STRATEGIC SUPPLY CHAIN ASSESSMENT FOR NISSAN SOUTH AFRICA

by

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I. Executive Summary

Aim of Project

The aim of this project is to identify critical areas within the supply chain that need to be optimised to support Nissan South Africa's (NSA) strategic business objectives: Stabilisation of market share and development of core capability to provide a base for growth.

Once projects have been raised to address the areas identified as critical, the aim will be to provide support to the project that would benefit the most from industrial engineering principle/ field of knowledge.

Project Overview

The supply chain assessment follows a proven 5 step approach that allows for qualitative as well as quantitative assessment:

- *Step 1: Understanding "As-Is"/ Baseline Condition*
- *Step 2: Gathering Best Practice & Benchmarks*
- *Step 3: Conducting Gap Analysis*
- *Step 4: Prioritise Improvement Opportunities*
- *Step 5: Provide Support to Pilot Project*

The project consists of a cross-industry scope within the automotive environment, and includes the following areas: Supply chain planning, procurement and distribution. The tools and methods discussed in this project were identified during research conducted on similar engagements across multiple industries.

Conclusion

The areas identified as critical was confirmed by NSA, the projects raised should address the real inefficiencies in NSA's supply chain, enabling NSA to get a competitive advantage. For NSA to keep the competitive advantage, a continuous improvement approach should be followed.

In regards to the pilot project, if NSA adjust their staging area according to demand, they might benefit financially. The new vehicle enhancement facility with its increased capacity may increase NSA's annual revenue, inherently it would allow for more onsite fitments which could lead to better quality preservation, shorter lead times and decreased logistics cost.

II. Glossary

3PL - Third Party Logistics

AHP - Analytic Hierarchy Process

APDP - Automotive Production Development Program

ASN - Advanced Shipping Notice

BOL - Bill of Lading

BOM - Bill of Material

CI - Consistency Index

CKD - Completely Knocked Down

COM - Customer Order Management

COP - Consolidated Operating Profit

CMM - Capability Maturity Model

CPFR - Collaborative Planning, Forecasting and Replenishment

CR - Consistency Ratio

DCT - Durban Car Terminal

EOQ - Economic Order Quantities

EU - Employee Union

GDP - Gross Domestic Product

IPO - Individual Parts Order

IT - Information Technology

KPI - Key Performance Indicators

LP - Linear Problem

MAPE - Mean Absolute Percentage Error

MIDP - Motor Industry Development Program

MPS - Master Production Schedule

MRP - Material Requirements Planning

NG - Nissan Global

NSA - Nissan South Africa

OVE - Optional Vehicle Enhancement

PO - Purchase Order

RFDC - Radio Frequency Data Collection

RFID - Radio Frequency Identification

RFS - Request for Service

RI - Random Index

ROI - Return on Investment

S&OP - Sales and Operations

SADC - South African Development Community

SCC - Supply Chain Council

SCM - Supply Chain Management

SKU - Stock Keeping Unit

SLA - Service Level Agreement

SVE - Standard Vehicle Enhancement

TMS - Transportation Management System

VAA - Volume Assembly Allowance

VE - Vehicle Enhancement

1. Introduction

1.1 Background

For the last 40 years, Nissan South Africa (NSA) has provided quality vehicles to local and international customers. NSA and its forerunner, Datsun, provided transport solutions initially through the importation and local assembly of Completely Knocked Down (CKD) vehicles, followed by the establishment of manufacturing facilities at Rosslyn. Currently, with the transformation of the country and along with it the unrestricted and highly competitive motor vehicle market, Nissan is set to continue its significant role in the South Africa automotive market.

In 2011 Nissan Global (NG) announced their strategic objectives for 2016, the Nissan Power 88. The name of the plan emphasizes key corporate goals: Nissan will renew its focus on the overall customer experience through actions that elevate its brand power and sales power. By the end of fiscal 2016, the company will aim to achieve a global market share of 8% and increase its corporate operating profit to a sustainable 8%. (Nissan Global, 2011).

In a competitive environment where global sales have decreased, there is a lot of pressure to increase the existing market share, consequently NSA’s Supply Chain Management (SCM) function has increased in importance. The SCM organisation plays a critical role in maintaining cost control and margin protection. NSA’s SCM organisation should be optimally structured to compete with peers both on a regional and global level. Metrics and measures will need to tie back to corporate strategies and drivers of success.

1.2 Need Requirement

NSA is constantly competing with the other NG subsidiaries for production rights of future Nissan models as well as current models with constrained plant production capacity. At present, NP200 and NP300’s are manufactured at the NSA plant in Rosslyn. The demand for these models are declining especially for the NP300, a common occurrence for products reaching the end of their life cycle, and NSA wishes to continue producing more than 50 000 units in a four quarter period.

The Automotive Production Development Program (APDP) is a government incentive that is designed to stimulate growth in the local automotive production environment. The Volume Assembly Allowance (VAA) section in the APDP states that if a registered light motor vehicle manufacturer produces more than 50 000 units over a four quarter period they are entitled to receive an offset in custom duties on imported automotive components. (Maxwell & Van Rooyen, 2012). For NSA this reduction in custom duties amounts to R260 000 000.

It is therefore imperative that NSA assess and optimise their Strategic supply chain to gain a competitive advantage over other NG subsidiaries competing for similar production rights. In parallel an optimised supply chain will align NSA with their strategic business objectives for 2016 of 100 000 units production and 15% of Africa's market share. This supports NG's objectives of 8% global market share, 8% Consolidated Operating Profit (COP) and 8 million vehicles. (Nissan Global, 2011).

NSA has provided the student with a Request for Service (RFS) to do an in depth assessment of the current "As-Is" state of the NSA supply chain, and identify problem areas in: Supply chain planning (PLAN), procurement (SOURCE) and distribution (DELIVER) that could potentially keep NSA from reaching its strategic objectives.

2. Project Aim

The aim of this project is to identify critical areas within the supply chain that need to be optimised to support NSA's strategic business objectives, stabilisation of market share and development of core capability to provide a base for growth.

<u>The completion of this project will aspire to provide NSA with:</u>

- "As-Is" analysis of their supply chain, complete with process maps for the PLAN, SOURCE and DELIVER activities
- Metrics and benchmark results for NSA as well as that of peer companies
- Best practice supply chain profile
- Quantitative and qualitative gap analysis
- A means and method of prioritising improvement opportunity within the supply chain
- Pilot project support

3. Project Approach, Scope & Deliverables

3.1 Project Approach

The Strategic supply chain assessment will follow a 5-step approach:

Step 1: Understanding "As-Is"/ Baseline Condition

- Develop questionnaires
- Develop data collection template
- Understand "As-Is" state for strategy, process, technology and organisation
- Create and validate Process Maps for PLAN, SOURCE and DELIVER

In this step, an understanding of NSA's business strategy, goals and objectives, and priorities will be gained. A SWOT analysis will be conducted to examine the external forces that shape NSA's business strategy. The "As-Is" documentation analysis will be supplemented by interviews with selected internal (functions impacting Supply Chain) and external (customers, suppliers, and service providers) stakeholders, and site (plants and distribution locations) visits to understand the level of alignment of the current Supply Chain structure with the overall business strategy and industry direction.

Step 2: Gathering Best Practice & Benchmarks

- Gather benchmarks and best practices
- Develop maturity models
- Interview Deloitte experts and gain industry-specific understanding

This will include a peer comparison as well as overall industry and cross-industry benchmark comparisons as applicable. The primary method for collecting organization data will be interviews with key stakeholders, use of Deloitte knowledge databases of peer companies, and peer group interviews where possible. Step 2 will also embrace the start of Capability Maturity Models comparison process, providing key stakeholders with questionnaires and conducting interviews to evaluate the current state with ideal state based on best practice scales.

Step 3: Conducting Gap Analysis

- Analyse transactional data and validate improvement opportunities

- Compare “As-Is” state of NSA’s supply chain with industry best practices
- Compare NSA metrics with industry metrics

In this step interviews are conducted to gather information that would shape the different hypotheses. This step includes a qualitative gap analysis (mapping NSA’s current capability for the activities involved with PLAN, SOURCE and DELIVER into four stages within the maturity model) as well as a quantitative gap analysis (various metrics are calculated for the NSA and compared to benchmark results from peer companies within the automotive production industry). The results of the maturity models and benchmark analysis are then used to validate or disprove hypotheses and identify the capability gaps within the NSA’s supply chain.

Step 4: Prioritise Improvement Opportunities

- Evaluate and prioritise improvement opportunities

This step involves the use of an Analytic Hierarchy Process (AHP) to help determine which improvement opportunities are worth pursuing. The AHP incorporates the results from the qualitative and quantitative assessment along with additional project criteria agreed upon by both parties. (Deloitte and Nissan South Africa).

Step 5: Support NSA in pilot project

Support NSA in one of the projects raised to address problematic areas within the NSA’s supply chain provide. The selection criteria for this project will be based on benefit from Industrial Engineering principles.

3.2 Project Scope

The Strategic Supply Chain Assessment project has a cross-industry scope within the automotive environment.

<u>The service offerings scope of the project includes the following:</u>

- Supply Chain Planning - PLAN
- Sourcing and Procurement - SOURCE
- Logistics and Distribution – DELIVER

This project will make use of the SCOR nomenclature (PLAN, SOURCE, and DELIVER).

3.3 Deliverables

The deliverables for each of the steps of the supply chain assessment 5 steps approach:

Step 1: Understanding "As-Is"/ Baseline

- "As-Is" supply chain process maps for PLAN, SOURCE and DELIVER
- Baseline for Plan, Source and Deliver functions within the supply chain
- SWOT analysis

Step 2: Gathering Best Practice & Benchmarks

- Industry-specific metrics and benchmarks
- Best practice supply chain profile

Step 3: Conducting Gap Analysis

- Qualitative gap analysis (NSA maturity model)
- Quantitative gap analysis (NSA benchmark comparison)

Step 4: Developing Improvement Opportunities

- Improvement opportunity prioritisation tool (calculator) based on AHP principles

Step 5: Pilot Project Deliverables (section 5.2.3)

- Capacity requirements for the new high value parking lot
- Capacity requirements for Standard Vehicle Enhancement I staging area
- Capacity requirements for the Standard Vehicle Enhancement II staging area
- Based on demand and capacity the ideal mix of vehicle enhancements (VE) to conduct on site

4. Literature Review & Problem Investigation

4.1 Introduction to the Supply Chain Assessment

A supply chain is a system of processes linked by the flow of resources across multiple business units, companies and countries. The SCM field seeks to understand the management of individual processes in order to maximise system wide value. (Webster, 2008).

Michael Porter's recommendation in his thesis on how to create a competitive advantage, states that a company should assess each activity in their value chain individually, to verify whether or not they have the competitive advantage in that activity. If not the company should consider outsourcing that activity to a partner who can provide a "value" advantage for the company. Michael Porter's logic regarding value and outsourcing is now widely accepted and a dramatic increase in outsourcing activities can be observed across various industries.

Outsourcing extends the value chain beyond a company's boundary, this extension in the value chain mean that the supply chain becomes the value chain. The increase in outsourcing activities has also increased the complexity of supply chains, hence effective supply chain management has become more important than ever before. (Christopher, 2005)

A company's business strategy provides the foundation of its competitive advantage. This business strategy can be grouped into one of the following generic business strategies: A cost, differentiation or focus business strategy. (Porter, 1998).

- A company pursuing a cost based strategy concentrates on the sourcing of low cost items, usually in bulk, to be able to price their products below the competing companies' prices (e.g. Checkers).
- A company pursuing a differentiation strategy will gain a competitive advantage by focusing on the uniqueness products/ services (e.g. Pagani).
- A company pursuing a focus strategy will typically identify a small market segment in which either differentiation or low cost may be accentuated (e.g. custom-made bicycle frames).

A company must revise its supply chain performance metrics and processes periodically to support the business strategy under ever changing conditions (e.g. markets and competition). (Webster, 2008).

To obtain a better understanding of the forces that shapes NSA's business strategy a SWOT analysis was conducted

4.2 Business Strategy Analysis

4.2.1 SWOT Analysis

A SWOT analysis examines the internal and external forces that shape a company's business strategy.

Figure 1: SWOT Analysis

4.2.1.1 Strengths

- Compared to first world countries South Africa has a high level of low cost labour available, this can also for some level of flexibility in the manufacturing activities.
- NSA has a first world manufacturing facility and access to a lot of locally produced minerals and metals.
- The South African economy is generally less volatile compared to rest of the African economies.
- NSA is positioned in a strong strategic position to serve the rest of Africa.

4.2.1.2 Weaknesses

- The automotive sector contributes only 4% of South Africa's overall Gross Domestic Product (GDP). (Business Monitor International, 2014).
- The global automotive sector is unprotected against changing markets and consumer trends.
- The new credit act makes it more difficult to obtain vehicle loans. *The credit act states that after all expenses have been deducted from a person's monthly income the monthly payback amount, of the loan, must less than or equal a third of the money still available in that person's account.*
- NSA is far from the big markets of North America and Europe, this result in a high export logistics cost.
- NSA experience constant pressure from the unions of workers.

4.2.1.2 Opportunities

- Despite the an overall decline in domestic vehicle sales of the commercial vehicles have shown a stable increase and is projected to increase even more over the following 5 years. (Business Monitor International, 2014)
- Several opportunities generated from ongoing measures such as free trade agreements with organisations such as the South African Development Community (SADC).
- The APDP offers new incentives to automotive manufacturers over the Motor Industry Development Program (MIDP), replaced in 2013, that could boost production.
- South Africa has a strong hospitality and tourism sector that represents a growing demand for Light Vehicles, due to the increase in rental vehicles.

4.2.1.3 Threats

- Due to high crime rates there has been a decrease of investment in the South African market.
- High and increasing inflation levels are directly influencing automotive sales and production.

- Frequent strikes are causing export markets to lose faith in the South African automotive production industry. *The number of working days lost due to a strike action in the United Kingdom (UK) was 24.2 days per year (per 1000 employees) over the period 2008-2012. The equivalent number for South Africa over the same period is 18 times higher at 440 days per year, despite the fact that South Africa's unemployment rate is more than 3 times greater than that of the UK.* (Eighty20, 2013)

4.3 Supply Chain Metrics Alignment

The following two frameworks may be considered for detecting misalignment between the business strategy and the supply chain metrics and processes.

4.3.1 Process - Product Matrix

The process-product matrix developed by Hayes and Wheelwright (1979) stipulates a relationship between the product type and the process structure that makes logical sense.

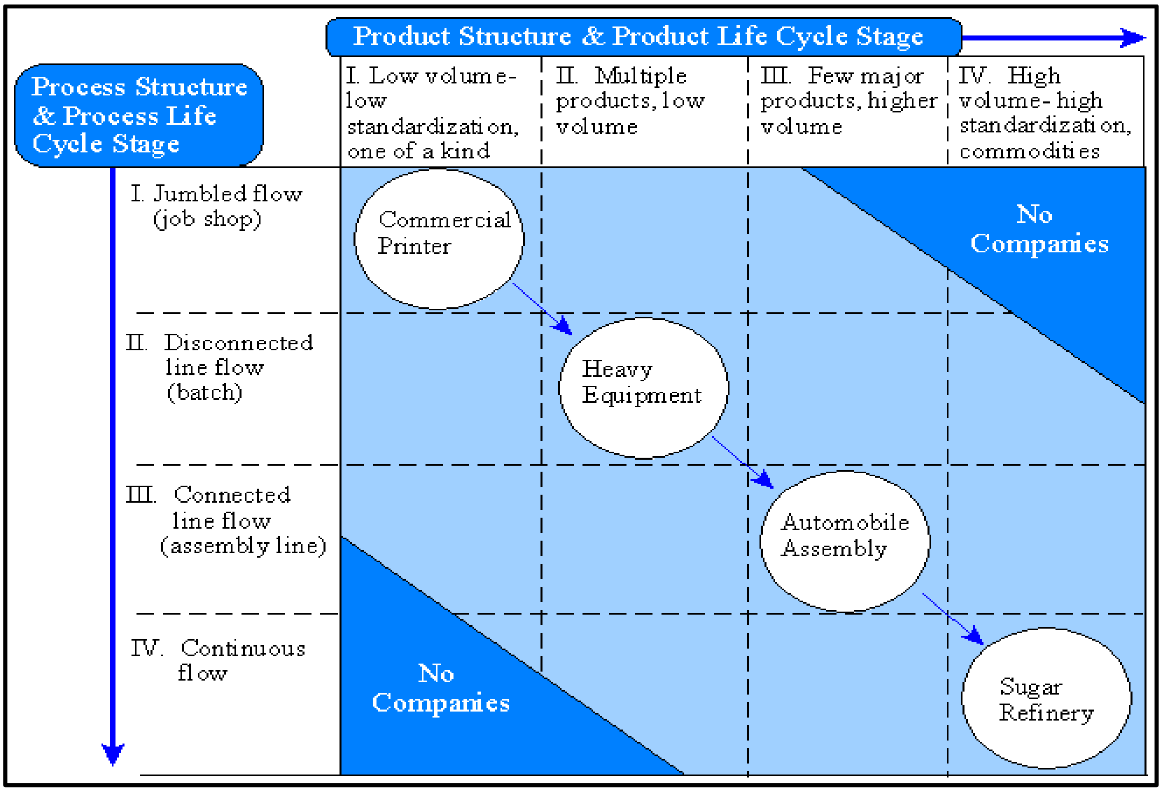

Figure 2: Process-Product Matrix (Hayes & Wheelwhright, 1979)

The vertical axis categorises process structure and process life cycle stage according to material flow, from jumbled to continuous. The horizontal axis categorise types of product structure and product life cycle stage produced by a process, from low to high level of standardisation on commodities.

The most important thing to take note of the process-product matrix is that certain process structures are suitable for certain types of products, reflected in the diagonal of figure 3.

4.1.3 Supply Chain - Product Matrix

The supply chain – product matrix developed by Fisher (1997), figure 3, is a framework that can be used to effectively fit the characteristics of supply chain design with a product type. The framework differs from the process-product matrix in the following ways:

- Products are classified as functional or innovative according to the predictability of product demand not based on the degree of standardisation.
- The processes are not classified according the material flow characteristics but instead based on performance.

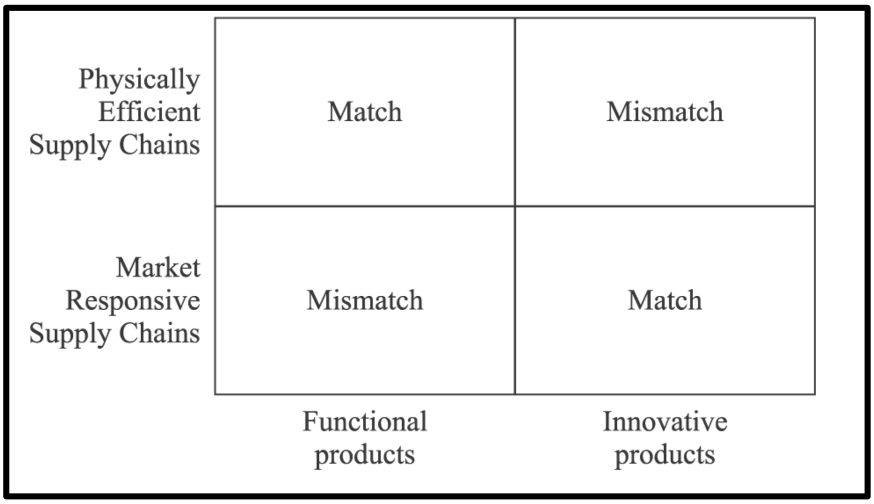

Figure 3: Supply Chain – Product Matrix (Fisher, 1997)

The vertical axis in figure 3 categorise the supply chain as either market responsive or physically efficient. The products are categorized along the horizontal axis according either as functional products or innovative products based on their demand patterns. As with the process-product matrix, the most important thing to take note of with the supply chain-product matrix is that certain processes are suitable to certain types of product. (Fisher, 1997)

According to Webster (2008) once the strategic business strategy for supply chain processes has been established, the following questions should be answered next:

- What metrics ought to be used when supply chain processes are measured for performance?
- In order to improve performance what changes/ investment ought to be made?

Historically there was no standard way to describe supply chain processes or to measure the performance of a supply chain, this can largely be contributed to the complexity and scope of supply chain assessments. The Supply Chain Operations Reference Model (SCOR) was introduced to provide such a standard. (Webster, 2008)

4.4 Supply Chain Models and Frameworks

4.4.1 Supply Chain Operations Reference Model and Framework

SCOR was developed, and currently maintained, by a nonprofit organisation called the Supply Chain Council (SCC). (Supply Chain Council, 2013).

The SCOR framework describes supply chain processes with associated terminology, metrics and best practice and integrates well-known concepts from benchmarking and business process reengineering. (Webster, 2008)

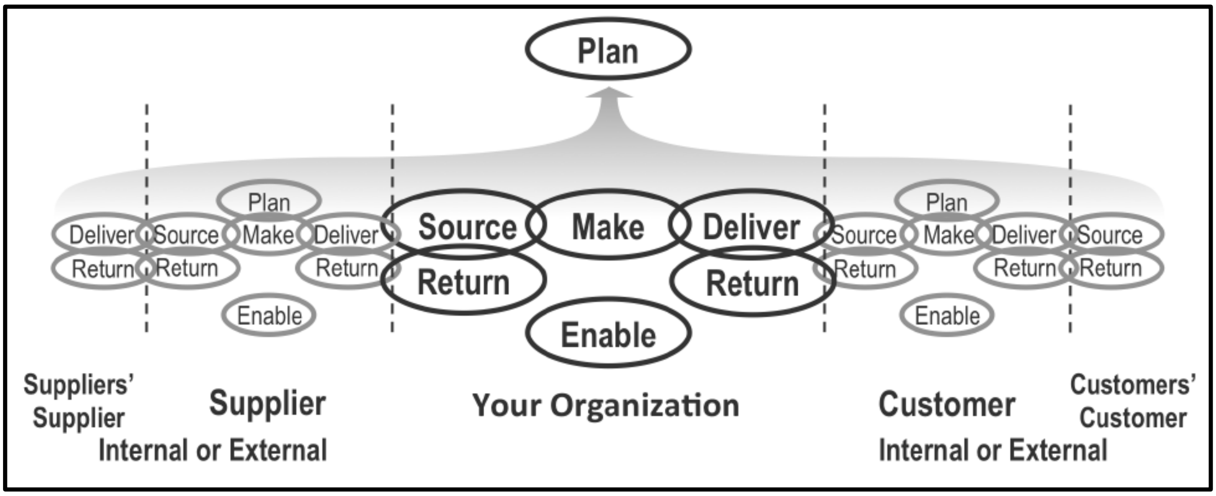

Figure 4: The Supply Chain Operations Reference Model (Supply Chain Council, 2013)

4.4.2 Deloitte Integrated Supply Chain Toolkit

The Deloitte Integrated Supply Chain (DISC) toolkit is based on the Supply Chain Council SCOR model, but enhanced for a more holistic approach to supply chain assessments. The

DISC features a framework for rapid diagnostics on the state of supply chains, identifying improvement opportunities that deliver significant value.

The DISC toolkit contains a set of questionnaires, capability maturity models and data collection templates. The capability maturity models allow the user to start assessing the supply chain while waiting for industry specific metrics and benchmarks for the company.

Below are some of the major benefits of using the DISC toolkit as a framework for supply chain assessment:

- Get a clear understanding of supply chain interdependencies
- Comprehensively diagnose pain points in the supply chain
- Accelerate data gathering and analysis
- Reduce project duration
- Reduce resource costs
- The DISC toolkit is based on the SCOR model consequently there are a lot of industry benchmarks available to compare a company' current AS-IS state too.

4.5 NSA Supply Chain Assessment

Due to the benefits highlighted in section 4.4.2 the supply chain assessment was conducted based on the Deloitte Integrated Supply Chain (DISC) toolkit principles and guidelines. The problem investigation focus on the PLAN (supply chain planning), SOURCE (sourcing and procurement) and DELIVER (logistics and distribution) areas and assess them according to NSA's business strategy with the goal to maximise NSA's competitive advantage. For the various "As-Is" PLAN, SOURCE and DELIVER process maps please refer to section 8.7 – 8.11.

The purpose of the qualitative assessment performed of this section is to highlight areas where the processes are lacking in maturity for a particular function. The qualitative assessment was conducted against a best practice profile developed by Deloitte.

4.5.1 Qualitative Assessment (PLAN)

The qualitative assessment consist of gap analyses, maturity models industry insight used to identify qualitative gaps in NSA's supply chain capability. Gap analysis often helps to determine the root cause of sub-optimal supply chain performance. A rigorously and competently performed gap analysis is seen as the foundation of opportunity identification.

The PLAN gap analysis, table 1, below provides a graphical representation of the findings from qualitative assessment conducted using the maturity models (section 8.4) to assess NSA's performance in terms of the PLAN function.

Maturity Model - Gap Analysis (PLAN)	*Lagging*	*Developing*	*Performing*	*Leading*
Demand Planning				
Enterprise Forecasting				
Demand Sensing				
Customer Collaboration				
Integrated Business Planning				
Innovation and Discontinuation				
Financial Reconciliation				
Supply Balancing				
Sales & Operations Meeting				
Production Planning				
Capacity Planning				
Master Production Scheduling				
Inventory Planning				
Track Product Lots and Batches				
Plan and Manage Inventory				
Inventory Control				
Material Requirements Planning				
BOM Explosion & Inventory Netting				
Manage Material Requirements				
Manage Inbound Receipts				
Distribution Requirements Planning				
Plan Distribution Requirements				
Deploy Constrained Supply and Publish Plan				

Table 1: Maturity Model – Gap Analysis(PLAN)

4.5.2.1 Demand Planning

Demand planning is performed by aggregating demand and incorporating market intelligence to generate a forecasted demand. The main inputs of a typical demand forecast are historical demand, market trends, competitive intelligence, new product introductions, discontinued product information, pricing plans, promotion plans, and seasonal factors. Inputs are prioritised to maximise customer benefit.

The analysis of NSA's demand planning falls into three categories; the rating received for the specific category will be indicated in bracket next to the heading:

Enterprise Forecasting (Performing)

Enterprise forecasting measures how well demand inputs incorporates the business intelligence of the applicable functions. Enterprise forecasting also evaluates the rationale / assumptions behind the inputs of a demand forecast.

It is important to have a repeatable, systematic process that is focused on understanding the various inputs to ensure an accurate demand forecast. Collaboration and consensus between all concerned business units and well trained personnel with statistical and supply chain experience are keys to generating an accurate forecast. Figure 5, below indicates a suggested forecasting framework:

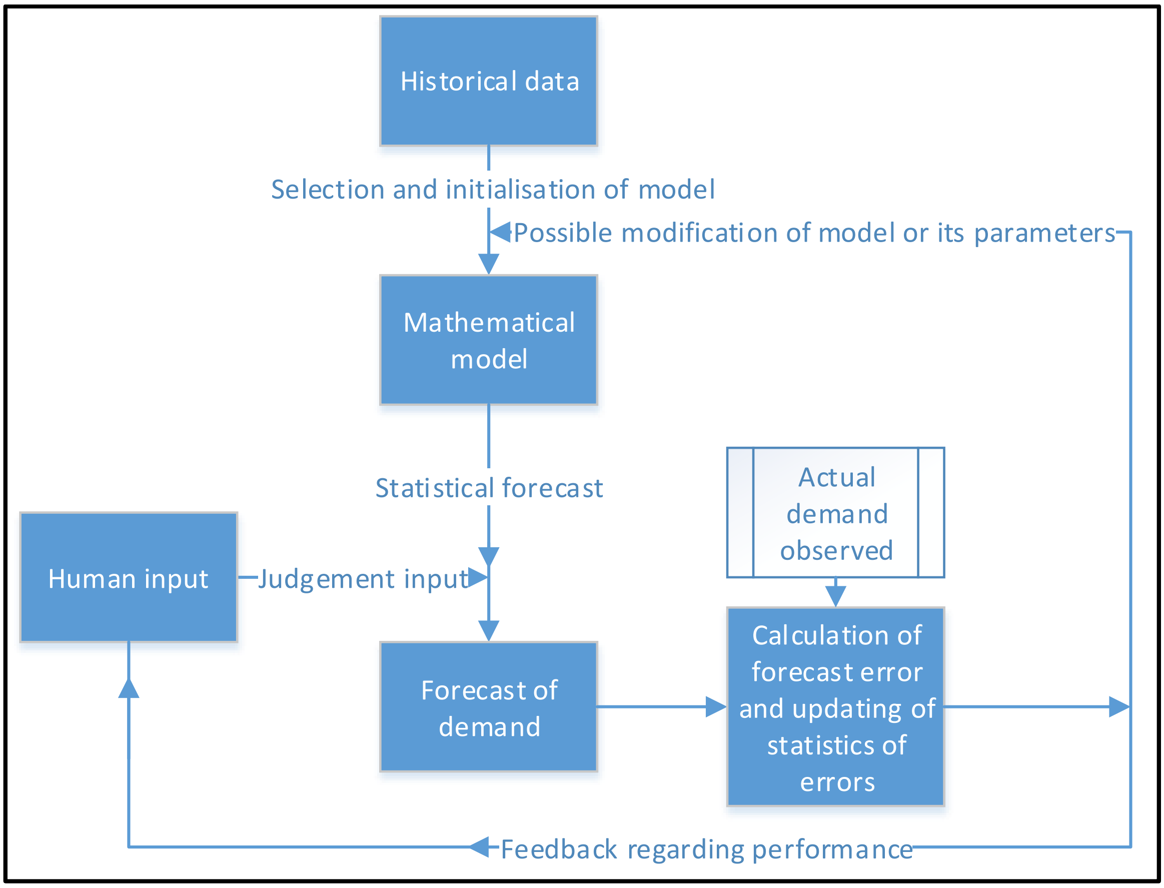

Figure 5: A suggested Forecasting Framework (Peterson, et al., 1998)

Demand Sensing (Developing)

Demand sensing measures how well a company reacts to, and manages consumer data. The diversity and availability of consumer related data is an important factor in creating an accurate forecast. The accurate interpretation of historical demand trends and trend analysis for demand forecast can provide a holistic demand sensing forecast.

It is important to understand how consumer data is used in the forecasting process and how this differs in the short term from the long term forecasting horizon.

Customer Collaboration (Developing)

Customer collaboration measures the inter-company collaboration. The plant (NSA plant at Rosslyn), suppliers and dealerships should openly share their forecasts to promote inter-company collaboration. This may help minimise the impact of unforeseen changes in demand and supply from trading partners on company operations.

There are advanced methods such as Collaborative Planning, Forecasting & Replenishment (CPFR) that allow linking of supply chain partners to jointly plan, forecast and replenish using the internet and pre-defined agreed upon policies/ processes. The trade-off between inventory and customer service is altered according to the CPFR (Oliveira & Barratt, 2001).

4.5.2.2 Integrated Business Planning (Sales & Operations)

Integrated business planning is a cross-functional, monthly process with the objective of reaching consensus and setting future direction in a single production plan. This process aims to balance critical resources (for e.g. people, capacity, materials and time) and budget to meet the needs of the marketplace in a profitable way. The analysis of NSA's integrated business planning falls into four categories; the rating received for the specific category will be indicated in bracket next to the heading:

Innovation and Discontinuation (Performing)

Innovation and discontinuation measures the incorporation of innovation strategies and product exit strategies into the forecast. A current example of product exit strategy will be what Nissan is doing for the current Nissan Qashqai model which will be replaced by a newer model later this year. Currently there is a limited edition model, various advertising campaigns and promotions to spike the demand for this vehicle so that the existing stock can be cleared out. If the current model Qashqai's stock is not depleted before the new model is introduced into the market, it will be very difficult to sell and might force dealers into dropping the price for the older model. This is why it is crucial to incorporate the product lifecycle consideration into the forecasting and sale and operations (S&OP) processes.

Financial Reconciliation (Performing)

Financial reconciliation validates the reconciliation of the marketing as well as the strategic plan. A well-defined financial reconciliation process helps to identify gaps and resolve issues in a timely fashion. Figure 6, below indicates the typical steps involved in a reconciliation process, as well as the four main categories of reconciliation solution:

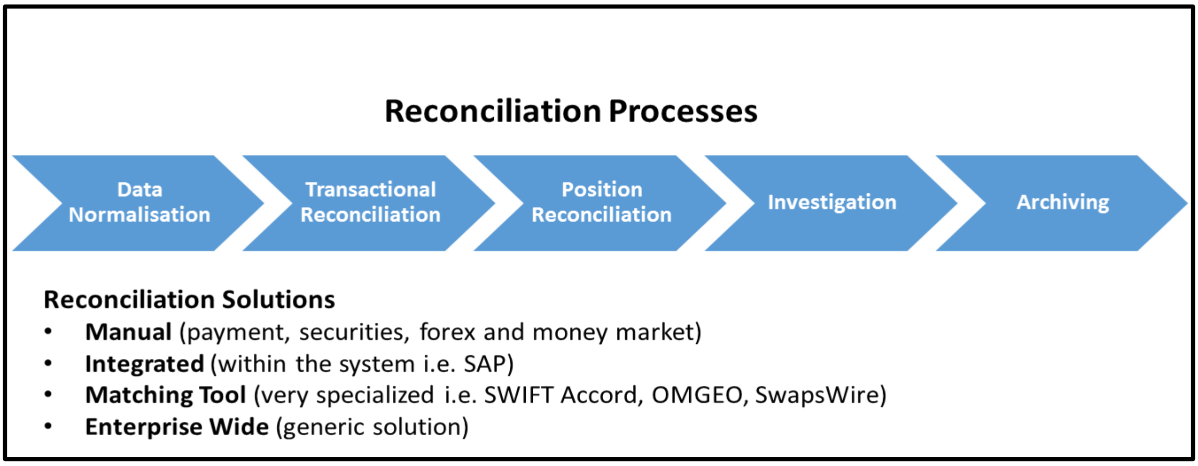

Figure 6: Reconciliation Processes (Savatier, 2011)

Supply Balancing (Developing)

Supply balancing measure the maturity of the processes involved in identifying gaps between demand and the resources available. Supply balancing operations are key to the development of the initial operating plans and recommendations for resource trade-offs.

Sales & Operations Meeting (Developing)

This section evaluates the quality of the Sales & Operations (S&OP) meetings to see if they would help to align the sales and operations plans of the company with the top management's perspective of organizational goals of product quality, service and cost. Presence of key stakeholders in an S&OP meeting ensures agreement and alignment of sales and operations plans with financial plans.

4.5.2.3 Production Planning

Production planning is the quarterly or monthly process of creating a long term, formal plan of production activity in monthly buckets at the product group level. Main inputs to the production plan are forecasting, strategic planning, financial planning, and available resources. Available resources include production, procurement and inventory capabilities. The time horizon should extend far enough into the future, approximately 18 months (based on best practices), for the plan to be adjusted or for resources to be increased without causing disruptions in day to day operations. The analysis of NSA's production planning falls into two categories; the rating received for the specific category will be indicated in bracket next to the heading:

Capacity Planning (Leading)

Capacity planning consists of long range network capacity plans and the capital budget inputs involved with capacity planning. It also resolves supply exceptions and determines initial product- to-plant allocations.

The section evaluates following to help ensure accurate production plans: A well-defined procedure exist across different planning horizons, there is good understanding of the demand, market and supply parameters use of advanced tools for planning and instituting Key Performance Indicators (KPI's).

Master Production Scheduling (Leading)

According to Harrison & Van Hoek (2011) the Master Production Schedule (MPS) is the disaggregated form of the sales order processing. The MPS evaluate production requirements against capacities and resolves exceptions to determine weekly production quantities. A well-developed master production schedule helps to smooth execution of the production plans. This includes management of pre-build requirements.

4.5.2.4 Inventory Planning

Inventory Planning, plans inventory levels, order quantities, safety stock, and lead times which drive company inventory and customer service levels based on established inventory policies. According to a study conducted by Jaber (2009), the fundamentals of modern inventory research is based on the three pillars:

- Inventory can be managed independently of other managerial circumstances (such as logistics, operations, or financial resources). This makes it possible to treat inventories via a single, controlled variable.
- The main role of inventories is to function as a buffer that can be used to smoothen processes and maintain flexibility across various organisational business units.
- The performance measure of operation of the inventory system is the level of total cost associated with the sum of holding and replenishing inventories and to handling shortages.

The analysis of NSA's inventory planning falls into three categories; the rating received for the specific category will be indicated in bracket next to the heading:

Track Product Lots and Batches (Leading)

Track product lots and batches measures how well a company tracks its products from point of origin through manufacturing and warehousing to the ultimate customer destination. Tracking products lots and batches entails the monitoring of batch information, labeling for tracking materials. Tracking may require the implementation of various technologies (e.g. bar coding and Radio Frequency Identification). Best practice also includes the monitoring of environmental and social criteria.Lot and batch traceability with real time systemic inventory visibility helps to improve inventory management and customer service.

Plan and Manage Inventory (Leading)

Planning and managing of inventory measures how well the execution of the strategy to achieve desired levels of inventory, order quantities, safety stock and lead times is performed. Clear roles and responsibilities and well-trained inventory management professionals are pre-requisites for an efficient and effective inventory planning system.

Understanding the key drivers of inventory movement and instituting KPIs for measuring inventory planning performance helps to improve accuracy of plans, reduce costs and better meet service requirements.

Inventory Control (Leading)

Inventory should be controlled in such a way that inventory turns are maximised and the working capital outlay minimised. Inventory control measures how well the following activities are performed: Monitoring inventory levels and planning replenishment, triggering replenishment orders, controlling supplier consignment stocks and managing physical inventories (including cycle counting).

A cycle count program along with a yearly physical inventory count is good inventory control practice. Multi-echelon models for calculation of Economic Order Quantities (EOQ) and safety stock help to minimise inventory levels and reduce the risk of stock outs.

4.5.2.5 Material Requirements Planning

Material Requirement Planning (MRP) is the process of using the MPS to calculate when manufactured goods are to be produced and providing recommendations for when material replenishment orders are to be released. MRP determines both the quantity of materials and the date that the materials will be required. Figure 7, below provides a high level overview of NSA's MRP and ordering:

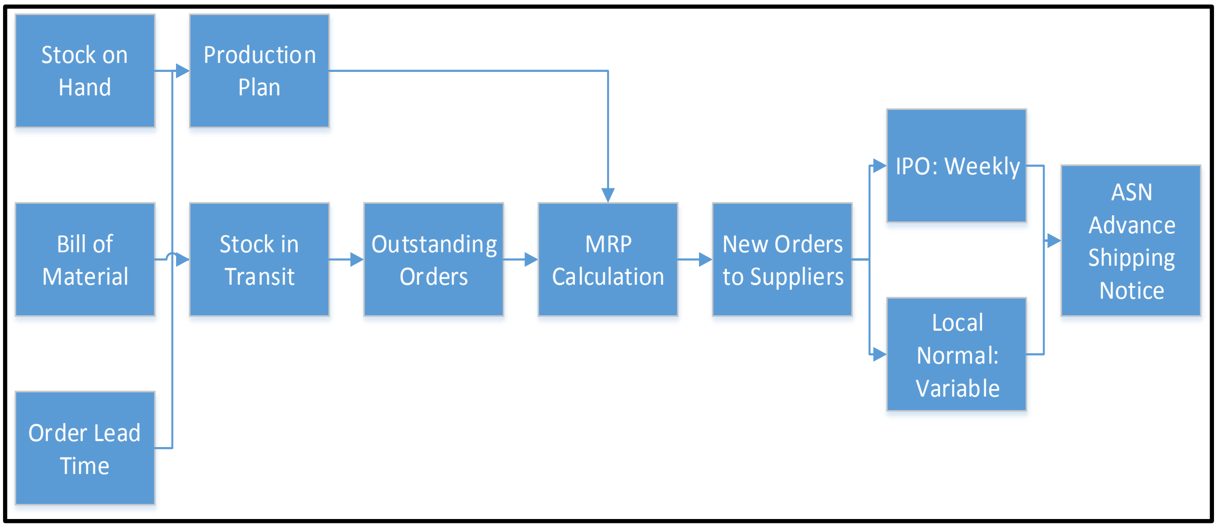

Figure 7: High Level Overview of NSA MRP Ordering

The analysis of NSA's MRP falls into three categories; the rating received for the specific category will be indicated in bracket next to the heading:

<u>BOM Explosion and Inventory Netting</u> (Leading)

Bill of Material (BOM) explosion and inventory netting measures how well the process is performed to deduct the BOM from on-hand inventory and safety stock requirements in order to drive a time phased replenishment system. Understanding the details of the BOM explosion process will give insight into potential areas of opportunity.

Manage Material Requirements (Leading)

Manage material requirements to what level of detail the purchase order requirements are netted against on-hand materials and safety stock levels. Visibility across different business units and geographies, reinforced with a well-defined process and use of data management systems, help to improve and efficiency of the materials planning process.

Manage Inbound Receipts (Leading)

This section measures the maturity of the processes involved with the management of inbound receipts for a production schedule. Inbound receipts must be managed regularly to cater for changes in production schedule.

4.5.2.6 Distribution Requirements Planning

Distribution Requirements Planning is the process of determining the need to replenish inventory at warehouses through production while meeting customer service guidelines and inventory levels specified by management policies. A time phased order point approach is established and planned orders are driven by the actual requirements by date. The analysis of NSA's distribution requirements planning falls into two categories; the rating received for the specific category will be indicated in bracket next to the heading:

Plan Distribution Requirements (Performing)

Plan distribution requirements measures how well the following activities are performed: Reviewing inventory policy, determining safety stock required for different Stock Keeping Units (SKUs), preparing consistent data for planning and developing what-if scenario planning with different capacity parameters for Sales and Operation (S&OP) meetings.

Understanding the key drivers for the replenishment and redeployment of inventory will improve the accuracy of the distribution requirements plan.

Deploy Constrained Supply and Publish Plan (Leading)

Deploy constrained supply and publish plan measures how well / accurate the deployment plans are executed. The development of accurate deployment plans depends on the execution of a clearly defined Distribution Requirements Planning (DRP) processes with realistic considerations of warehouse and transportation constraints. It involves the management of supply shortages, exceptions and referrals. The use of a well-integrated DRP systems by qualified and trained supply chain professionals can improve the efficiency of the deployment planning process.

4.5.3 Qualitative Assessment (SOURCE)

The SOURCE gap analysis, table 2, below provides a graphical representation of the findings from qualitative assessment conducted using the maturity models (section 8.5) to assess NSA's performance in terms of the SOURCE function.

Maturity Model - Gap Analysis (SOURCE)	*Lagging*	*Developing*	*Performing*	*Leading*
Business Initiatives				
Business Initiatives				
Sourcing Strategy				
Sourcing Strategy by Commodity				
Analyse Spend and Assess Opportunity				
Analyse Supply Market and Qualify Suppliers				
Conduct RFx/Auctions and Optimise Bid				
Negotiate Contract				
Select and Activate Supplier				
Finalise KPIs and Implement Contract				
Operational Procurement				
Requisition and Approval				
Purchase Orders				
Receive and Verify Product				
Authorize Supplier Payment				
Collect Performance Data				
Manage and Develop Suppliers				
Segment Suppliers				
Measure and Drive Performance				
Conduct Supplier Reviews				
Terminate / Transition Suppliers				
Track Continuous Improvement				
Manage Contracts				
Create Contract				
Monitor and Enforce Contracts				
Manage Commodities				
Develop Commodity Strategy				
Manage Commodity Price				
Manage Commodity Risk				
Integrate Commodity Supply Chain				

Table 2: Maturity Mode – Gap Analysis (SOURCE)

4.5.3.1 Business Initiatives

Business initiatives integrate the strategic sourcing capability and procurement execution to assist in corporate initiatives and strategic investments. The analysis of NSA's business initiatives falls into only one category; the rating received for the specific category will be indicated in bracket next to the heading:

Business Initiatives (Leading)

It is necessary to have a good understanding of the key corporate initiatives to align the procurement processes and business functions for optimal efficiency. It is also important to understand the capital asset and expense structure to make better decisions around utilization and procurement of capital assets.

4.5.3.2 Sourcing Strategy

The sourcing strategy is a set of procurement policies, processes, and procedures that enable efficient procurement of products (direct and indirect goods), services, and capital equipment. Precise category specifications will ensure better sourcing decisions which is why category specific information on the marketplace, suppliers and historical spending is key to the development of a sourcing strategy. The analysis of NSA's sourcing strategy falls into seven categories; the rating received for the specific category will be indicated in bracket next to the heading:

Define Sourcing Strategy by Commodity (Leading)

This section measures how well the sourcing strategy and tactics for each category are applied as well as the level of collaboration between the procurement organisation and internal groups. Best practices to define sourcing strategy by commodity include the following activities:

- Consider the relative importance of specific commodity and the quantity of those commodities in producing a good.
- Consider the public perception of certain commodities, potential to substitute, and competitor activities and select commodities that align with sustainable strategies.
- Define sustainability goals and standards.
- Assess the environmental impact of each commodity, considering all aspects – from carbon and/or water impact to the release of hazardous substances.

Analyse Spend and Assess Opportunity (Leading)

Analyse spend and assess opportunity measures how well the systematic categorization, archival, retrieval and analysis of spend-related information are performed. Opportunities are identified and prioritised according to a pre-defined set of decision making criteria.
Spend also includes a contract management process which provides timely updates on which contracts are up for renewal.

Analyse Supply Market and Qualify Suppliers (Leading)

Analyse supply market and qualify suppliers' measures how well a company keeps track of industry trends and changes in the supplier base (in order to choose the best times to source a category). Best practice in analysing supply market and qualifying suppliers is to use technology in order to automate the definition and management of a preferred supplier network.

Conduct RFx/Auctions and Optimise Bid (Leading)

Conduct RFx/auctions and optmise bid measures the process maturity of the processes used to: Conduct an RFx, create documents, do supplier qualification and send notification, perform event administration, as well as the evaluation and analysis to optimise a bid. Best practice indicates that it is advisable to use technology for the automation of workflow and analysis. The use of cross-functional stakeholder teams is also advisable as it can provide additional category-specific expertise and RFx evaluation assistance.

An RFx is a document that includes the following processes initiated by a buyer in order to solicit information proposals from multiple suppliers and competitive quotes. (An & Fromm, 2005)

Negotiate Contract (Leading)

Negotiate contracts evaluates the contracts to see if they were done in a way that capture maximum value from each supplier and bid. The negotiations team should have a good understanding of the following areas: Negotiation strategy, scenario modelling and the cost/benefit trade-off of commercial terms. The team should also integrate as best as possible the agreed upon sustainability metrics into the negotiated contract to enable monitoring and allow for enforcement.

Select and Activate Supplier (Performing)

This section measure how well a company evaluates a supplier before selecting the supplier or mix of suppliers depending on the feasibility. The select and activate supplier process should be conducted objectively and determine the optimal number and mix of suppliers for each region and category. Cross-functional stakeholders should participate in the process in order to determine a solution that can be implemented and accepted by the entire organisation.

Best practices indicates that contingency planning should be considered before choosing the final supplier(s).

KPIs and Implement Contract (Performing)

KPIs and implement contract measures a company's metrics in terms of sustainability and internal compliance to the preferred supplier lists and contracts. It also evaluates the company's reporting cycles based on best practices.

4.5.3.3 Operational Procurement

Accurate and efficient procurement of products and services in accordance to contracts, and policies insure that the terms and service agreements with suppliers on different categories are maintained with a list of exceptions for dispute resolution and supplier chargeback. The analysis of NSA's operational procurement falls into seven categories; the rating received for the specific category will be indicated in bracket next to the heading:

A lot of manufacturing companies have a supplier charge-back program, this is a program where a supplier is charged for the additional cost incurred by a manufacturer due to late deliveries from supplier and components not conforming to the quality specifications.
A charge-back system is an effective technique to enforce business discipline and accountability into a supply chain. (MetricStream Inc., 2014)

Requisition and Approval (Developing)

This section measures how well product and service requisition are performed, especially in terms of efficiency. Best practices indicate it is advisable to use technology to automate the requisition and approval workflow and distribute purchase requisition activity closest to the end-user.

Purchase Orders (Leading)

This section measures the process involved in issuing a Purchase Order (PO) to a supplier in terms of accuracy and efficiency. The use of technology, when appropriate, to issue automatic orders against blanket PO, track PO status, and reconcile PO discrepancies is advisable as it could drastically improve the accuracy and efficiency of the process.

Receive and Verify Product (Performing)

This section measures the process maturity of the processes that ensure timely feedback to the procurement department on any potential shipping issues from suppliers and/or include revised shipping specifications for future category sourcing. "Goods receipt" of indirect materials, direct materials, and services in compliance with Sarbanes-Oxley requirements.

The Sarbanes-Oxley act of 2002 was implemented to protect investors by ensuring that the corporate disclosures are accurate, reliable and comply to with various security laws.

Authorise Supplier Payment (Leading)

Authorise supplier payment measures the efficiency and accuracy of the supplier payment verification of goods receipt and PO matching. The payment process is instrumental in monitoring demand management and also achieving advantageous payment terms with suppliers.

Collect Performance Data (Leading)

This section is responsible for the measurement and collection of metrics used for continuous improvement of operational performance, including sustainability performance metrics.

4.5.3.4 Manage and Develop Suppliers

Manage and develop suppliers involves the segmentation of suppliers according to their relative value to an organization. The relative value of a supplier should be kept in mind when dedicating time and resources in order to optimise the supplier relationship. The analysis of NSA's manage and develop of supplier falls into five categories; the rating received for the specific category will be indicated in bracket next to the heading:

Segment Suppliers (Leading)

This section evaluates the segmentation of suppliers according to their relative value to the company (depending on the importance of the category and the dynamics of the supply market and ensuring segmentation is harmonized with overall business, program, and supplier collaboration strategies/goals). Focus areas of supplier segmentation usually include cost, supply chain performance and risk. Supplier segmentation consist of a defined approach that provides the necessary supplier relationship management team, process for reviews, and tools to effectively optimise each type (e.g., strategic vs. transactional) of supplier relationship.

According to Cox (2004) it is better to combine buyer-supplier relationship types with the power a distribution matrix than to examine them in isolation when performing a supplier/ buyer segmentation

Measure and Drive Performance (Performing)

Measure and drive performance involves the use of general and category-specific supplier metrics to evaluate supplier performance and drive continuous improvement. It involves the identification of current state metrics and collaboration between internal stakeholders and suppliers to set realistic and measurable targets for a consensus of expectations.

Conduct Supplier Reviews (Performing)

This section measures how well a company measures their suppliers' performance against service level agreements and industry specific metrics. Depending on the segmentation of supplier, internal stakeholders may be involved in the process. Formation of partnership with supplier at this phase is essential to timely completion of review and continued support with future efforts.

Terminate / Transition Suppliers (Leading)

Terminate / transition supplier measure how well or if a company performs the necessary steps to mitigate risk and minimize transition cost when terminating a suppliers contract. Typical reasons for termination of supplier contract includes the following: Poor performance, conflict of interest, failing supplier financial position and the inability to meet sustainability performance targets.

Track Continuous Improvement (Developing)

This section measures the maturity of processes involved in the tracking, resolution and continuous improvement of suppliers' performance. Depending on the importance of the category and performance of the supplier, the company may look to increase the level of integration with the supplier. Continued knowledge transfer and partnership with suppliers are key to future success of programs and relationship.

4.5.3.5 Manage Contracts

This section evaluates the systematic creation, execution, analysis and compliance enforcement of corporate contracts for the purpose of maximising operational performance, reducing costs, and minimizing risks (regulatory risk associated with environmental compliance). The analysis of NSA's management of contracts falls into two categories; the rating received for the specific category will be indicated in bracket next to the heading:

Create Contract (Leading)

Create contract measures the maturity of the processes involved with creation of commercial contracts. Industry best practice indicates the creation of contract aims should make efficient use of process, policy, and technology.

Monitor and Enforce Contracts (Performing)

This section measures the maturity of the processes involved to monitor and enforce contracts. The continuous monitoring, updating and enforcement of contracts ensures that suppliers meet commercial and legal requirements, and internal stakeholders comply with contract-related policies and processes.

4.5.3.6 Manage Commodities

Commodity management is a systematic approach to manage price volatility, and mitigate risk for a group of commodities. The analysis of NSA's commodity management falls into two categories; the rating received for the specific category will be indicated in bracket next to the heading:

Develop Commodity Strategy (Leading)

This section measures the commodity strategy in terms of alignment with the corporate strategy/ operating plan and integration with sustainability strategy.

Manage Commodity Price (Performing)

This section measures a company's ability to anticipate future commodity price volatility and structure supplier negotiations, contracts, and relationships to take advantage of price volatility and create a relative competitive advantage. Best practice for commodity price management is to also consider the impact that regulations have on prices to enable more effective management of supplier price volatility.

Manage Commodity Risk (Performing)

Commodity risk may be mitigated by operational, financial and contractual hedging. Manage commodity risk examines how well a company can quantify their total risk exposure (which includes regulatory changes and shifts in consumer preferences), and build the operational flexibility to adapt to changing market conditions. They also use financial instruments and contractual terms to dampen expected future volatility.

Integrate Commodity Supply Chain (Leading)

Integrate commodity supply chain measure a company's ability to coordinate the planning activities of internal department and functions, and the behaviour of external supply chain partners to reduce commodity cost and mitigate risk of commodity volatility.

Note on SOURCE:

The findings regarding SOURCE were shared with NSA procurement/ sourcing department. A new procurement tool Natrix was obtained by NSA and the procurement tool appeared to be promising. A recommendation was also made to have a cross functional team to hasten the requisition and approval process for new product launches.

Due to the reason mentioned above SOURCE will be excluded from the quantitative assessment

4.5.4 Qualitative Assessment (DELIVER)

The DELIVER gap analysis, table 3, below provides a graphical representation of the findings from qualitative assessment conducted using the maturity models (section 8.6) to assess NSA's performance in terms of the DELIVER function.

Maturity Model - Gap Analysis (DELIVER)	*Lagging*	*Developing*	*Performing*	*Leading*
Process Orders				
Process Inquiry and Quote – Term, Policies and Procedures				
Receive, Enter & Validate Order				
Check for Inventory Availability, Reserve Inventory & Determine Delivery Date				
Release and Consolidate Orders				
Generate Invoice and Collect Payment				
Process Complaints and Inquiries				
Manage Warehousing				
Receive Product from Source (Supplier) or Make (Production)				
Pick Product				
Pack and Label Shipment				
Manage Warehouse Operations				
Manage Transportation				
Build Loads				
Route Shipments				
Select, Rate and Schedule Shipments				
Load Vehicle and Generate Shipping Documents				
Deliver Product to Customer				
Manage Import / Export and Customs Compliance				
Manage and Operate Transportation Assets				
Manage Freight Pay and Audit Processes				

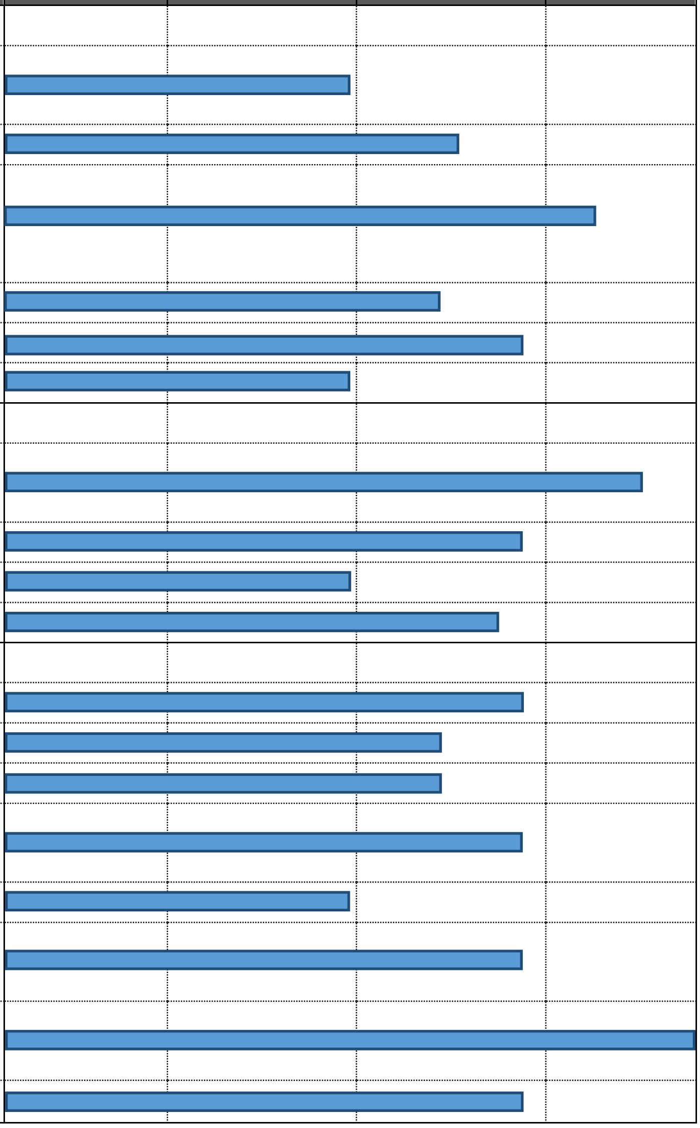

Table 3: Maturity Model – Gap Analysis (DELIVER)

4.5.4.1 Process Orders

Process orders include all operational activities right from inquiry about orders, to order receipt and validation, checking for inventory availability and releasing orders to pick and process, invoicing and collections and managing customer complaints/issues. The analysis of NSA's order processing falls into six categories; the rating received for the specific category will be indicated in bracket next to the heading:

Process Inquiry and Quote – Term, Policies and Procedures (Developing)

The section measures how well a company define and maintain the rules which affect the acceptance of an order, based on quantity, method of delivery, credit and customer experience.

Receive, Enter & Validate Order (Performing)

Receive, enter and validate order measures the performance of a company's order processing system. Orders can be received through multiple channels such as telephone, fax, or electronic media, and should be examined to ensure an orderable configuration and provide accurate pricing.

Check for Inventory Availability, Reserve Inventory & Determine Delivery Date (Leading)

This section measures how well inventory and/or planned capacity (both on hand and scheduled) is recognised for specific orders and a delivery date is scheduled by a company.

Release and Consolidate Orders (Performing)

Release and consolidate orders measures the maturity of the involved in releasing an order to be shipped from the shipping location/warehouse. Best practice includes the process of analysing orders to determine the groupings that result in least cost/least environmental impact/best service fulfilment and transportation.

Generate Invoice and Collect Payment (Leading)

This section measures the maturity of the processes involved in generating an invoice and collecting payments. This typically includes the following: A signal is sent to the financial organization that the order has been shipped and that the billing process should begin and payment be received or be closed out if payment has already been received. Payment is received from the customer within the payment terms of the invoice.

Process Complaints and Inquiries (Developing)

Process complaints and inquiries measure the maturity of the processes involved in handling and mitigating customer inquiries and complaints.

4.5.4.2 Manage Warehousing

Manage warehousing includes all activities involved in the management of all warehouse operations (receiving, storage, picking, packing and labeling), assets and labour. The analysis of NSA's warehouse management falls into four categories; the rating received for the specific category will be indicated in bracket next to the heading:

Receive Product from Source (Supplier) or Make (Production) (Leading)

Receive product from source or make measures the maturity of the following processes: Receiving product at a warehouse or distribution centre, verifying, recording product receipt, determining put-away location, putting away and recording storage location. Best practice includes quality inspection procedures to verify received product quality.

Pick Product (Performing)

Pick product measures the performance of the series of activities included in retrieving orders to pick, determining inventory availability, building the pick wave, picking the product, recording the pick and sending product for packing and labeling in response to an order.

Pack and Label Shipment (Developing)

This section measures the performance of activities such as sorting / combining the products, packing / kitting the products, paste labels and barcodes, adding customer invoices and sending the products to the shipping area for loading.

Manage Warehouse Operations (Performing)

Manage warehouse operations measures how well a company performs storage and logistics operations. Best practice includes cross-docking, wave picking and simulation for optimal space utilisation.

4.5.4.3 Manage Transportation

Manage transportation includes all activities required to comply with import and export policies of international shipments as well as the management of transportation operations (right from building loads selecting carrier and vehicle loading, to product delivery) and the equipment used in transportation. The analysis of NSA's transportation management falls into eight categories; the rating received for the specific category will be indicated in bracket next to the heading:

Build Loads (Performing)

This section evaluates the selected transportation modes to for efficiency, cost and environmental impact. Best practice in terms of build loads involves the integration of inbound and outbound logistics using a Transportation Managements System (TMS).

Route Shipments (Performing)

Route shipments measures a company's transportation planning. Route shipments involve load consolidation by route, mode, lane and location with consideration to the environmental impact of the route selected.

Select, Rate and Schedule Shipments (Performing)

This section measures how well carriers are selected, based on cost per route and environmental records.

Load Vehicle and Generate Shipping Documents (Performing)

Load vehicle and generate shipping documents measures the maturity of the processes involved in loading products onto modes of transportation and generating the documentation necessary to meet internal, customer, carrier and government needs. Best practice includes the automated Bill of Lading (BOL).

Deliver Product to Customer (Developing)

Deliver product to customer measures the maturity of the processes involved with delivering the shipments to the customer site and verifying that the order was shipped complete and meets delivery terms. Best practice includes sending an Advanced Shipping Notification (ASN) to the customer.

Manage Import / Export and Customs Compliance (Performing)

This section measures the maturity of the processes involved within recording and maintaining import and export regulations and rates, determine customs requirements and also to establish letters of credit terms and conditions. Best practice includes carbon tariff consideration when managing custom compliance.

Manage and Operate Transportation Assets (Leading)

This section measures the maturity of processes involved with managing and operating the private fleet (if any) of transportation assets with a focus on least cost and minimisation of environmental impact during transport.

Manage Freight Pay and Audit Processes (Performing)

Manage freight pay and audit processes measure the maturity of processes involved in making payments on freight invoices and auditing freight invoices for overcharges against the agreed contracted rates and service levels.

4.5.5 Quantitative Assessment (PLAN)

The purpose of the quantitative assessment is to benchmark NSA against other auto manufacturing companies. Benchmarking allows a company to strategically prioritise improvement opportunities, and provides an indication of the performance expectation.

Key Benchmarks (PLAN)	*Sample Size*	*Median Metric Value*	*NSA Metric Value*
Demand Planning			
Demand planning cost as a percentage of revenue	197	0.14%	0.08%
Forecast accuracy	29	80.0%	49.6%
Integrated Business Planning			
Cash-to-cash cycle time in days	899	52.0 days	59.9 days
Production Planning			
Unplanned machine downtime as percentage of scheduled run time unaccounted time to be downtime	21	2.2%	2.4%
Actual production rate as percentage of the maximum capable production	21	88.0%	88.9%
Inventory Planning			
Inventory carrying cost as percentage of average inventory value	208	6.0%	0.48%
Annual inventory turns (based on COGS)	29	3.1	3.03
Material Requirements Planning			
Order fill rate in percentage	29	96%	100%

Table 4: Key Benchmarks for PLAN

4.5.5.1 Demand Planning

Demand planning cost as a percentage of revenue (Performing)

Demand planning cost includes all the cost involved in forecasting customer demand and coordinating inventory plans across the end to end supply chain to meet the forecasted customer demand.

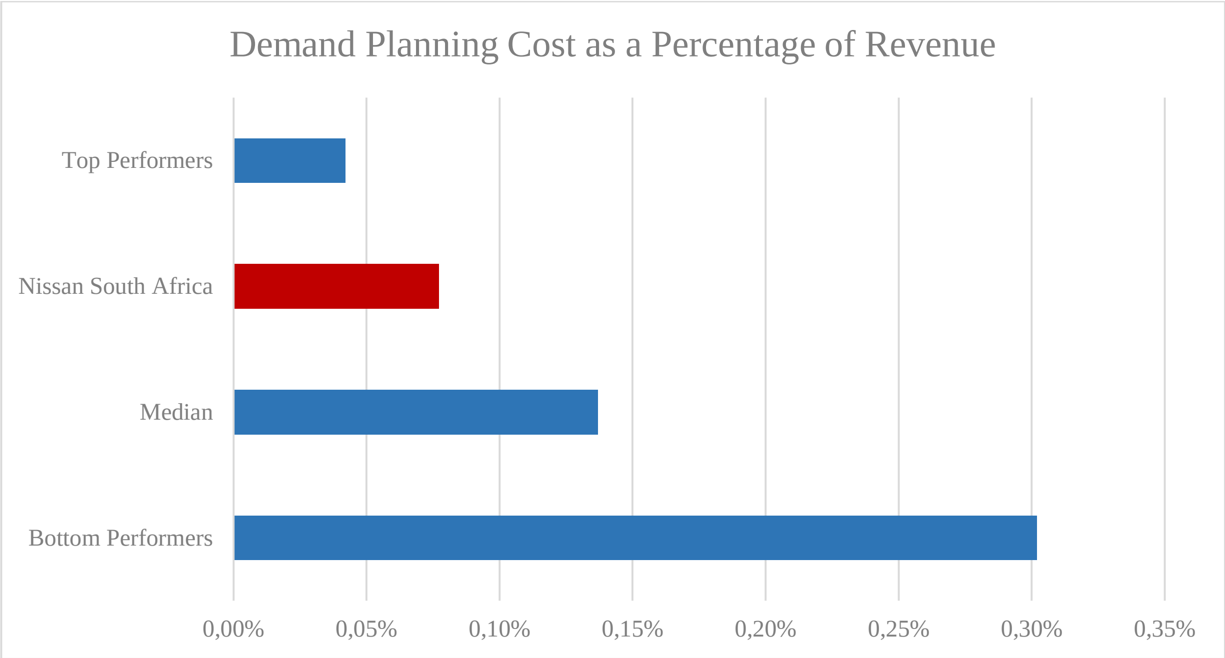

Figure 8: Demand Planning Cost as a Percentage of Revenue

Demand planning cost can be reduced by standardising the supply chain procedures and policies. Well defined and streamlined processes allow for automation of certain procedures enabling working capital reduction as well as the risk for user bias introduced into the forecast. Leading companies incorporate real time demand data into supply chain planning allowing the supply chain to be more responsive to consumer trends. (APQC, 2014)

Forecast Accuracy (Lagging)

Forecast accuracy measure how well forecast sales tracks to actual sales.

Let:

E_t = forecast error for period *t*

A_t = forecast value for period *t*

F_t = forecast for period *t*

t = the time series $\{i = 1, 2, 3, \dots, n\}$

$MAPE$ = Mean Absolute Percentage Error

Then:

$$MAPE = \frac{100\%}{n} \sum_{t=1}^{n} \left| \frac{A_t - F_t}{At} \right|$$

And:

$$forecast\ accuracy = 100\% - MAPE$$

In certain instances MAPE can be larger than 100%, then the forecast accuracy is 0%. Forecast accuracy is a percentage value between 0% and 100%, it cannot be less than 0%. Please consider the following example. (DemandPlanning.Net, 2014)

	SKU A	***SKU B***	***SKU X***	***SKU Y***
Forecast	75	0	25	75
Actual	25	50	75	74
Error	50	50	50	1
Error (%)	200%	100%	67%	1%
Accuracy (%)	0%	0%	33%	99%

Table 5: Percentage Error and the Impact on Forecast Accuracy (DemandPlanning.Net. 2014)

When reviewing data, a reviewer can introduce bias into a meta-analysis in four ways: excluding relevant research, including irrelevant results, by fitting inappropriate statistical models to the data, and by running analyses with insufficient statistical power. (Ellis, 2010)

4.5.5.2 Integrated Business Planning

Cash-to-cash cycle time in days (Developing)

Cash-to-Cash cycle time measures the time from when a company spends money to procure (SOURCE) materials/ products until the company receives payment for selling (post-DELIVER) the materials/ products.

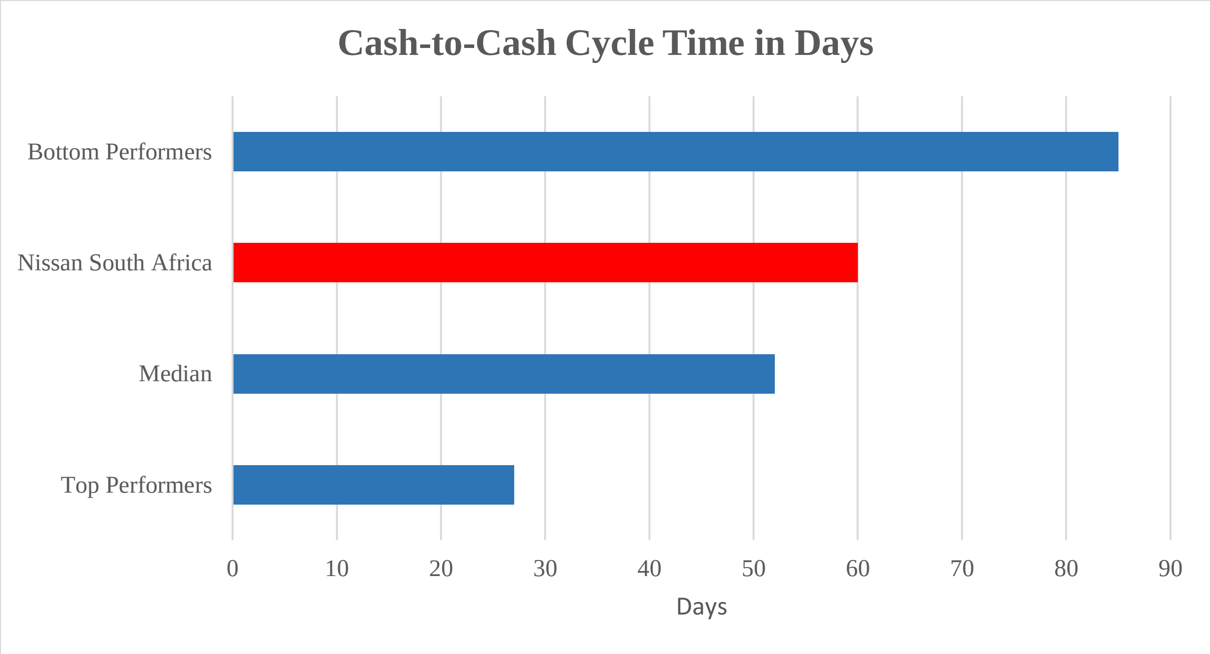

Figure 9: Cash-to-Cash Cycle Time in Days

Longer cash-to-cash cycle times are associated with higher risk and also contribute to lost opportunity cost, since the operating capital ("cash") could have been invested elsewhere. Optimizing inventory by reducing inventory while maintaining the necessary stock to meet customer demand, will improve the cash-to-cash cycle. To achieve an optimised inventory strategy it is essential to identify and align the processes involved in obtaining, transforming and delivering the product to the customer. (APQC, 2014). The following metrics measure the main drivers of cash-to-cash cycle time: days payable outstanding, days inventory, days sales outstanding.

4.5.5.3 Production Planning

Unplanned machine downtime as a percentage of scheduled run time (Performing)

Unplanned downtime can cause serious disruptions in the production schedule, and ultimately reduce the return on investment of plant equipment due to lower utilisation of equipment caused by the unplanned downtime. To avoid/ reduce the occurrence of unplanned machine downtime a preventive maintenance program should be installed. (APQC, 2014). The graph below indicates how NSA compares to the industry median metric value for unplanned machine downtime.

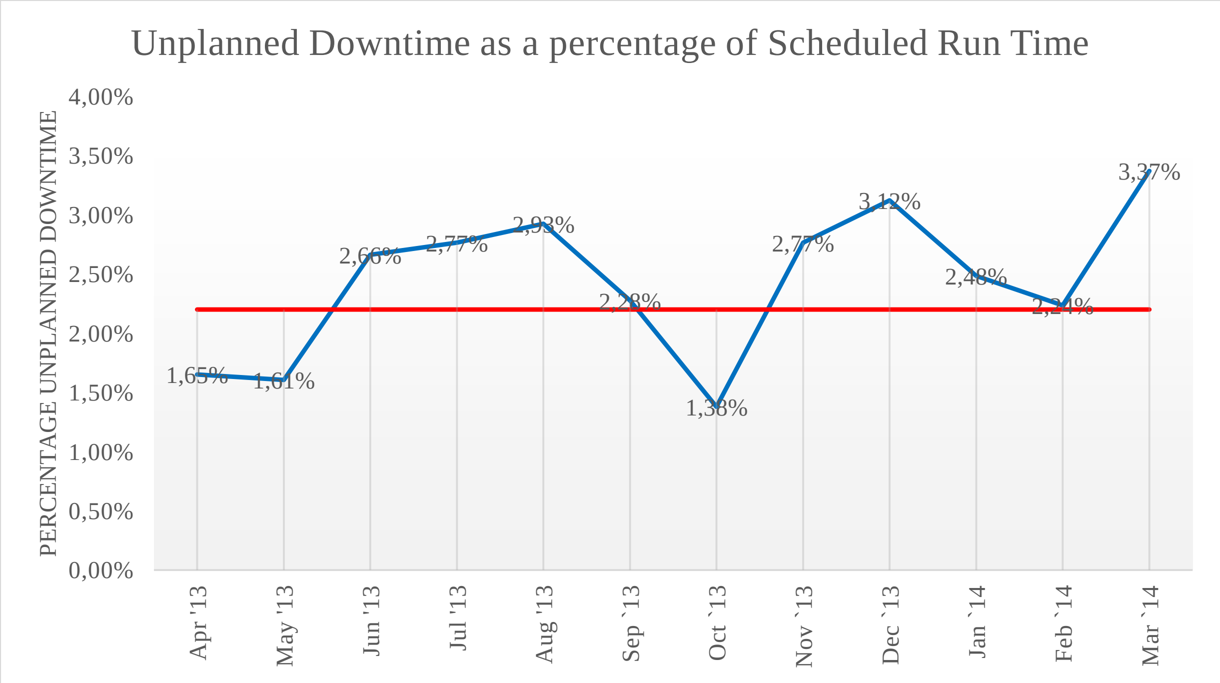

Figure 10: Unplanned Machine Downtime

<u>Actual production rate as a percentage of the maximum capable production</u>

Actual production rate as a percentage of the maximum capable production provides an indication of the plant equipment utilization, and also links up to the return on investment for the plant equipment.

4.5.5.4 Inventory Planning

<u>Inventory carrying cost as a percentage of average inventory value</u> (Leading)

Inventory carrying cost plays a major role in determining the economic order quantity, it is the cost associated with having inventory on hand for a given time period.

Calculation:

- Step 1: Add up the annual inventory cost: storage cost, material handling cost and insurance.
- Step 2: Add the cost of lost opportunity of capital (interest that could have been earned if the inventory was sold).
- Step 3: Divide the total inventory cost (lost opportunity cost included) by the average inventory value. (SupplyChainMetric, 2014).

Annual inventory turns (Performing)

Annual inventory turns serves as an indication of whether the “correct” quantity of inventory is kept.

Calculation:

$$Inventory\ Turns = \frac{Cost\ of\ Goods\ Sold}{Average\ Inventory}$$

In the automotive industry 3.1 annual inventory turns and greater are seen as an acceptable frequency. Too few inventory turns can mean the following - too much inventory is kept on hand or the wrong inventory is kept on hand or both. (IAC, 2014).

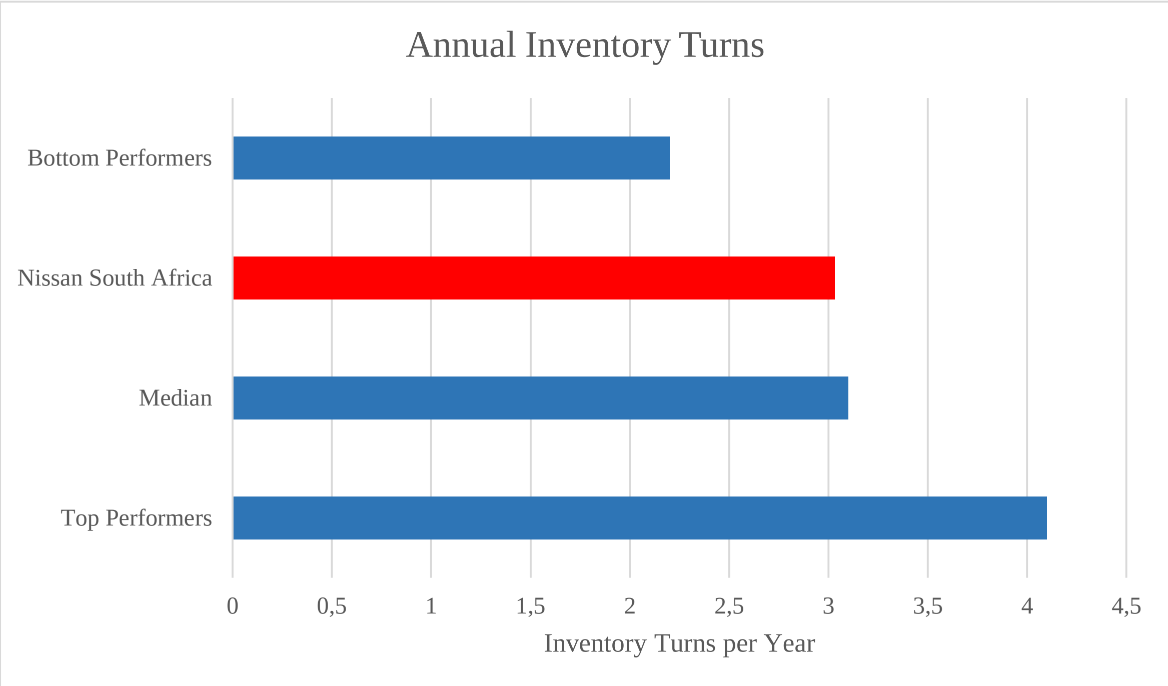

Figure 11: Annual Inventory Turns

4.5.5.5 Material Requirements Planning

Order fill rate in percentage (Leading)

Order fill rate is a measure of the inventory's capacity to meet demand.

Calculation:

$$Line\ Item\ Fill\ Rate = 100 \times \left(\frac{Line\ Items\ Filled\ From\ Stock}{Line\ Items\ Ordered}\right)$$

The order fill rate needs to be kept as high as possible to avoid delays in production. (MBASkool, 2008).

4.5.6 Quantitative Assessment (DELIVER)

Key Benchmarks (DELIVER)	*Sample Size*	*Median Metric Value*	*NSA Metric Value*
Process Orders			
Perfect Order Fulfilment	29	95.25%	50.51%
Manage Warehousing			
Dock-to-stock cycle time in hours for supplier deliveries	26	4.0 hours	10.4 hours
Inventory accuracy	22	97.5%	100%
Pick-to-ship cycle time in hours for customer orders	24	15.1 hours	26.3 hours
Total cost to operate warehousing as a percentage of revenue	27	0.64%	0.55%
Manage Transportation			
Inbound transportation cost as percentage of revenue	29	3.5%	6.7%
Outbound transportation cost as percentage of revenue	29	5.0%	2.8%
Total logistics cost as a percentage of revenue	29	11.7%	10.0%

Table 6: Key Benchmarks for DELIVER

4.5.6.1 Process Orders

Perfect Order Fulfilment (Lagging)

Perfect order fulfilment is a composite metric/ quality measure that calculates the probability of delivering a perfect order to the customer. (Deloitte, 2009) Perfect order fulfilment is calculated on the following base components:

- On Time delivery percentage
- In full (product is according to specified requirements i.e. model and colour).
- Without damages

Let:

A = On Time Delivery %
B = In full %
C = Without Damages %

Then:

$$Perfect\ Order\ Fulfilment = A \times B \times C$$

Perfect order fulfilment is arguably the most important metric concerning customer satisfaction available at present. If the perfect order fulfilment rate is low a root cause analysis should be conducted so that the true problem of customer dissatisfaction can be resolved.

4.5.6.2 Manage Warehousing

Dock-to-stock cycle time in hours for supplier deliveries (Lagging)

The dock-to-stock cycle time is the time required to store the products/materials delivered by suppliers. The cycle time starts from when products/materials arrive until the products/materials are warehoused and recorded in the inventory management system. (WERC, MESA, SCE, 2008).

Inventory Accuracy (Leading)

Inventory accuracy indicates the variation between the perceived and the actual inventory as a percentage value.

Calculation:

$$Inventory\ Accuracy = 100 \times \left(\frac{Number\ of\ Items\ With\ Correct\ Inventory\ Counts}{Total\ Number\ of\ Inventory\ Counts}\right)$$

Companies with inaccurate inventories run two major risks:

- The company might sell products not in stock, resulting in an unfulfilled customer request.
- The company would fail to sell products that are in stock as a result of the lack of knowledge that the specific item is in stock. This would result in excess inventory that would eventually become obsolete.

To improve inventory accuracy regular inventory counts could be conducted also using technology such as RFID (Radio Frequency Identification) supported by inventory management software systems that incorporate RFDC (Radio Frequency Data Collection) equipment. The best practice is to conduct a Pareto analysis to determine the most important inventory items and then conduct more regular inventory counts on those specific items. (Brown & Williams, 2012).

Pick-to-ship cycle time in hours for customer orders (Lagging)

Pick-to-ship cycle time indicates the average time frame involved from when an order is released for picking until the order has been shipped or loaded on the carrier.

Total cost to operate warehousing as a percentage of revenue (Performing)

The total cost to perform the "process operate warehousing" includes the cost associated with the personnel, equipment and space involved in operating the warehouse. It excludes the cost associated with inventory value and outbound transportation.

The operational cost of warehousing may be decreased via process based strategies such as slotting so that the fast moving products are placed in a position that is easily accessible to the order picker and kept within close proximity of the product's destination. (APQC, 2014).

4.5.6.3 Manage Transportation

Inbound transportation cost as a percentage of revenue (Lagging)

The inbound transportation cost for Nissan is accumulated from the following four groups of activities:

- Imported vehicles transported from source country to Durban stock yard
- Imported vehicles transported from source country to NSA's stock yard in Rosslyn
- Imported parts from source country to NSA's container yard in Rosslyn
- Locally procured parts transported from source to NSA's local receiving yard in Rosslyn

Outbound transportation cost as percentage of revenue (Leading)

Outbound transportation cost for Nissan is accumulated from the following three groups of activities:

- Imported vehicles distributed from Durban to end destination
- Imported vehicles distributed from Rosslyn to end destination
- Locally built vehicles distributed from Rosslyn to end destination

Outbound transportation cost can be improved by improving truck fill rate. This carrier will then only transport the vehicles once a certain number of vehicles are ready to be transported on that specific route. Improving fill rate comes with a trade off since it may cause delivery delays. Proper planning is key to maintaining service level and holding transportation cost at a minimum.

Total logistics cost as a percentage of revenue (Leading)

The total logistics cost includes all the transportation costs as well as insurance, clearing, wharfage and handling cost.

4.5.7 Prioritization of the Improvement Opportunities

The following table provides a summary of the the improvement oppoertunities for PLAN and DELIVER activites within the NSA supply chain.

Improvement Opportunities	*Metric(s) that will be Impacted the most*	*Qualitative Assessment Result*	*Quantitative Assessment Result*
PLAN			
Demand Planning			
-Improve forecast accuracy through statistical modelling	-Forecast accuracy	Developing	Developing
Integrated Business Planning			
-Reduce lead times by determining best source of supply	-Cash-to-cash cycle time in days	Performing	Developing
Inventory Planning			
-Reduce production of slow moving inventory -Improve inventory visibility by enhanced data management	-Annual inventory turns -Inventory carrying cost as a percentage of average inventory value	Performing	Performing
Material Requirements Planning			
-Optimize service level through customer segmentation -Reduce lead times by determining best source of supply	-Order fill rate in percentage	Leading	Leading
DELIVER			
Process Orders			
-Eliminate non value adding activities, reduce lead time and perform better quality control	-Perfect Order Fulfilment	Performing	Lagging
Manage Warehousing			
-Improve efficiency of receiving and pick-pack processes -Improve labor productivity (implement lean techniques and labor management) -Optimize warehouse layout and configuration	-Pick-to-ship cycle time in hours for customer orders -Dock-to-stock cycle time in hours for supplier deliveries -Total cost to operate warehousing as a percentage of revenue	Performing	Developing
Manage Transportation			
-Rationalize number, size and location of distribution facilities	-Total logistics cost as a % of revenue	Performing	Performing

Table 7: Improvement Opportunities

Analytic Hierarchy Process (AHP) allows developing priorities for alternatives and the criteria used to judge the alternatives, allowing for more objective decision making. The first step of AHP is selecting the criteria that will be used to govern the decision making. The table below indicates the agreed upon criteria.

Project Prioritisation Criteria	
Cost Saving/ ROI	The potential cost saving/ return on investment associated with the execution of the particular project
Technical Complexity	The technical complexity inherent to the particular project
Business Value	The business value associated with the particular project, benefits that might not be directly linked to cost but still adds value from a customer's point of view
Time to Implement	Time to implement the particular solution/ complete project
Cost to Implement	Cost to implement the particular solution/ complete project
Current Maturity	The current maturity of the problem area that the particular project will address, based on results of qualitative assessment
Benchmark Results	The current condition of the benchmark results (lagging, developing, performing, leading) of the problem area that the particular project will address, based on results of quantitative assessment.

Table 8: Project Prioritisation Criteria

The next step involves deriving priorities for the different elements in the set of criteria by making pairwise comparisons. Pairwise comparison is where a pair of elements are compared relative to each other in terms of their importance to achieve the goal.

Scale of Importance for Pairwise Comparisons								
abs more	v strongly more	strongly more	weakly more	equal	weakly less	strongly less	v strongly less	abs less
0.11111	0.1428	0.2	0.33333	1	3	5	7	9

Table 9: Scale of Importance for Pairwise Comparisons

Before the priorities determined for each element can be used for further calculations, a consistency analysis must be conducted to evaluate the judgments made.

<u>Consistency Analysis</u>

There are three steps involved in the AHP consistency analysis:

1. **Calculate the consistency index (CI)** -To approximate the consistency index the pairwise comparison is multiplied by the corresponding weight and the sum of the row entries divided by the corresponding weight. The averages of these results are then computed and denoted γmax. Let n denote the number of criteria used in the AHP model then:

$$CI = \frac{\gamma max - n}{n - 1}$$

2. **Calculate the Random Index (RI)** -To calculate the RI a random matrix is generated using the Saaty scale with uniform distribution of probabilities. The mean value of a random matrix, size $n \times n$, is then calculated and denoted as RI. The table below indicates the results obtained from a study conducted where 500 000 matrices were simulated for of each size n. José-Antonio Alonso and Maria Teresa Lamata constructed the table so that it may be used in consistency ratio equations.

RI	0.5247	0.8816	1.1086	1.2479	1.3417	1.4057	1.4477	1.4854	1.514	1.5365
n	3	4	5	6	7	8	9	10	11	12

Table 10: Random Indices (Alonso & Lamata, 2006)

3. **Determine the consistency ratio (CR)** - To determine whether the inputs were consistent enough for the result of the AHP to be used for project prioritisation, CR must be smaller or equal to 0.1. (Saaty, 2008)

$$CR = \frac{CI}{RI}$$

Once the pairwise comparisons are proven consistent enough for further calculation, the alternatives, in this case improvement opportunities, are then compared to each other in a similar fashion with a different matrix for each of the criteria.

The total score for an improvement opportunity is the sum of the priority calculated for the evaluation criteria multiplied by the corresponding score achieved by the improvement opportunity based on that criteria.

The following two improvement opportunities received the highest priority and a project was raised for each of them:

- **Improve forecast accuracy through statistical modelling**
  A forecasting tool, Steelworks, was obtained by NSA and a recommendation was made to perform a data cleansing exercise.

- **Eliminate non value adding activities, reduce lead time and perform better quality control**
  NSA does not have the capacity currently to conduct all the vehicle enhancements onsite. The offsite fitments result in longer lead time and increased handling of vehicle (non value adding activity), which inherently increases the transport cost and potential damage to the vehicles.

  The later of the two improvement opportunities was identified as the pilot project (section 5).

  For confidentiality reasons, generic terms will be used to describe the vehicle enhancement referred to in the pilot project.

5. Pilot Project

5.1 Need Requirement

NSA has recognised that the current Vehicle Enhancement Facility is neither efficient nor effective in supporting their evolving business needs, particularly in respect of perfect order fulfilment.

Vehicle Enhancements (VE) represent accessories or services that are added to vehicles before wholesale achievement. NSA currently supports fitment of these accessories on site at the production facility in Rosslyn, at the port in Durban, at the respective dealers that constitute the domestic dealer network as well as at certain logistics suppliers. Accessories and services are seperated into Standard Vehicle Enhancements (SVE) and Optional Vehicle Enhancements (OVE). The former is applied to all vehicles and the latter is installed to order. At least 2100 units per annum receive VE, major VE clients include: ADT, South African Police, Eskom & MTN. The NSA vehicle enhancement facility currently does not have the capacity to meet the demand for the OVE and SVE vehicle enhancement, and consequently much of the work is conducted offsite. To address this problem NSA is expanding and upgrading the current VE facility at Rosslyn, to allow for more VE fitments of Nissan automobiles to be conducted on site under NSA supervision.

NSA wishes to obtain the maximum return on investment (ROI) from the VE facility and in parallel to improve perfect order fulfilment.

5.2 Pilot Project Scope, Aim & Deliverables

5.2.1 Scope

The high level scope of the pilot project includes:

- All the VE operations conducted onsite at the NSA.
- NSA vehicles that are booked into stock and not yet wholesaled.
- The focus will be for Nissan, Datsun & Infiniti imported and/or locally manufactured vehicles.

5.2.2 Aim

The NSA Stock Yard Operational Excellence project aims to provide NSA's with guidelines on obtaining the maximum return on investment from the VE fitment centre and improving perfect order fulfilment.

The project will provide NSA with answers on the quantity and combinations of VE fitments to be conducted onsite. Bringing the correct the VE's onsite could also contribute to the following: shorter lead times, decreased logistic cost, increased flexibility and improved and continuous quality control due to NSA supervision over the most important VE fitments.

5.2.3 Deliverables

- Capacity requirements for the new high value parking lot
- Capacity requirements for Standard Vehicle Enhancement I staging area
- Capacity requirements for the Standard Vehicle Enhancement II staging area
- Based on demand and capacity the ideal mix of vehicle enhancements (VE) to conduct on site

5.3 NSA Stock Yard Operational Excellence

5.3.1 High Value Vehicles Parking Lot

As part of NSA's commitment to improve perfect order fulfilment (on time delivery, according to specifications and without damages) the supply chain management has put a special emphasis on stock stockyard quality preservation.

The latest edition of the new vehicle handling manual advised that that new and used vehicles should be completely separated in the stockyard. A divider will be set up in the current NSA stockyard at Rosslyn between new and used vehicles and as a result the high value parking lot needs to be relocated. The high value parking lot is fenced off from other new vehicles.

NSA wished to know how many parking lots to cater for within the high value parking lot.

5.3.1.1 High Value Vehicles

Infiniti Range:

Figure 12: Infiniti Model Range (Infiniti, 2014)

The entire Infiniti vehicle range are stored at distributed from the Durban Vehicle Terminal (DCT), unless a unit becomes aged stock (older than 3 months). Infiniti aged stock are moved to the NSA stockyard at Rosslyn. From historical data a conclusion was drawn (and confirmed by NSA) that a certain percentage of all Infiniti's eventually becomes aged stock.

Selected Nissan Vehicles:

Figure 13: High Value Nissan Vehicles (Nissan Global, 2014)

All Nissan GTR and 370Z are immediately brought up to the Rosslyn stockyard and a high percantage of all Nissan Leaf become aged stock and are also transported up to the NSA stockyard at Rosslyn.

5.3.1.2 High Value Vehicles Parking Lot Calculations

To best estimate the capacity requirements of monthly average between ideal and worst stock conditions for that month was used, where:

- **Ideal stock conditions** = Stock on hand at the end of the month
- **Worst stock conditions** = Stock on hand at the end of the month + vehicles sold within that month

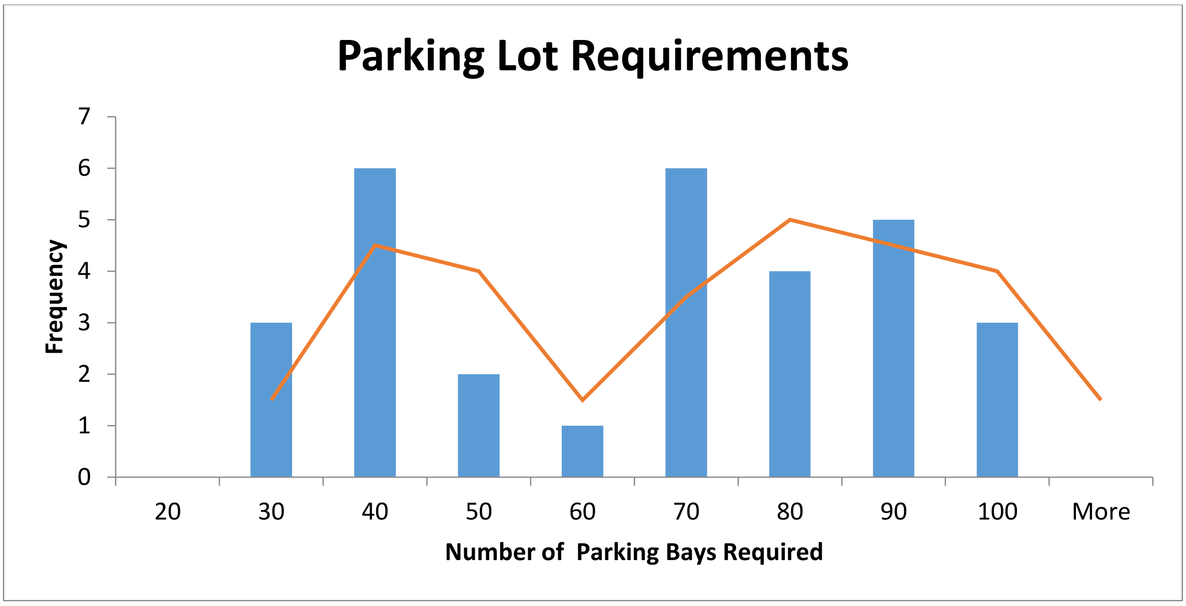

Figure 14: High Value Parking Lot Requirements

The above graph (figure 15) and the table below (table 8) are based on the values calculated for the high value parking lot requirements. The values were calculated based on the average stock conditions for the months from January 2013 to September 2015 (June 2014 to September 2015 was retrieved from NSA forecast).

Summary information	
Minimum	27
Maximum	96
Average	61,22
Standard Deviation	22,96

Table 11: Summary Information -High Value Parking Lot Demand

The relatively large standard deviation and the trend line suggest a bimodal distribution. A bimodal distribution consists of two normal distribution within one data set. The two normal distributions can be completely separated if Ashman's D is greater than 2. (Ashman, et al., 1994). If the high value months were to be separated from the lower value months consider the following.

Summary information	High Value Months	Low Value Months
Mean	78,17	35.79
Standard Deviation	9,78	8.16

Table 8: Summary Information High Value and Low Value Months

Ashman's D Test

Let:

μ_1 = mean of high value months

μ_2 = mean of lower value months

σ_1 = standard deviation of the high value months

σ_2 = standard deviation of the lower value months

D = an indicator, indicating whether the mixture of two normal distributions may be completely separated, where $D > 2$ is required for a clean separation..

Then:

$$D = 2^{\frac{1}{2}} \frac{|\mu 1 - \mu 2|}{\sqrt{(\sigma_1^2 + \sigma_2^2)}}$$

$$D = 2^{\frac{1}{2}} \frac{|78.17 - 35.79|}{\sqrt{(9.78^2 + 8.16^2)}}$$

$$D = 4.705$$

$\therefore D > 2$, distribution may be completely separated

5.3.1.3 High Value Vehicles Parking Lot Recommendation

Bearing in mind that the parking will be fenced off, a parking lot designed for high value months will have sufficient capacity for high and lower value months, whereas a parking lot designed for lower value months will only have sufficient capacity for low value months. Therefore it is recommended to design the parking bay for high value months.

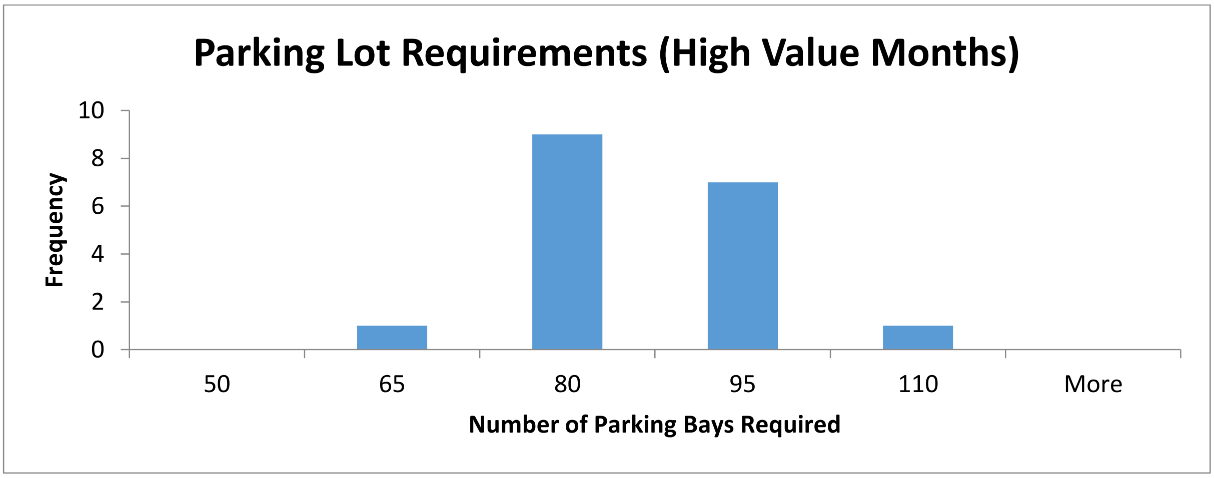

Figure 15: Parking Lot Requirements - High Value Months

When examining the high value months in isolation a normal distribution may be recognized. Using the properties of the normal distribution, the probability that the parking lot will be sufficient to cater for the needs of the high value months will be equal to the cumulative probability.

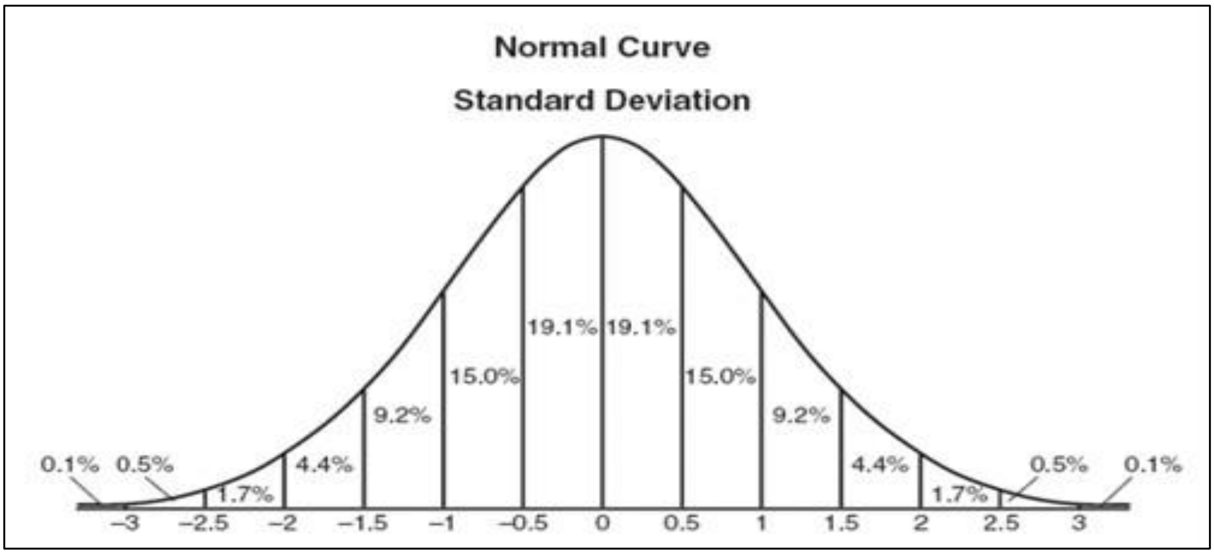

Figure 16: Normal Curve and Standard Deviation (Roberts, 2012)

Normal Curve, Standard Deviation Table	Parking Bays	Cumulative Probability
$\boldsymbol{Average}$	78.17	50.00%
$\boldsymbol{Average + (0.5 \times standard\ deviation)}$	83.06	69.10%
$\boldsymbol{Average + (1.0 \times standard\ deviation)}$	87.95	84.10%
$\boldsymbol{Average + (1.5 \times standard\ deviation)}$	92.84	93.30%
$\boldsymbol{Average + (2.0 \times standard\ deviation)}$	97.73	97.70%
$\boldsymbol{Average + (2.5 \times standard\ deviation)}$	102.62	99.40%
$\boldsymbol{Average + (3.0 \times standard\ deviation)}$	107.51	99.90%

Table 12: Normal Curve and Standard Deviation Table

5.3.2 Standard Vehicle Enhancement I Staging Area

The graph below (Figure 18) provide a graphical representation of the demand for vehicles to receive Standard Vehicle Enhancement I (SVE_I). Similar to the *High Value Parking Bay* data, the data displays a bimodal distribution. According to Ashman's D test the data may be completely separated ($D = 5.901 \quad \therefore \quad D > 2$). *Please refer to section 8.3.*

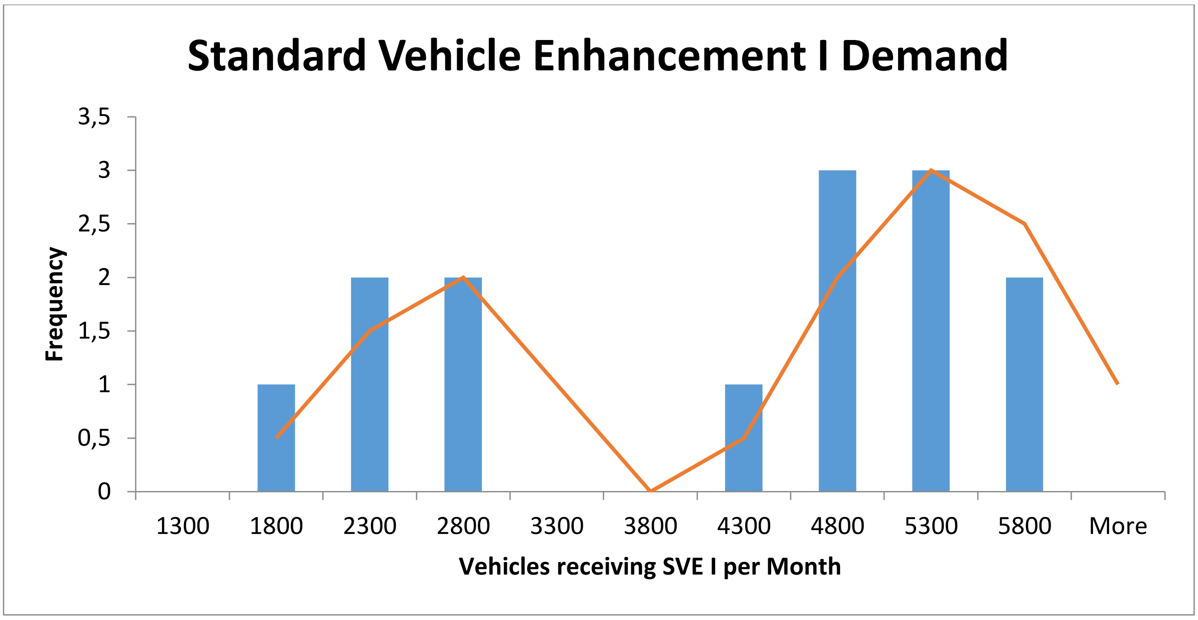

Figure 17: SVE_I Demand over 14 Months

The bimodal distribution is caused by the on and off peak seasons observed throughout the year. The SVE_I facility has three pits, and based on the time studies conducted the average service time per vehicle per SVE_I pit is 3.5 minutes. A normal working day (without overtime) consists of 8 hours' work per day for an estimated 20 working days per month.

SVE_I Monthly Demand (Off Peak)		**SVE_I Monthly Demand (Peak)**	
Mean	2 138	Mean	4 906
Standard Deviation	431,943	Standard Deviation	503,442
Minimum	1 546	Minimum	4 258
Maximum	2 725	Maximum	5 653

Table 13: Summary Information for SVE_I Demand

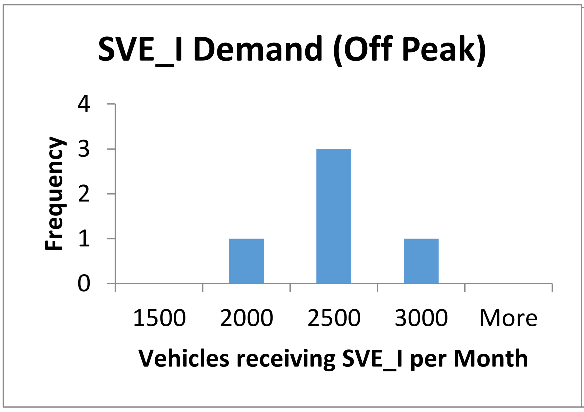

Figure 18: SVE_I off Peak Demand

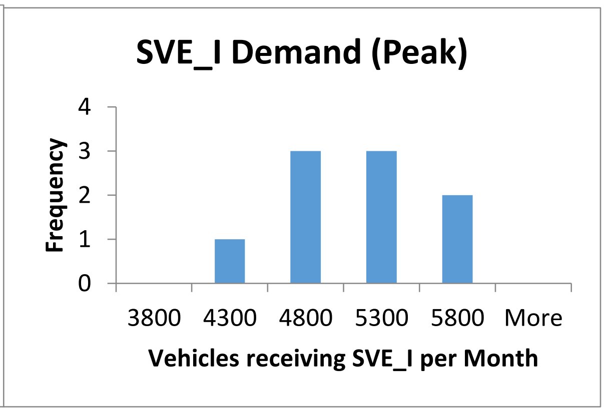

Figure 19: SVE_I Peak Demand

To calculate this queueing problem the following model has been identified:

5.3.2.1 Queueing Theory - M/M/GD/∞/∞ Model (SVE_I Off Peak Demand)

Let:

Arrival time follows a Poisson distribution and service times an exponential distribution.

$\lambda =$ Average number of vehicles arriving per unit time

$\mu =$ Average number of service completions per unit time

$p =$ Traffic intensity

$s =$ Number of servers in the system

Performing the calculations with a demand that has a 92.4% probability to be larger than actual demand for SVE_I observed during an off peak month.

$$Monthly\ Demand = (Average\ Monthly\ Demand) + (1.5\ \times Standard\ Deviation)$$

$$Monthly\ Demand = (2138) + (1.5\ \times 431.943)$$

$$\therefore Monthly\ Demand = 2786.114$$

Then:

$$\lambda = \frac{Vehicles\ Demanding\ SVE\_I\ per\ Month}{Working\ Days\ per\ Month\ \times Working\ Hours\ per\ Day}$$

$$\lambda = \frac{2786.114}{20 \times 8}$$

$$\therefore\ \lambda = 17.413\ \ vehicles\ arrive\ per\ hour$$

$$\mu = \frac{Minutes\ per\ Hour}{Minutes\ to\ Service\ \ One\ Vehicle}$$

$$\mu = \frac{60}{3.5}$$

$$\therefore\ \mu = 17.143\ \ vehicles\ \ serviced\ per\ hour, per\ pit$$

$$p = \frac{\lambda}{s\mu}$$

$$p = \frac{17.413}{3 \times 17.143}$$

$$\therefore\ p = 0.339$$

$\therefore p < 1$, steady state exists

Let:

π_j = Steady-state probability that j vehicles are in the system

Then:

$$\pi_0 = \frac{1}{\sum_{i=0}^{i=s-1} \frac{(sp)^i}{i!} + \frac{(sp)^s}{s!\,(1-p)}}$$

$$\pi_0 = \frac{1}{\sum_{i=0}^{i=2} \frac{((3)(0.339))^i}{i!} + \frac{((3)(0.339))^3}{3!\,(0.661)}}$$

$$\therefore\ \pi_0 = 0.3572$$

For $(j = 1, 2)$

$$\pi_j = \frac{(sp)^j \pi_0}{j!}$$

$$\pi_1 = \frac{\big((3)(0.339)\big)^1 (0.3572)}{1!}$$

$$\therefore \pi_1 = 0.6684$$

$$\pi_2 = \frac{\big((3)(0.339)\big)^2 (0.3572)}{2!}$$

$$\therefore \pi_2 = 0.1847$$

$$p(queue) = p(j \geq s) = 1 - p(j < s)$$

$$p(j \geq 3) = 1 - p(j < 3)$$

$$p(j \geq 3) = 1 - (\pi_0 + \pi_1 + \pi_2)$$

$$p(j \geq 3) = 1 - (0.3572 + 0.6684 + 0.1847)$$

$$p(j \geq 3) = -0.2103$$

$\therefore\ p(j \geq 3) < 0$; No queue will exist

5.3.2.2 Queueing Theory - M/M/GD/∞/∞ Model (SVE_I Peak Demand)

Performing the calculations with a demand that has a 92.84% probability to be larger than actual demand for SVE_I observed during a peak month.

$$\therefore Monthly\ Demand = 5660.830$$

$$\lambda = \frac{Vehicles\ Demanding\ SVE\_I\ per\ Month}{Working\ Days\ per\ Month\ \times Working\ Hours\ per\ Day}$$

$$\lambda = \frac{5660.830}{20 \times 8}$$

$$\therefore\ \lambda = 35.380\ \ vehicles\ arrive\ per\ hour$$

$$\mu = 17.143\ \ vehicles\ serviced\ per\ hour, per\ pit$$

$$p = \frac{\lambda}{s\mu}$$

$$p = \frac{35.380}{3\ \times\ 17.143}$$

$$\therefore\ p = 0.688$$

$\therefore p\ < 1$, steady state exists

<u>Let:</u>

π_j = Steady-state probability that j vehicles are in the system

<u>Then:</u>

$$\pi_0 = \frac{1}{\sum_{i=0}^{i=2} \frac{((3)(0.688))^i}{i!} + \frac{((3)(0.688))^3}{3!\,(0.312)}}$$

$$\therefore\ \pi_0 = 0.1011$$

For $(j = 1, 2)$

$$\pi_1 = \frac{\left((3)(0.688)\right)^1 (0.101)}{1!}$$

$$\pi_1 = 0.2085$$

$$\pi_2 = \frac{\left((3)(0.688)\right)^2 (0.101)}{2!}$$

$$\pi_2 = 0.2151$$

$$p(j \geq 3) = 1 - (\pi_0 + \pi_1 + \pi_2)$$

$$p(j \geq 3) = 1 - (0.1011 + 0.2085 + 0.2151)$$

$$\therefore\ p(j \geq 3) = 0.4753$$

Let:

$L_q =$ Expected number of vehicles in queue

Where:

$$L_q = \frac{p(j \geq s)p}{1 - p}$$

$$L_q = \frac{(0.4753)(0.688)}{0.312}$$

$$\therefore L_q = 1.048$$

6.3.2.3 SVE_I Staging Area Recommendation

Even during peak demand SVE_I only has a 47.53% chance that a queue will exist, and an expected average queue of 1.048 vehicles. The following image (Figure 21) depicts the layout of SVE_I and Standard Vehicle Enhancement II (SVE_II) in the new VE facility. Please note that there is already sufficient space for 18 vehicles to queue ahead of SVE_I, according to the calculation there is no need for an additional staging area for SVE_I.

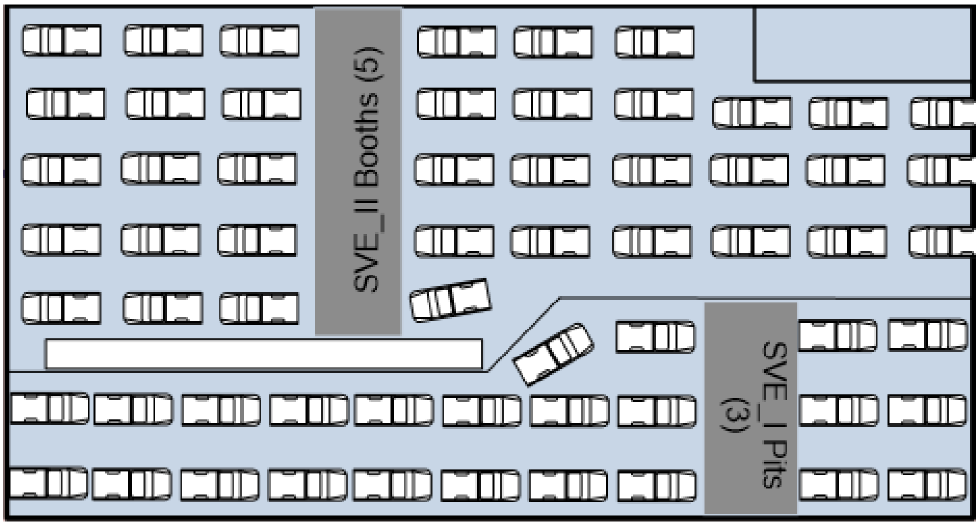

Figure 20: SVE_I Pits & Staging Area

5.3.3 Standard Vehicle Enhancement II Staging Area

Below is a summary of the demand for vehicles to receive SVE_II, similar to SVE_I and *High Value Parking Bay*, the data have a bimodal distribution and may be completely separated. ($D = 2.968 \therefore D > 2$). *Please refer to section 8.3.*

SVE_II Monthly Demand (Off Peak) **SVE_II Monthly Demand (Peak)**

Mean	1 152	Mean	2 308
Standard Deviation	286,4760025	Standard Deviation	470,5271276
Minimum	893	Minimum	1624
Maximum	1575	Maximum	2898

Table 14: Summary Information for SVE_II Demand

The SVE_II facility has five booths, and based on the time studies conducted the weighted average service time per vehicle per booth is 17.5 minutes.

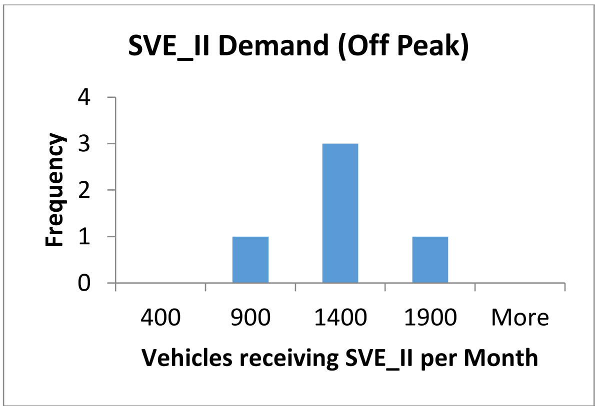

Figure 21: SVE_II off Peak Demand

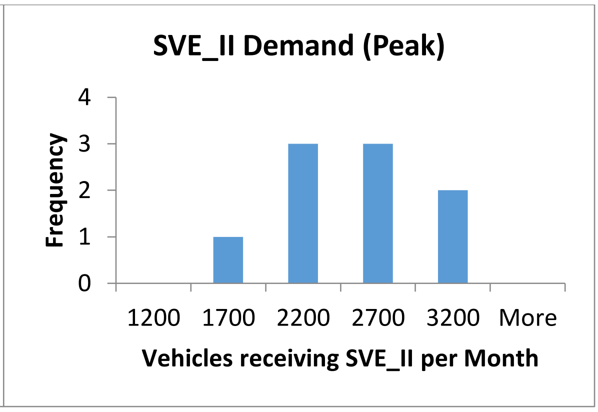

Figure 22: SVE_II Peak Demand

5.3.3.1 Queueing Theory - M/M/GD/∞/∞ Model (SVE_II Off Peak Demand)

Performing the calculations with a demand that has a 93.8% probability to be larger than actual demand for SVE_II observed during an off peak month. Arrival time follows a Poisson distribution and service times an exponential distribution.

$$\lambda = \frac{Vehicles\ Demanding\ SVE\_II\ per\ Month}{Working\ Days\ per\ Month\ \times Working\ Hours\ per\ Day}$$

$$\lambda = \frac{1581.714}{20 \times 8}$$

$$\therefore\ \lambda = 9.886\ vehicles\ arrive\ per\ hour$$

$$\mu = \frac{Minutes\ per\ Hour}{Minutes\ to\ Service\ One\ Vehicle}$$

$$\mu = \frac{60}{17.5}$$

$$\therefore\ \mu = 3.429\ \ vehicles\ Service\ per\ hour, per\ booth$$

$$p = \frac{\lambda}{s\mu}$$

$$p = \frac{9.886}{5\ \times\ 3.429}$$

$$\therefore\ p = 0.577$$

$\therefore p\ < 1$, steady state exists

Let:

π_j = Steady-state probability that j vehicles are in the system

Then:

$$\pi_0 = \frac{1}{\sum_{i=0}^{i=s-1} \frac{(sp)^i}{i!} + \frac{(sp)^s}{s!\,(1-p)}}$$

$$\pi_0 = \frac{1}{\sum_{i=0}^{i=4} \frac{((5)(0.577))^i}{i!} + \frac{((5)(0.577))^5}{5!\,(0.423)}}$$

$$\therefore\ \pi_0 = 0.0530$$

For $(j = 1, 2,3,4)$

$$\pi_j = \frac{(sp)^j \pi_0}{j!}$$

$$\pi_1 = \frac{\left((5)(0.577)\right)^1 (0.0530)}{1!}$$

$$\pi_1 = 0.1529$$

$$\pi_2 = 0.2206$$

$$\pi_3 = 0.2121$$

$$\pi_4 = 0.1530$$

$$p(j \geq 5) = 1 - p(j < 5)$$

$$p(j \geq 5) = 1 - (\pi_0 + \pi_1 + \pi_2 + \pi_3 + \pi_4)$$

$$p(j \geq 5) = 1 - (0.1529 + 0.2206 + 0.2121 + 0.1530)$$

$$\therefore p(j \geq 5) = 0.2614$$

$$L_q = \frac{p(j \geq s)p}{1 - p}$$

$$L_q = \frac{(0.2614)(0.577)}{0.423}$$

$$\therefore L_q = 0.357$$

$$staging\ area\ capacity \geq L_q$$

$$staging\ area\ capacity \geq 0.357$$

$$\therefore staging\ area\ capacity \geq 1\ parking\ bays$$

5.3.3.2 Queueing Theory - M/M/GD/∞/∞ Model (SVE_II Peak Demand)

Performing the calculations with a demand that has a 93.8% probability to be larger than actual demand for SVE_II observed during a peak month.

$$Monthly\ Demand = 3013.346$$

$$\therefore \lambda = 18.833\ vehicles\ arrive\ per\ hour$$

$$\mu = 3.429 \ \ vehicles\ serviced\ per\ hour, per\ booth$$

$$p = \frac{\lambda}{s\mu}$$

$$p = \frac{18.833}{5 \times 3.429}$$

$$\therefore \ p = 1.101$$

$\therefore p > 1$, no steady state exists

5.3.3.3 Alternative Queueing Theory Solutions (SVE_II Peak Demand)

In order to meet daily requirements, the SVE_II facility needs to work overtime (2 hours). Consider two scenarios:

I. Both the stockyard operator and the SVE_II facility work 2 hours a day overtime during peak demand.
II. Stockyard operators pick vehicles for 8 hours. The staging area is sufficiently large, so that when stockyard operators stop working, the SVE_II facility can deplete the buffer stock in the staging area and that will be sufficient to meet the daily requirements

<u>Alternative Scenario I:</u>

$$\lambda = \frac{3013.346}{20 \times 10}$$

$$\therefore \ \lambda = 15.067 \ vehicles\ arrive\ per\ hour$$

$$\mu = 3.429 \ \ vehicles\ serviced\ per\ hour, per\ booth$$

$$p = \frac{\lambda}{s\mu}$$

$$p = \frac{15.067}{5 \times 3.429}$$

$$\therefore \ p = 0.879$$

$\therefore p < 1$, steady state exists

Let:

π_j = Steady-state probability that j vehicles are in the system

Then:

$$\pi_0 = \frac{1}{\sum_{i=0}^{i=s-1} \frac{(sp)^i}{i!} + \frac{(sp)^s}{s!\,(1-p)}}$$

$$\therefore\ \pi_0 = 0.0063$$

For $(j = 1, 2{,}3{,}4)$

$$\pi_j = \frac{(sp)^j \pi_0}{j!}$$

$$\pi_1 = 0.0277$$

$$\pi_2 = 0.0608$$

$$\pi_3 = 0.0891$$

$$\pi_4 = 0.0980$$

$$p(j \geq 5) = 1 - (\pi_0 + \pi_1 + \pi_2 + \pi_3 + \pi_4)$$

$$\therefore\ p(j \geq 5) = 0.7244$$

$$L_q = \frac{p(j \geq s)p}{1-p}$$

$$L_q = \frac{(0.7244)(0.897)}{0.121}$$

$$\therefore L_q = 5.370$$

$$staging\ area\ capacity\ \geq L_q$$

$$staging\ area\ capacity\ \geq 5.370$$

$$\therefore staging\ area\ capacity\ \geq 6\ parking\ bays$$

Alternative Scenario II:

Let:

$$p = 0.879; \quad p < 1; \quad \text{Steady state exists;}$$

$$\lambda = 15.067\ vehicles\ arrive\ per\ hour; \ L_q = 5.370$$

Then:

$$staging\ area\ capacity \geq 150.667 - vehicles\ picked + L_q$$

$$staging\ area\ capacity \geq 150.667 - (8 \times 15.067) + 5.370$$

$$staging\ area\ capacity \geq 35.501$$

$$\therefore staging\ area\ capacity \geq 36\ parking\ bays$$

SVE_II has been identified as a bottleneck in the stockyard, it is therefore crucial that the buffer stock (vehicles in staging area) should be correctly calculated. For that reason SVE_II operations were also simulated using Arena.

5.3.3.4 Simulating SVE_II Operations using Arena

The Arena model consist of three different modules:

Create Module

The *Create* module simulates vehicles being picked from the stock yard.

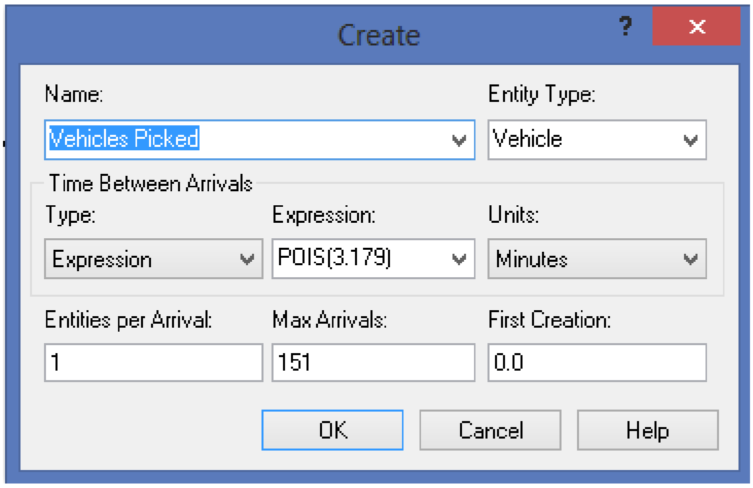

Figure 23: Create Module (Rockwell Arena, 2014)

The most important action to perform when creating this particular module is to specify the *time between arrivals* and the *max arrivals* (the maximum number of vehicles picked for SVE_II operations for a specific time period, e.g. per day). For the SVE_II operating models the *time between arrivals* expression is calculated as follows:

$$Expression = poisson(mean)$$

$$\therefore Expression = poisson(\frac{60\ minutes\ per\ hour}{vehicles\ arriving\ per\ hour})$$

<u>Process Module</u>

The process module simulates vehicles being serviced. The module represents the machine, including resource, queue and the entity (vehicle) delay time.

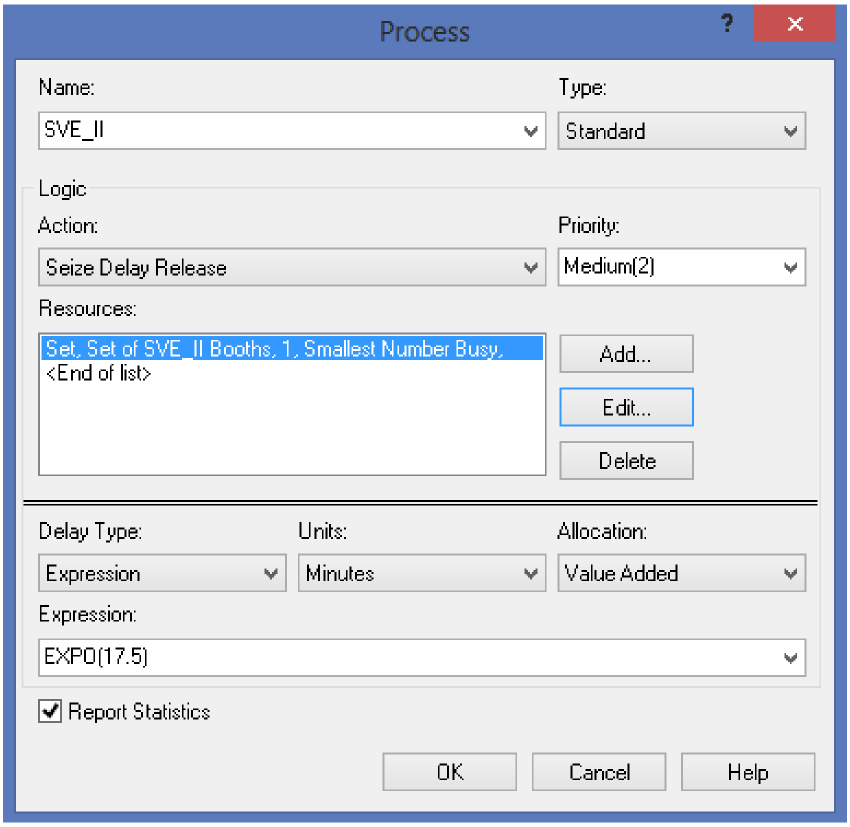

Figure 24: Process Module (Rockwell Arena, 2014)

The *Seize Delay Release* action seizes an entity (after a possible wait in the queue), then delay the entity for a time representing the service time (17.5 minutes), and finally release the entity. (Kelton, et al., 2010)

In the resource block resources may be added individually or as a set. The set in this case consist of 5 resources (SVE_II booths). The expression represents the service time for each of the resources in the set. Similar to the queueing theory calculations for SVE_II operations, the service time was set to follow an exponential random distribution with a service time of 17.5 minutes per vehicle, per booth.

<u>Dispose Module</u>

Simulates vehicles coming out of SVE_II facility and also record the entity statistics, e.g. the number of vehicles that received SVE_II.

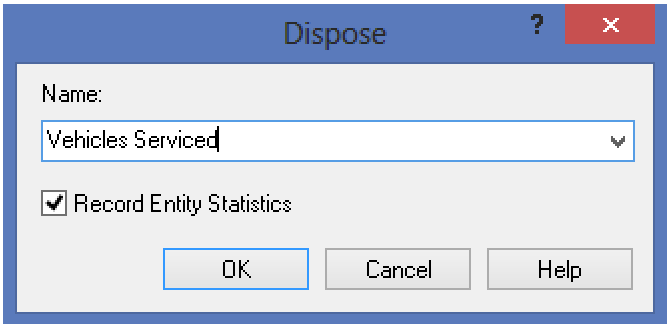

Figure 25: Dispose Module (Rockwell Arena, 2014)

6.3.3.4 Summary of SVE_II Operating Models Simulated in Arena

SVE_II Operating Models Simulated on Rockwell Arena Software	**Model 1** Pick for 8 hours, service for 8 hours	**Model 2** Pick for 8 hours, service for 10 hours	**Model 3** Pick for 10 hours, service for 10 hours	**Model 4** Pick for 10 hours (increased pace), service for 10 hours
Create *- Represents vehicles picked from the stockyard*				
Time between Arrivals (min)	Poisson(3.177)	Poisson(3.177)	Poisson(3.982)	Poisson(3.783)
Maximum Arrivals	151	151	151	151
Process *- Represents the 5 SVE_II booths*				
Expression (min)	Random Exponential (17.5)	Random Exponential (17.5)	Random Exponential (17.5)	Random Exponential (17.5)
Run time (hours)	8	10	10	10
Results *- Average results obtained from 1000 replications*				
Average Number Vehicles Picked	148.69	151	148.92	150.71
Average Number Vehicles Serviced	130.54	150	143.88	147.53
Average maximum queue	27.6120	26.6319	18.5874	17.5479

Table 15: Summary of SVE_II Operating Models Simulated in Arena

<u>Model 4:</u> Pick for 10 hours at an increased pace.

The reason for the increased picking pace is to ensure that the vehicles are picked in time, allowing for better utilisation from the bottleneck (SVE_II operations).

$$\lambda = \frac{Vehicles\ Demanding\ SVE\_II\ per\ Month}{Working\ Days\ per\ Month\ \times Working\ Hours\ per\ Day}$$

$$\lambda = \frac{3013.346}{20 \times 9.5}$$

$$\therefore\ \lambda = \ 15.860\ vehicles\ arrive\ per\ hour$$

$$Expression = poisson(mean)$$

$$Expression = poisson(\frac{60\ minutes\ per\ hour}{vehicles\ arriving\ per\ hour})$$

$$Expression = poisson(\frac{60}{15.860})$$

$$Expression = poisson(7.783)$$

5.3.3.5 SVE_II Staging Area Recommendation

Peak staging area:

For the peak demand the 2 most viable options were simulated model 2 and 4, the number of vehicles serviced in the other models was too far from the daily target. To choose the most viable option, it is necessary to study the cost implication associated with model 2 and 4. First consider the following

Stockyard Operators Overtime Rate:

The cost associated with overtime stockyard picking

- Team leader R X_1 per hour
- Driver R X_2 per hour

Off site storage rates:

Currently the NSA stockyard is at capacity, and it is fair to assume that every parking bay used as a staging occupies one parking bay. A vehicle can be stored off-site at an off-site stockyard for R Y_1 per day, transport to and from the off-site stockyard is currently priced at R Y_2 for one direction.

Peak and off peak assumption:

Currently there are 8 months a year with a high demand for SVE_II, and 4 months per year with a low demand for SVE_II, assume this trend would to continue.

Model 2	**Model 4**
Staging area required for $26.6319 \approx 27$ vehicles	Staging area required for $17.5479 \approx 18$ vehicles
8 Months peak per year (20 working days per month)	8 Months peak per year (20 working days per month)
No overtime time picking	2 hours overtime picking per working day

Table 16: Model Comparison

Cost Comparison:

$$\boldsymbol{Cost\ Model\ 2} = (addtional\ parking\ bays\ \times 8\ Months \times 30\ Days \times\ Y_1) + (Transport\ cost \times additional\ parking\ bays)$$

$$Cost\ Model\ 2 = (9 \times 8 \times 30 \times\ Y_1\ ) + (2 \times Y_2 \times 9)$$

$$\therefore\ Cost\ Model\ 2 = R27\ 360{,}00$$

$$\boldsymbol{Cost\ Model\ 4} = (Hours\ Overtime\ per\ Day \times 20\ Working\ Days \times 8\ Months \times Overtime\ Rate)$$

$$Cost\ Model\ 2 = (2 \times 20 \times 8 \times R112.37)$$

$$\therefore\ Cost\ Model\ 2 = R35\ 958{,}00$$

Model 2 results in a $R8\ 625{,}00$ cost saving

Off peak staging area:

Contrary to the high value parking lot, the staging areas are not fenced off, they are only demarcated by lines painted on the stock yard. It was confirmed by the stockyard operator that the parameters for the staging area can be changed on a monthly basis to support off peak and peak demand.

The vehicles indicated in red below are being prepared for SVE_II and should therefore not be seen as staging areas, but as part of the SVE_II process.

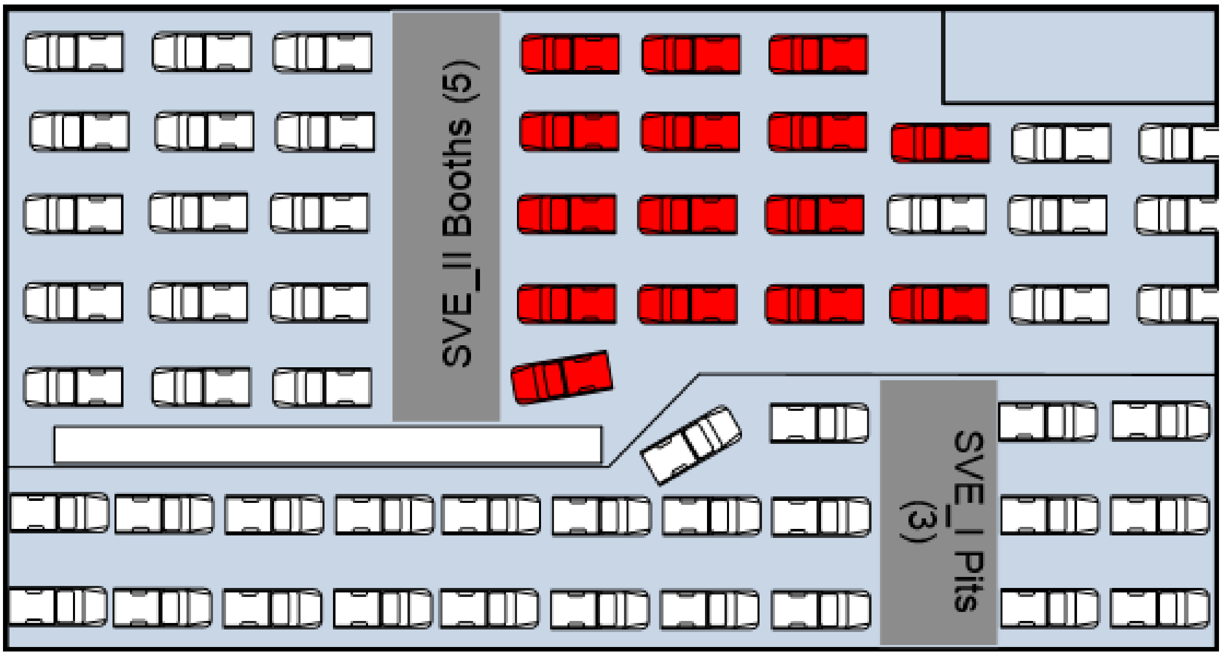

Figure 26: SVE_II Staging Area

Recall that from the queueing theory calculations indicated an average expected queue of 0.357 vehicles, and the probability that a vehicle might be waiting in the queue of only 26.14%. The 7 staging area bays available in the SVE_II facility should be sufficient.

Assuming that model 2 is used for peak demand and no staging areas outside the SVE_II facility used during off peak the following saving could expect:

$$Potential\ savings = (Additional\ parking\ bays\ \times 4\ Months \times 30\ Days \times R12) + (Transport\ cost \times additional\ parking\ bays)$$

$$\therefore\ Potential\ savings = ((27-7)\ \times 4 \times 30 \times R12) + (160 \times (27-7))$$

$$\therefore\ Potential\ savings = R32\ 000,00$$

$$\boldsymbol{Total\ potential\ savings\ from\ recommendation\ per\ year} = \mathbf{R40\ 625,00}$$

5.3.4 Vehicle Enhancement - Ideal Combination

5.3.4.1 Linear Programming and Assumptions

To calculate the ideal combination of VE's to conduct at the NSA VE facility in Rosslyn, several Pure Integer Programs were created representing different scenarios. A Pure Integer Program as a Linear Program (LP) in which all of the variables are required to be non-negative integers.

An LP is an optimisation program used for the following to maximise or minimise a linear function of the decision variables, and in doing so making it an objective function. The values represented by the decision variable must satisfy a set of constraints, consisting of either a linear equation or linear inequality.

<u>Necessary Assumption for LP:</u>

- Proportionality assumptions - The contribution of the objective is proportional to the value of the decision, and the contribution of a variable is proportional to the value of the variable.
- Additivity assumption - The contribution to the objective function as well as the contribution to the left-hand side of each constraint by a variable is independent of the values of the other decision variables.
- Divisibility Assumption - The divisibility assumption requires all decision variables to be allowed fractional values.
- Certainty Assumption - The certainty assumption is that each objective function coefficient/ parameter is known with certainty.

<u>Notes on LP Assumptions</u>

All of the above assumptions are satisfied for the NSA VE LP except for the divisibility assumption. A fractional tow bar cannot be fitted to a vehicle. That is why Pure Integer Programs were created represent the different scenarios that could be experienced in the VE

<u>Feasible Region and Optimal Solution</u>

The feasible region for an LP is the set of points, point meaning a specification of the value for of each variable, which satisfies all the LP's constraints and sign restrictions. For a maximization problem, an optimal solution to an LP is a point in the feasible region with the largest objective value. (Winston & Venkataramanan, 2003)

5.3.4.2 The Demand and Capacity for Vehicle Enhancements

The table below was constructed be examining the VE's that were conducted to new Nissan and Infiniti vehicles in South Africa.

On the NSA software VE's are represented by combination packs with unique identifiers. To truly understand the demand for the individual VE's an in depth investigation was conducted. Finally the VE combination packs were broken down into 45 different types of VE fitments.

Vehicle Enhancement (VE) Demand & Information				Average Demand		"Hockey Stick" Demand	
VE Identifier	Average Revenue	Time (h)	REQUIRE	Week Min	Week Max	Week Min	Week Max
VE1	R 6 587,19	2,5	Service Bay	0	21	0	30
VE2	R 1 278,88	2	Service Bay	0	14	0	24
VE3	R 2 373,57	0,5	Service Bay	1	1	1	1
VE4	R 306,02	1	Service Bay	1	1	1	1
VE5	R 964,65	1	Service Bay	0	0	0	0
VE6	R 9 091,34	0,75	Service Bay	0	5	0	7
VE7	R 432,74	0,16667	Service Bay	6	60	10	97
VE8	R 139,17	0,05833	SVE_I Pit	979	979	1227	1227
VE9	R 1 941,11	0,66667	Service Bay	6	19	9	29
VE10	R 4 499,00	4	Service Bay	0	0	0	0
VE11	R 872,00	0,2	Service Bay	0	6	0	8
VE12	R 426,33	0,5	Service Bay	19	34	27	50
VE13	R 793,70	1,5	Service Bay	0	14	0	21
VE14	R 1 245,10	0,1	Service Bay	0	0	0	0
VE15	R 6 870,46	0,5	Lift	5	11	7	16
VE16	R 1 068,40	0,75	PD Pit	0	181	0	290
VE17	R 1 228,07	0,75	Service Bay	0	19	0	29
VE18	R 71,56	0,25	Service Bay	27	138	40	204
VE19	R 2 991,31	0,75	Service Bay	0	2	0	3
VE20	R 2 571,20	0,45	Service Bay	3	5	4	7
VE21	R 2 720,74	0,83333	Service Bay	0	0	0	0
VE22	R 2 110,90	0,6	Service Bay	3	64	4	95
VE23	R 81,78	0,01	Service Bay	0	16	0	28
VE24	R 719,25	0,29167	SVE_II Booth	472	474	575	577
VE25	R 2 197,37	1	Service Bay	1	1	1	1
VE26	R 1 939,31	2,5	Service Bay	0	1	0	2
VE27	R 3 892,40	0,33333	Service Bay	0	0	0	0
VE28	R 8 622,51	0,75	Service Bay	1	1	1	2

VE29	R -	0,16667	Service Bay	24	24	42	42
VE30	R 450,00	0,5	Service Bay	0	13	0	19
VE31	R 6 754,39	0,75	Service Bay	0	0	0	0
VE32	R 420,23	0,9	Service Bay	3	6	5	10
VE33	R 464,01	0,5	Service Bay	0	0	0	0
VE34	R 1 015,90	0,1	Service Bay	0	0	0	0
VE35	R 768,29	0,5	Lift	0	0	0	0
VE36	R 3 419,05	2	Lift	1	22	2	37
VE37	R10 348,76	0,5	Service Bay	0	2	0	3
VE38	R 2 276,70	0,91667	Service Bay	5	23	8	34
VE39	R 924,00	2,5	Service Bay	2	2	2	2
VE40	R 119,48	0,1	Service Bay	0	0	0	0
VE41	R 270,53	0,1	Service Bay	0	0	0	0
VE42	R 40,45	0,1	Service Bay	27	258	40	381
VE43	R 61,03	0,1	Service Bay	0	14	0	20
VE44	R 59,68	0,1	Service Bay	0	0	0	0
VE45	R 1 754,39	1,5	Service Bay	0	1	0	1

Table 17: VE Demand and Relevant Information

The "hockey stick" demand is caused by dramatic incline in sales during the last week of a month. This causes the VE facility as well as the auto carries to be idle throughout the month and then overloaded at month end. One of the major drivers of the hockey stick has been contributed to the month end sales target and KPI's driving the wrong behaviour within the company.

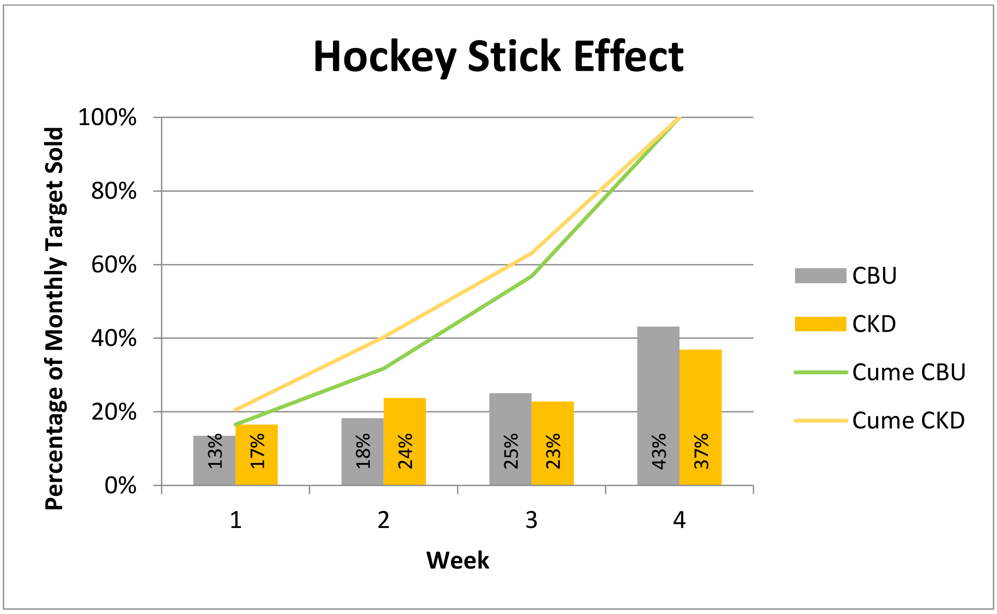

Table 18: The "Hockey Stick" Effect

The “hockey stick” effect has a direct influence on the Optional Vehicle Enhancements (OVE), since OVE’s may only be conducted once a vehicle is sold.

All standard vehicle enhancements (SVE’s) are conducted on a vehicle as soon as the vehicle arrives in stockyard. Therefor SVE_I (VE8) and SVE_II (VE24) are not really influenced by the hockey stick, but rather more by production which due to capacity constraints has a fairly uniform distribution throughout the month.

The two tables (20 &21) below provide summary information on the current and new VE facility.

Current Facility Capacity		Hours per Week		$Capacity\ per\ Week = Number\ available \times Time\ per\ Week$	
Option	**Number Available**	**Without Overtime**	**With Overtime**	**Without Overtime**	**With Overtime**
Service Bays	28	40	50	1120	1400
Lifts	10	40	50	400	500
PD Pits	2	40	50	80	100
SVE_I Pits	3	40	50	120	150
SVE_II Booths	5	40	50	200	250

Table 19: Summary Information - Current VE Facility

New Facility Capacity		Hours per Week		$Capacity\ per\ Week = Number\ available \times Time\ per\ Week$	
Option	**Number Available**	**Without Overtime**	**With Overtime**	**Without Overtime**	**With Overtime**
Service Bays	74	40	50	2960	3700
Lifts	10	40	50	400	500
PD Pits	5	40	50	200	250
SVE_I Pits	3	40	50	120	150
SVE_II Booths	5	40	50	200	250

Table 20: Summary Information - New VE Facility

5.3.4.3 Linear Programs

Model 1 - Current facility with average demand, without overtime

Let:

$X_i =$ VE $i \in j$, where $j = \{1,2,3, \dots 45\}$

$C_i =$ the revenue associated with X_i

T_i = the time associated with X_i

a_i = the minimum number of times that X_i needs to be performed to meet weekly requirements during average demand

b_i = the maximum number of times that X_i can be performed without exceeding the weekly average demand

Objective Function:

Max Z = $\sum_{i=1}^{45} CiXi$

Subject To:

Service bays weekly capacity

$$\sum_{i=1}^{7} T_i X_i + \sum_{i=9}^{15} T_i X_i + \sum_{i=17}^{23} T_i X_i + \sum_{i=25}^{45} T_i X_i \leq 1120;$$

Lifts weekly capacity

$$T_{15}X_{15} + T_{35}X_{35} + T_{36}X_{36} \leq 400$$

PD pits weekly capacity

$$T_{16}X_{16} \leq 80$$

SVE_I pits weekly capacity

$$T_8 X_8 \leq 120$$

SVE_II booths weekly capacity

$$T_{24}X_{24} \leq 200$$

Minimum required and maximum demand

$$a_i \leq X_i \leq b_i; \quad \forall \quad i \in j$$

Non negativity

$$X_i \geq 0; \quad \forall \quad i \in j$$

End:

All variables (X_i) are required to be integer

$$GIN\ X_i; \quad \forall \quad i \in j$$

The LP models were modelled to represent the typical demand for VE's as well as the "hockey stick" demand for both the current and the new VE facility were modelled, to provide NSA with a short and a long term recommendations.

Model 1 – Current facility with average demand, without overtime		**Demand**		**LP Selected**
VE(s) which LP could not fully maximise due to capacity constraint	Optimal Solution	Min	Max	Max
VE16	R1 335 290,00	0	181	106
Model 2 – Current facility with average demand, with overtime		**Demand**		**LP Selected**
VE(s) which LP could not fully maximise due to capacity constraint VE Identifier	Optimal Solution	Min	Max	Max
VE16	R1 364 130,00	0	181	133
Model 3 – Current facility "hockey stick" demand, without overtime		**Demand**		**LP Selected**
VE(s) which LP could not fully maximise due to capacity constraint VE Identifier	Optimal Solution	Min	Max	Max
VE16	R1 815 540,00	0	290	106
Model 4 – Current facility "hockey stick" demand, with overtime		**Demand**		**LP Selected**
VE(s) which LP could not fully maximise due to capacity constraint VE Identifier	Optimal Solution	Min	Max	Max
VE16	R1 844 380,00	0	290	133
Model 5 – New facility with average demand, without overtime		**Demand**		**LP Selected**
VE(s) which LP could not fully maximise due to capacity constraint VE Identifier	Optimal Solution	Min	Max	Max
-	R1 415 420,00			
Model 6 – New facility with average demand, with overtime		**Demand**		**LP Selected**
VE(s) which LP could not fully maximise due to capacity constraint VE Identifier	Optimal Solution	Min	Max	Max
-	R1 415 420,00			
Model 7– New facility "hockey stick" demand, without overtime		**Demand**		**LP Selected**
VE(s) which LP could not fully maximise due to capacity constraint VE Identifier	Optimal Solution	Min	Max	Max
VE16	R1 986 489,00	0	290	266
Model 8 – New facility "hockey stick" demand, with overtime		**Demand**		**LP Selected**
VE(s) which LP could not fully maximise due to capacity constraint VE Identifier	Optimal Solution	Min	Max	Max
-	R2 012 120,00	0	290	290

Table 21: Summary Information - Linear Programming Models

The image below is a screenshot from one of the result obtained using LINDO 6.1 to solve the linear problem.

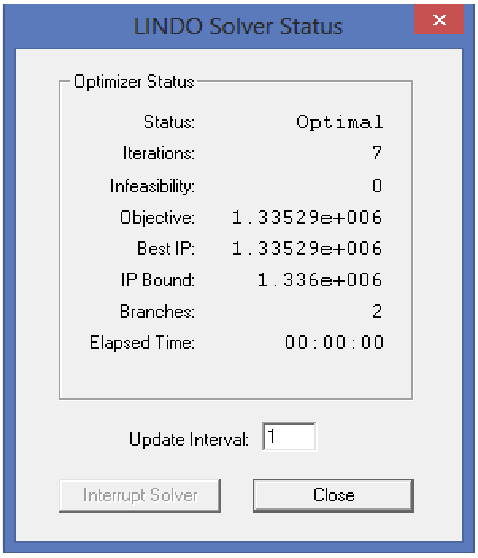

Figure 27: LINDO Results Screenshot

To see which VE's were selected during each LP please refer to section 8.2

According to the calculations the capacity constraint that keeps NSA from meeting the VE demand is the amount of PD pits. The values in the table 23, below, were calculated using the logic indicating in the following formula:

$$Est.revenue\ per\ year\ =\ 12 \times \begin{bmatrix} (3 \times (average\ demand\ optimal\ solution)) \\ +(1 \times (hockey\ stick\ demand\ optimal\ solution)) \end{bmatrix}$$

Option	Estimated Revenue without Overtime	Estimated Revenue with Overtime
Current VE Facility	R 69 736 920,00	R 71 241 240,00
New VE Facility	R 74 792 988,00	R 75 100 560,00

Table 22: Estimated Revenue

If Nissan South Africa prefers to not work overtime, the new Vehicle Enhancement facility may enable Nissan South Africa to increase their annual increase revenue by **R 5 056 068,00.**

6. Conclusion

The areas identified as critical was confirmed by Nissan South Africa (NSA), the projects raised should address the real inefficiencies in NSA's supply chain, enabling NSA to get a competitive advantage. For NSA to keep the competitive advantage, a continuous improvement approach should be followed.

If NSA adjust their staging area according to demand, they might draw a financial benefit from the exercise. The new vehicle enhancement facility may increase NSA's annual revenue, inherently it would allow for more onsite fitments which could lead to better quality preservation, shorter lead times and decreased logistics cost.

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8. Appendices

8.1 Appendix A: Industry Sponsorship Form

Department of Industrial & Systems Engineering
Final Year Projects
Identification and Responsibility of Project Sponsors

All Final Year Projects are published by the University of Pretoria on *UPSpace* and thus freely available on the Internet. These publications portray the quality of education at the University and have the potential of exposing sensitive company information. It is important that both students and company representatives or sponsors are aware of such implications.

Key responsibilities of Project Sponsors:

A project sponsor is the key contact person within the company. This person should thus be able to provide the best guidance to the student on the project. The sponsor is also very likely to gain from the success of the project. The project sponsor has the following important responsibilities:

1. Confirm his/her role as project sponsor, duly authorised by the company. Multiple sponsors can be appointed, but this is not advised. The duly completed form will considered as acceptance of sponsor role.
2. Review and approve the Project Proposal, ensuring that it clearly defines the problem to be investigated by the student and that the project aim, scope, deliverables and approach is acceptable from the company's perspective.
3. Review the Final Project Report (delivered during the second semester), ensuring that information is accurate and that the solution addresses the problems and/or design requirements of the defined project.
4. Acknowledges the intended publication of the Project Report on UP Space.
5. Ensures that any sensitive, confidential information or intellectual property of the company is not disclosed in the Final Project Report.

Project Sponsor Details:

Company:	NISSAN SOUTH AFRICA
Project Description:	STRATEGIC SUPPLY CHAIN ASSESSMENT FOR NISSAN SOUTH AFRICA
Student Name:	STEFAN JOHANNES VAN WYK
Student number:	29094373
Student Signature:	SvWyk
Sponsor Name:	JELSARIE VAN DER MERWE
Designation:	SNR MANAGER : SCM PROJECTS
E-mail:	delsariev@nissan.co.za
Tel No:	082 556 1087
Cell No:	" "
Fax No:	
Sponsor Signature:	DvdMerwe.

8.2 Appendix B: Linear Programming Models

Model 1 – Current facility with average demand, without overtime

Let:

X_i = VE $i \in j$, where $j = \{1,2,3, \dots 45\}$

C_i = the revenue associated with X_i

T_i = the time associated with X_i

a_i = the minimum number of times that X_i needs to be performed to meet weekly requirements during average demand

b_i = the maximum number of times that X_i can be performed without exceeding the weekly average demand

Objective Function:

Max Z = $\sum_{i=1}^{45} CiXi$

Subject To:

Service bays weekly capacity

$$\sum_{i=1}^{7} T_i X_i + \sum_{i=9}^{15} T_i X_i + \sum_{i=17}^{23} T_i X_i + \sum_{i=25}^{45} T_i X_i \leq 1120;$$

Lifts weekly capacity

$$T_{15}X_{15} + T_{35}X_{35} + T_{36}X_{36} \leq 400$$

PD pits weekly capacity

$$T_{16}X_{16} \leq 80$$

SVE_I pits weekly capacity

$$T_8 X_8 \leq 120$$

SVE_II booths weekly capacity

$$T_{24}X_{24} \leq 200$$

Minimum required and maximum demand

$$a_i \leq X_i \leq b_i; \quad \forall \quad i \in j$$

Non negativity

$$X_i \geq 0; \quad \forall \quad i \in j$$

End:

All variables (X_i) are required to be integer

$$GIN\ X_i; \quad \forall \quad i \in j$$

Optimal Solution:

1.33529e+006

Table 23: LP Model 1 Results

Vehicle Enhancement (VE) Demand & Information				Average Demand		LP Selected
VE Identifier	Average Revenue	Time (h)	REQUIRE	Week Min	Week Max	
VE1	R 6 587,19	2,5	Service Bay	0	21	21
VE2	R 1 278,88	2	Service Bay	0	14	14
VE3	R 2 373,57	0,5	Service Bay	1	1	1
VE4	R 306,02	1	Service Bay	1	1	1
VE5	R 964,65	1	Service Bay	0	0	0
VE6	R 9 091,34	0,75	Service Bay	0	5	5
VE7	R 432,74	0,166667	Service Bay	6	60	60
VE8	R 139,17	0,058333	SVE_I Pit	979	979	979
VE9	R 1 941,11	0,666667	Service Bay	6	19	19
VE10	R 4 499,00	4	Service Bay	0	0	0
VE11	R 872,00	0,2	Service Bay	0	6	6
VE12	R 426,33	0,5	Service Bay	19	34	34
VE13	R 793,70	1,5	Service Bay	0	14	14
VE14	R 1 245,10	0,1	Service Bay	0	0	0
VE15	R 6 870,46	0,5	Lift	5	11	11
VE16	R 1 068,40	0,75	PD Pit	0	181	106
VE17	R 1 228,07	0,75	Service Bay	0	19	19
VE18	R 71,56	0,25	Service Bay	27	138	138
VE19	R 2 991,31	0,75	Service Bay	0	2	2
VE20	R 2 571,20	0,45	Service Bay	3	5	5
VE21	R 2 720,74	0,833333	Service Bay	0	0	0
VE22	R 2 110,90	0,6	Service Bay	3	64	64
VE23	R 81,78	0,01	Service Bay	0	16	16
VE24	R 719,25	0,291667	SVE_II Booth	472	474	474
VE25	R 2 197,37	1	Service Bay	1	1	1
VE26	R 1 939,31	2,5	Service Bay	0	1	1
VE27	R 3 892,40	0,333333	Service Bay	0	0	0
VE28	R 8 622,51	0,75	Service Bay	1	1	1
VE29	R -	0,166667	Service Bay	24	24	24
VE30	R 450,00	0,5	Service Bay	0	13	13
VE31	R 6 754,39	0,75	Service Bay	0	0	0
VE32	R 420,23	0,9	Service Bay	3	6	6
VE33	R 464,01	0,5	Service Bay	0	0	0
VE34	R 1 015,90	0,1	Service Bay	0	0	0
VE35	R 768,29	0,5	Lift	0	0	0
VE36	R 3 419,05	2	Lift	1	22	22
VE37	R10 348,76	0,5	Service Bay	0	2	2
VE38	R 2 276,70	0,916667	Service Bay	5	23	23
VE39	R 924,00	2,5	Service Bay	2	2	2
VE40	R 119,48	0,1	Service Bay	0	0	0
VE41	R 270,53	0,1	Service Bay	0	0	0
VE42	R 40,45	0,1	Service Bay	27	258	258
VE43	R 61,03	0,1	Service Bay	0	14	14
VE44	R 59,68	0,1	Service Bay	0	0	0
VE45	R 1 754,39	1,5	Service Bay	0	1	1

Model 2 – Current facility with average demand, with overtime

Let:

X_i = VE $i \in j$, where $j = \{1,2,3, \dots 45\}$

C_i = the revenue associated with X_i

T_i = the time associated with X_i

a_i = the minimum number of times that X_i needs to be performed to meet weekly requirements during average demand

b_i = the maximum number of times that X_i can be performed without exceeding the weekly average demand

Objective Function:

Max Z = $\sum_{i=1}^{45} CiXi$

Subject To:

Service bays weekly capacity

$$\sum_{i=1}^{7} T_i X_i + \sum_{i=9}^{15} T_i X_i + \sum_{i=17}^{23} T_i X_i + \sum_{i=25}^{45} T_i X_i \leq 1400;$$

Lifts weekly capacity

$$T_{15}X_{15} + T_{35}X_{35} + T_{36}X_{36} \leq 500$$

PD pits weekly capacity

$$T_{16}X_{16} \leq 100$$

SVE_I pits weekly capacity

$$T_8 X_8 \leq 150$$

SVE_II booths weekly capacity

$$T_{24}X_{24} \leq 250$$

Minimum required and maximum demand

$$a_i \leq X_i \leq b_i; \quad \forall \quad i \in j$$

Non negativity

$$X_i \geq 0; \quad \forall \quad i \in j$$

End:

All variables (X_i) are required to be integer

$$GIN\ X_i; \quad \forall \quad i \in j$$

Optimal Solution:

1.36413e+006

Table 24: LP Model 2 Results

Vehicle Enhancement (VE) Demand & Information				Average Demand		LP Selected
VE Identifier	Average Revenue	Time (h)	REQUIRE	Week Min	Week Max	
VE1	R 6 587,19	2,5	Service Bay	0	21	21
VE2	R 1 278,88	2	Service Bay	0	14	14
VE3	R 2 373,57	0,5	Service Bay	1	1	1
VE4	R 306,02	1	Service Bay	1	1	1
VE5	R 964,65	1	Service Bay	0	0	0
VE6	R 9 091,34	0,75	Service Bay	0	5	5
VE7	R 432,74	0,166667	Service Bay	6	60	60
VE8	R 139,17	0,058333	SVE_I Pit	979	979	979
VE9	R 1 941,11	0,666667	Service Bay	6	19	19
VE10	R 4 499,00	4	Service Bay	0	0	0
VE11	R 872,00	0,2	Service Bay	0	6	6
VE12	R 426,33	0,5	Service Bay	19	34	34
VE13	R 793,70	1,5	Service Bay	0	14	14
VE14	R 1 245,10	0,1	Service Bay	0	0	0
VE15	R 6 870,46	0,5	Lift	5	11	11
VE16	R 1 068,40	0,75	PD Pit	0	181	133
VE17	R 1 228,07	0,75	Service Bay	0	19	19
VE18	R 71,56	0,25	Service Bay	27	138	138
VE19	R 2 991,31	0,75	Service Bay	0	2	2
VE20	R 2 571,20	0,45	Service Bay	3	5	5
VE21	R 2 720,74	0,833333	Service Bay	0	0	0
VE22	R 2 110,90	0,6	Service Bay	3	64	64
VE23	R 81,78	0,01	Service Bay	0	16	16
VE24	R 719,25	0,291667	SVE_II Booth	472	474	474
VE25	R 2 197,37	1	Service Bay	1	1	1
VE26	R 1 939,31	2,5	Service Bay	0	1	1
VE27	R 3 892,40	0,333333	Service Bay	0	0	0
VE28	R 8 622,51	0,75	Service Bay	1	1	1
VE29	R -	0,166667	Service Bay	24	24	24
VE30	R 450,00	0,5	Service Bay	0	13	13
VE31	R 6 754,39	0,75	Service Bay	0	0	0
VE32	R 420,23	0,9	Service Bay	3	6	6
VE33	R 464,01	0,5	Service Bay	0	0	0
VE34	R 1 015,90	0,1	Service Bay	0	0	0
VE35	R 768,29	0,5	Lift	0	0	0
VE36	R 3 419,05	2	Lift	1	22	22
VE37	R10 348,76	0,5	Service Bay	0	2	2
VE38	R 2 276,70	0,916667	Service Bay	5	23	23
VE39	R 924,00	2,5	Service Bay	2	2	2
VE40	R 119,48	0,1	Service Bay	0	0	0
VE41	R 270,53	0,1	Service Bay	0	0	0
VE42	R 40,45	0,1	Service Bay	27	258	258
VE43	R 61,03	0,1	Service Bay	0	14	14
VE44	R 59,68	0,1	Service Bay	0	0	0
VE45	R 1 754,39	1,5	Service Bay	0	1	1

Model 3 – Current facility with hockey stick demand, without overtime

Let:

X_i = VE $i \in j$, where $j = \{1,2,3, \dots 45\}$

C_i = the revenue associated with X_i

T_i = the time associated with X_i

a_i = the minimum number of times that X_i needs to be performed to meet weekly requirements during hockey stick demand

b_i = the maximum number of times that X_i can be performed without exceeding the weekly hockey stick demand

Objective Function:

Max Z = $\sum_{i=1}^{45} CiXi$

Subject To:

Service bays weekly capacity

$$\sum_{i=1}^{7} T_i X_i + \sum_{i=9}^{15} T_i X_i + \sum_{i=17}^{23} T_i X_i + \sum_{i=25}^{45} T_i X_i \leq 1120;$$

Lifts weekly capacity

$$T_{15}X_{15} + T_{35}X_{35} + T_{36}X_{36} \leq 400$$

PD pits weekly capacity

$$T_{16}X_{16} \leq 80$$

SVE_I pits weekly capacity

$$T_8 X_8 \leq 120$$

SVE_II booths weekly capacity

$$T_{24}X_{24} \leq 200$$

Minimum required and maximum demand

$$a_i \leq X_i \leq b_i; \quad \forall \quad i \in j$$

Non negativity

$$X_i \geq 0; \quad \forall \quad i \in j$$

End:

All variables (X_i) are required to be integer

$$GIN\ X_i; \quad \forall \quad i \in j$$

Optimal Solution:

1.81554e+006

Table 25: LP Model 3 Results

Vehicle Enhancement (VE) Demand & Information				Hockey Stick/ Peak Demand		LP Selected
VE Identifier	Average Revenue	Time (h)	REQUIRE	Week Min	Week Max	
VE1	R 6 587,19	2,5	Service Bay	0	30	30
VE2	R 1 278,88	2	Service Bay	0	24	24
VE3	R 2 373,57	0,5	Service Bay	1	1	1
VE4	R 306,02	1	Service Bay	1	1	1
VE5	R 964,65	1	Service Bay	0	0	0
VE6	R 9 091,34	0,75	Service Bay	0	7	7
VE7	R 432,74	0,166667	Service Bay	10	97	97
VE8	R 139,17	0,058333	SVE_I Pit	1227	1227	1227
VE9	R 1 941,11	0,666667	Service Bay	9	29	29
VE10	R 4 499,00	4	Service Bay	0	0	0
VE11	R 872,00	0,2	Service Bay	0	8	8
VE12	R 426,33	0,5	Service Bay	27	50	50
VE13	R 793,70	1,5	Service Bay	0	21	21
VE14	R 1 245,10	0,1	Service Bay	0	0	0
VE15	R 6 870,46	0,5	Lift	7	16	16
VE16	R 1 068,40	0,75	PD Pit	0	290	106
VE17	R 1 228,07	0,75	Service Bay	0	29	29
VE18	R 71,56	0,25	Service Bay	40	204	204
VE19	R 2 991,31	0,75	Service Bay	0	3	3
VE20	R 2 571,20	0,45	Service Bay	4	7	7
VE21	R 2 720,74	0,833333	Service Bay	0	0	0
VE22	R 2 110,90	0,6	Service Bay	4	95	95
VE23	R 81,78	0,01	Service Bay	0	28	28
VE24	R 719,25	0,291667	SVE_II Booth	575	577	577
VE25	R 2 197,37	1	Service Bay	1	1	1
VE26	R 1 939,31	2,5	Service Bay	0	2	2
VE27	R 3 892,40	0,333333	Service Bay	0	0	0
VE28	R 8 622,51	0,75	Service Bay	1	2	2
VE29	R -	0,166667	Service Bay	42	42	42
VE30	R 450,00	0,5	Service Bay	0	19	19
VE31	R 6 754,39	0,75	Service Bay	0	0	0
VE32	R 420,23	0,9	Service Bay	5	10	10
VE33	R 464,01	0,5	Service Bay	0	0	0
VE34	R 1 015,90	0,1	Service Bay	0	0	0
VE35	R 768,29	0,5	Lift	0	0	0
VE36	R 3 419,05	2	Lift	2	37	37
VE37	R10 348,76	0,5	Service Bay	0	3	3
VE38	R 2 276,70	0,916667	Service Bay	8	34	34
VE39	R 924,00	2,5	Service Bay	2	2	2
VE40	R 119,48	0,1	Service Bay	0	0	0
VE41	R 270,53	0,1	Service Bay	0	0	0
VE42	R 40,45	0,1	Service Bay	40	381	381
VE43	R 61,03	0,1	Service Bay	0	20	20
VE44	R 59,68	0,1	Service Bay	0	0	0
VE45	R 1 754,39	1,5	Service Bay	0	1	1

Model 4 – Current facility with hockey stick demand, with overtime

Let:

X_i = VE $i \in j$, where $j = \{1,2,3, \ldots 45\}$

C_i = the revenue associated with X_i

T_i = the time associated with X_i

a_i = the minimum number of times that X_i needs to be performed to meet weekly requirements during hockey stick demand

b_i = the maximum number of times that X_i can be performed without exceeding the weekly hockey stick demand

Objective Function:

Max Z = $\sum_{i=1}^{45} CiXi$

Subject To:

Service bays weekly capacity

$$\sum_{i=1}^{7} T_iX_i + \sum_{i=9}^{15} T_iX_i + \sum_{i=17}^{23} T_iX_i + \sum_{i=25}^{45} T_iX_i \leq 1400;$$

Lifts weekly capacity

$$T_{15}X_{15} + T_{35}X_{35} + T_{36}X_{36} \leq 500$$

PD pits weekly capacity

$$T_{16}X_{16} \leq 100$$

SVE_I pits weekly capacity

$$T_8X_8 \leq 150$$

SVE_II booths weekly capacity

$$T_{24}X_{24} \leq 250$$

Minimum required and maximum demand

$$a_i \leq X_i \leq b_i; \quad \forall \quad i \in j$$

Non negativity

$$X_i \geq 0; \quad \forall \quad i \in j$$

End:

All variables (X_i) are required to be integer

$$GIN\ X_i; \quad \forall \quad i \in j$$

Optimal Solution:

1.84438e+006

Table 26: LP Model 4 Results

Vehicle Enhancement (VE) Demand & Information				Hockey Stick/ Peak Demand		LP Selected
VE Identifier	**Average Revenue**	**Time (h)**	**REQUIRE**	**Week Min**	**Week Max**	
VE1	R 6 587,19	2,5	Service Bay	0	30	30
VE2	R 1 278,88	2	Service Bay	0	24	24
VE3	R 2 373,57	0,5	Service Bay	1	1	1
VE4	R 306,02	1	Service Bay	1	1	1
VE5	R 964,65	1	Service Bay	0	0	0
VE6	R 9 091,34	0,75	Service Bay	0	7	7
VE7	R 432,74	0,166667	Service Bay	10	97	97
VE8	R 139,17	0,058333	SVE_I Pit	1227	1227	1227
VE9	R 1 941,11	0,666667	Service Bay	9	29	29
VE10	R 4 499,00	4	Service Bay	0	0	0
VE11	R 872,00	0,2	Service Bay	0	8	8
VE12	R 426,33	0,5	Service Bay	27	50	50
VE13	R 793,70	1,5	Service Bay	0	21	21
VE14	R 1 245,10	0,1	Service Bay	0	0	0
VE15	R 6 870,46	0,5	Lift	7	16	16
VE16	R 1 068,40	0,75	PD Pit	0	290	133
VE17	R 1 228,07	0,75	Service Bay	0	29	29
VE18	R 71,56	0,25	Service Bay	40	204	204
VE19	R 2 991,31	0,75	Service Bay	0	3	3
VE20	R 2 571,20	0,45	Service Bay	4	7	7
VE21	R 2 720,74	0,833333	Service Bay	0	0	0
VE22	R 2 110,90	0,6	Service Bay	4	95	95
VE23	R 81,78	0,01	Service Bay	0	28	28
VE24	R 719,25	0,291667	SVE_II Booth	575	577	577
VE25	R 2 197,37	1	Service Bay	1	1	1
VE26	R 1 939,31	2,5	Service Bay	0	2	2
VE27	R 3 892,40	0,333333	Service Bay	0	0	0
VE28	R 8 622,51	0,75	Service Bay	1	2	2
VE29	R -	0,166667	Service Bay	42	42	42
VE30	R 450,00	0,5	Service Bay	0	19	19
VE31	R 6 754,39	0,75	Service Bay	0	0	0
VE32	R 420,23	0,9	Service Bay	5	10	10
VE33	R 464,01	0,5	Service Bay	0	0	0
VE34	R 1 015,90	0,1	Service Bay	0	0	0
VE35	R 768,29	0,5	Lift	0	0	0
VE36	R 3 419,05	2	Lift	2	37	37
VE37	R10 348,76	0,5	Service Bay	0	3	3
VE38	R 2 276,70	0,916667	Service Bay	8	34	34
VE39	R 924,00	2,5	Service Bay	2	2	2
VE40	R 119,48	0,1	Service Bay	0	0	0
VE41	R 270,53	0,1	Service Bay	0	0	0
VE42	R 40,45	0,1	Service Bay	40	381	381
VE43	R 61,03	0,1	Service Bay	0	20	20
VE44	R 59,68	0,1	Service Bay	0	0	0
VE45	R 1 754,39	1,5	Service Bay	0	1	1

Model 5 – New facility with average demand, without overtime

Let:

X_i = VE $i \in j$, where $j = \{1,2,3, \dots 45\}$

C_i = the revenue associated with X_i

T_i = the time associated with X_i

a_i = the minimum number of times that X_i needs to be performed to meet weekly requirements during average demand

b_i = the maximum number of times that X_i can be performed without exceeding the weekly average demand

Objective Function:

Max Z = $\sum_{i=1}^{45} CiXi$

Subject To:

Service bays weekly capacity

$$\sum_{i=1}^{7} T_i X_i + \sum_{i=9}^{15} T_i X_i + \sum_{i=17}^{23} T_i X_i + \sum_{i=25}^{45} T_i X_i \leq 2960;$$

Lifts weekly capacity

$$T_{15}X_{15} + T_{35}X_{35} + T_{36}X_{36} \leq 400$$

PD pits weekly capacity

$$T_{16}X_{16} \leq 200$$

SVE_I pits weekly capacity

$$T_8 X_8 \leq 120$$

SVE_II booths weekly capacity

$$T_{24}X_{24} \leq 200$$

Minimum required and maximum demand

$$a_i \leq X_i \leq b_i; \quad \forall \quad i \in j$$

Non negativity

$$X_i \geq 0; \quad \forall \quad i \in j$$

End:

All variables (X_i) are required to be integer

$$GIN\ X_i; \quad \forall \quad i \in j$$

Optimal Solution:

1.41542e+006

Table 27: LP Model 5 Results

Vehicle Enhancement (VE) Demand & Information				Average Demand		LP Selected
VE Identifier	**Average Revenue**	**Time (h)**	**REQUIRE**	**Week Min**	**Week Max**	
VE1	R 6 587,19	2,5	Service Bay	0	21	21
VE2	R 1 278,88	2	Service Bay	0	14	14
VE3	R 2 373,57	0,5	Service Bay	1	1	1
VE4	R 306,02	1	Service Bay	1	1	1
VE5	R 964,65	1	Service Bay	0	0	0
VE6	R 9 091,34	0,75	Service Bay	0	5	5
VE7	R 432,74	0,166667	Service Bay	6	60	60
VE8	R 139,17	0,058333	SVE_I Pit	979	979	979
VE9	R 1 941,11	0,666667	Service Bay	6	19	19
VE10	R 4 499,00	4	Service Bay	0	0	0
VE11	R 872,00	0,2	Service Bay	0	6	6
VE12	R 426,33	0,5	Service Bay	19	34	34
VE13	R 793,70	1,5	Service Bay	0	14	14
VE14	R 1 245,10	0,1	Service Bay	0	0	0
VE15	R 6 870,46	0,5	Lift	5	11	11
VE16	R 1 068,40	0,75	PD Pit	0	181	181
VE17	R 1 228,07	0,75	Service Bay	0	19	19
VE18	R 71,56	0,25	Service Bay	27	138	138
VE19	R 2 991,31	0,75	Service Bay	0	2	2
VE20	R 2 571,20	0,45	Service Bay	3	5	5
VE21	R 2 720,74	0,833333	Service Bay	0	0	0
VE22	R 2 110,90	0,6	Service Bay	3	64	64
VE23	R 81,78	0,01	Service Bay	0	16	16
VE24	R 719,25	0,291667	SVE_II Booth	472	474	474
VE25	R 2 197,37	1	Service Bay	1	1	1
VE26	R 1 939,31	2,5	Service Bay	0	1	1
VE27	R 3 892,40	0,333333	Service Bay	0	0	0
VE28	R 8 622,51	0,75	Service Bay	1	1	1
VE29	R -	0,166667	Service Bay	24	24	24
VE30	R 450,00	0,5	Service Bay	0	13	13
VE31	R 6 754,39	0,75	Service Bay	0	0	0
VE32	R 420,23	0,9	Service Bay	3	6	6
VE33	R 464,01	0,5	Service Bay	0	0	0
VE34	R 1 015,90	0,1	Service Bay	0	0	0
VE35	R 768,29	0,5	Lift	0	0	0
VE36	R 3 419,05	2	Lift	1	22	22
VE37	R10 348,76	0,5	Service Bay	0	2	2
VE38	R 2 276,70	0,916667	Service Bay	5	23	23
VE39	R 924,00	2,5	Service Bay	2	2	2
VE40	R 119,48	0,1	Service Bay	0	0	0
VE41	R 270,53	0,1	Service Bay	0	0	0
VE42	R 40,45	0,1	Service Bay	27	258	258
VE43	R 61,03	0,1	Service Bay	0	14	14
VE44	R 59,68	0,1	Service Bay	0	0	0
VE45	R 1 754,39	1,5	Service Bay	0	1	1

Model 6 – New facility with average demand, with overtime

Let:

X_i = VE $i \in j$, where $j = \{1,2,3, \dots 45\}$

C_i = the revenue associated with X_i

T_i = the time associated with X_i

a_i = the minimum number of times that X_i needs to be performed to meet weekly requirements during average demand

b_i = the maximum number of times that X_i can be performed without exceeding the weekly average demand

Objective Function:

Max Z = $\sum_{i=1}^{45} CiXi$

Subject To:

Service bays weekly capacity

$$\sum_{i=1}^{7} T_i X_i + \sum_{i=9}^{15} T_i X_i + \sum_{i=17}^{23} T_i X_i + \sum_{i=25}^{45} T_i X_i \leq 3700;$$

Lifts weekly capacity

$$T_{15}X_{15} + T_{35}X_{35} + T_{36}X_{36} \leq 500$$

PD pits weekly capacity

$$T_{16}X_{16} \leq 250$$

SVE_I pits weekly capacity

$$T_8X_8 \leq 150$$

SVE_II booth weekly capacity

$$T_{24}X_{24} \leq 250$$

Minimum required and maximum demand

$$a_i \leq X_i \leq b_i; \quad \forall \quad i \in j$$

Non negativity

$$X_i \geq 0; \quad \forall \quad i \in j$$

End:

All variables (X_i) are required to be integer

$$GIN\ X_i; \quad \forall \quad i \in j$$

Optimal Solution:

1.41542e+006

Table 28: LP Model 6 Results

Vehicle Enhancement (VE) Demand & Information				Average Demand		LP Selected
VE Identifier	**Average Revenue**	**Time (h)**	**REQUIRE**	**Week Min**	**Week Max**	
VE1	R 6 587,19	2,5	Service Bay	0	21	21
VE2	R 1 278,88	2	Service Bay	0	14	14
VE3	R 2 373,57	0,5	Service Bay	1	1	1
VE4	R 306,02	1	Service Bay	1	1	1
VE5	R 964,65	1	Service Bay	0	0	0
VE6	R 9 091,34	0,75	Service Bay	0	5	5
VE7	R 432,74	0,166667	Service Bay	6	60	60
VE8	R 139,17	0,058333	SVE_I Pit	979	979	979
VE9	R 1 941,11	0,666667	Service Bay	6	19	19
VE10	R 4 499,00	4	Service Bay	0	0	0
VE11	R 872,00	0,2	Service Bay	0	6	6
VE12	R 426,33	0,5	Service Bay	19	34	34
VE13	R 793,70	1,5	Service Bay	0	14	14
VE14	R 1 245,10	0,1	Service Bay	0	0	0
VE15	R 6 870,46	0,5	Lift	5	11	11
VE16	R 1 068,40	0,75	PD Pit	0	181	181
VE17	R 1 228,07	0,75	Service Bay	0	19	19
VE18	R 71,56	0,25	Service Bay	27	138	138
VE19	R 2 991,31	0,75	Service Bay	0	2	2
VE20	R 2 571,20	0,45	Service Bay	3	5	5
VE21	R 2 720,74	0,833333	Service Bay	0	0	0
VE22	R 2 110,90	0,6	Service Bay	3	64	64
VE23	R 81,78	0,01	Service Bay	0	16	16
VE24	R 719,25	0,291667	SVE_II Booth	472	474	474
VE25	R 2 197,37	1	Service Bay	1	1	1
VE26	R 1 939,31	2,5	Service Bay	0	1	1
VE27	R 3 892,40	0,333333	Service Bay	0	0	0
VE28	R 8 622,51	0,75	Service Bay	1	1	1
VE29	R -	0,166667	Service Bay	24	24	24
VE30	R 450,00	0,5	Service Bay	0	13	13
VE31	R 6 754,39	0,75	Service Bay	0	0	0
VE32	R 420,23	0,9	Service Bay	3	6	6
VE33	R 464,01	0,5	Service Bay	0	0	0
VE34	R 1 015,90	0,1	Service Bay	0	0	0
VE35	R 768,29	0,5	Lift	0	0	0
VE36	R 3 419,05	2	Lift	1	22	22
VE37	R10 348,76	0,5	Service Bay	0	2	2
VE38	R 2 276,70	0,916667	Service Bay	5	23	23
VE39	R 924,00	2,5	Service Bay	2	2	2
VE40	R 119,48	0,1	Service Bay	0	0	0
VE41	R 270,53	0,1	Service Bay	0	0	0
VE42	R 40,45	0,1	Service Bay	27	258	258
VE43	R 61,03	0,1	Service Bay	0	14	14
VE44	R 59,68	0,1	Service Bay	0	0	0
VE45	R 1 754,39	1,5	Service Bay	0	1	1

Model 7 – New facility with hockey stick demand, without overtime

Let:

X_i = VE $i \in j$, where $j = \{1,2,3, \ldots 45\}$

C_i = the revenue associated with X_i

T_i = the time associated with X_i

a_i = the minimum number of times that X_i needs to be performed to meet weekly requirements during hockey stick demand

b_i = the maximum number of times that X_i can be performed without exceeding the weekly hockey stick demand

Objective Function:

Max Z = $\sum_{i=1}^{45} CiXi$

Subject To:

Service bays weekly capacity

$$\sum_{i=1}^{7} T_i X_i + \sum_{i=9}^{15} T_i X_i + \sum_{i=17}^{23} T_i X_i + \sum_{i=25}^{45} T_i X_i \leq 2960;$$

Lifts weekly capacity

$$T_{15}X_{15} + T_{35}X_{35} + T_{36}X_{36} \leq 400$$

PD pits weekly capacity

$$T_{16}X_{16} \leq 200$$

SVE_I pits weekly capacity

$$T_8X_8 \leq 120$$

SVE_II booths weekly capacity

$$T_{24}X_{24} \leq 200$$

Minimum required and maximum demand

$$a_i \leq X_i \leq b_i; \quad \forall \quad i \in j$$

Non negativity

$$X_i \geq 0; \quad \forall \quad i \in j$$

End:

All variables (X_i) are required to be integer

$$GIN\ X_i; \quad \forall \quad i \in j$$

Optimal Solution:

1.986489e+006

Table 29: LP Model 7 Results

Vehicle Enhancement (VE) Demand & Information				Hockey Stick/ Peak Demand		LP Selected
VE Identifier	**Average Revenue**	**Time (h)**	**REQUIRE**	**Week Min**	**Week Max**	
VE1	R 6 587,19	2,5	Service Bay	0	30	30
VE2	R 1 278,88	2	Service Bay	0	24	24
VE3	R 2 373,57	0,5	Service Bay	1	1	1
VE4	R 306,02	1	Service Bay	1	1	1
VE5	R 964,65	1	Service Bay	0	0	0
VE6	R 9 091,34	0,75	Service Bay	0	7	7
VE7	R 432,74	0,166667	Service Bay	10	97	97
VE8	R 139,17	0,058333	SVE_I Pit	1227	1227	1227
VE9	R 1 941,11	0,666667	Service Bay	9	29	29
VE10	R 4 499,00	4	Service Bay	0	0	0
VE11	R 872,00	0,2	Service Bay	0	8	8
VE12	R 426,33	0,5	Service Bay	27	50	50
VE13	R 793,70	1,5	Service Bay	0	21	21
VE14	R 1 245,10	0,1	Service Bay	0	0	0
VE15	R 6 870,46	0,5	Lift	7	16	16
VE16	R 1 068,40	0,75	PD Pit	0	290	266
VE17	R 1 228,07	0,75	Service Bay	0	29	29
VE18	R 71,56	0,25	Service Bay	40	204	204
VE19	R 2 991,31	0,75	Service Bay	0	3	3
VE20	R 2 571,20	0,45	Service Bay	4	7	7
VE21	R 2 720,74	0,833333	Service Bay	0	0	0
VE22	R 2 110,90	0,6	Service Bay	4	95	95
VE23	R 81,78	0,01	Service Bay	0	28	28
VE24	R 719,25	0,291667	SVE_II Booth	575	577	577
VE25	R 2 197,37	1	Service Bay	1	1	1
VE26	R 1 939,31	2,5	Service Bay	0	2	2
VE27	R 3 892,40	0,333333	Service Bay	0	0	0
VE28	R 8 622,51	0,75	Service Bay	1	2	2
VE29	R -	0,166667	Service Bay	42	42	42
VE30	R 450,00	0,5	Service Bay	0	19	19
VE31	R 6 754,39	0,75	Service Bay	0	0	0
VE32	R 420,23	0,9	Service Bay	5	10	10
VE33	R 464,01	0,5	Service Bay	0	0	0
VE34	R 1 015,90	0,1	Service Bay	0	0	0
VE35	R 768,29	0,5	Lift	0	0	0
VE36	R 3 419,05	2	Lift	2	37	37
VE37	R10 348,76	0,5	Service Bay	0	3	3
VE38	R 2 276,70	0,916667	Service Bay	8	34	34
VE39	R 924,00	2,5	Service Bay	2	2	2
VE40	R 119,48	0,1	Service Bay	0	0	0
VE41	R 270,53	0,1	Service Bay	0	0	0
VE42	R 40,45	0,1	Service Bay	40	381	381
VE43	R 61,03	0,1	Service Bay	0	20	20
VE44	R 59,68	0,1	Service Bay	0	0	0
VE45	R 1 754,39	1,5	Service Bay	0	1	1

Model 8 – New facility with hockey stick demand, with overtime

Let:

X_i = VE $i \in j$, where $j = \{1,2,3, \dots 45\}$

C_i = the revenue associated with X_i

T_i = the time associated with X_i

a_i = the minimum number of times that X_i needs to be performed to meet weekly requirements during hockey stick demand

b_i = the maximum number of times that X_i can be performed without exceeding the weekly hockey stick demand

Objective Function:

Max Z = $\sum_{i=1}^{45} CiXi$

Subject To:

Service bays weekly capacity

$$\sum_{i=1}^{7} T_i X_i + \sum_{i=9}^{15} T_i X_i + \sum_{i=17}^{23} T_i X_i + \sum_{i=25}^{45} T_i X_i \leq 3700;$$

Lifts weekly capacity

$$T_{15}X_{15} + T_{35}X_{35} + T_{36}X_{36} \leq 500$$

PD pits weekly capacity

$$T_{16}X_{16} \leq 250$$

SVE_I pits weekly capacity

$$T_8 X_8 \leq 150$$

SVE_II booths weekly capacity

$$T_{24}X_{24} \leq 250$$

Minimum required and maximum demand

$$a_i \leq X_i \leq b_i; \quad \forall \quad i \in j$$

Non negativity

$$X_i \geq 0; \quad \forall \quad i \in j$$

End:

All variables (X_i) are required to be integer

$$GIN\ X_i; \quad \forall \quad i \in j$$

Optimal Solution:

2.01212e+006

Table 30: LP Model 8 Results

Vehicle Enhancement (VE) Demand & Information				Hockey Stick/ Peak Demand		LP Selected
VE Identifier	**Average Revenue**	**Time (h)**	**REQUIRE**	**Week Min**	**Week Max**	
VE1	R 6 587,19	2,5	Service Bay	0	30	30
VE2	R 1 278,88	2	Service Bay	0	24	24
VE3	R 2 373,57	0,5	Service Bay	1	1	1
VE4	R 306,02	1	Service Bay	1	1	1
VE5	R 964,65	1	Service Bay	0	0	0
VE6	R 9 091,34	0,75	Service Bay	0	7	7
VE7	R 432,74	0,166667	Service Bay	10	97	97
VE8	R 139,17	0,058333	SVE_I Pit	1227	1227	1227
VE9	R 1 941,11	0,666667	Service Bay	9	29	29
VE10	R 4 499,00	4	Service Bay	0	0	0
VE11	R 872,00	0,2	Service Bay	0	8	8
VE12	R 426,33	0,5	Service Bay	27	50	50
VE13	R 793,70	1,5	Service Bay	0	21	21
VE14	R 1 245,10	0,1	Service Bay	0	0	0
VE15	R 6 870,46	0,5	Lift	7	16	16
VE16	R 1 068,40	0,75	PD Pit	0	290	290
VE17	R 1 228,07	0,75	Service Bay	0	29	29
VE18	R 71,56	0,25	Service Bay	40	204	204
VE19	R 2 991,31	0,75	Service Bay	0	3	3
VE20	R 2 571,20	0,45	Service Bay	4	7	7
VE21	R 2 720,74	0,833333	Service Bay	0	0	0
VE22	R 2 110,90	0,6	Service Bay	4	95	95
VE23	R 81,78	0,01	Service Bay	0	28	28
VE24	R 719,25	0,291667	SVE_II Booth	575	577	577
VE25	R 2 197,37	1	Service Bay	1	1	1
VE26	R 1 939,31	2,5	Service Bay	0	2	2
VE27	R 3 892,40	0,333333	Service Bay	0	0	0
VE28	R 8 622,51	0,75	Service Bay	1	2	2
VE29	R -	0,166667	Service Bay	42	42	42
VE30	R 450,00	0,5	Service Bay	0	19	19
VE31	R 6 754,39	0,75	Service Bay	0	0	0
VE32	R 420,23	0,9	Service Bay	5	10	10
VE33	R 464,01	0,5	Service Bay	0	0	0
VE34	R 1 015,90	0,1	Service Bay	0	0	0
VE35	R 768,29	0,5	Lift	0	0	0
VE36	R 3 419,05	2	Lift	2	37	37
VE37	R10 348,76	0,5	Service Bay	0	3	3
VE38	R 2 276,70	0,916667	Service Bay	8	34	34
VE39	R 924,00	2,5	Service Bay	2	2	2
VE40	R 119,48	0,1	Service Bay	0	0	0
VE41	R 270,53	0,1	Service Bay	0	0	0
VE42	R 40,45	0,1	Service Bay	40	381	381
VE43	R 61,03	0,1	Service Bay	0	20	20
VE44	R 59,68	0,1	Service Bay	0	0	0
VE45	R 1 754,39	1,5	Service Bay	0	1	1

8.3 Appendix C: Ashman's D, bimodality test

SVE_I Ashman's D Test:

Let:

μ_1 = mean SVE_I monthly demand (off peak)

μ_2 = mean SVE_I monthly demand (peak)

σ_1 = standard deviation of the SVE_I monthly demand (off peak)

σ_1 = standard deviation of the SVE_I monthly demand (off peak)

$D =$ an indicator, indicating if the mixture of two normal distributions may be cleanly separated, where $D > 2$ is required for a clean separation. (Ashman, et al., 1994).

Then:

$$D = 2^{\frac{1}{2}} \frac{|\mu 1 - \mu 2|}{\sqrt{(\sigma_1^2 + \sigma_2^2)}}$$

$$D = 2^{\frac{1}{2}} \frac{|4906 - 2138|}{\sqrt{(431.943^2 + 503.442^2)}}$$

$$D = 5.901$$

$\therefore D > 2$, distribution may be cleanly separated

SVE_II Ashman's D Test:

$$D = 2^{\frac{1}{2}} \frac{|\mu 1 - \mu 2|}{\sqrt{(\sigma_1^2 + \sigma_2^2)}}$$

$$D = 2^{\frac{1}{2}} \frac{|2308 - 1152|}{\sqrt{(286.476^2 + 470.527^2)}}$$

$$D = 2.968$$

$\therefore D > 2$, distribution may be cleanly separated

8.4 Appendix D: PLAN Maturity Models

CONFIDENTIAL INFORMATION,

Please Refer To Hard Copy

8.5 Appendix E: SOURCE Maturity Models

CONFIDENTIAL INFORMATION,

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8.6 Appendix F: DELIVER Maturity Models

CONFIDENTIAL INFORMATION,

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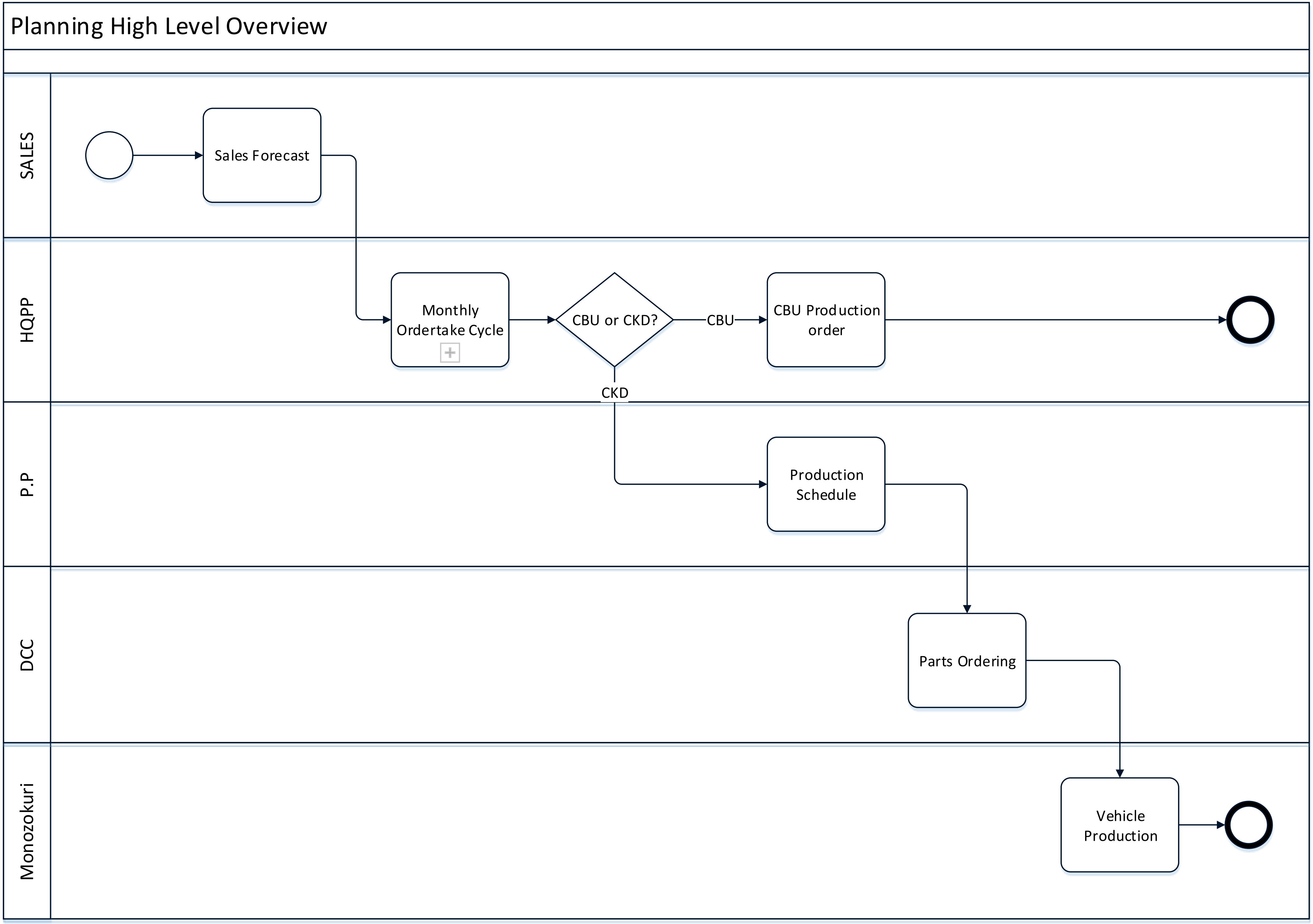
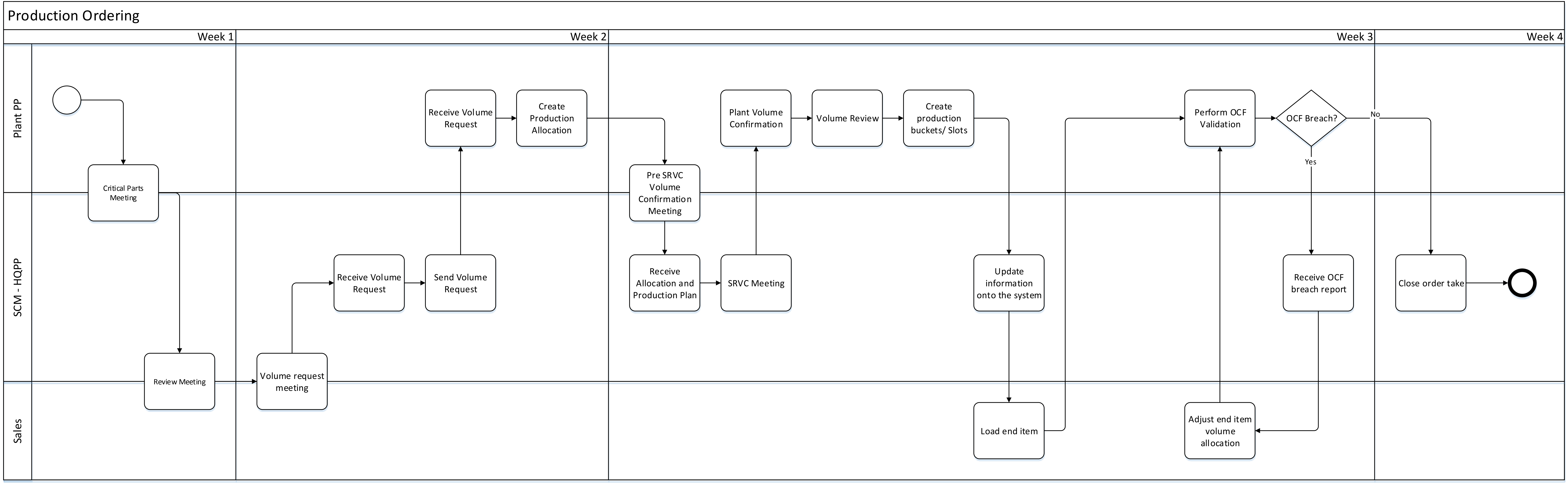
8.7 Appendix G: PLAN Process Map (CBU & CKD)


Planning High Level Overview
SALES
HQPP
P.P
DCC
Monozokuri
Sales Forecast
Monthly Ordertake Cycle
CBU or CKD?
CBU
CKD
CBU Production order
Production Schedule
Parts Ordering
Vehicle Production



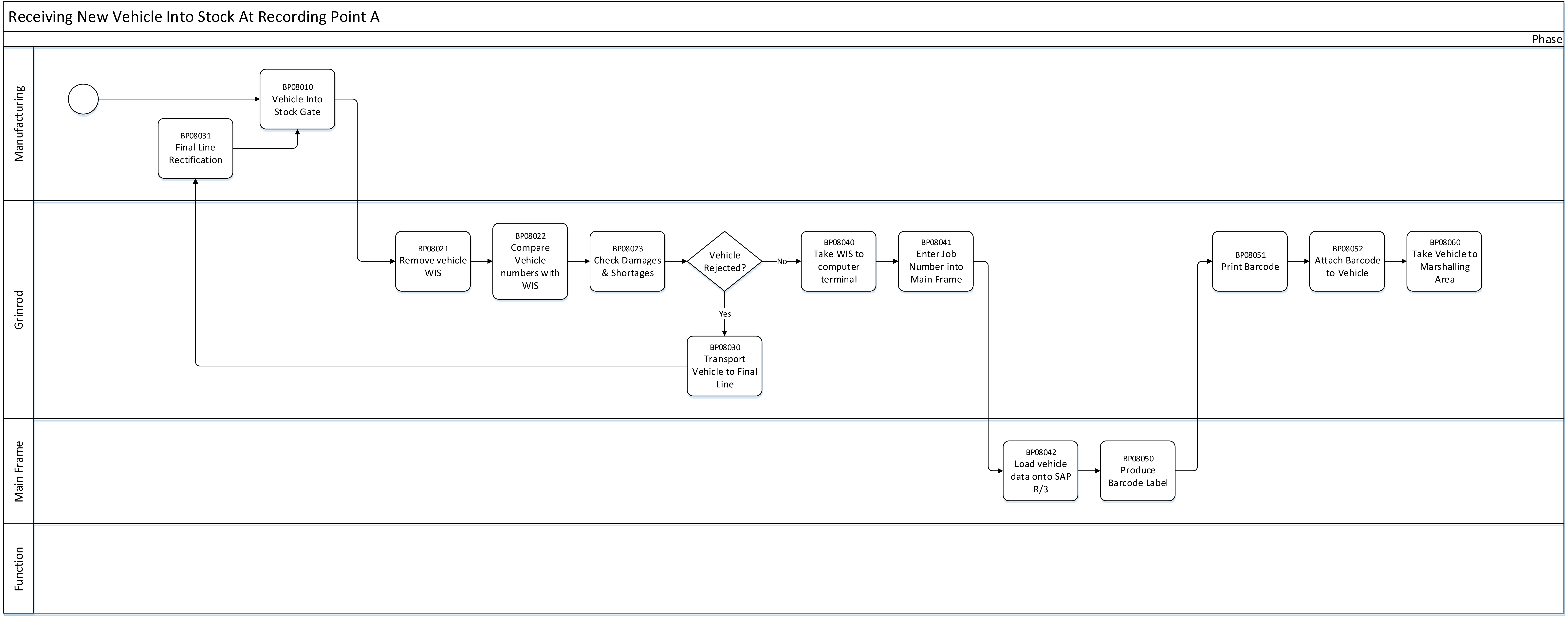
Production Ordering
Week 1
Week 2
Week 3
Week 4
Plant PP
SCM - HQPP
Sales
Critical Parts Meeting
Review Meeting
Volume request meeting
Receive Volume Request
Send Volume Request
Receive Volume Request
Create Production Allocation
Pre SRVC Volume Confirmation Meeting
Receive Allocation and Production Plan
SRVC Meeting
Plant Volume Confirmation
Volume Review
Create production buckets/ Slots
Update information onto the system
Load end item
Perform OCF Validation
OCF Breach?
No
Yes
Receive OCF breach report
Adjust end item volume allocation
Close order take

8.8 Appendix H: SOURCE Process Map (CBU)


Inbound CBU
Durban Car Terminal
NSA Approved Dealership
In Transit
Durban Stock Yard
In Transit
NSA Dispatch
NSA Car Train Siding
NSA Stock Yard
Durban Car Terminal
Transnet Freight Rail
Marine Surveyor
BPL
NSA Stock Yard Manager
Carrier (Grinrod)
3rd Party Vendor
NSA Sales
NSA Vehicle Logistics Operations
NSA Refurb/ NSA Approved Dealer
Receive Vehicle
Move Vehicle Into Holding Area
Either 370 or GTR?
Yes
No
Mode of Transport
Train
Carrier
Move Vehicle to Gate out
Perform Subsequent Processes
Quality Inspection
Quality?
OK
Load Vehicle Onto Train
Notify NSA & DCT Of Damages / Defects
Transport Vehicle
Transport Vehicle
Quality Inspection By Marine Surveyor
Quality?
OK
NG
Notify NSA SCM Of Damages / Defects
Perform Customs Clearance
Two types of clearing processes can be actioned: 1- Clearing into the bonded warehouse 2- Duty paid
Duty Paid?
Yes
No
Perform Bond to Bond Transfer
Make Booking with Transnet Freight Rail
Duty Paid?
Yes
No
Perform Bond to Bond Transfer
Handover Inspection Performed Between TFR & Stock Yard Manager
Achieve Stock Shift on EVL
Into Dispatch (Scan E)
Into Stock (Scan D) Achieve Stock shift on EVL
Quality Inspection By Stock Yard Management
Quality?
OK
NG
Bin Into Stock
Quality Inspection by Carrier
Quality?
NG
OK
Notify NSA SCM & DCT Of Damages / Defects
Transport Vehicle
Bin Vehicle Into Durban Stock Yard
Stock shift required?
Yes
No
See Outbound CBU Process
Quality Inspection by Carrier
Quality?
OK
NG
Transport Vehicle
Notify NSA SCM Of Damages / Defects
Perform DataDot
Move Vehicle Back Into Holding area
Request Mode of Transport
Perform Subsequent Processes
Remove Hold Delay on EVL
Apply Hold Delay on EVL
Remove Hold Delay on EVL
Apply Hold Delay on EVL
Remove Hold Delay on EVL
Apply Hold Delay on EVL
Restore To NSA New Vehicle Quality
Restore to NSA New Vehicle Quality
Restore to NSA New Vehicle Quality
Restore to NSA New Vehicle Quality

8.9 Appendix I: SOURCE Process Map (CKD)


Nissan Inbound Logistics- Process Map
Durban
Local Supplier Plant
In Transit
NISCON
Local Parts Receiving
In Transit
Warehouse
In Transit
Stamping Plant
In Transit
Assembly Plant
Local Suppliers
Milkrun Service Provider (DHL)
Production
Material Handling
BPL
BPL NISCON Yard Managers
Parts Control
Transnet
Durban Container Terminal
Produce Part
JIT Parts?
Yes
No
Transport
Milkrun Parts?
No
Transport
Transport
Stamping Plant Operation
Production
Final Line
Scan A
Transport
Transport
Parts into Receiving
Yes
Direct to Line?
No
Shunt to Correct Warehouse
No
Shunt to Stamping Plant Warehouse
Bin Into Warehouse
Pick Parts
Transport
Deliver at designated NSP station
New part into outbound warehouse
Transport
Into Marshalling Area
Correct Warehouse?
No
Stamping Plant Part?
Transport
Taken to Marshalling area
Standard MRP Part
Parts into Receiving
Yes
Bin Into Warehouse
Picking list generated by MRP
Pick Parts
Parts into picking Handover area
Part type?
Sequence
Kit
Transport
Deliver to sequencing area
Sequence parts
Deliver at designated line side station
Transport
Deliver to kitting area
Kit parts
Clearing Process
Road Haul Container
MRP Requirements
Receive Containers
Bin Container
Call Container
Pick Container
Devan Containers based on devanning list
Picking list generated by MRP
Yes
Emergency Parts?
No
Rail Container
Container Arrives at Port


Receiving New Vehicle Into Stock At Recording Point A
Phase
Manufacturing
Grinrod
Main Frame
Function
BP08010 Vehicle Into Stock Gate
BP08031 Final Line Rectification
BP08021 Remove vehicle WIS
BP08022 Compare Vehicle numbers with WIS
BP08023 Check Damages & Shortages
Vehicle Rejected?
No
Yes
BP08030 Transport Vehicle to Final Line
BP08040 Take WIS to computer terminal
BP08041 Enter Job Number into Main Frame
BP08042 Load vehicle data onto SAP R/3
BP08050 Produce Barcode Label
BP08051 Print Barcode
BP08052 Attach Barcode to Vehicle
BP08060 Take Vehicle to Marshalling Area

8.10 Appendix J: DELIVER Process Map (CBU)


Outbound CBU
Durban Stock Yard
In Transit
Final Destination
BPL
Carrier (Grinrod)
3rd Party Vendor
NSA Sales
Vehicle Logistics Operations
NSA SCM/ Nissan Approved Dealer
Order Attach?
Yes
No
Quality Inspection By Carrier
Quality?
OK
NG
OVE?
No
Yes
Durban Fitment?
Notify NSA SCM Of VE
Transport Vehicle to NSA and Perform Subsequent Processes
Financial Release
Duty Paid?
Obtain SAD 500 Clearance Documents
Quality Inspection By Carrier
Quality?
Notify NSA of NG
Transport Vehicle
Deliver to Specified Address
Indicate Concern On POD / Notify Within 24 hours
Perform VE
VE Quality Inspection
Quality?
Notify VLO VE Is Completed
Notify NSA of NG
Restore VE To NSA New Vehicle Quality
Sell Vehicle
Attach Sales Order on EVL
Remove Hold Delay on EVL
Apply Hold Delay on EVL
Remove Hold Delay on EVL
Apply Hold Delay on EVL
Achieve VE manually on System
Remove Hold Delay on EVL
Apply Hold Delay on EVL
Transmission
Restore to NSA New Vehicle Quality
Restore to NSA New Vehicle Quality
Deliver to Specified Address
Perform Quality Inspection (As Part of POD process)
Quality?
Sign POD Document

8.11 Appendix K: DELIVER Process Map (CKD)


Outbound CKD
Scan A
VE Facility(Rubberising/ DataDot/ PIO)
Stockyard Parking Bays
VE Facility(Rubberising/ PIO/ Offsite)
Stockyard Parking Bays
Scan C
Dispatch
In Transit
Final Destination
Sales
Stockyard Management System
Stockyard Operator
Refurbishment
3rd Party Vendor
Carrier
End Customer
Gate Vehicle In
Print Parking Ticket
SVE?
Yes
No
Move Vehicle to Stockyard Parking Bays
Move Vehicle to VE Facility
Gate Vehicle Into VE Facility
Perform SVE
Rework/ Replace Damaged Components
Perform VE Quality Inspection
Conform to NSA Quality?
Yes
No
Attach Hold Delay
Hold Attached?
Detach Hold Delay
Achieve VE
Gate Vehicle Out of VE Facility
Print Parking Ticket
Move Vehicle to Stock Yard Parking Bays
Sell Vehicle
Attach Sales Order
Sales Order Attached?
Yes
No
OVE?
Yes
No
Gate Vehicle Into VE Facility
Move Vehicle to VE Facility
Perform OVE
Rework/ Replace Damaged Components
Perform VE Quality Inspection
Conform to NSA Quality?
Yes
No
Attach Hold Delay
Hold Attached?
Yes
No
Detach Hold Delay
Achieve VE
Gate Vehicle Out of VE Facility
Move Vehicle to Stockyard Parking Bays
Financial Released?
No
Yes
Financial Release
Move Vehicle to Scan C
Rework/ Replace Damaged Components
Perform Flash Aves
Conform to NSA Quality?
Yes
No
Attach Hold Delay
Hold Attached?
Yes
No
Detach Hold Delay
Gate Vehicle Out of NMC & Auto Gate in ACR
Move Vehicle to Dispatch Yard
Collect Vehicle from Dispatch
Transport Vehicle
Deliver to Specified Address
Receive Vehicles
Perform Quality Inspection (As Part of POD process)
Quality?
NG
OK
Indicate Concern On POD / Notify Within 24 hours
Sign POD Document
Transmission