliers?. The question was addressed through *Statement 28: "There are no penalties imposed on suppliers for causing project delays"*. The results of the findings were as follows: 75% of respondents strongly-agreed, 25% agreed to Statement 28. Project delays are attributed to supplier stock-outs or defective materials arriving to site which may require rework.

The opportunity costs due to stock-outs or rework are not passed on to the supplier. Penalties should be imposed that are consistent with the level of risk. For example, projects that supply strategic customers such as Richards Bay Minerals (RBM), should have higher penalties built in the contract than non-critical refurbishment projects.

Figure 5.3.4.7.(g) There are no penalties imposed on suppliers for causing project delays (Statement 28)

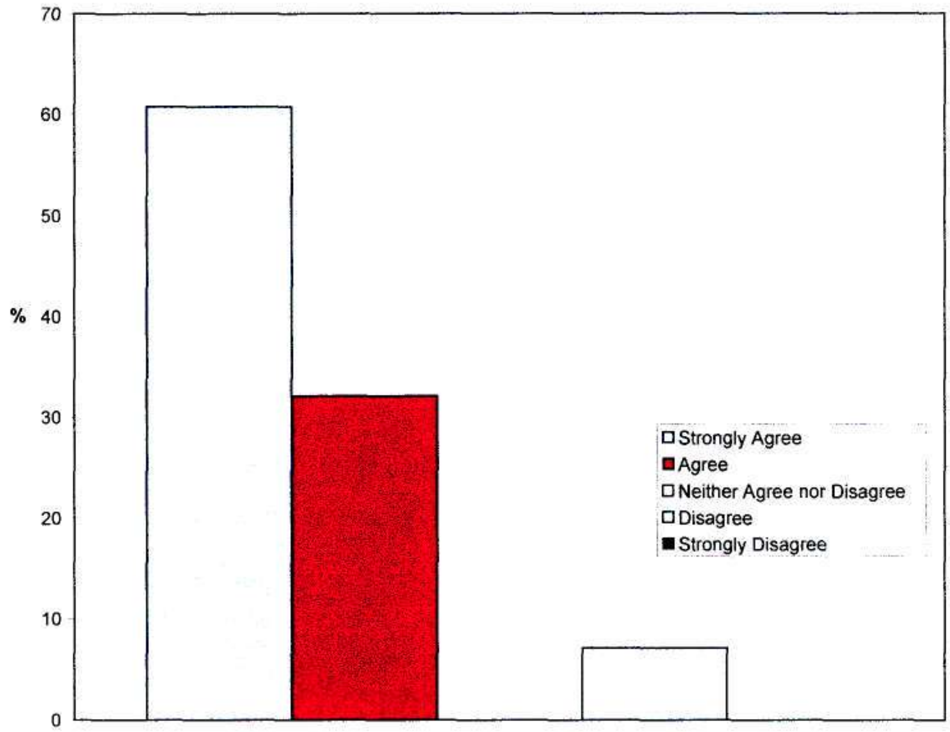


The opportunity costs due to stock-outs or rework are not passed on to the supplier. Penalties should be imposed that are consistent with the level of risk. For example, projects that supply strategic customers such as Richards Bay Minerals (RBM) should have higher penalties built in the contract than non-critical refurbishment projects (Eskom 2003:331). Likewise the opposite should hold true. For emergency projects, for instance when infrastructure has been damaged by storms and has to be restored immediately, incentives need to be built in contracts with negotiated suppliers to expedite restoration of such infrastructure (Eskom 2003:352).

5.3.4.8. Strategic Partnerships and Supplier Integration

The importance of strategic partnerships and supplier integration cannot be under-estimated as has been demonstrated in the literature survey (Burt *et al*, 2003:336, Preis 2003:36). The lack of such integration is a major cause of the bullwhip effect. The investigation into the extent of such partnerships was probed through Statement *29: "There are no long term partnerships with good suppliers"*. The results from respondents were as follows: 61% strongly-agreed, 32% agreed and 7% disagreed with the statement. Majority (93%) of respondents are in agreement with statement 29. .

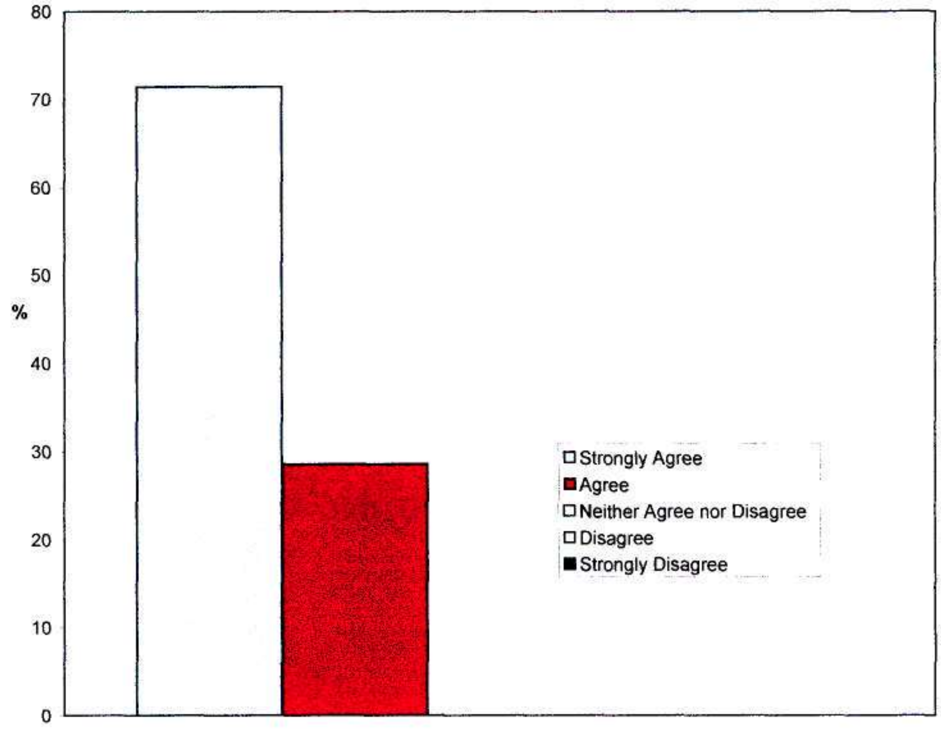
Figure 5.3.4.8.(a) There are no long term partnerships with good suppliers (Statement 29)



The findings are cause for concern as it has been demonstrated in the literature survey that the benefits of supplier integration leads to improved logistics, lower costs, lower stock levels and reliability in delivery times .

Statements 24, 25 and 26 follow a similar trend to cross-check the validity of Statement 29. *Statement 24: "Project delays are attributed to poor quality of materials supplied"*. The results of the survey were as follows: 71% strongly-agreed and 29% agreed with the statement. The solution is to perform quality checks at the source, so that any anomalies may be rectified before the equipment or product is installed.

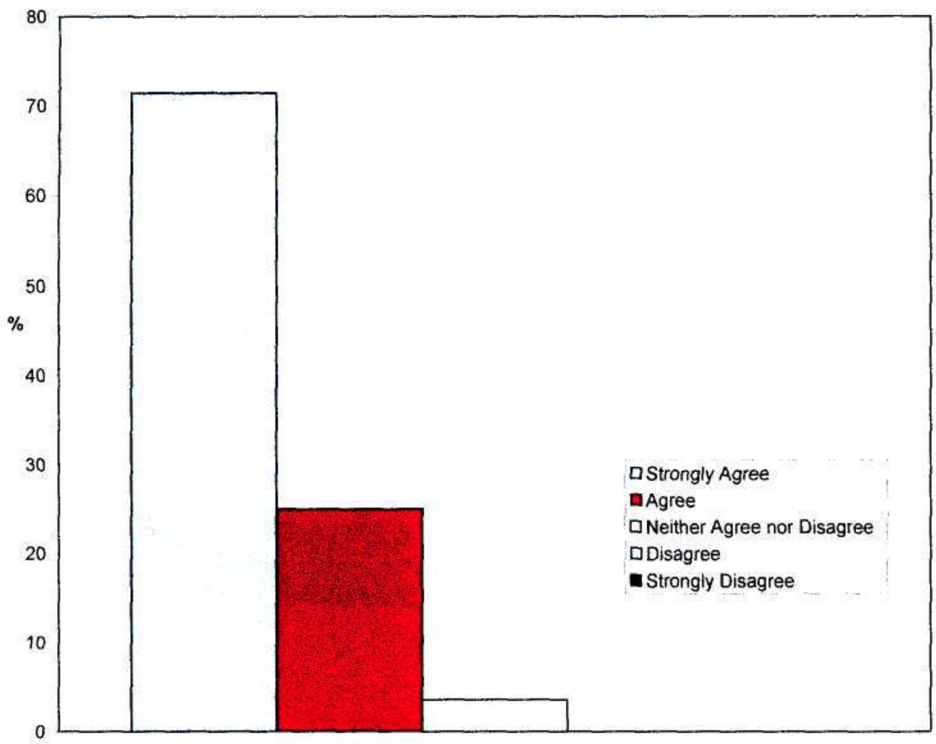
Figure 5.3.4.8.(b) Project delays are attributed to poor quality of materials supplied (Statement 24)



Statement *26: "Project delays are attributed to incorrect materials arriving to site"*. The root cause of the problem pertaining to incorrect materials getting to site is attributed to incorrect batching. For example, a truckload of goods may contain deliveries to several sites and due to the large order filled; it is easy to deliver the incorrect materials to site.

The results from respondents for Statement 26 were as follows: 71% strongly-agreed, 25% agreed and 4% disagreed with the statement. Majority (96%) of respondents were in agreement with Statement 26. The knock-on effect of project delays as a result of incorrect materials arriving to site may not be easily quantifiable. For instance, the opportunity costs for not having a point of supply on time may lead to disgruntled communities working against the interests of Eskom and any other future developments in the area.

Figure 5.3.4.8.(c) Project delays are attributed to incorrect materials arriving to site (Statement 26)



The results from respondents for Statement 25 (Figure 5.3.4.8.d.) were as follows: 71% strongly-agreed and 29% agreed to the statement. The late delivery of materials are due to double handling that occurs when materials arrive from the supplier to New Germany stores and then from the stores to site. A substantial savings is realized in both time and cost if materials are sent directly from the supplier to site, avoiding the double-handling of materials.

Other reasons for materials arriving late to site are supplier-related or company related or both. For instance, suppliers may not adhere to delivery schedules or where suppliers are over-committed. Company-related issues may arise when the materials scheduler enters in unrealistic material need dates on the SAP system. For example, a transformer has a lead time of eight to twelve months and anything less is unrealistic. However, there have been a number of reported incidents by the PC of this type of materials schedule. Hence there is no "flagging" mechanism to minimize the population of incorrect data into the SAP system.

Table 5.4. Results from real-time project data

ID	Project Name	F10	F15	BEE %	Mat returns	% of total materials	Defective Materials	% of total materials	Delays-Defective Materials (days)	Number of suppliers
12034	Edendale 20MVA 132/22kV Transformer Establish	R 3,104,000	R 4,140,020	32.0	R 62,278	1.3	R 32,378	0.8	10	1
EP2003225197126	Nongoma SS NB78 Equip 22 kV Feeder Bay	R 274,740	R 246,054	43.2	R 59,682	24.3	R 15,279	14.5	15	3
EP2003225197228	Ludeke 132-22kV 20MVA SS est	R 5,869,000	R 10,806,61	48.6	R 34,897	0.3	R 15,072	0.2	8	2
EP2003225197238	Eros-Dumasi 132kV Ludeke Tee Line	R 2,362,500	R 5,376,441	44.4	R 59,361	1.1	R 11,496	0.3	8	4
EP2003225580657	Bloedrivier Hlobane 88kV lines 1&2 insulator rearrangement for road crossing	R 51,950	R 63,552	45.5	R 89,551	73.2	R 1,698	1.6	19	1
EP2003225580827	Mtwalume 88/11kV SS - installation of NECR/Aux	R 60,000	R 93,721	52.2	R 33,565	29.3	R 5,235	6.3	12	1
EP2004230663314	Howick SS - 2 * 11kV Feeder Bays for Dunlop	R 207,508	R 263,351	36.1	R 25,566	9.6	R 4,587	2.9	14	5
EP2004231238782	Empangeni Ngoye 88kV Line	R 500,000	R 1,423,676	63.0	R 49,682	3.5	R 8,956	2.0	6	3
N010145	Empangeni Mandini 88kV Line Refurb	R 8,631,146	R 7,137,547	41.6	R 155,897	1.2	R 58,562	0.5	19	2
N010230	Empangeni Umfolozi 88kV Line Refurb	R 14,284,327	R 14,570,69	69.3	R 69,875	0.6	R 7,868	0.1	21	1
N010347	Madungela SS 11kV board upgrade	R 1,270,000	R 1,379,171	32.1	R 56,569	3.2	R 4,582	0.3	12	1
N020009	Darnell 22/11kV SS Refurb	R 576,660	R 560,750	75.8	R 23,655	3.1	R 4,897	0.6	18	1
N020011	Hillbrow 22/11kV SS Refurbishment	R 543,216	R 494,582	43.3	R 54,468	9.1	R 1,544	0.3	14	3
N020096	St Lucia 22/11kV S/S Relocation & Upgrade	R 5,700,000	R 5,160,992	28.1	R 98,323	1.8	R 94,456	1.9	5	5
N020149	Empangeni Eshowe 88kV Line Refurbishment	R 4,683,640	R 4,946,495	90.8	R 101,986	1.7	R 98,454	1.7	9	3
N020154	Nqabeni Tee Line	R 1,000,000	R 1,505,199	56.9	R 112,589	6.8	R 5,468	0.3	13	4
N020192	Wetherby 132_88kV substation	R 7,000,000	R 5,765,427	44.6	R 156,021	2.7	R 8,954	0.2	6	1
N020194	Wetherby turn in lines (Kokstad Wetherby 88kV line)	R 359,000	R 330,307	52.6	R 26,822	3.9	R 5,489	0.8	4	1
N030022	PMB Area. Substation Security	R 800,000	R 374,123	39.7	R 25,698	3.8	R 5,698	1.1	5	1
N030139	Mtubatuba SS New Relic Feeder Bay 22kV	R 246,129	R 577,206	40.8	R 65,982	11.4	R 6,569	1.4	13	3
N970429	Nqabeni 132 22kV SS Est	R 5,500,000	R 4,330,753	52.3	R 53,456	1.1	R 6,985	0.1	14	2
N990060	Willowford Wembezi 33kV Tee 62 (Mdwebu Tee)	R 1,380,000	R 1,397,475	34.7	R 34,546	2.2	R 9,865	0.6	7	5
N990061	Mdwebu 33 11kv SS Establishment N990061 rev 1	R 1,200,000	R 2,527,378	74.1	R 35,454	1.0	R 5,499	0.2	14	1
N990111	Driefontein SS Refurb	R 468,579	R 675,796	74.1	R 45,665	6.0	R 6,546	0.9	12	1
N990134	Greytown 33kV SS Refurbishment	R 373,132	R 1,043,680	30.4	R 25,689	1.6	R 56,856	3.6		1
					R 1,557,277		R 482,983		278	

(Eskom, 2003:2-50)

Table 5.8. Results from real-time project data f

ID	Project Name	F10	F15	BEE %	Mat returns	% of total materials	Defective Materials	% of total materials	Delays-Defective Materials (days)	Number of suppliers
N010236	Georgedale Northdene 88kV Line 1 Refurbishment	R 1,070,041	R 7,803,838	36.6	R 180,000	3.1	R 180,000	#VALUE!	10	1

(Eskom, 2003: 1-12)

5.5. DISCUSSION ON THE FINDINGS OF THE STUDY ON REAL-TIME PROJECTS

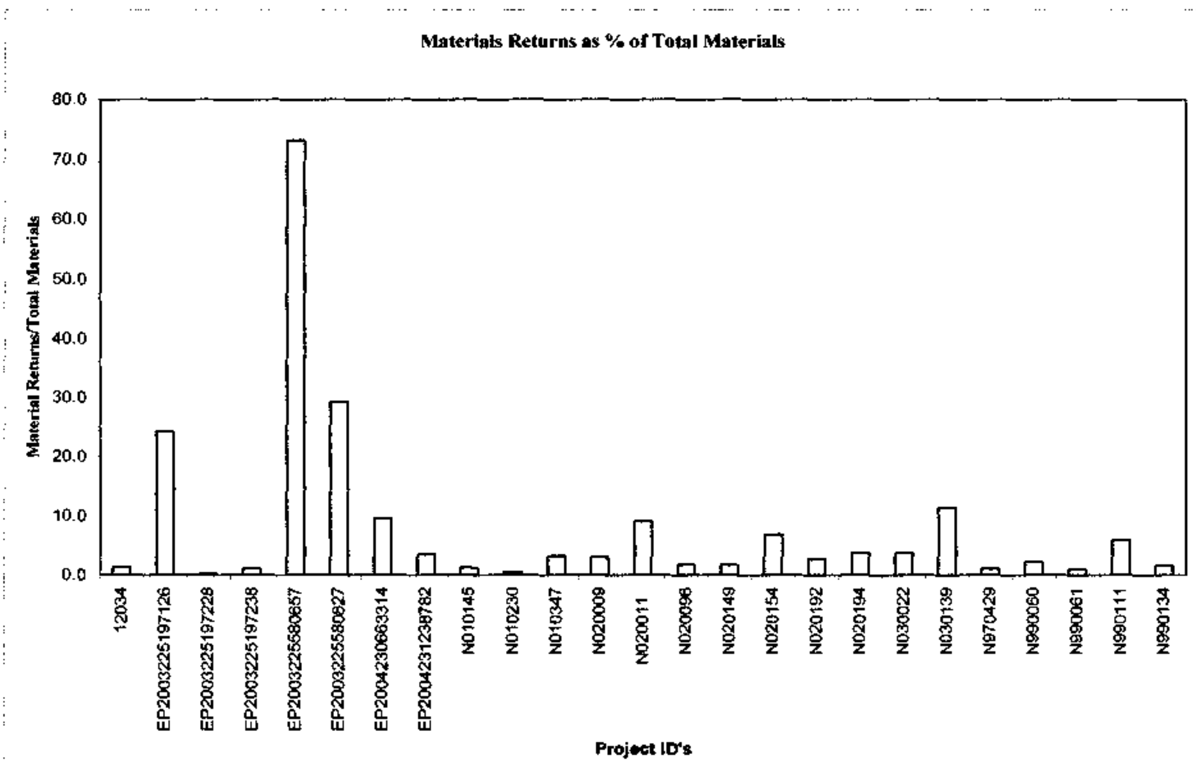
The study focused on 25 completed projects within Eskom Eastern Region spanning over a three year cycle. The projects were a mix of power lines and substations, new or refurbished. The detailed mix and population size was stipulated in Table 4.7.2. of Chapter 4.

Where possible, this section is arranged under similar headings of section 5.3. for ease of comparison between the two independent studies.

5.5.1. SAFE HARBOUR BEHAVIOUR

As there are no repercussions for over-ordering of materials, the stores at New Germany becomes a dumping ground for excess materials in anticipation for use in future projects that may or may not materialize. The extent of the problem is illustrated in Figure 5.5.1 below.

Figure 5.5.1. Material Returns as a percentage of Total Materials



(Eskom, 2003:1-547)

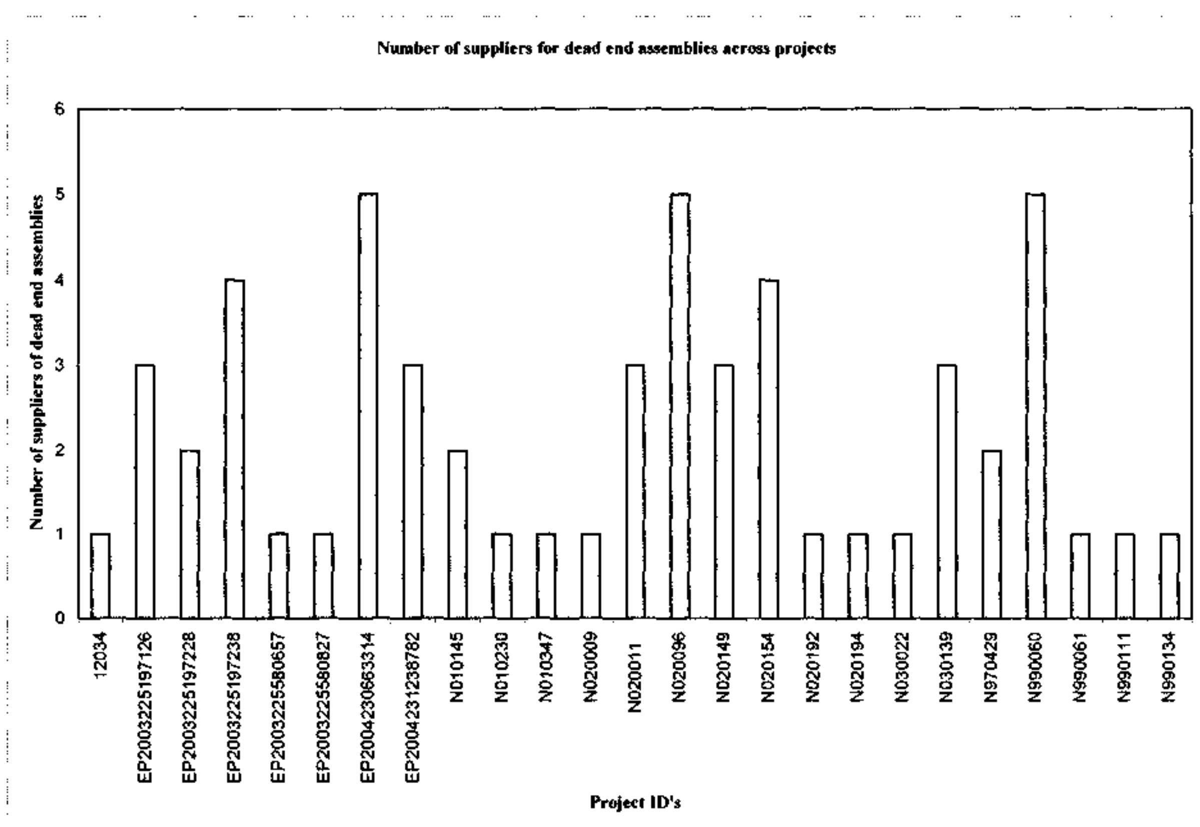
The cost of materials returns is expressed as a percentage of totals materials per project. The total cost of the materials returned was approximately R1.6 million which is 2% of the total material project cost. As discussed in the previous chapter, the funds could have been spent on more capital projects instead of been tied up in excess stock.

The results are consistent with the behaviour of supply-chain role-players over-ordering materials.

5.5.2. PANIC BEHAVIOUR

An analysis of the projects has shown that orders were placed with up to five different suppliers for the same product as illustrated in Figure 5.5.2. For the purpose of this exercise, the focus was on one scarce product, namely a dead end assembly (that is various clamping components of a conductor attachment to various equipment including pylons).

Figure 5.5.2. Number of suppliers for scarce materials



(Eskom, 2003:1-547)

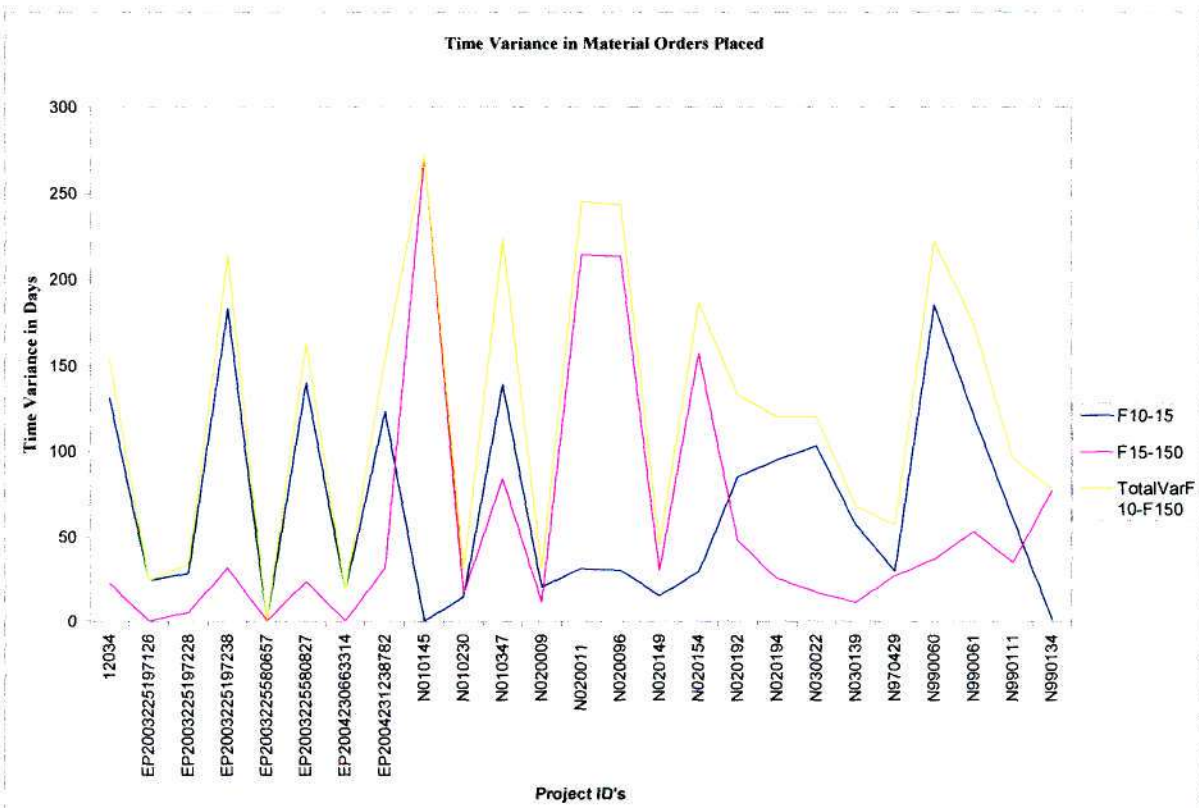
The problem with a multiple-supplier strategy is the bullwhip caused in the supply-chain of the supplier as a result of cancelled orders. The analysis is in agreement with the findings of Statement 14 in the previous section.

5.5.3. LEAD TIME OF INFORMATION AND MATERIALS

5.5.3.1. Material Orders Placed

Long lead time materials are shown as "F10-15" in Figure 5.5.3.1. (a). The variance is due to the time lapse from when long-lead time materials should have been ordered as scheduled to when they were actually ordered.

Figure 5.5.3.1.(a). Time variance in material orders placed

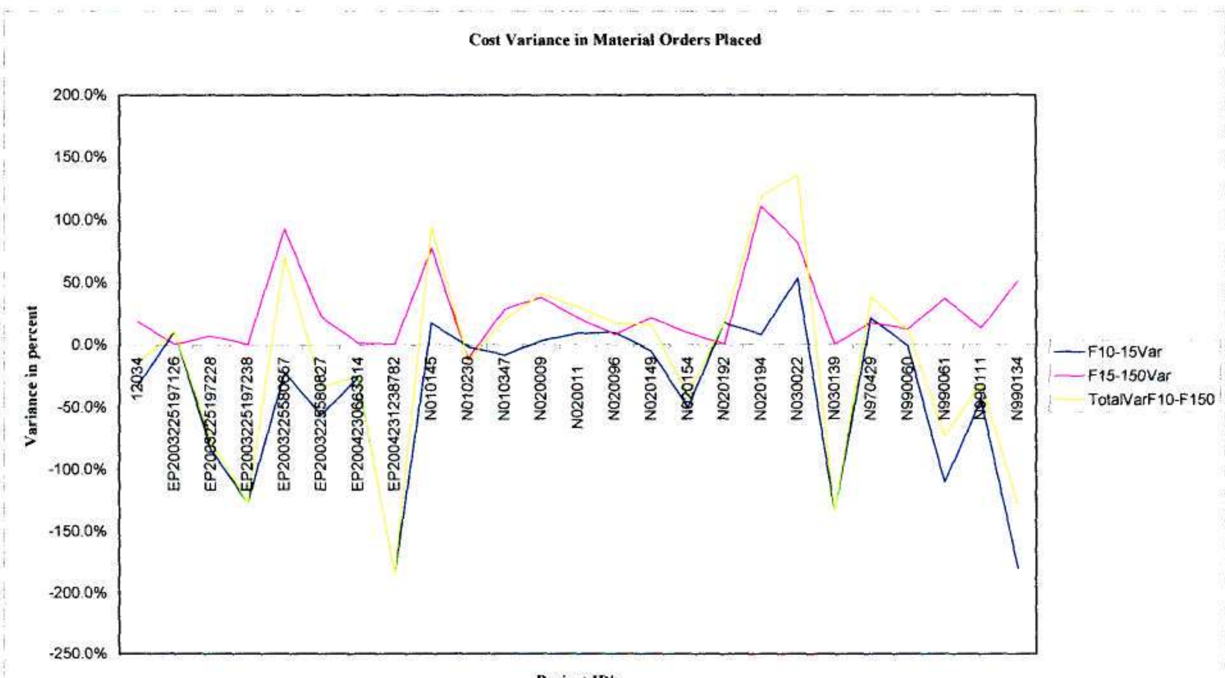


(Eskom, 2003:1-547)

Similarly other materials are shown as "F15-150" with variance in orders placed. The variance in orders is consistent with the findings expressed by respondents of Statement 4 in the previous section. One plausible reason for the delay in placement of materials is the incomplete information punched into the SAP system by the materials scheduler. The procurement officer has then to query the information which takes time. Another reason is the delay by customers in committing to funding of long-lead time materials. Also the Eskom policy in seeking three quotes for small items is bottlenecking the supply chain process. The procurement officers end up spending 80% of his or her time chasing 20% of materials.

The combined variance in time for all orders placed is indicated by "TotalVar F10-150". The cost variance due to estimating the materials cost to the actual costs when quotations are received, is illustrated in Figure 5.5.3.1. (b). This variation could have been avoided had there been long term partnerships with suppliers.

Figure 5.5.3.1.(b). Cost variance in material orders placed



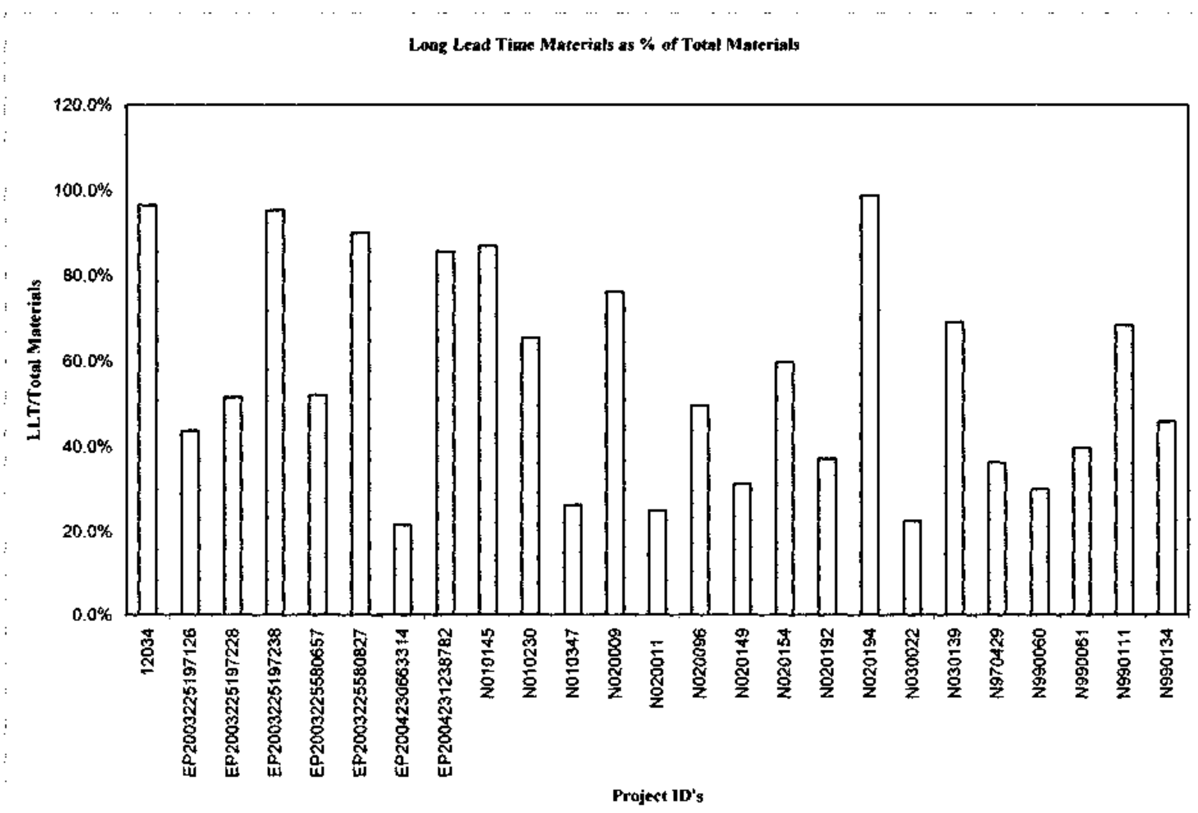
(Eskom, 2003:1-547)

When materials forecasts are done, the projected figures are used. Hence the forecast is substantially inaccurate as shown in Figure 7.4. The consequential impact is on the regional KPI, where funds are allocated to regions according to their forecasts; the more accurate the forecast, the better is the KPI and subsequently the slice of the bonus pool.

More effort needs to be placed on follow-up on long-lead time materials as on average, 50% of all material costs and time in a project is attributed to long-lead time materials (Eskom, 2003:431-3). Figure 5.5.3.1. (c) illustrates the long lead time materials as a percentage of overall materials per project. Project procurement officers must therefore focus on getting the long-lead time materials within time and cost as a priority than diluting their efforts on chasing short-lead time materials. This approach follows the ABC inventory application of the Pareto principle, where resources must focus on the "few critical inventory" than the "many trivial ones (Heizer and Render, 2001:475).

These materials should be stored by the supplier which is advantageous for the following reasons: firstly, the project time and cost risk is passed onto the supplier and secondly valuable warehousing space is freed up for strategic stock and spares.

Figure 5.5.3.1. (c). Long-lead time materials as a percentage of total materials



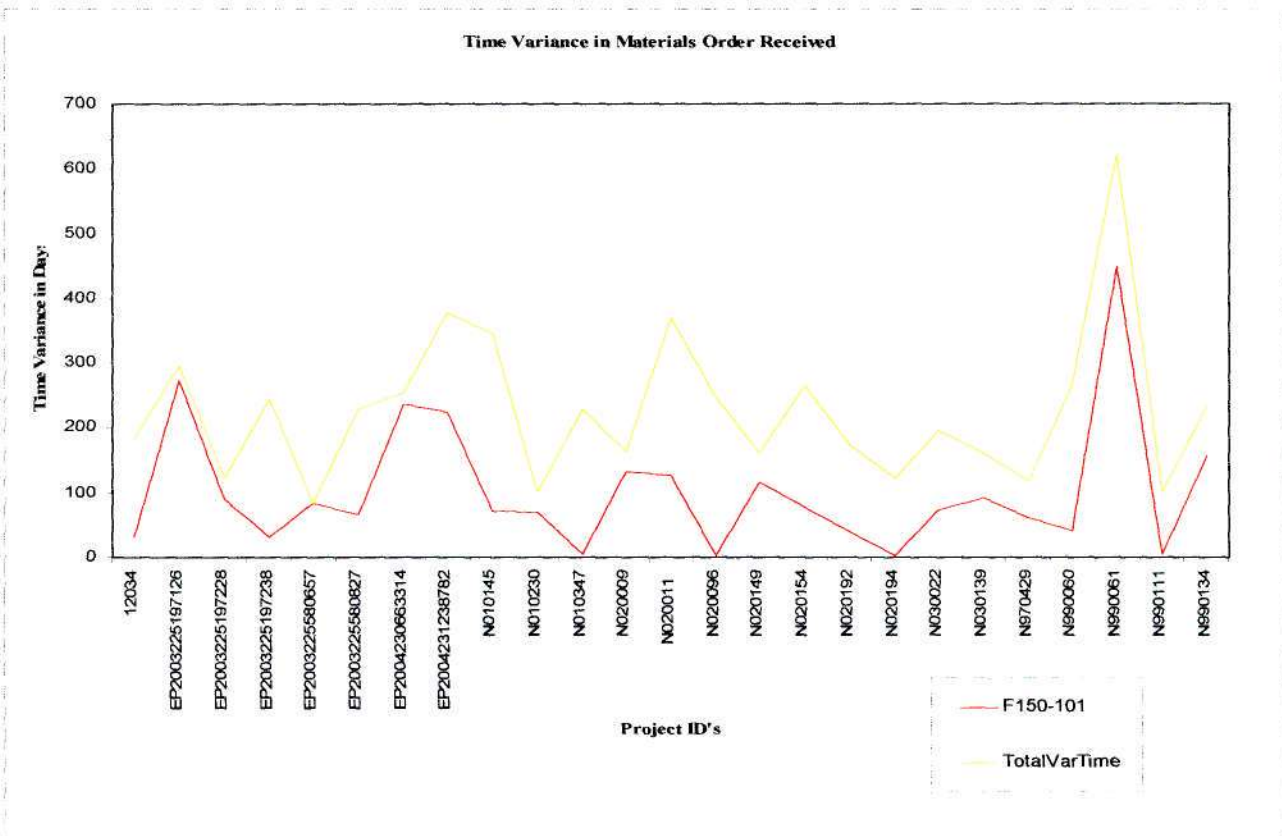
(Eskom, 2003:1-547)

The establishment of long-term partnerships with suppliers will ensure consistency in costs and time especially for long-lead time materials.

5.5.3.2. Material Orders Received

The variance between the scheduled times of receiving materials to the actual time they are received on site, is illustrated by "F150-101" in Figure 5.5.3.2 (a). The total variance in the supply of materials is illustrated by "TotalVartime". The findings are consistent with Statement 7 of the previous section, where 100% of respondents have indicated that materials are not received timeously on site.

Figure 5.5.3.2. (a). Time variance in material orders received



(Eskom, 2003:1-547)

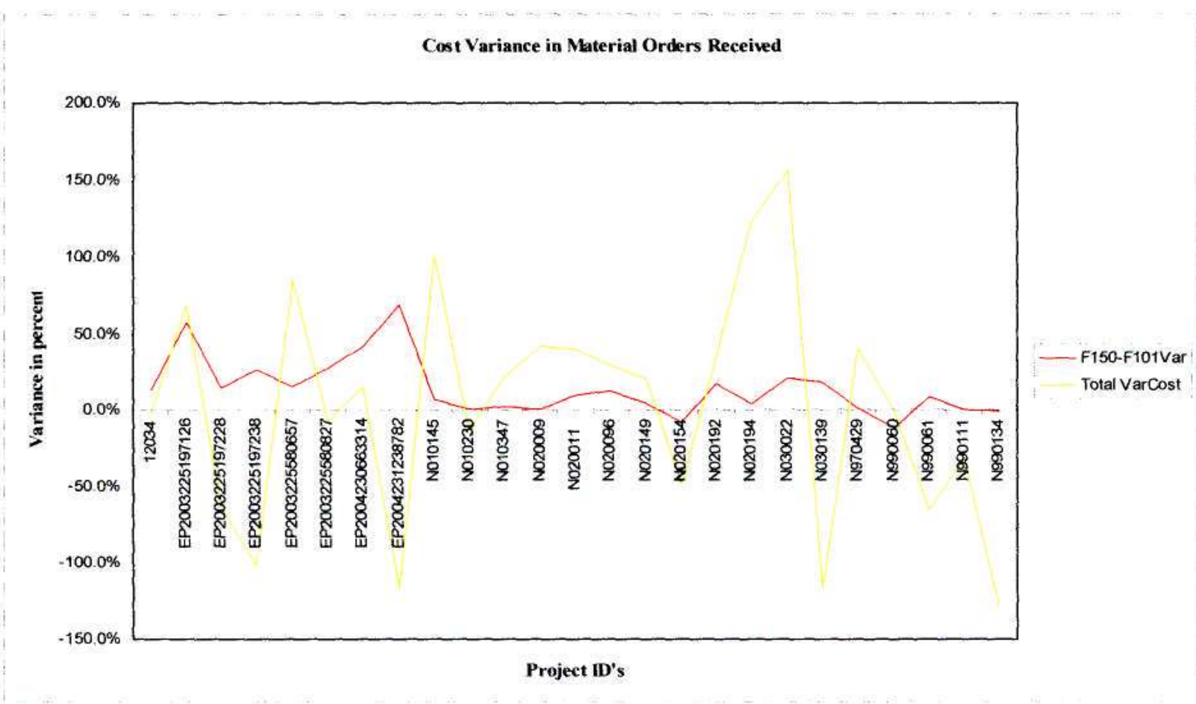
The cost variance in materials received is shown in Figure 5.5.3.2. (b). this variance is attributed to a number of factors. Firstly, fluctuations in exchange rate due to the delays in ordering the materials. Secondly, change in order quantities due to project scope creep.

Thirdly, incomplete or inaccurate information flow between procurement and supplier (Eskom, 2003:10).

The business implications of major fluctuations in materials cost is severe. A financial rolling plan is drawn up quarterly and submitted to Eskom Corporate Division for finance. Finance is distributed based on the forecasted financial figures in the rolling plan. The knock-on effect on effect of not having finance when required in a specified time-frame is detrimental as project would then have to be delayed until the next quarter. (Eskom, 2003:6).

Furthermore, the projected and actual costs are monitored and there are Key Performance Indicators (KPI's) for financial instruments as was illustrated in Chapter One which ultimately become part of the Regional Performance Report.

Figure 5.5.3.2. (b). Cost variance in material orders received



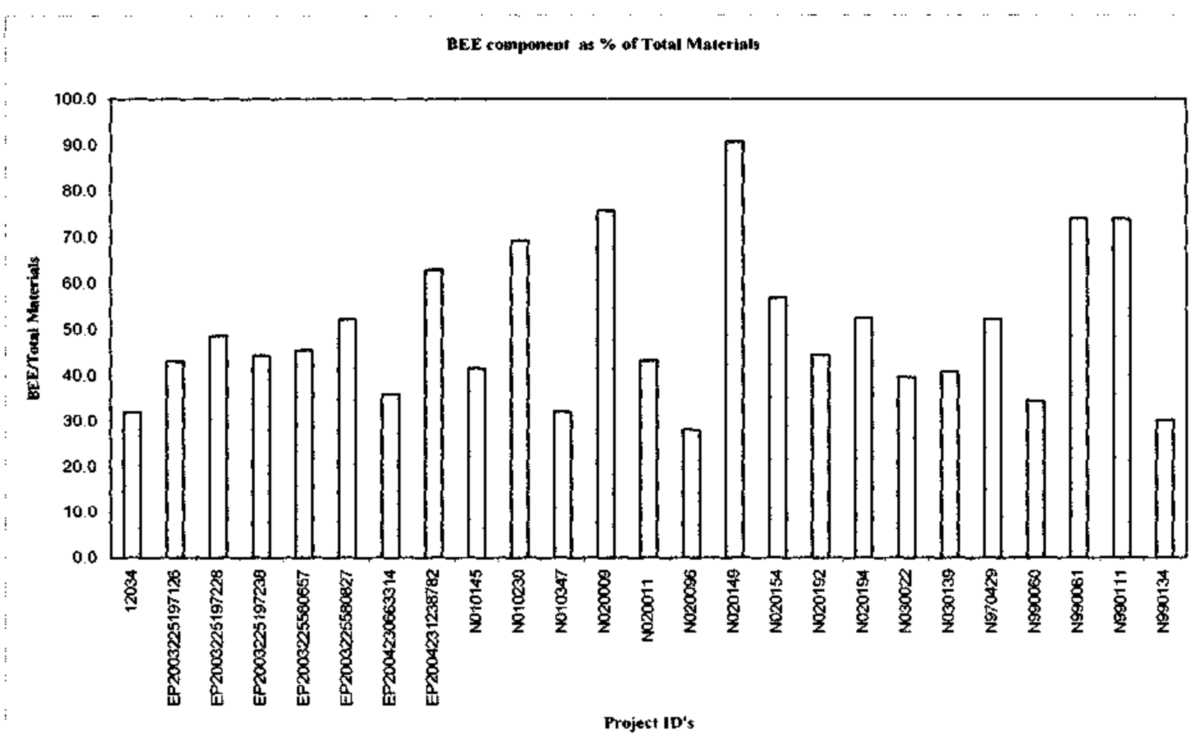
(Eskom, 2003:1-547)

5.5.4. SUPPLIER SELECTION AND EVALUATION

The supplier selection is done according to Eskom's purchasing pact with suppliers and has been discussed in the previous section. BEE companies are given preference to supply materials as indicated by the exploratory study (Eskom 2004c:1-21). An analysis of the BEE component in the sample of projects is illustrated in Figure 5.5.4. This component constitutes 57% of the total materials supplied for all projects in the sample.

It was noted that there has been no detailed briefing of BEE suppliers into the business. These suppliers do not visit Eskom construction sites and are only partially aware of the application of the product that they are supplying. For instance, a BEE supplier (called Supplier X for anonymity) tendered to supply specialized screw anchor foundation for pylons. Supplier X owned a hardware store and tendered for the project based on domestic screws as he had no knowledge of the application (Eskom:2003,101-102).

Figure 5.5.4. BEE component as a percentage of total materials



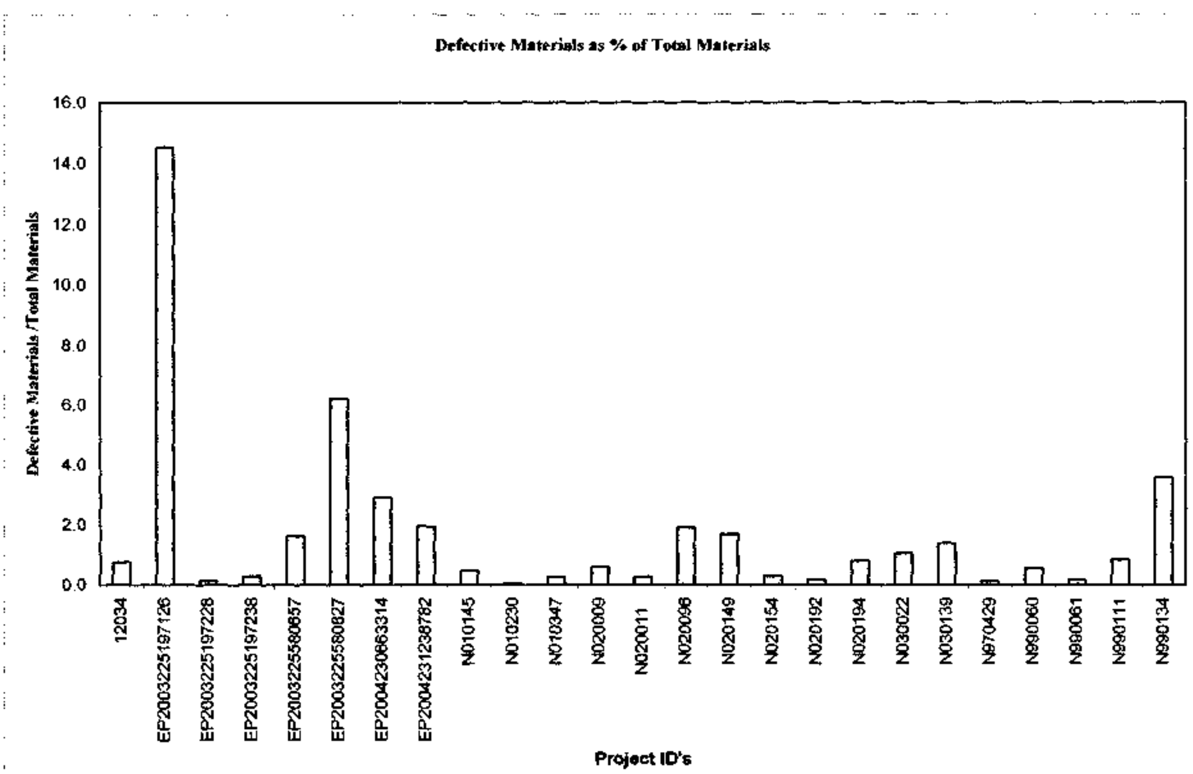
(Eskom, 2003:1-547)

5.5.5. STRATEGIC PARTNERSHIPS AND SUPPLIER INTEGRATION

There are no long term relationships with suppliers due to preference given to BEE companies as shown in Figure 5.5.4. (Eskom, 2004c:1-21). The results obtained in Figure 5.5.4. are consistent with the findings of Statement 18, where 100% of respondents agreed that BEE companies were given preference to supply materials. These companies will need to develop a good track record to prove their reliability as long-term suppliers.

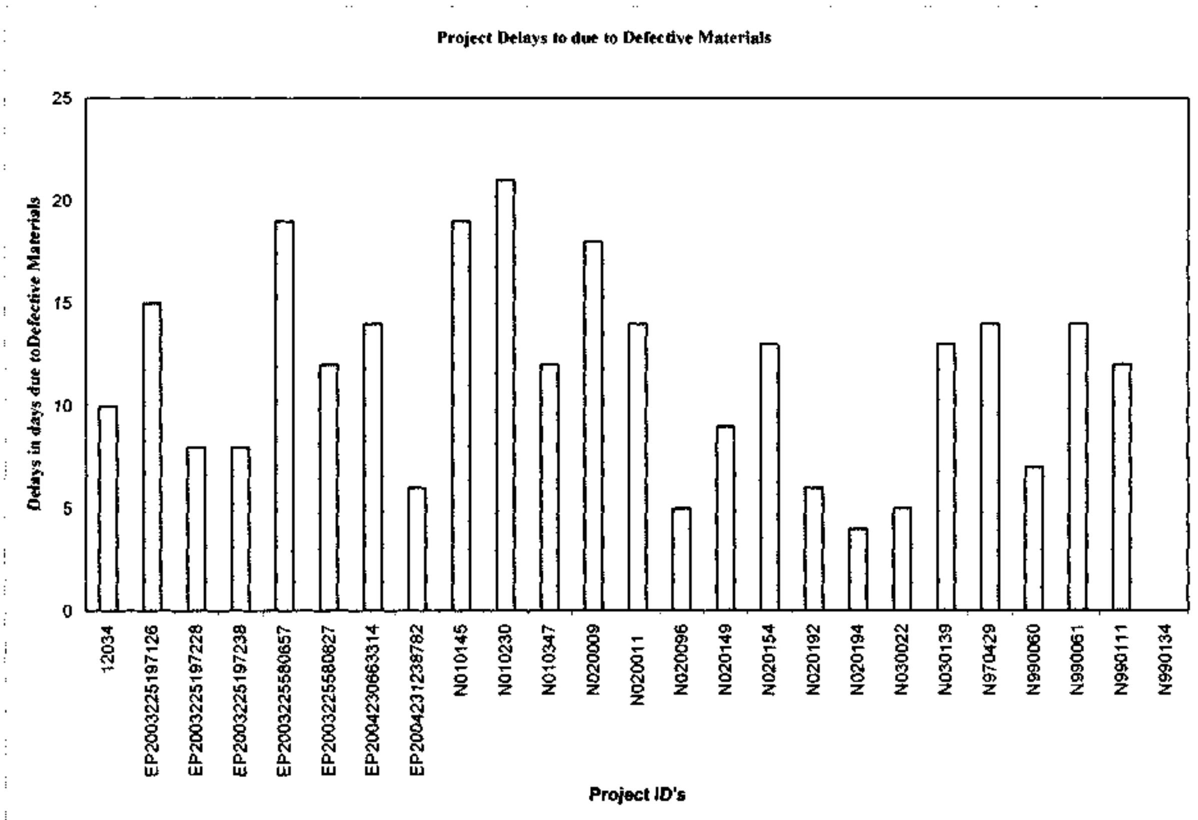
One of the metrics used to measure material quality is the number of defective materials (Eskom, 2003:5-18). As shown in Figure 5.5.5 (a), the cumulative cost of defective materials was R482 993. The consequential costs are substantial. For instance the direct labour cost of delays due to standing time from defective materials is 278 days. This translates to a cost of R2.78 million as the standing time for construction is on average R10 000 per day. The delays per project due to defective materials are illustrated in Figure 5.5.5 (b).

Figure 5.5.5. (a). Defective materials as a percentage of total materials



(Eskom, 2003:1-547)

Figure 5.5.5. (b). Project delays due to defective materials



(Eskom, 2003:1-547)

From the discussions, it is evident that the results obtained from the exploratory study on human behaviour and interaction and the investigation of real-time projects are consistent with the impact of human behaviour on the bullwhip effect and the impact of fluctuation in materials and information flow on the bullwhip. Major fluctuations materials and information flow was attributed to both the impact of human behaviour as well as the impact of fluctuation from the supply chain process.

The next section provides a discussion on the comparison of the two independent studies, that is, the study on human behaviour and the study on real-time projects.

5.6. DISCUSSION ON THE COMPARISON BETWEEN THE STUDY ON HUMAN BEHAVIOUR AND THE STUDY ON REAL-TIME PROJECTS

A comparison was drawn between the results obtained from Table 5.3. and 5.4. The discussion was structured under the main headings of the causal factors of the bullwhip to provide a basis for comparison.

5.6.1. SAFE HARBOUR BEHAVIOUR

In the study of real-time projects, it was illustrated in Figure 5.5.1. that the total cost of the materials returned to New Germany Stores was approximately R1.6 million which is 2% of the total material project cost. As discussed in the previous section, the funds could have been spent on more capital projects instead of been tied up in excess stock.

A comparison with Figure 5.3.2. of the study on human behaviour has shown that 100% of respondents were in support of Statement 16: *"It is better to over-order materials to ensure that at least the right quantity arrives on site"*. Hence the results are consistent with the study on real-time projects.

5.6.2. PANIC BEHAVIOUR

In the study on real-time projects, it was shown in Figure 5.5.2, that orders were placed with up to five different suppliers for the same scarce product.

A comparison of Figure 5.3.3 of the study on human behaviour of *Statement 14, "When the supply of a type of material is scarce, then one may place orders with several suppliers"* has shown that 93% of respondents were in support of the statement. Hence the results are consistent with the study on real-time projects.

5.6.3. LEAD TIME OF INFORMATION AND MATERIALS

5.6.3.1. Material Orders Placed

In the study of real-time project, it was shown that long lead time materials had chronic variances as illustrated in Figure 5.5.3.1. (a). The variance was due to the time lapse from when long-lead time materials should have been ordered as scheduled to when they were actually ordered.

In the study on human behaviour, the results of *Statement 4: "Long lead time materials orders are placed on time as scheduled"* were as follows: 4% of respondents strongly agreed and 4% agreed to the statement. However, 53% strongly disagreed while 39% disagreed to the statement as illustrated in Figure 5.3.4.1.(a). Hence there is consistency between the two independent studies.

5.6.3.2. Material Orders Received

In the study on real-time projects it was shown in Figure 5.5.3.2 (a), that the variance between the scheduled times of receiving materials to the actual time was erratic.

In the study on human behaviour, the extent of turnaround time from ordering materials to receiving it was illustrated through *Statement 7: "Materials are received timeously on site".* Results of the survey were as follows: 29% disagreed while 71% of respondents strongly disagreed to the statement. It is deduced that 100% of respondents were not in favour of Statement 7. The findings are consistent with that obtained from the study of real-time projects.

5.6.4. SUPPLIER SELECTION AND EVALUATION

In the study on real-time projects, the supplier selection was done according to Eskom's purchasing pact with suppliers, where BEE companies were awarded the project as illustrated in Figure 5.5.4.

In the study on human behaviour, it was demonstrated through *Statement 18: "During Form150 stage, BEE companies are given preference to supply materials"*. The results were as follows: 54% strongly-agreed and 46% agreed to the statement. The findings (100% of respondents) are in agreement with ESKADAAX7, Eskom's purchasing pact with suppliers and consistent with the study on real-time projects.

5.6.5. <u>STRATEGIC PARTNERSHIPS AND SUPPLIER INTEGRATION</u>

In the study on real-time projects it was shown that there were no long term relationships with suppliers due to preference given to BEE companies as shown in Figure 5.5.4. (Eskom, 2004c:1-21).

In the study on human behaviour similar results obtained through Statement 18, where 100% of respondents agreed that BEE companies were given preference to supply materials. Hence there is consistency in between the two studies.

The next section provides an overview and discussion of the case study.

5.7. <u>OVERVIEW OF THE CASE STUDY</u>

The purpose of the case study is to validate the third objective of this study, namely the relationship between the impact of human behaviour on the bullwhip effect and the impact of the fluctuation in materials and information flow on the bullwhip.

The Georgedale Northdene Lotuspark 88-kV powerlines consist of the Georgedale Northdene and Georgedale Lotuspark powerlines. Both powerlines share common pylons and are an alternative back-up to Durban Municipality. The powerlines supply numerous traction substations owned by Spoornet and Metro-rail. The trigger for the refurbishment was the poor condition of the earthwire (the wire that runs on the peak of the pylon to shield it from lightning), the poor condition of the insulation and corroded pylons. The project is about 70% complete and scheduled for completion by the end of August 2006.
As both powerlines are identical and have the same scopes of works and costs, the focus will be on one, namely the Georgedale Northdene powerline.

5.7.1. Project Minutes

There has been more than 15 meetings held to date. For the purpose of this study, Minutes of the meeting Number 13 are included in Appendix 2: project data reference.

5.7.2. Project Forms

The project forms may be viewed in Appendix2: project data reference. The forms consist of Forms 10, 15, 150. The Form 101 is not complete as the project is still under construction.

5.7.3. Project Bills of Materials (BOM)

The BOM (Revision 13) is included in the Appendix2: project data reference.

5.7.4. The scope of work

The scope of work is as follows:

- Paint 225 pylons
- Relabel 225 pylons
- Re-string 69km of earthwire
- Replace 1715 glass disk insulators and all associated hardware
- Clear the servitude of trees and shrubs

5.7.5. The total project costs

The total project cost was R1 110 041 (Form10) and R 9 067 062 (Form 15). This is a variance of 716.8% (F10-F15). The project cost at F150 was R12 040 295, which is a variance of 32.8% (F15-F150) .

5.7.6. Material Costs

The materials cost was estimated at R1 070 041 (Form 10). The Form 15 materials cost was R7 803 838 (The combined value of materials and paint contract on Page 2). This is a variance of 629.3%. The Form 150 material cost was R5 874 030. (The combined value of materials and paint contract on Page 2). This is variance of 24.7% .

5.8. RESULTS OF THE CASE STUDY

The case study was chosen from a total of four projects within Eskom in the Eastern Region currently in the construction phase.

The results of the case study are shown in Table 5.8. The discussions are structured in accordance with the causal factors of the bullwhip for comparison.

5.9. DISCUSSION OF THE CASE STUDY

The ensuing discussion will be structured to address the objectives of the study.

5.9.1. The impact of human behaviour on the bullwhip effect

5.9.1.1. Safe Harbour Strategy

According to Nienhaus *et al* (2003:5), human co-makers act as "safe harbours" in the supply chain. This implies that this group of co-makers order more than is required thereby increasing safety stock.

According to the minutes (item 4.2), extra socket clevis clamps were ordered but not needed and had to be booked back to Stores. Referring to the BOM, 1002 socket clevis clamps were ordered and only 202 were used. A total of 800 units costing R44 000 were tied up in stock for more than 2 years.

5.9.1.2. The impact of fluctuation in materials and information flow on the bullwhip effect

According to Niehaus *et al*, (2003:2), the value of information is often under-estimated.

The scope of work was not quantified up front. The scope of work at Form10 was vague: "Re-insulate approximately 80% of the line. Re-insulate 100% of the line". For a multi-million rand project, especially one that supplies strategic customers such as Spoornet and Metrorail, a two-line scope is unacceptable. Incomplete information flow has passed through the supply chain. At Form 15 stage, the vague scope (of Form 10) was acknowledged (Refer to Form15 page 12 under cost variance explanation). However, a detailed scope of work was not done. The scope at Form 15 was based on a detailed inspection of 11 pylons. Clearly the sample chosen is not representative as it translates to a sample size of 11 of 225 or 4.8%. On a project of this magnitude and the fact that no two pylons are identical in terms of the refurbishment work, a detailed inspection should have been carried out up front to prevent variability in the project due to scope creep. This has a direct impact on cost and time variability.

5.9.1.3. <u>Lead times of information and materials</u>

Lead time of information and material lead times is reported to be one of the primary reasons for the bullwhip effect (Niehaus *et al* ,2003:5).

There was no allowance for long-lead time materials on the Form 10 (Page 3 of the Form). The long-lead time material was then placed in the Form 15 (Page 3 of the Form). The value of the long lead time materials was R 2 986 500 for the earthwire and insulators. From the BOM, the materials cost as of 8 March 2006 were R5 603 981.

According to the BOM (line 3), the earthwire insulators (with a lead time of at least 3 months) was ordered on three separate occasions under BOM revisions 8, 10 and 11. The order placed on 18 October 2005 for 200 insulators is still outstanding and is minuted under 4.1.

5.9.1.4. <u>Supplier selection and evaluation</u>

The choice of suppliers is critical to the success of the supply chain. According to Burt *et al* (2003:332), potential suppliers must be evaluated individually based on their capability in terms of capacity to deliver products on time according to the right quality and quantity. The ability to be flexible is also taken into consideration in the evaluation process.

The delivery of accurate long-lead time materials is crucial to the success of a project. The supply of incorrect earthwire insulators is cause for concern (item 4.1 of the minutes). Three other projects were delayed due to late deliveries by the offending supplier. Other long lead time items such as cables and conductors arrived on site in damaged drums and had to be returned to the supplier. (item 4.5 of the minutes).

5.9.1.5. Batch Ordering

The effort spent on waiting to fill large batches, is inefficient as it ties up capacity to produce goods that are not needed immediately. According to Saunders, M.(1997:210), the longer the lead times, the greater the capacity and time period held up in stock.

Large batch ordering can be expensive. As indicated in the report by Eskom Construction (Appendix 2) , 225 tins of paint had to be re-ordered as the tins of paint were damaged in handling. The cost of the damaged paint was R180 000 (Refer to the BOM for costing).

5.9.2. The relationship between the impact of human behaviour on the bullwhip effect and the impact of fluctuation in materials and information flow on the bullwhip effect

Lee *et al* (1997:95) argue that companies wanting to control the bullwhip effect should focus on "modifying the chain's infrastructure and related processes rather than the decision makers' behaviour." Nienhaus *et al* (2003:7) on the other hand, demonstrates that human behaviour does influence the efficiency of a supply chain. The reasons put forward on the impact of human behaviour on the bullwhip effect are in addition to other reasons influencing this phenomenon. (Niehaus *et al, 2003:8*).

It is evident that human influence of defining a vague scope of work has in turn impacted on the project schedule and fluctuation of materials and information flow on the bullwhip effect.

Batch ordering is through systems run by humans. According to Saunders, M.(1997:210), the longer the lead times, the greater the capacity and time period held up in stock. Thus projects are delayed by waiting to fill large batches.

According to Burt *et al* (2003:332), potential suppliers must be evaluated individually based on their capability in terms of capacity to deliver products on time according to the right quality and quantity. The ability to be flexible is also taken into consideration in the evaluation process. This is a direct human influence on the supply chain process (Burt *et al* 2003:333).

5.10. <u>CONCLUSION</u>

Studies reported by Nienhaus *et al* (2003:7) on the beer distribution game played online, with more than 400 participants, show how humans perform as co-makers in the supply chain. These co-makers display the behaviour of "panic" or safe-harbour" by ordering too little or too much stock.

Lee *et al* (1997:95) argue that companies wanting to control the bullwhip effect should focus on "modifying the chain's infrastructure and related processes rather than the decision makers' behaviour." Nienhaus *et al* (2003:7) on the other hand, demonstrates that human behaviour does influence the efficiency of a supply chain.

The reasons put forward on the impact of human behaviour on the bullwhip effect are in addition to other reasons influencing this phenomenon (Niehaus *et al, 2003:8*).

From the discussion on the findings in section 5.6. it was demonstrated that there is a relationship between the study on human behaviour and that of real-time projects.

In section 5.9, it was demonstrated in the case study that there is a relationship between the impact of human behaviour on the bullwhip effect and the impact of fluctuation in materials and information flow on the bullwhip effect.

It is a combination of both people and processes that attribute to the impact of the bullwhip effect.

The next chapter provides the conclusion to this study.

Chapter Six: Conclusion

Lee *et al* (1997:95) argue that companies wanting to control the bullwhip effect should focus on "modifying the chain's infrastructure and related processes rather than the decision makers' behaviour." Nienhaus *et al* (2003:7) on the other hand, demonstrates that human behaviour does influence the efficiency of a supply chain. The reasons put forward on the impact of human behaviour on the bullwhip effect are in addition to other reasons influencing this phenomenon.(Niehaus *et al* ,2003:8).

This chapter is structured in terms of the objectives of the study.

6.1. The impact of human behaviour on the bullwhip effect

Studies reported by Nienhaus *et al* (2003:7) on the beer distribution game played online, with more than 400 participants, show how humans perform as co-makers in the supply chain. These co-makers display the behaviour of "panic" or safe-harbour" by ordering too little or too much stock.

From the findings of Chapter 5, it was demonstrated that humans increase the bullwhip effect by ordering too much material thereby displaying "safe-harbour" behaviour. In the study of real-time projects, it was illustrated in Figure 5.5.1. that the total cost of the materials returned to New Germany Stores was approximately R1.6 million which is 2% of the total material project cost. A comparison with Figure 5.3.2. of the study on human behaviour had shown that 100% of respondents were in support of Statement 16: *"It is better to over-order materials to ensure that at least the right quantity arrives on site"*. Hence the results were consistent with the study on real-time projects.

However when materials were scarce, then role-players tendered to order from several suppliers. In the study on real-time projects , it was shown in Figure 5.5.2 , that orders were placed with up to five different suppliers for the same scarce product. A comparison of Figure 5.3.3 of the study on human behaviour of *Statement 14, "When the supply of a type of material is scarce, then one may place orders with several suppliers"* has shown that 93% of respondents were in support of the statement. Hence the results are consistent with the study on real-time projects.

The management implication of both types of behaviours are that in the "safe harbour" situation, there is the added cost of warehousing materials for anticipated use. Other problems is that of redundant materials.

In the case study of Chapter 5, extra socket clevis clamps were ordered but not needed and had to be booked back to Stores. Referring to the BOM in Appendix 2, 1002 socket clevis clamps were ordered and only 202 were used. A total of 800 units costing R44 000 were tied up in stock for more than 2 years.

6.2. <u>The impact of fluctuation in materials and information flow on the bullwhip effect</u>

Lead time of information and material lead times is reported to be one of the primary reasons for the bullwhip effect (Niehaus *et al* ,2003:5).

According to Niehaus *et al* ,(2003:2), the value of information is often under-estimated. Research conducted among operational managers from 200 companies has shown that the more important the information from customers is, the more frequently it is available to the company. However, it was discovered that operational managers would pass on the same information less frequently to their suppliers. By not passing on customer information to suppliers when it is available, the operational manager then becomes a hindrance to the flow of information throughout the supply chain, causing the bullwhip effect to be amplified by the increase in information lead times.

The research findings based on statements 4, 5, 6 and 7 are relevant to the issue on lead times of information and material flow. The results of *Statement 4: "Long lead time materials orders are placed on time as scheduled"* were as follows: 4% of respondents strongly agreed and 4% agreed to the statement. However, 53% strongly disagreed while 39% disagreed to the statement.

Statement 5 "reducing material lead times will ensure timely completion of projects" is in line with the theory as mentioned earlier regarding the beer game simulation. Feedback from the survey regarding the afore-mentioned statement was as follows: 75% of respondents strongly agreed to statement 5 while 18% were in agreement to the statement. 7% of respondents were undecided.

In Chapter 5, the total cost of the materials returned was approximately R1.6 million which is 2% of the total material project cost. The funds could have been spent on more capital projects instead of been tied up in excess stock.

In the case study of Chapter 5, the scope of work was not quantified up front. The scope of work at Form10 was vague: "Re-insulate approximately 80% of the line. Re-insulate 100% of the line". For a multi-million rand project , especially one that supplies strategic customers such as Spoornet and Metrorail, a two-line scope is unacceptable. Incomplete information flow has passed through the supply chain. At Form 15 stage, the vague scope (of Form 10) was acknowledged (Refer to Form15 page 12 under cost variance explanation). However, a detailed scope of work was not done. The scope at Form 15 was based on a detailed inspection of 11 pylons. Clearly the sample chosen is not representative as it translates to a sample size of 11 of 225 or 4.8%. On a project of this magnitude and the fact that no two pylons are identical in terms of the refurbishment work, a detailed inspection should have been carried out up front to prevent variability in the project due to scope creep. This has a direct impact on cost and time variability.

6.3. The relationship between the impact of human behaviour on the bullwhip effect and the impact of fluctuation in materials and information flow on the bullwhip effect

According to Chen *et al,* (2000:437), efforts to quantify the bullwhip effect has led to two mathematical inequality models which quantify the impact of lead time on the bullwhip effect. The application of the model has shown that variance in orders increase additively in total lead time of a centralized supply chain. However, the variance in orders increases multiplicatively in a decentralized supply chain.

The conclusion derived by Simchi-Levi *et al*, (2000:90), is that by centralizing demand data, the bullwhip effect can be significantly reduced.

In Chapter 5, the variance between the scheduled times of receiving materials to the actual time they are received on site, is illustrated by "F150-101" in Figure 7.3.2 (a). The total variance in the supply of materials is illustrated by "TotalVartime". The findings are consistent with Statement 7 of the previous chapter, where 100% of respondents have indicated that materials are not received timeously on site.

In Chapter 5, the total cost of the materials returned was approximately R1.6 million which is 2% of the total material project cost. The funds could have been spent on more capital projects instead of been tied up in excess stock. The results were consistent with the behaviour of supply-chain role-players over-ordering materials.

In Chapter 5, there was no allowance for long-lead time materials on the Form 10 (Page 3 of the Form-Appendix 2). The long-lead time material was then placed in the Form 15 (Page 3 of the Form-Appendix 2). This was due to human error which led to project delays.

The choice of suppliers is critical to the success of the supply chain. According to Burt *et al* (2003:332), potential suppliers must be evaluated individually based on their capability in terms of capacity to deliver products on time according to the right quality and quantity. The ability to be flexible is also taken into consideration in the evaluation process.

In Chapter 5, it was demonstrated that there are no long term relationships with suppliers due to preference given to BEE companies as shown in Figure 7.4. (Eskom, 2004c:1-21). In Chapter 5, the results obtained in Figure 7.4. are consistent with the findings of Statement 18, where 100% of respondents agreed that BEE companies were given preference to supply materials. These companies will need to develop a good track record to prove their reliability as long-term suppliers.

6.4. <u>Final Comments</u>

The argument expressed by Lee *et al* (1997:95) that companies wanting to control the bullwhip effect should focus on "modifying the chain's infrastructure and related processes rather than the decision makers' behaviour." while Nienhaus *et al* (2003:7) on the other hand, demonstrates that human behaviour does influence the efficiency of a supply chain.

It was demonstrated that there is a relationship between both studies and that it is both people and processes that need to be changed to achieve supply chain efficiency.

Chapter Seven: Recommendations

The recommendations have been divided into those for a Generic Company, those for Eskom specifically and those for the case study and are structured under the main headers of mitigating the bullwhip effect.

7.1 Recommendations for a Generic Company

The bullwhip effect is a consequence of people and processes and can be mitigated or tamed by the following actions:

7.1.1. Avoiding "Safe-Harbour" behaviour

Studies reported by Nienhaus *et al* (2003:7) on the beer distribution game played online, with more than 400 participants, show how humans perform as co-makers in the supply chain. These co-makers display the behaviour of "panic" or safe-harbour" by ordering too little or too much stock.

Any role-player of the supply chain displaying this type of behaviour affects the functioning of the entire supply chain. When role-players order more than what is required, then safety stock increases. The costs of carrying inventory are substantial. For instance, special storage facilities are needed if the inventory is perishable or hazardous and has a limited shelf-life. Other inventory may require warehousing. Transport costs of the materials from the warehouse to where it is needed, are incurred. These costs are substantial. On average about 5% of the materials cost is attributed to transportation of materials to site. The supply chain of the supplier is negatively impacted on as the supplier will employ more resources to meet the increased demand for his/her product (Eskom, 2003:10-25).

Another factor to consider when carrying excess stock is that the stock may at some stage be rendered obsolete due to technology change or change in specifications and standards. There may be disposal costs to consider associated with obsolete stock (Young, 2005).

From the findings of Chapter 5, it was demonstrated that humans increase the bullwhip effect by ordering too much materials thereby displaying "safe-harbour" behaviour.

The recommendation is to order materials in the right quantity to arrive directly to where they are needed. Orders to suppliers should stipulate the safety stock and replenishment stock components as this assists the supplier in forecasting demand (Young, 2005).

7.1.2. Avoiding "Panic" behaviour

Role-players displaying "panic" behaviour order too little stock (Nienhaus *et al* (2003:7).

According to Nienhaus *et al* (2003:7), this type of behaviour is the extreme opposite of the "safe" harbour behaviour but the consequences are similar. Role-players do not replenish stock which results in stock-outs as the safety stock has been used. The implications to the business are severe as the opportunity cost of not having the materials available on time, is high.

Materials planning and forecasting should be implemented to avoid stock-outs. The company should make use of robust inventory tools such as MRP to improve inventory management. However, training of procurement officers and other system users must be initiated before the implementation of MRP software systems. (Lee *et al*, 1997:99).

7.1.3 Reducing lead-times

It has been demonstrated by Nienhaus *et al* (2003:7) , through the beer game simulation and independent studies through Eskom's supply chain, that the increase in lead times increases the bullwhip effect. The main components of lead-times are order-lead times, delivery lead-times and information lead times. The main components of materials are long-lead time materials and short-lead time materials. The effects caused by an increase in lead-times for long-lead time materials are more severe than that of short-lead time materials.

It is recommended that the focus should be more on reducing the lead-times of long-lead time materials than short-lead time ones. It was demonstrated in the studies on real time-projects that, on average, 50% of the materials consist of long-lead time materials.

Strategic partnerships with long-term accredited suppliers will ensure reliability in orders placed and the delivery of long-lead time materials. Delivery of materials should be coordinated to arrive directly to site to reduce delivery lead times and reduce warehousing costs. The use of innovation such as cross-docking, where supplier products arrive directly to the shop floor, can be used to reduce delivery lead times.(Burt *et al*, 2003:332).

Information lead-time can be reduced by information sharing. Successful companies like IBM, HP and Apple insist on POS data from their retailers as part of their contract to assist the companies in forecasting demand. Innovations such as EDI can facilitate the sharing of information by supply chain partners (Lee *et al*, 1997:99).

Another innovation that companies can implement is VMI (Lee *et al*, 1997:99).

It is recommended that this innovation be implemented as the responsibility of ensuring that the correct inventory levels are maintained rests with the supplier. The advantages of the system are that stock-outs or excess stock is prevented. Furthermore, there is substantial savings from reduction of warehousing costs as the inventory is held by the supplier and delivered when needed.

7.1.4. Sharing information through a centralized supply chain

Information sharing is pivotal to the sustainability of the supply chain. In a centralized supply chain, the same customer demand information is shared at each stage of the supply chain to forecast demand. In a decentralized supply chain, each stage in the supply chain uses information from the previous stage as the customer demand information is not available to all role-players (Simchi-Levi *et al*, 2000:91).

Companies must use a centralized supply chain to reduce variability. In this way the project demand data for each stage comes from the same base data. Furthermore, it is easier to keep all role-players updated as there is a single repository of information.

7.1.5. Prevention of multiple demand forecast updates

The effect of the bullwhip is amplified when each stage of the supply chain forecasts demand using information from the previous stage. Furthermore the variability increases as each stage use a different technique to forecast demand.

The solution is to make demand data centrally available, as has been discussed in section 9.4. Innovations such as VMI and CRP at the upstream stage of the supply chain control the re-supply of inventory from upstream to downstream. Companies such as Campbell Soup, Nestle and Nabisco have successfully used CRP with successes in reducing inventory by up to 25 percent. P&G uses VMI in the diaper industry, starting with its supplier 3M and ending with its customer, Walmart (Lee *et al,* 1997:99).

For companies that use multi-echelon inventory systems, up-to-date information sharing from downstream to upstream is crucial to ensure accurate demand forecasts. A strategy to use is to ensure that the control of total inventory, both at upstream and downstream stages is optimized.

Another solution to reducing the variability in demand forecasting is to supply direct to the customer and bypass the downstream stage of the supply chain. This strategy has been successfully implemented by companies like Dell and Apple Computers (Lee *et al,* 1997:99).

7.1.6. Reducing order batches

Supply chain variability increases when orders are not placed on time. As the costs of filling orders are high, some companies prefer to order in batches. For example, at P&G the cost to fill an order is between $35 to $75. Another reason for ordering in batches is to save on transport costs. However, the lead times are increased as orders are postponed until full truckloads are achieved (Lee *et al,* 1997:99).

The solution is to reduce batch sizes and increase the frequency of re-supply. It is not economical to use full-truckloads as the order frequency is higher. Furthermore higher transportation costs are incurred due to the additional handling and administration. Another problem is the damage of materials that may occur during handling operations, which causes further increase in lead time awaiting replacement of the damaged component.

Another solution in reducing the bullwhip is by spreading the customers periodic order cycle evenly over time. For example P&G coordinate re-supply with their customers by frequent deliveries. The consequence is that the replenishment stocks to retailers are evenly spread.

7.1.7. Stabilizing Prices

Price promotions and discounts increase the variability in the supply chain. Customers engage in forward buying and buy more than what is needed. Manufacturers may also offer incentives to distributors and wholesalers which are passed onto the customer. Customers then buy in large quantities and stock for future demand (Lee *et al,* 1997:101).

The solution is to reduce incentives for retailers by adopting a uniform wholesale pricing policy. Companies such as Pillsbury, P&G and Kraft have an "EDLP" policy to stabilize prices and prevent promotions and discounts.

Companies must make use of the ABC systems to promote EDLP. The ABC system will expose the costs of inventory, warehousing, premium transportation and special handling that were previously hidden by conventional accounting systems.

7.1.8. Prevention of Gaming in a shortage situation

Suppliers allocate products according to the proportion of their sales records and not according to orders placed, during a product shortage situation. Large companies that implement this strategy are General Motors, Texas Instruments and Hewlett-Packard (Lee *et al*,1997:101) .

The solution is one of co-operation between the customer and the manufacturer. For example a steel galvanizing plant in Durban shuts down in October of each year. Customers who are aware of this will send their product in advance to prevent a spike in demand and consequently an increase in product lead times.

7.1.9. Good supplier selection and evaluation processes

There is a distinction between low value and high value purchasing which is made by Burt *et al* (2003:332). For purchases of low value, evaluations can be made from the website or brochures. For high value purchases, the procedures are more complex. Site visits are conducted to plants to evaluate quality, capacity and service.

The solution is to set an evaluation process based on a set of criteria with ratings and weightings. The assessment must be objective and quantifiable. Suppliers should be evaluated on performance rather than price. As Preis (2003:36) points out, the evaluation process and rating system must be objective by choosing criteria such as price, performance and quality rather than just interpersonal satisfaction to ensure an effective evaluation.

7.1.10 Formation of strategic partnerships and supplier integration

According to Simchi-Levi *et al*, (2000:91),the bullwhip effect is reduced by the constructive use of strategic partnerships. Techniques already discussed in the previous sections may be used. These are VMI and centralized demand information. For example, in VMI , the manufacturer is not dependant on the retailer's orders and consequently eliminates the bullwhip as the management of the inventory at the retailer stage is the responsibility of the manufacturer.

7.2. Recommendations for Eskom

The recommendations for the Generic Company are also applicable to Eskom. These are additional recommendations emanating from the research.

7.2.1. Avoiding "Safe-Harbour" behaviour

Role-players displaying "panic" behaviour order too little stock (Nienhaus *et al* (2003:7).

Supply chain role-players must avoid ordering materials in excess of what is required. If the project scope was done systematically, then there should be no variance in material demand.

Eliminate storage of project materials at New Germany as it encourages poor supply chain practice by hiding the inefficiencies due to the acceptance of redundant materials from site. Furthermore, valuable warehouse space is used for redundant and obsolete stock that is adding no value to the business. (Young, 2005).

7.2.2. Avoiding "Panic" behaviour

Role-players displaying "panic" behaviour order too little stock (Nienhaus *et al* (2003:7).

Role-players who have experienced this are known to display "safe-harbour" strategies the next time orders are placed. Careful project planning and ensuring that all long lead time materials are placed at Form 10, will eliminate stock-outs. Safety stock, as the name suggests, is for an emergency and not to be used as part of a routine project. Role-players have the tendency of accepting reworked or redundant materials from previous batches to alleviate the problem.(Rajkarran, 2006). However, mixing and matching components is unacceptable as it does not support a uniform maintenance strategy for the same asset. Furthermore, the life-cycle of the asset is compromised by accepting materials that are sub-standard.

7.2.3. Reducing lead-times

The research findings based on statements 4, 5, 6 and 7 are relevant to the issue on lead times of information and material flow. The results of *Statement 4: "Long lead time materials orders are placed on time as scheduled"* were as follows: 4% of respondents strongly agreed and 4% agreed to the statement. However, 53% strongly disagreed while 39% disagreed to the statement.

The research findings based on *Statement 5 "reducing material lead times will ensure timely completion of projects"* is in line with the theory as mentioned earlier regarding the beer game simulation. Feedback from the survey regarding the afore-mentioned statement was as follows: 75% of respondents strongly agreed to statement 5 while 18% were in agreement to the statement. 7% of respondents were undecided.

The employment of specialist procurement officers for the sourcing of long-lead time materials should be in place. As shown in the studies 50% of a project consists of long-lead time materials. Emphasis should be placed on long-lead time. For external contractor projects, place the onus on the contractor to supply the short-lead time items. This will enable procurement officers to assist specialist procurement officers in reducing the lead times of long-lead time materials. (Ferns, 2005).

Rotran should not be used to transport materials because the company is a subsidiary of Eskom. The premium is on average about 30% more than other competitors. This would translate to a savings per project of about R39 000. (Young, 2005).

All materials should be sent to site where they are needed. This will eliminate the double-handling of materials and prevent storage at New Germany (Ferns, 2005).

The stores at New Germany should be for the storage of strategic stock for emergency preparedness only. The composition of the strategic stock to include cables, wood-poles for use in temporary power-line deviations, insulators and transformers with multi-voltage transformation such as 132kV/88kV/33kV/11kV, that is a transformer capable of stepping down the voltage from 132kV or 88kV to 33kV or 11kV. Fewer transformers need to be kept in stock due to this flexibility.

7.2.4. Sharing information through a centralized supply chain

Project Coordinators (PC's) must be proactive in ensuring that project information is accurate and updated. The PC must ensure that all role-players are kept in the loop and have access to centralized project information through regular project meetings. Projects that are fast-tracked must be given a higher priority over other projects due to their tight deadlines.

All supply chain role-players must be included in the preparation of quotations for customers. This will avoid inaccurate quotes as the information available is complete and fairly accurate. The time-frames for customer quotes must be adhered to by both parties.

7.2.5. Prevention of multiple demand forecast updates

Currently there are three different project schedules for the same projects. These schedules have been drawn up by the Network Services Manager with the primary objective of optimizing cash flows, independent of resource constraints and customer need dates. The Project Engineering Manager has set up demand schedules (updated every 6 months) with his staff to distribute the work load equitably, independent of the priority list. The Project Manager has demand schedules (updated every 2 weeks) without liaising with the Network Services Manager or the Project Engineering Manager, (Eskom, 2003:11-12).

7.2.6. Reducing order batches

Materials such as paint must be delivered directly to site in batches according to usage so as to preserve shelf life of the product. Batch materials in smaller quantities to avoid damage which can prove to be costly. The extent of the problem was highlighted in the case study.

The "full-truckload" trap should be avoided. The savings from using a full-truckload to transport materials is eroded by the expense of lengthening lead-times and damage of materials due to handling and storage.

7.2.7. Stabilizing Prices

Suppliers of paint and power-line hardware, offer a tiered discount structure linked to the number of items purchased. Hence the larger the volume purchased, the greater is the discount. Procurement officers delay projects that have the same items in an effort to obtain a large batch to take advantage of the discount structures.

Promotions and discounts offered by material suppliers should be avoided as the cost of delaying a project is greater than the discounts offered

7.2.8. Prevention of Gaming in a shortage situation

Customer reaction to rationing may lead to inflated orders to the manufacturer, in view of the anticipated short supply. However, when the demand reduces, customers may cancel orders, hence "game" the rationing. Lee *et al* (1997:97) are of the view that customer orders in this instance, give scarce data to the supplier. An example cited by Lee *et al* (1997:98), is the perceived shortage of computer chips. Customers placed duplicate orders with multiple suppliers and purchased only from the supplier that delivered the product first. The other orders were subsequently cancelled.

Inflating orders of scarce materials with several suppliers should be avoided in an attempt to get the correct quantity and then cancel the remaining orders as this practice leads to the bullwhip effect in the supply chain of the suppliers.

7.2.9. Good supplier selection and evaluation processes

The evaluation process may be based on a set of selection criteria and corresponding rating based on its weighting. According to Burt *et al* (2003:336), an assessment is based on the numerical ratings as well as site investigations. As Preis (2003:36) points out, that the evaluation process and rating system must be objective by choosing criteria such as price, performance and quality rather than just interpersonal satisfaction to ensure an effective evaluation.

An analysis of projects awarded to the lowest tender has shown that the successful tenderer makes money not from the contract but from variations to the contract. Variations are in the form of consequential non-performance of work due to inclement weather, or scope creep.

Materials suppliers must be evaluated objectively and awarded contracts based on their historical performance and cost Preis (2003:36). Quality issues must be addressed at the source, rather than the project site where it is too late to remedy the situation.

The Non-conformance process must be utilized as a mechanism to sustain good supplier behaviour. According to regional stance on this issue, if a supplier has three non-conformance reports for the same project, he or she is then removed from the vendor list. As this process involves reams of paperwork, role-players are reluctant to fill the reports. Furthermore, once the report is filled in, there is a follow-up procedure to rectify the problem. It is difficult to discipline the offending suppliers without the necessary paperwork in place.

Suppliers must be charged for consequential costs of delays. For instance, if the construction crew is standing at R10 000 per day as a result of late deliveries, then the supplier must be charged for the standing time (Ferns,2005).

7.2.10. Formation of strategic partnerships and supplier integration

There are no long term relationships with suppliers due to preference given to BEE companies as shown in Figure 7.4. (Eskom, 2004c:1-21).

There must be a long term partnership with few suppliers. Long term suppliers develop an understanding of the company's policies and work towards a common objective.

One of Eskom's core values is "Customer Satisfaction". Strategic partnerships will enable long term suppliers to be flexible to customer demands so that customer expectations can be met.

7.3. Recommendations for Georgedale Northdene-Lotus park project (Case Study)

Effective supply chain co-ordination be implemented to minimize variability and eliminate bottlenecks in the supply chain.

Detailed investigations be carried out for the remaining project to quantify materials requirements.

The choice of suppliers is critical to the success of the supply chain. According to Burt *et al* (2003:332), potential suppliers must be evaluated individually based on their capability in terms of capacity to deliver products on time according to the right quality and quantity. The ability to be flexible is also taken into consideration in the evaluation process.

Implement an effective supplier selection and evaluation policy. Black-list the supplier of incorrect earthwire insulators and late delivery of strategic materials. Charge suppliers for opportunity costs as a consequence of project delays from incorrect materials and late deliveries.

The effort spent on waiting to fill large batches, is inefficient as it ties up capacity to produce goods that are not needed immediately. According to Saunders, M.(1997:210), the longer the lead times, the greater the capacity and time period held up in stock.

7.4. Way forward for Eskom

Eskom needs to change as a region and company as a whole to stay competitive. In order to sustain its role as a leading electricity producer of global stature, the company must implement the following changes to realize its vision of maintaining sustainable growth and development.

7.4.1. Policy of zero tolerance

All supply-chain role-players must be held accountable for their decisions by having a policy of not tolerating any fruitless and wasteful expenditure due to role-players' behaviour of ordering more than what is needed or alternatively not placing orders in time. Key Performance Indicators pertaining to inventory management must be incorporated into the job compacts of role-players. This instrument can be measured objectively and would ultimately influence the performance (and bonuses) of role-players.

7.4.2. Improving on long-lead time deliverables

There is a need to reduce the lead-times of long lead- time materials to facilitate deliverables to customers. The company can employ specialist procurement officers to focus specifically on long lead time materials.(Eskom,2003:11).

A supplier forum needs to be initiated as a platform for suppliers to discuss new technologies. The opportunity should be used to network and improve supply chain efficiency.

Avoid patronizing Eskom subsidiaries such as Rotran. These subsidiaries charge premium fees of 30% above the industry average. By coordinating the delivery of long lead time materials from the supplier directly to site, there is no need for transportation.

7.4.3. Sharing information through a centralized supply chain

There should be a central repository for storage of information. The company has a data system called "Projectwise" that is shared with the engineers and surveyors. It is populated with project design data from project inception to completion. The database should be extended to include all aspects of the project incorporating data from all role-players. For instance, customer demand data should be a part of the database. The database should be made available to all supply-chain role-players and updated weekly by a single administrator (Pieterse, 2005).

7.4.4. Forecasting customer demand

There is currently a divide between the technical and marketing entities of the business. As a company, resources need to be optimally utilized to meet or exceed customer expectations. This barrier must be removed to align individuals with company objectives. More effort is needed to promote an all inclusive cross-functional team that is empowered to liaise with the customer.

Where practically possible, having the customer as part of the team is a strategy worth exploring. In this way, accurate updated customer demand data is available for forecasting future demand.

7.4.5. Transformation of the warehousing function in New Germany

The warehousing function in New Germany must be changed to house only strategic stock and emergency spares. The rest of the warehouse could be converted to much-needed training facilities for the training of technical staff. This facility was located at the warehouse in Pietermaritzburg but has since been destroyed by fire.

7.4.6. No thanks to discounts and promotions

One of the ways of reducing the bullwhip effect caused by forward buying is to reduce both the frequency and level of wholesale price discounting (Lee *et al*, 1997:101). A solution proposed by Lee *et al* (1997:101), is to reduce incentives for retailers by adopting a uniform wholesale pricing policy.

The company should avoid any discount and promotion structures offered by material suppliers as it causes unnecessary spikes in the supply chain by forward buying. These supplier policies are not sustainable.

7.4.7. Prevention of Gaming in a shortage situation

Having the policy of zero tolerance in place should prevent this detrimental practice. Furthermore, the gaming is not aligned with the best practice principles of procurement. The company needs to protect its goodwill and branding by following best practice principles.

7.4.8. Implement a new purchasing pact with suppliers

According to *Tucker (2005)*, no company should be competing on price alone but rather by the value it is offering.

The existing pact with suppliers, Directive ESKADAAX7 revision 2 refers to supplier selection based on the lowest tenderer (Eskom, 2004c:1-21). The policy document must be changed to reflect the vision and objectives of the company. The current vision is based on sustainability and suppliers must be aligned to this vision. There needs to be long term partnerships with suppliers to promote sustainable growth and development.

Lee *et al* (1997:95) argue that companies wanting to control the bullwhip effect should focus on "modifying the chain's infrastructure and related processes rather than the decision makers' behaviour." Nienhaus *et al* (2003:7) on the other hand, demonstrates that human behaviour does influence the efficiency of a supply chain.

It was demonstrated in the studies that there is a relationship between the impact of human behaviour on the bullwhip effect and the impact of fluctuation in materials and information flow on the bullwhip effect. Companies seeking competitive advantage need to mitigate with regards to both the human impact and the process impact to achieve supply chain efficiency.

Chapter Eight: Limitations and Recommendations for Future Research

8.1. LIMITATIONS OF THE RESEARCH

The research was based on the Eastern Region in Eskom Distribution Division. There are 5 other regions in the country and two additional divisions (namely Generation and Transmission) within Eskom Holdings which may be investigated in terms of this study.

Furthermore the supply chain of suppliers may be investigated in relation to the Eskom supply chain.

8.2. RECOMMENDATIONS FOR FUTURE RESEARCH

Further research needs to determine the extent of the bullwhip effect in 5 other regions in the country and two additional divisions (namely Generation and Transmission) within Eskom Holdings.

The research can be extended to include the supply chain of suppliers and implement ways of improving operational efficiencies within the suppliers' supply chain.

A benchmarking exercise can be initiated to compare Eskom's supply chain with world class supply chain entities.

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APPENDIX 1 -SAMPLE OF RESEARCH QUESTIONNAIRE

Dear Participant
This survey is for research purposes only in fulfilling the requirements of the MBA degree.
All information supplied will be treated as confidential.
Please find below a set of statements. Please place a tick in the column that you think best describes the statement

Statement	1-Strongly Agree	2-Agree	3-Neither Agree nor Disagree	4-Disagree	5-Strongly Disagree
1 There are too many project schedules for the same project					
2 Project information is not centrally available and shared by all parties					
3 Fast -tracked projects are given priority in material orders placed					
4 Long lead time materials orders are placed on time as scheduled					
5 Reducing material lead times will ensure timely completion of projects					
6 It is preferable to supply materials direct to site than warehouse in New Germany					
7 Materials are received timeously on site.					
8 Ordering materials in batches such as concrete and paint saves on transportation					
9 It is cheaper to order materials in batches as one can make use of discount structures					
10 The information available at Form 10 stage is sufficient to do a feasibility quote					
11 Customers have sufficient time to respond to the feasibility quote					
12 The information available at Form 15 stage is adequate to do a budget quote					
13 Customers have sufficient time to respond to the budget quote					
14 When the supply of a type of material is scarce, then one may place orders with several suppliers					
15 It is easy to place and then cancel orders with suppliers					
16 It is better to over-order materials to ensure that at least the right quantity arrives to site					
17 Materials not used are easy to get rid off by returning the materials to stores					
18 During Form 150 stage, BEE companies are given preference to supply materials					
19 Suppliers are chosen based on the lowest tendered price					
20 The choice of material suppliers can determine the success of a project					
21 Supplier selection and evaluation is done objectively and openly					
22 All project roleplayers have an opportunity to evaluate suppliers					
23 Material quality is often compromised resulting in rework on site					
24 Project delays are attributed to poor quality of materials supplied					
25 Project delays are attributed to materials arriving late to site					
26 Project delays are attributed to incorrect materials arriving to site					
27 Project delays are attributed to incorrect batching of materials to site					
28 There are no penalties imposed on suppliers for causing project delays					
29 There are no long term partnerships with good suppliers					
30 Once a project is commissioned, projects are evaluated objectively					
Comments					

Thank You for participating in this survey
Kind Regards
Dan Dukhan

Appendix 2: Project Data Reference

- **PROJECT MINUTES**
- **PROJECT FORMS**
- **BILL OF MATERIALS**
- **REPORT BY CONSTRUCTION ON MATERIALS HANDLING AND STORAGE**

GEORGEDALE-NORTHDENE-LOTUS PARK LINE REFURBISHMENT

MEETING NO 13

VENUE: Cato Ridge TSC

DATE: 14/02/2006

JOB No WKL2GN/WKS2GG
Project Coordinator – Chris Gxumisa
Project Engineer – Dan Dukhan
Survey – Futhi Ndwandwe
Internal Construction – Willy Bull
TSC Cato Ridge – Mandla Mpanza
Clerk of Works – Eddie Rencken

PRESENT : H S Strydom, C Ferns, M Mpanza, D Dukhan, T Nekhalale, A Ndlovu, C Nkwanyana.

APOLOGIES/ABSENT : G Gxumisa, W Bull.

ABSENT : E Rencken, S Mbuyazi, F Ndwandwe, B Cooper.

OUTAGES: To be arranged through the Commissioning Co-ordinator .

MINUTES ACCEPTED (CONTRACTOR)______________________

(PROJECT MANAGER)____________________________

FORM 150 : AGREED & SIGNED *SIGNATORY :* ____________ **DATE :** _____________

OPENING *ACTION*

The PC opened the meeting at 09:20.

1. PROJECT SCOPE

1.1 **Georgedale Lotus Park 88kV Line Refurbishment**

Paint 225 towers on line 1 including tees. Relabel 225 towers . Restring 69km of earthwire. Repace 1715 insulators and all associated hardware.Clearing the servitude of trees and shrubs

1.2 **Georgedale Northdene 88kV Line 1 Refurbishment**

Paint 225 towers on line 2 including tees. Relabel 225 towers. Restring 69km of earthwire. Replace 1715 insulators and all associated hardware. Clear the servitude of trees and shrubs.

2. PROJECT COMMUNICATION

2.1 Communication on this project will be via telephone, fax, verbal, site meetings and site meeting minutes, and E-mail.

3. DRAWINGS/DESIGN

3.1 Nil.

4. MATERIAL

4.1	Earth wire insulators in Stores are incorrect, and now have a serious effect on the project. It was pointed out to Logistics during October 2005. Logistics to urgently resolve the matter.	*Simphiwe Mb: yazi*
4.2	Socket clevis ordered for the project, were not all needed, and MEW to return the balance of approximately 800 to Stores.	*Cliff Ferns*
4.3	PE and MEW Site Supervisor visited Stores and found many damaged tins of paint. Logistics to replace these tins, as they cannot be issued to site.	*Cliff Ferns*
4.4	PE to revise the BOM to include additional paint required for the project. All future paint deliveries to be arranged on a "as and when required" basis. This may limit wastage as paint has a shelve life. It also creates a storage problem. **Procurement to take note.**	*Dan Dukhan* *Danny Rajkumar*
4.5	The issue of damaged cable/conductor drums delivered to site has been taken up with the Regional Warehousing Manager, and he requested that MEW do not accept any damaged drums on site.	*Cliff Ferns* *Ernest Makau* *Patrick Kiley*

5. PROJECT PACKAGE UPDATES

5.1	BOM to be revised to include additional paint required.	*Dan Dukhan*

6. PROJECT QUALITY

6.1 QUALITY INSPECTIONS / DEFECTS

6.1.1	There seems to be no quality document in place for the project. MEW and CoW to rectify urgently.	*Cliff Ferns* *Eddie Rencken*
6.1.2	There seems to be confusion as to where the 500mm below ground level starts when the tower legs are painted. PE informed the meeting that the 500mm will start at the existing ground level, and not the original (natural) ground level as understood by the CoW. Where the tower is on an embankment, and becomes a safety issue, then a retaining wall should be installed. CoW to issue a list of these towers to the PE. It will then be decided if these retaining walls will be included in this project, or treated as a separate project.	*Eddie Rencken* *Dan Dukhan*
6.1.3	CoW to issue a report highlighting all quality problems.	*Eddie Rencken*

6.1.4 The concrete pole at structure 285 Lotus Park line, which was possibly cracked when the new cross arm was installed, needs to be repaired. PE issued the following procedure to be followed when repairing pole.

1. Create a 20mm deep longitudinal groove on all 4 sides of the pole. The groove must be 150mm from either side of the crack , ie, the total groove length must be 300mm.

2. Clean out the grooves and crack and apply PROSTRUCT epoxy to grooves and crack.

3. Install Y10 rebar (300mm in length) into the grooves.

4. After 24 hours , apply Sika repair mortar to the cracks and grooves in the pole.

5. Create a 25mm thick collar around the repair section using the Sika mortar.

The structure can then be painted as per instruction in scope of work

"**Appendix Two : Procedure for the repair of spalling concrete.**

6.2 SAFETY

6.2.1	SITE SAFETY REP.	Cliff Ferns
6.2.2	No of medical incidents/accidents	1 See explanation below.
6.2.3	No of disabling/fatal ACCIDENTS	0
6.2.4	Incidents/accidents -	0
6.2.5	Near hit incidents	0

6.2.6 Loss incidents

One staff member of MEW, who was not deem fit for work by the Construction Official, ignored the CO's instruction not to work, climb tower 269, and fell approximately 9m to the ground. The case is under investigation.

6.3 SAFETY ISSUES

6.3.1	Retaining walls needed at some of the towers. CoW to issue report, highlighting all these towers.	*Eddie Rencken*
6.3.2	Trenches dug at various towers, for water run off, are seen as a safety hazard. Risk Management to investigate and recommend corrective action.	*Ted Barnard*
6.3.3	At tower 100/5, an embankment was created to allow access to the tower foundations. This has now become a safety hazard, as an existing toilet door is approximately one metre from the embankment, which can cause people using the toilet, to fall down the embankment. The embankment is approximately 1,2m high. Risk Management to investigate, and recommend corrective action.	*Ted Barnard*
6.3.4	MEW to inform the Construction team, that all instructions to deviate from the original scope of work are to be issued by the Project Engineer.	*Cliff Ferns* *Dan Dukhan*

7. PROJECT RISKS

- Rain, as it is a rainy season
- Access to properties
- Highway crossings
- Crime in some areas
- Environmental issues
- Access due to urbanisation / squatting - this needs to be addressed urgently with Land Development as it poses a huge a risk to the completion of the project.
- Dan pointed out the risk of mechanical insulator failure was high and there is a risk of conductor parting across the N3 freeway, railway crossings and other strategic spots.
- Span between twr 221 and twr 222 running above the 400kV line risks in getting a Tx outage, PC to establish if it can be done live.
- No access between twr 243 and 246 cause of squatters. Futhi to investigate.
-
- Spans between twr 247 and twr 249 cross over railway lines. PC to establish if it can be done live or get an outage from metrorail.
- Access to string tower to beam inside Umlazi traction, PC to check if it can be done live or an outage to be arranged.
- Span between twrs 221 and 222 cannot be done live, customer execs to investigate the possibilities of getting an outage on the 275kV which runs underneath belonging to DBN metro. KSACS please treat this as an extreme emergency.
- Outages.
- Metrorail's refusal of giving outage to Northdene.

8. CONSTRUCTION PLAN

8.1 Construction plan to be forwarded to PC by Friday 17/02/2006. *Cliff Ferns*

9. OCCUPATIONAL HEALTH and SAFETY ACT REGULATIONS

9.1 MEW to comply. *Willy Bull*

10. PROJECT DURATION

10.1 OVERALL PROGRESS : 54%

10.2 TIME BASE LINE
Planned start date : 01 Sept 04
Actual start date: **01/09/2004**

Planned completion date: March 05
Anticipated completion date: Dec 05

10.3 Expenditure: Expenditure on the projects has been discussed, and the PC pointed out to the Team that the project is only 54% complete, but overspent. PC and MEW Contracts Superintendent to investigate over expenditure, and PC to revise the Form 150. Some of the main reasons for over expenditure are as follows.

1. At the time of the Form 150, no detailed line inspection done, which resulted in additional work and material.
2. No provision for bush clearing.
3. No provision made for correction of tower labels, and to remove labels again when painting in progress.
4. Lost time due to awaiting outage.
5. Increased resources cost, ie labour and material

11. SITE INSTRUCTIONS/VARIATION ORDERS

11.1 Nil.

12. PROJECT RESOURCES

12.1 SITE PERSONNEL

Site Supervisor:	Cliff Ferns
Skilled workers	10
Semi-skilled workers	61

12.2 PLANT ON SITE

Trucks	6
LDV vehicles	3
Toyota condor	1

13. LAND DEVELOPMENT/ENVIRONMENTAL

13.1 There are some towers where land owners fenced off underneath towers, another one where a wall is built under the tower, etc. Land Development to investigate, as MEW cannot get access to these towers. A list of these instances to be made available to Land Development Department. *Tshililo Nekhalale* *Eddie Rencken*

13.2 Eskom Environmental Department to visit site and recommend necessary action where needed. *Tshililo Nekhalale*

14. LABELLING

14.1	MEW to confirm that all labels are on site. All labels short, to be reported to the PC. PE to ensure that all labels are on the label schedule, and forwarded to TSG Label Section.	*Cliff Ferns* *Dan Dukhan*
14.2	MEW to ensure that all labels, taken off when painting is done, to be tied back properly.	*Cliff Ferns*

15. TSG/MKONDENI WORKSHOPS

15.1	MEW to negotiate with TSG Live Line when their services are required. PC to be informed of times and cost, as the Form 150 is to be revised.	*Cliff Ferns* *Anderson Ndlovu* *Chris Gxumisa*

16. TURN IN LINES

16.1 Nil.

17. OUTAGE ARRANGEMENTS

17.1 OUTAGE DATE

17.1.1	MEW, TSC and C o W to issue outage plan, and confirm dates.	*Cliff Ferns* *Mandla Mpanza* *Eddie Rencken*

17.2 COMMISSIONING DATE/PROCEDURE

17.2.1	To be drawn up by Cato Ridge TSC.	*Mandla Mpanza*

17.3 COMMISSIONING CO-ORDINATOR

17.3.1	The Commissioning Co-ordinator on the project is Mandla Mpanza, from Cato Ridge TSC.	*Mandla Mpanza*

17.4 ISSUING of DD's

17.4.1	PE to ensure that all DD's are correct, and submitted to Mkondeni Control.	*Dan Dukhan*

18. GENERAL

18.1 Compensation report to be drawn up, and Form 150 to be revised once compensation events are agreed upon. — *Hennie Strydom*, *Willy Bull*

18.2 The following sections on the project have not been done/completed due to no outages. Outages are required to change earth wire, hard ware, steel work, and to paint the tops of the towers.

- Umlazi to Reunion Traction Station
- Umlazi to Crossmoor
- Cavendish T lines
- Assegay T lines
- Delville Wood T lines
- Cliffdale T lines
- Marian Hill T lines
- Georgedale T lines
- Dassenhoek T lines
- Northdale T lines

18.3 The Project Team recommended that more traing to be given to staff doing line patrols, as it appears that items such as earth tests and inspection of tower foundations are not done. TSC to follow up. — *Brad Cooper*

18.4 Construction to make the final completion date of the project available to — *Cliff Ferns*

	Customer Services.	*Celo Nkwanyana*
18.5	There seems to uncertainty as to when the project will be completed. MEW Contracts Superintendent to confirm completion date.	*Willy Bull*

As there were no further issues to discuss, the meeting closed at 11:15

NEXT MEETING

DATE : 9/03/2006
TIME : 09:00
VENUE : Cato Ridge TSC

FORM 10	PROJECT REGISTRATION		Standard
PROJECT DETAILS			
Asset Name	**Georgedale Northdene 88kV Line 1 Refurbishment**		
Parent Project Name			
Project ID	N010236	Form Registration Date	15-May-2002
Project Initiator Name	Manogaran Chetty	Form Registered By	Manogaran Chetty
Engineering Region	Eastern	Initiator Tel No	+27 31 7105057
Technical Service Area	Cato Ridge	Distribution Cust. Load Network	
Customer Service Area	Pietermaritzburg	Network Develop. Plan / F1 Area	Hammars/ Elangeni
Field Service Area	Pietermaritzburg	Project Latitude Coordinate	
Magisterial District		Project Longitude Coordinate	

BUSINESS CATEGORY / PROGRAMMES

Refurbishment

PROJECT DESCRIPTION & MOTIVATION

Executive Summary / Motivation

Gerogedale Northdene 88kV Line 2 was investigated as part of the Hammersdale NDP. The physical condition, and performance of the Georgedale Lines has triggered the refurbishment scope below.

Scope of Work Description

Re-insulate approximately 80% of the line.
Re-earthwire 100% of the line.
NB: At the time of the investigation, Catoridge TSC was re-labelling the lines. Asset names to be checked. Not included in scope/costing.

Relevant Reference Documents

Refer to Planning Department's Hammersdale NDP Report.
Available in Teammate.

Project Family Details

Interdependent Asset Names	Project ID	Form 10 Value
Total Parent Project Value		R 1,110,041

PROJECT ECONOMIC SENSITIVITY ANALYSIS

Economic Classific.			Please select
Optimistic MIRR (%)		Pessimistic MIRR (%)	
Optimistic NPV (R)		Pessimistic NPV (R)	
Optimistic ERR (%)		Pessimistic ERR (%)	

PROJECT DATES

Project Required Completion Date	25-Feb-2004	Budget Year / s	2004

TOTAL COST ESTIMATE PER REPORTING CATEGORY (BENCHMARK COSTS)

Job Category	Amount (Rands) 2004	Contribution Source & Type	Contribution Funding Amount	Eskom Fund Required
Sub-Transmission Lines (66-132 kV)	R 1,327,422			R 1,327,422
Less : Dismantle Costs (Supply Account)	R (217,381)			R (217,381)
Total Capital Project Cost (Benchmark)	**R 1,110,041**		**R -**	**R 1,110,041**

PLANNING REQUIREMENTS

Role	Name	Tel. No.	Signature	Date
Project Initiator	Manogaran Chetty	031 710 5057	M Chetty	15-May-2002
Plant Manager	Raymond Kodi	031 710 5497	RK	15-May-2002
Network Planning Manager	for EL Bunge	8311 3692	MD Pallett	30-Jul-2002

PROJECT DETAILS	FORM 10 PAGE 2			
Asset Name	Georgedale Northdene 88kV Line 1 Refurbishment			
Project ID	N010236	WBS ROOT ELEMENT		WKL2G2/WKL2G3

CAPITAL PROJECT COSTS				
Preliminary Engineering Cost	**Int**	**Ext**	**Amount (Rands)**	**%**
Preliminary Design	40000		R 40,000	2.6%
Total Pre-Engineering Costs			R 40,000	2.6%
Long Lead Time Material			R -	
Remaining Project Cost			R 1,070,041	69.3%
(a) Revised Capital Cost (Proj. Team)			R 1,110,041	
(b) Tot Capital Cost (pg 1 - Benchmark)			R 1,110,041	
Variance (a) - (b)			R -	
Cost Variance Explanation				
DISMANTLE < R20,000	**No**			
DISMANTLE COST CONFIRMED	**R 434,763**	**CONTRIBUTION FUNDING**		**R -**
CURRENT OVERHEAD %	**10.0%**	**CURRENT IDC %**		**3.22%**

PROJECT SCHEDULE	
Committed F15 Completion Date	31-May-2003
(a) Estimated Project Completion Date (Resource Scheduling - PM)	25-Feb-2004
(b) Project Required Completion Date (Planning pg 1)	25-Feb-2004
Schedule Variance Explanation	
ENVIRONMENTAL STATUS	No Environmental Impact

PROJECT ACCEPTANCE (Relevant to Project)				
Role	**Name**	**Tel. No.**	**Signature**	**Date**
Project Engineering manager	P v Heeswijk	8311 - 3769	P v Heeswijk	08-Aug-2002
EDNS manager	C Roux	8321 - 5498		
Land Development Manager	N Purdon	8311 - 3711	pp R Moore	08-Aug-2002
Project manager	A Ball	8311 - 3657	A Ball	08-Aug-2002
Resource Program Manager	A. Naidoo	8321 - 3718	pp. R Buckroodeen	08-Aug-2002
Planning Manager	Ed Bunge	8311 - 3692	pp M Pallett	08-Aug-2002

NSM / CIC APPROVAL FOR EXPENDITURE			R 40,000	2.6%
CIC Meeting Date	19/8/2002	CIC Meeting No.		248
NSM / CIC Comments				
Approved by: M Kanji, S Chili, G Sprunt				
Network Services Manager / CIC Signatory	J. R. Fath		J Fath	15/8/2002
TOTAL PROJECT COST CONTRACTED (VALUE A)			**R 1,544,804**	**100%**
TOTAL ASSET VALUE (VALUE B)			**R 1,110,041**	**72%**
TOTAL CAPITAL CASH FLOW REQUIRED (VALUE C)			**R 1,110,041**	**72%**
CUSTOMER QUOTATION PROJECT VALUE (VALUE D)			**R 1,575,078**	**102%**

PROJECT DETAILS	FORM 10 PAGE 3
Asset Name	**Georgedale Northdene 88kV Line 1 Refurbishment**
Project ID	**N010236**

LONG LEAD TIME MATERIAL APPROVED

Item Description	Lead Time (Mths)	Quantity	Amount (Rands)	%
Tot. Long Lead Time Material Approved			**R -**	
NEW MATERIAL COSTS (CUSTOMER PROJECT)				
RE-USED MATERIAL COST (DEPRECIATED)				

PROJECT PHYSICAL STATISTICS

Build / Install / Refurbish	Km's HV	Km's MV	Km's LV	Comments
Line	33.0			
Cable				
Dismantle / Recover	**Km's HV**	**Km's MV**	**Km's LV**	**Comments**
Line				
Cable				
Build / Install / Refurbish	**Quantity**	**Total MVA**	**Comments**	
Transformers				
Dismantle / Recover	**Quantity**	**Total MVA**		
Transformers				
Customer Connections	**Quantity**	**Total Cost**	**Cost / Conn.**	**Comments**
Electrification Connections		R -	#DIV/0!	
Minor Works Customer Connections		R -	#DIV/0!	
BUSINESS PLAN KPI'S	**KPI THIS PROJECT**	**TARGET KPI**	**UNITS**	**COMMENTS**
Cost per Transformer	#DIV/0!		**R / Unit**	
Cost per MVA (Subtransmission only)	#DIV/0!		**R / MVA**	
Cost per Kilometer (Subtransmission only)	R 33,638		**R / Km**	
MVA per Transformer	#DIV/0!		**MVA / Unit**	
MVA per Kilometer (Retic & Electrification)	#DIV/0!		**MVA / Km**	
Transformers per Kilometer (Retic & Elec)	#DIV/0!		**No / Km**	
Connections per Kilometer (Retic & Elec)	#DIV/0!		**No / Km**	

RESOURCES

Project Manager / Consultant	
Project Engineer Primary	
Project Engineer Control Plant	
Project Engineer Telecontrol	
Survey	
Environmental	
Construction	

DISMANTLING INFORMATION

Asset Dismantled Description	Asset number / Year	Cost	Acc Depreciation	Book Value

FORM 15	PROJECT APPROVAL		Standard
PROJECT DETAILS			
Asset Name	**Georgedale Northdene 88kV Line 1 Refurbishment**		
Parent Project Name			
Project ID	N010236	Form Registration Date	15-May-2002
Project Initiator Name	Manogaran Chetty	Form Registered By	Manogaran Chetty
Engineering Region	Eastern	Initiator Tel No	+27 31 7105057
Technical Service Area	Cato Ridge	Distribution Customer Load Network	
Customer Service Area	Pietermaritzburg	Network Development Plan / F1 Area	Hammars/ Elangeni
Field Service Area	Pietermaritzburg	Project Latitude Coordinate	
Magisterial District / Municipality		Project Longitude Coordinate	

BUSINESS CATEGORY / PROGRAMMES

Refurbishment

PROJECT DESCRIPTION & MOTIVATION

Executive Summary / Motivation

Gerogedale Northdene 88kV Line 2 was investigated as part of the Hammersdale NDP. The physical condition, and performance of the Georgedale Lines has triggered the refurbishment scope below.

Scope of Work Description

Paint 225 towers on line 2 including tees. Relabel 225 towers. Restring 69km of earthwire. Replace 1715 insulators and all associated hardware. Clear the servitude of trees and shrubs.

Relevant Reference Documents

Refer to Planning Department's Hammersdale NDP Report.
Available in Teammate.

Project Family Details

Interdependent Asset Names	Project ID	Form 10 Value
Georgedale Northdene 88kV line 1 refubishment	N010234	R 9,032,998
Total Parent Project Value		R 1,110,041

PROJECT ECONOMIC SENSITIVITY ANALYSIS

Economic Classific.			Strategic
Optimistic MIRR (%)		Pessimistic MIRR (%)	
Optimistic NPV (R)	R -	Pessimistic NPV (R)	R -
Optimistic ERR (%)		Pessimistic ERR (%)	

PROJECT DATES

Project Required Completion Date	25-Feb-2004	Budget Year	2004

TOTAL COST ESTIMATES PER REPORTING CATEGORY

JOB CATEGORY Sub-Transmission Lines (66-132 kV)	Year (Rands)	
TOTAL PROJECT CAPITAL COST	**R 9,067,062**	**97%**
TOTAL DISMANTLE COST	**R 248,904**	**3%**
CONTRIBUTION FUNDING	**R 7,716,572**	**83%**
TOTAL PROJECT COST (VALUE A) (Capital + Supply)	**R 9,315,966**	**100%**
TOTAL ASSET VALUE (VALUE B)	**R 1,350,490**	**14%**
TOTAL CAPITAL CASH FLOW REQUIRED (VALUE C)	**R 1,350,490**	**14%**
CUSTOMER QUOTATION VALUE (VALUE D)		

PROJECT DETAILS	**FORM 15 PAGE 2**			
Asset Name	**Georgedale Northdene 88kV Line 1 Refurbishment**			
Project ID	**N010236**	**WBS ROOT ELEMENT**		**WKL2G2/WKL2G3**
PROJECT COSTS (CAPITAL ONLY)				
Job Category			**Amount (Rands)**	**%**
Total Pre-Eng Costs (from F10)			R 40,000	0.4%
Additional Pre-Eng Costs			R 368,153	4.0%
Total Engineering Costs at F15 stage			R 408,153	4.4%
Materials (new , re-used & transport)			R 5,656,030	60.7%
Contracts			R 2,147,808	23.1%
Internal Construction			R -	
Other Internal Labour			R 75,000	0.8%
Less: Dismantle Costs (If Total Dismantle Job)			R -	
Sub-Total Direct Costs			R 8,286,991	89.0%
Overheads			R 497,219	5.3%
IDC			R 282,852	3.0%
Total Project Capital Cost (F15)			**R 9,067,062**	**97.3%**
F10 (or last approved form 15)Cost			R 1,110,041	n/a
Variance			R (7,957,021)	-716.82%
Cost Variance Explanation				
Scope of work for F10 vague and incomplete				
DISMANTLE < R20,000	**No**			
DISMANTLE COSTS	***R 248,904***	***CONTRIBUTION FUNDING***		***R 7,716,572***
CURRENT OVERHEAD %	**6.0%**	**CURRENT IDC %**		**3.22%**
PROJECT SCHEDULE				
Estimated F150 Completion Date	04-Aug-2003	CONSTRUCTION START DATE		01-Sep-2003
(a) Estimated Project Completion Date (Resource Scheduling - PM)				30-Jun-2004
(b) Project Committed Completion Date (Base line in Scheduling System)				25-Feb-2004
Schedule Variance Explanation				-126
Increased scope requires longer duration.				
Environmental Status	No Environmental Impact			
PROJECT ACCEPTANCE (Relevant to Project)				
Role	**Name**	**Tel. No.**	**Signature**	**Date**
Project Engineering Manager	P van Heeswijk	3769	PvH	04-Jul-2003
Project Manager	AV Ball	8311 3657	AVB	15-Jul-2003
Project Accountant				
Network Planning Manager	for EL Bunge	8311 3692	MD Pallett	03-Jul-2003
EDNS Manager				
Land Development Manager	NW Purdon	8321-5483	NWP	03-Jul-2003
CIC APPROVAL FOR F15 EXPENDITURE			**R 3,394,653**	**37%**
CIC Meeting Date	21-Jul-2003	CIC Meeting No.		270
CIC Comments				
Approved				
CIC Signatory			D Conradie	21-Jul-03

PROJECT DETAILS	FORM 15 PAGE 3
Asset Name	Georgedale Northdene 88kV Line 1 Refurbishment
Project ID	N010236

LONG LEAD TIME MATERIAL APPROVED

Item Description	Lead Time (Mths)	Quantity	Amount (Rands)	%
88kV insulators	4	1715	R 2,572,500	28.4%
3No8 earthwire	3	69000m	R 414,000	4.6%
			R -	
			R -	
			R -	
			R -	
			R -	
			R -	
			R -	
Total Long Lead Time Material Approved			R 2,986,500	32.9%
NEW MATERIAL COSTS (CUSTOMER PROJECT)				
RE-USED MATERIAL COST (DEPRECIATED)				

PROJECT PHYSICAL STATISTICS

Build / Install / Refurbish	Km's HV	Km's MV	Km's LV	Comments
Line	64.00			Refurb
Cable				
Dismantle / Recover	**Km's HV**	**Km's MV**	**Km's LV**	**Comments**
Line				
Cable				

Build / Install / Refurbish	Quantity	Total MVA	Comments
Transformers			
Dismantle / Recover	**Quantity**	**Total MVA**	
Transformers			

Customer Connections	Quantity	Total Cost	Cost / Conn.	Comments
Electrification Connections		R -	#DIV/0!	
Minor Works Customer Connections		R -	#DIV/0!	

BUSINESS PLAN KPI'S	KPI THIS PROJECT	TARGET KPI	UNITS	COMMENTS
Cost per Transformer	#DIV/0!		R / Unit	
Cost per MVA (Subtransmission only)	#DIV/0!		R / MVA	
Cost per Kilometer (Subtransmission only)	R 141,673		R / Km	
MVA per Transformer	#DIV/0!		MVA / Unit	
MVA per Kilometer (Retic & Elect)	#DIV/0!		MVA / Km	
Transformers per Kilometer (Retic & Elec)	#DIV/0!		No / Km	
Connections per Kilometer (Retic.& Elec)	#DIV/0!		No / Km	

DISMANTLING INFORMATION

Asset Dismantled Description	Asset number / Year	Cost	Acc Depreciation	Book Value

FORM 150 REV 1	PROJECT CAPITAL RELEASE		Standard
PROJECT DETAILS			
Asset Name	Georgedale Northdene 88kV Line 1 Refurbishment		
Parent Project Name			
Project ID	N010236	Form Registration Date	15-May-2002
Project Initiator Name	Manogaran Chetty	Form Registered By	Manogaran Chetty
Engineering Region	Eastern	Initiator Tel No	+27 31 7105057
Technical Service Area	Cato Ridge	Distribution Customer Load Network	
Customer Service Area	Pietermaritzburg	Network Development Plan / F1 Area	Hammars/ Elangeni
Field Service Area	Pietermaritzburg	Project Latitude Coordinate	
Magisterial District		Project Longitude Coordinate	
BUSINESS CATEGORY / PROGRAMMES			
Refurbishment			
PROJECT DESCRIPTION & MOTIVATION			
Executive Summary / Motivation			
Gerogedale Northdene 88kV Line 2 was investigated as part of the Hammersdale NDP. The physical condition, and performance of the Georgedale Lines has triggered the refurbishment scope below.			
Scope of Work Description			
Paint 225 towers on line 2 including tees. Relabel 225 towers. Restring 69km of earthwire. Replace 1715 insulators and all associated hardware. Clear the servitude of trees and shrubs.			
Relevant Reference Documents			
Refer to Planning Department's Hammersdale NDP Report. Available in Teammate.			
Project Family Details			

Interdependent Asset Names	Project ID	Form 10 Value
Georgedale Northdene 88kV line 1 refubishment	N010234	R 9,032,998
Total Parent Project Value		R 1,110,041

PROJECT ECONOMIC SENSITIVITY ANALYSIS			
Economic Class.			Strategic
Optimistic MIRR (%)		Pessimistic MIRR (%)	
Optimistic NPV (R)		Pessimistic NPV (R)	
Optimistic ERR (%)		Pessimistic ERR (%)	
PROJECT DATES			
Project Required Completion Date	31-Jul-2005	Budget Year	2004

TOTAL COST ESTIMATES PER REPORTING CATEGORY				
JOB CATEGORY	Sub-Transmission Lines (66-132 kV)	Year (Rands)		
TOTAL PROJECT CAPITAL COST		**R**	**9,170,504**	**100%**
TOTAL DISMANTLE COST		**R**	**-**	
CONTRIBUTION FUNDING		**R**	**7,716,572**	**84%**
TOTAL PROJECT COST CONTRACTED (VALUE A)		**R**	**9,170,504**	**100%**
TOTAL ASSET VALUE (VALUE B)		**R**	**1,453,932**	**16%**
TOTAL CASH FLOW REQUIRED (VALUE C)				
CUSTOMER QUOTATION VALUE (VALUE D)				

Project Name	Georgedale Northdene 88kV Line 1 Refurbishment			
Project ID	N010236	WBS ROOT		WKL2G2/WKL2G3
PROJECT COSTS (CAPITAL ONLY)				
Job Category			**Amount (Rands)**	**%**
Total Engineering costs from F15			R 408,153	4.5%
Additional Engineering Costs			R -	
Total Direct Engineering Costs			R 408,153	4.5%
Materials (new , re-used & transport)			R 5,656,030	61.7%
Contracts			R 218,000	2.4%
Internal Construction			R 2,228,134	18.5%
Other Internal Labour			R 35,000	0.4%
Less: Dismantle Costs (if Total Dismantle Job)			R -	
Sub-Total Direct Costs			R 8,545,317	93.2%
Overheads			R 495,184	5.4%
IDC			R 130,003	1.4%
Total Capital Projects Costs			**R 9,170,504**	**100%**
F15 (or latest approved form 150) Costs			R 12,040,295	n/a
Variance			R 2,869,791	23.83%

Cost Variance Explanation

Original F150 costs for internal construction and other internal labour were inadvertently doubled and thus this reduction is as a result of that mistake being rectified.

DISMANTLE < R20,000	No		
DISMANTLE COSTS		**CONTRIBUTION FUNDING**	**R 7,716,572**
CURRENT OVERHEAD %	**6.0%**	**CURRENT IDC %**	**1.8%**
PROJECT SCHEDULE			
(a) Estimated Project Completion Date	18-Sep-2005	CONSTRUCTION START DATE	01-Sep-2004
(b) Project Committed Completion Date (Base line in Scheduling System)			30-Jun-2004

Schedule Variance Explanation

Group approval processes in terms of customer contributions delayed the project.Negotiations with the customer in terms of the contribution, took longer than anticipated.Quantifying of the scope of work.

Environmental Status	No Environmental Impact			
PROJECT ACCEPTANCE (Relevant to Project)				
Role	**Name**	**Contact Tel. No.**		
Project Manager	A Ball	8311-3685	AVB	14-Oct-2004
Project Services Officer	A Filtane	8311 3441	A Filtane	14-Oct-2004
Project Controller	E Deere	8311 3741	E Deere	14-Oct-2004
CIC APPROVAL FOR EXPENDITURE			**R 9,170,504**	**100%**
CIC Meeting Date	18-Oct-2004	CIC Meeting No.		300
CPM / CIC Comments				
Capital Programme Manager / CIC Signatory			D Conradie	18-Oct-04

PROJECT DETAILS	**FORM 150 PAGE 3**		
Project Name	**Georgedale Northdene 88kV Line 1 Refurbishment**		
Project ID	**N010236**		
NEW MATERIAL COSTS (CUSTOMER PROJECTS)			
RE-USED MATERIAL COSTS (DEPRECIATED)			
PROJECT PHYSICAL STATISTICS			

Build / Install / Refurbish	Km's HV	Km's MV	Km's LV	Comments
Line	64.00			
Cable				
Dismantle / Recover	**Km's HV**	**Km's MV**	**Km's LV**	**Comments**
Line				
Cable				

Build / Install / Refurbish	Quantity	Total MVA	Comments
Transformers			
Dismantle / Recover	**Quantity**	**Total MVA**	
Transformers			

Customer Connections	Quantity	Total Cost	Cost / Conn.	Comments
Electrification Connections		R -	#DIV/0!	
Minor Works Customer Connections		R -	#DIV/0!	

BUSINESS PLAN KPI'S	KPI THIS PROJECT	TARGET KPI	UNITS	COMMENTS
Cost per Transformer	#DIV/0!		R / Unit	
Cost per MVA (Subtransmission only)	#DIV/0!		R / MVA	
Cost per Kilometer (Subtransmission only)	R 143,289		R / Km	
MVA per Transformer	#DIV/0!		MVA / Unit	
MVA per Kilometer (Retic & Elec)	#DIV/0!		MVA / Km	
Transformers per Kilometer (Retic & Elec)	#DIV/0!		No / Km	
Connections per Kilometer (Retic & Elec)	#DIV/0!		No / Km	

DISMANTLING INFORMATION

Asset Dismantled Description	Asset number / Year	Cost	Acc Depreciation	Book Value

FORM 101 : COMPLETION CERTIFICATE — Standard

PROJECT DETAILS

Asset Name	Georgedale Northdene 88kV Line 1 Refurbishment		
Parent Project Name			
Project ID	N010236	Form Registration Date	15-May-2002
Project Initiator Name	Manogaran Chetty	Form Registered By	Manogaran Chetty
Engineering Region	Eastern	Initiator Tel No	+27 31 7105057
Technical Service Area	Cato Ridge	Distribution Customer Load Network	
Customer Service Area	Pietermaritzburg	Network Development Plan / F1 Area	Hammars/ Elangeni
Field Service Area	Pietermaritzburg	Project Latitude Coordinate	
Magisterial District		Project Longitude Coordinate	

BUSINESS CATEGORY / PROGRAMMES

Refurbishment

PROJECT DESCRIPTION & MOTIVATION

Executive Summary / Motivation

Gerogedale Northdene 88kV Line 2 was investigated as part of the Hammersdale NDP. The physical condition, and performance of the Georgedale Lines has triggered the refurbishment scope below.

Scope of Work Description

Paint 225 towers on line 2 including tees. Relabel 225 towers. Restring 69km of earthwire. Replace 1715 insulators and all associated hardware. Clear the servitude of trees and shrubs.

Relevant Reference Documents

Refer to Planning Department's Hammersdale NDP Report.
Available in Teammate.

Project Family Details

Interdependent Asset Names	Project ID	Form 10 Value
Georgedale Northdene 88kV line 1 refubishment	N010234	R 9,032,998
Total Parent Project Value		R 1,110,041

PROJECT ECONOMIC SENSITIVITY ANALYSIS

Economic Class.			Strategic
Optimistic MIRR (%)		Pessimistic MIRR (%)	
Optimistic NPV (R)		Pessimistic NPV (R)	
Optimistic ERR (%)		Pessimistic ERR (%)	

PROJECT DATES

Project Required Completion Date	31-Jul-2005	Budget Year	2004

TOTAL COST ESTIMATES PER REPORTING CATEGORY

JOB CATEGORY	Sub-Transmission Lines (66-132 kV)		Rands (Year)	
	FORM 10	**FORM 15**	**FORM 150**	**FORM 101**
TOTAL PROJECT CAPITAL COST	R 1,110,041	R 9,067,062	R 9,170,504	R -
TOTAL DISMANTLE COST	R 434,763	R 248,904	R -	R -
CONTRIBUTION FUNDING	R -	R 7,716,572	R 7,716,572	R -
TOTAL PROJECT COST (VALUE A)	R 1,544,804	R 9,315,966	R 9,170,504	R -
TOTAL ASSET VALUE (VALUE B)	R 1,110,041	R 1,350,490	R 1,453,932	R -
TOTAL CASH FLOW REQUIRED (VALUE C)	R 1,110,041	R 1,350,490	R -	R -
CUSTOMER QUOTATION VALUE (VALUE D)	R 1,575,078	R -	R -	R -

PROJECT DETAILS	FORM 101 PAGE 2		
Asset Name	Georgedale Northdene 88kV Line 1 Refurbishment		
Project ID	N010236	WBS ROOT	WKL2G2/WKL2G3
Environmental Status	No Environmental Impact		
Used Material Costs	R -	New Material Costs	R -
Dismantle Costs (Construction)	R -	O/H Rate Used	6%

SUMMARY OF SCHEDULE VARIANCES	BASELINE	ACTUAL	VARIANCE
FORM 15	31-May-2003	21-Jul-2003	-51
FORM 150	04-Aug-2003	18-Oct-2004	-441
FINAL PLANT ENERGISED / MADE AVAILABLE DATE			
CONSTRUCTION DURATION (DAYS)	382		38200%

SCHEDULE VARIANCE EXPLANATIONS

SUMMARY OF EXPENDITURE

RESOURCE	APPROVED	SPENT	VARIANCE	%VAR
Direct Engineering Costs	R 408,153		R 408,153	100%
Materials (new , re-used & transport)	R 5,656,030		R 5,656,030	100%
Contracts	R 218,000		R 218,000	100%
Internal Construction	R 2,228,134		R 2,228,134	100%
Commissioning	R 35,000		R 35,000	100%
			R -	
			R -	
			R -	
Sub-Total Direct Costs	R 8,545,317	R -	R 8,545,317	100%
Overheads	R 495,184		R 495,184	100%
IDC	R 130,003		R 130,003	100%
Less : Customer Contribution	R -7,716,572		R -7,716,572	100%
Total	**R 1,453,932**	**R -**	**R 1,453,932**	**100%**

PROJECT FINALISATION

Role	Name	Contact Tel. No.	Signature	Date

CPM / CIC APPROVAL

CIC Meeting Date		CIC Meeting No.	
CPM / CIC Comments			
Capital Programme Manager / CIC Signatory			

FORM F150 REVISIONS

Revision No.	Reason For Revised F150	Variance Amount

PROJECT DETAILS	F101 PAGE 3		
Asset Name	Georgedale Northdene 88kV Line 1 Refurbishment	Project ID	N010236

COST VARIANCE EXPLANATION AND COMMENTS

DIRECT ENGINEERING COSTS	VARIANCE	%
	R 408,153	100%
MATERIALS	**VARIANCE**	**%**
	R 5,656,030	100%
CONTRACTS	**)VER) / UNDE**	**%**
	R 218,000	100%
CONSTRUCTION CONTRACTOR	**VARIANCE**	**%**
	R 2,228,134	100%
COMMISSIONING	**VARIANCE**	**%**
	R 35,000	100%
OTHER	**VARIANCE**	**%**
	R -	N/a
OVERHEADS / I D C	**VARIANCE**	**%**
	R 625,187	100%
SCHEDULE VARIANCE	**VARIANCE**	**%**
	382	38200%

TO : HEAD OF LOGISTICS

FROM : PROJECT ENGINEERING

DATE : 8/03/06

REV : 13

GEOGEDALE NORTHDENE 88kV LINE 1 REFURBISHMENT
WBS : WKL2GN/WKL2GG

BILL OF MATERIALS : FINAL

NOTES .

1. This BOM is based on FINAL line design.

2. Materials Management shall confirm all materials ordered by marking up a copy of this BOM and returning same to Project Engineering

MATERIAL DESCRIPTION	SAP No.	DWG No.	DWG REV	UNIT	REV 0	REV 1	REV 2	REV 3	REV 4	REV 5	REV 6	REV 7	REV 8	REV 9	REV 10	REV 11	REV 12	REV 13	Total Qty	Unit Cost	Total Cost
HARDWARE					28/07/03	28/09/03	7/07/04	20/08/04		25/11/04	8/02/05	11/03/05	05/05/05	19/07/05	12/10/05	19/10/05	8/11/05				
WIRE STRAND 3/4mm STEEL 1100 Mpa	0185944	D-DT-7036	1	m	69000														69000	R 3.50	R 241,500
INSULATOR, LONG ROD 88-kV 120kN 31mm/kV	0167515			ea	1715														1715	R 1,200.00	R 2,058,000
INSULATOR, SUSP, C+T S/WIRE 70kN	0167605	D-DT-7012	1	ea									80	250		200			530	R 100.00	R 53,000
BALL-EYE, OVAL 16mm 120kN	0010258	D-DT-7008	0	ea		174											1200		1374	R 13.00	R 17,862
BALL-EYE, OVAL , LIVE LINE 16mm 120kN	BUY OUT					1002													1002	R 32.50	R 32,565
SHACKLE, STRAIGHT BOLT TYPE, 120 KN	0153406	D-DT-7017	2	ea		1844													1844	R 15.00	R 27,660
BANDIT BUCKLE, STAINLESS STEEL 12mm	0106541			ea		4000													4000	R 0.35	R 1,400
STRAPPING, STAINLESS STEEL 12mm X 0.75mm	0108554			30m roll		8													8	R 45.00	R 360
SAG ADJUSTER, 120KN	0175857	D-DT-7042	1	ea		50													50	R 60.00	R 3,000
SOCKET CLEVIS 16mm IEC,120KN	0010259	D-DT-7021	0	ea		1002											-800		202	R 55.00	R 11,110
SOCKET TONGUE,120KN	10270			ea		174									320		1380		1874	R 42.60	R 79,832
ARMOUR GRIP SUSPENSION UNIT-WOLF	001145	D-DT-7033	0	ea		136													136	R 185.00	R 25,530
ARMOUR GRIP SUSPENSION UNIT-MINK	0168965	D-DT-7033	1	ea		36								150					186	R 85.00	R 15,810
JOINT, NON-TENSION ALUMINIUM, Mink C/CRIMP	166013	D-DT-3098	7	ea										100					100	R 14.30	R 1,430
U-BOLTS FOR SUSPENSION S/C & D/C TOWERS	CONSTRUCTION TO PROCURE AS REQUIRED																				
COMPRESSION DEAD END-WOLF	0010839	D-DT-7000	2	ea		714													714	R 130.00	R 92,820
COMPRESSION DEAD END-MINK				ea		288													288	R 80.00	R 23,040
RAZOR MESH FLAT WRAP 450mm DIAMETER	BUY OUT			m		16500													16500	R 5.00	R 82,500
GALVANSIED 4mm WIRE STRAND -MILD STEEL	BUY OUT			m		16500													16500	R 0.40	R 6,600
CLAMP, PISTOL 3 BOLT TYPE 5-16mm FOR EARTHWIRE	0185253	D-DT-7022	6	ea		668													668	R 42.00	R 28,056
CROSBY CLAMP, 12mm	0000225	D-DT-7032	2	ea		668													668	R 4.50	R 3,006
CONDUCTOR, ACSR MINK, GREASED	0171327	D-DT-3136	7	m			4500												4500	R 5.50	R 24,750
CONCERTINA RAZOR WIRE -STAINLESS STEEL -450 DIA	BUY OUT			m			1000												1000	R 35.00	R 35,000
(INDEPENDENT RAZOR AND WELD MESH SUPPLIERS-MARK TEL 031-7005555)																					
DAMPER, VIBRATION SPIRAL 8.29-11.71	0010699	D-DT-3175	2	ea					50	450									500	R 15.00	R 7,500
DAMPER, VIBRATION STOCKBRIDGE 16.13-19.98	0168960	D-DT-7005	4	ea															540	R 115.00	R 62,100
ABB CHAIN LINKS -CAT NO 977005-00 A=70 B=28 C= 18				ea						100									100	R 20.00	R 2,000
CLAMP, SUSPENSION CRADLE, CONDUCTOR 8.0 - 18.0	0166534	D-DT-3008	10	ea						100									100	R 45.00	R 4,500
PAINTING-CONCRETE TOWERS																					
SIKA MONOTOP 612 REPAIR MORTAR	BUY OUT	SIKA (PTY) LTD		20 KG			24												24	R 800.00	R 19,200
SIKAGARD 550 ELASTIC PRIMER	BUY OUT	SIKA (PTY) LTD		25 LITRES			24												24	R 950.00	R 22,800
SIKAGARD 550W ELASTIC TOP GREY	BUY OUT	SIKA (PTY) LTD		20 LITRES			24												24	R 950.00	R 22,800
GALVANISED STEEL MEMBERS FOR LATTICE TOWERS	BUY OUT			KG							10000								10000	R 15.00	R 150,000

MATERIAL DESCRIPTION	SAP No.	DWG No.	DWG REV	UNIT	REV 0	REV 1	REV 2	REV 3	REV 4	REV 5	R	REV 7	REV 8	REV 9	REV 10	REV 11	REV 12	REV 13	Total Qty	Unit Cost	Total Cost
DAMPER, VIBRATION SPIRAL 8.29-11.71	0010899	D-DT-3175	2	ea								1800							1800	R 15.00	R 27,000
DAMPER, VIBRATION STOCKBRIDGE 18 13-19.98	0168960	D-DT-7005	4	ea								500							500	R 115.50	R 57,750
WOOD-POLE STRUCTURES FOR TEMPORARY WORKS																					
POLE, WOOD 13m x 180-199 TOP DIA.	0164577	D-DT-0056	5					20	20	20									20	R 530.00	R 10,600
POLE, WOOD 9m x 160-179 TOP DIA.	0164561	D-DT-0055	6					10	10	10									10	R 610.00	R 6,100
PAINTING-STEEL LATTICE TOWERS																					
AMERLOCK 400AL EPOXY PRIMER				5 LITRES			876											100	976	R 800.00	R 780,800
AMERCOAT 385 M10 EPOXY BASE COAT				5 LITRES			876											75	951	R 800.00	R 760,800
AMERCOAT 450 EPOXY FINAL COAT				5 LITRES			876											50	926	R 800.00	R 740,800
EPOXY THINNERS				5 LITRES			110												110	R 500.00	R 55,000
UTILITY PAINT BRUSH, 75mm				ea			125												125	R 25.00	R 3,125
UTILITY PAINT BRUSH, 50mm				ea			125												125	R 20.00	R 2,500
WIRE BRUSH WITH HANDLE				ea			50												50	R 30.00	R 1,500
80 GRIT EMERY PAPER (400mm WIDE ROLL)				m			50												50	R 20.00	R 1,000
60 GRIT EMERY PAPER (400mm WIDE ROLL)				m			50												50	R 15.00	R 750
VESTING MATERIAL				KG			15												15	R 35.00	R 525

TOTAL COST R 5,603,981

Report by Eskom Construction on Materials Handling and Storage

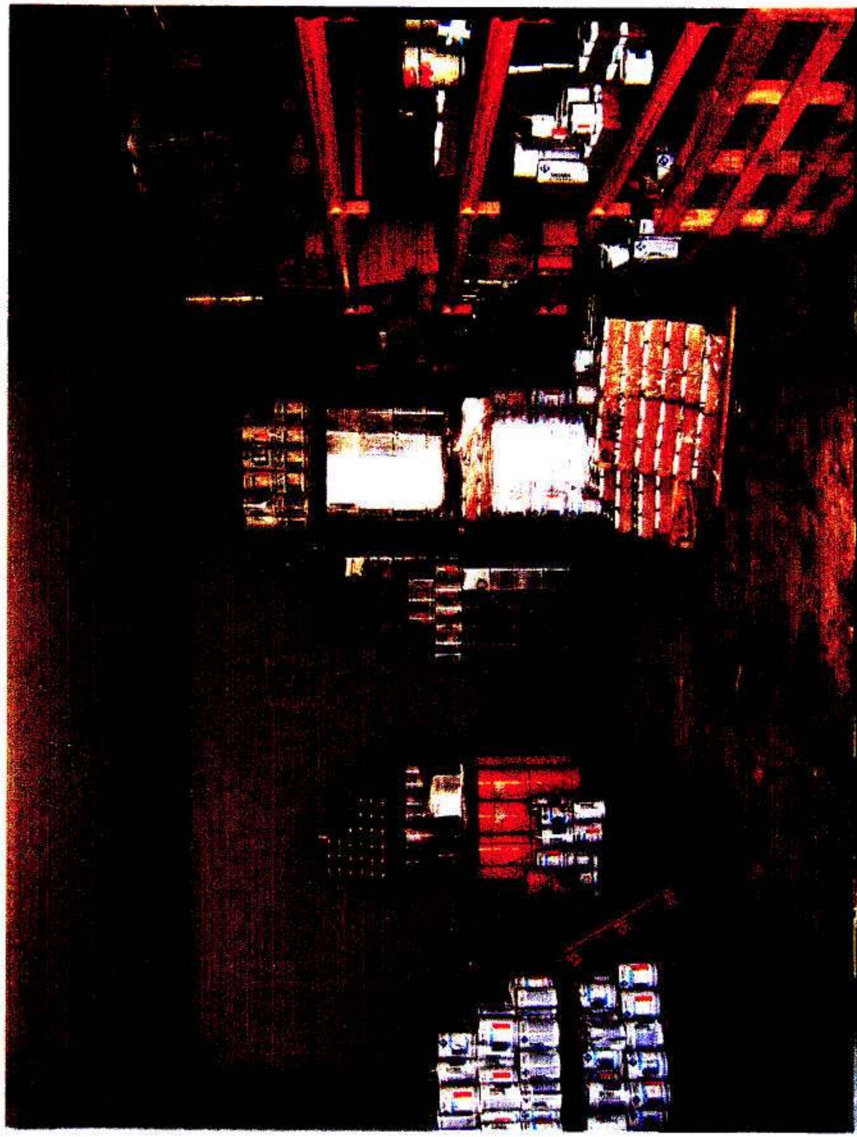
Dan Dukhan,Eddie Rencken and I visited New Germany stores on 25/01/2006 to verify what materials might be available for us to collect. At ward 4 we found 162 22kV long rod insulators which are supposed to be the ones ordered by Chris i.e. the 40kN single skirt earthwire insulator. This item is therefore still outstanding and WILL cause a loss on this project. The correct drawing is D-DT-7012.

As for SIGMA paint we have 270 first coat, 360 second coat and 600 third coat left at ward 3. We will need 100 tins of first coat, 75 tins of second coat and 50 tins of third coat (plus hardener for each coat). Please order 60 of 25litre tins of ordinary lacquer thinners as well. When ordering the Sigma product ensure that it is held by the supplier and we will take it as and when we need it direct from the supplier.

At dispatch there is a consignment of small hardware that we will collect early next week. (Socket-tongues, socket-clevises and AGS units for "Mink")

At ward 3, we came across some damaged materials of which photos are attached. Also, for your interest, are photo's of the cracked concrete pole at Mlazi.

Very roughly, 183 towers of 471 are completely painted and have had the hardware and earthwire changed, another 211 have been painted 1st and 2nd coat only and only half the tower coated.




SIGMA
COATINGS