A Contingency framework for the after-sales inventory at Nissans Part Distribution Centre

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Executive Summary

Nissan South Africa currently has a manufacturing plant in Rosslyn, north of Pretoria. This plant houses Nissans only after-sales warehouse in Southern Africa. Parts are sourced through various pipelines to the warehouse and inventory levels are monitored. These parts are distributed to all the dealerships through out South Africa and its borders. Currently there is no contingency framework in the event of a stock – loss. This project seeks to provide a contingency plan (framework) for the inventory in the unlikely event of an emergency.

Through information gathering, in the form of a literature study, a suitable methodology was devised to build the contingency plan. Tools and techniques that are applicable to the methods are discussed. The methodology of the plan is illustrated by means of a pilot study. The phases of the methodology are:

- Damage Assessment
- Inventory analysis
- Needs Analysis
- Procurement policy

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1. Introduction and Background

1.1 Corporate background

Nissan initially started as the Kwaishinsha Automotive Company in 1911 and produced its first Datsun cars in the Japanese market. In the next 20 years the company was taken over and rebadged as the Nissan Motor Company of Japan.

In the following years plants were created in the US and UK markets. Throughout the company's existence Nissan was acknowledged as a front runner in the world of technology with an ever expanding company profile.

In the 1990s however, global production overloading was more prominent and new solutions need to be sought. In order to survive during this period Nissan formed an international alliance with the Renault car company. This alliance created the fourth largest car company in the world.

Nissan's involvement in South Africa has grown over the past 40 years, initially as Datsun, with vehicles meeting the expanding and emerging South African market. Nissan plays a significant part in the country's motor industry with about 10% of the automotive market with vehicle ranges across the light, medium and heavy commercial sectors. Currently over 2 500 people are employed by the company in South Africa.

Nissan is one of six companies to have a vehicle assembly and manufacturing plant in South Africa, with its facilities situated in Rosslyn, north of Pretoria.
This plant has won numerous awards due to environmental efforts and practises.

1.2 Introduction

Currently the After-Sales inventory is housed at the Parts Distribution Centre (PDC) at Nissan Rosslyn. The spare parts[1] stored here are distributed to the dealerships in South Africa. Parts through the pipeline are delivered to the PDC centre for storage and categorised as high, medium or low impact parts (based on importance of the part, high being of high importance) and in terms of how fast they move. This is categorised in the order of A through J (A being the fastest).

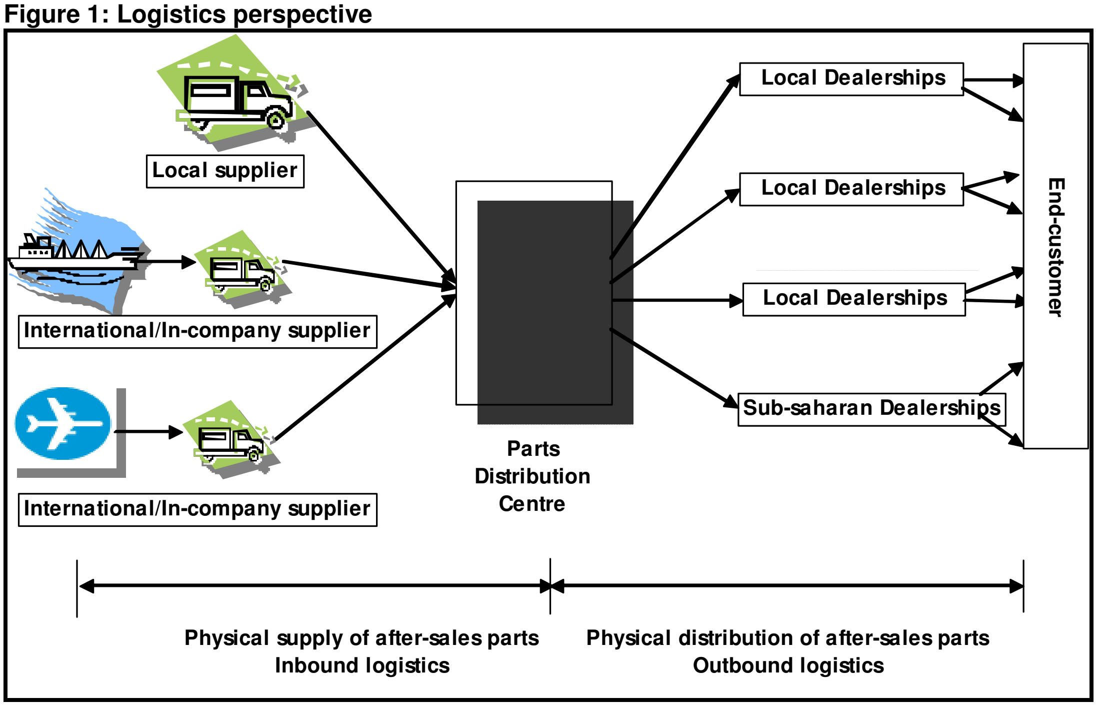
The two forms of transportation of parts to Nissan from International borders are by air and sea. The lead time for shipments to the centre by ship is usually 70 days (10 weeks) compared to 14 days (2 weeks) for air-transport. Local suppliers send parts through various routes within South Africa, the main mode of transport being trucks, with variations of 7 to 120 days from the time the order is placed, till it is received. The majority of stock is brought in from Nissan Japan, and the remaining stock must comply with Nissan Global's standards as a Nissan approved part, used for vehicles under warranty.

[1] . Please note 'spare parts' and 'after-sales parts' are used interchangeably, as are 'items' , 'lines', and 'centre',' warehouse', in the literature.

1.3 Environment Analysis

The after-sales parts are stored at the PDC (centralized warehouse) before being shipped out to dealers. Once the parts arrive at the dealers they're used on the vehicles brought into the dealerships, thus supplying the demand of the end-customer.

Figure 1: Logistics perspective



The current order processing at Nissan's PDC works off of the Custom Resource Planner (CRP)-based system they currently employ, in MS Access. By employing the system, order preparation through to order filling is monitored and maintained.

The information gathered and processed by the system will be used and updated in the event of an emergency, discussed in the literature that follows.

2. Problem Statement

Currently Nissan's PDC has no disaster management plan (encompassing various contingency plans) in the event of an emergency. These types of emergencies (such as, but not limited to, partial or full destruction of the PDC by means of fire, rain, theft and other inbound supply risks) are defined as disasters and are not to be confused with "everyday emergencies" (Altay 2005) such as sudden demand for one part.

Pearson et al (1998) define a disaster/crisis as:
'A low probability, high impact event that threatens the viability of the organisation and is characterised by ambiguity of cause, effect and means of resolution, as well as by a belief that decisions must be made quickly.'

As such a contingency plan for the inventory at the warehouse is essential in the event of damage and/or destruction to the warehouse. In the unlikely event, the company would need to react quickly with limits not usually experienced, in order to deal with and eventually recover from the disaster.

What and when to do it, are questions that need to be addressed in a logical and concise way to allow Nissan to make effective decisions in handling what happens to the supply chain after disaster. More specifically how this applies to that of the inventory. Thus the procurement of parts plays a vital role in recovery from impact and as such what decisions need to be made in order to recover them.

3. Project Aim & Scope

3.1 Aim

The aim of the project is to provide the framework for a contingency plan in the event of an emergency to the Parts Distribution Centre. Introduced in the framework is a contingency methodology, a methodology employed to provide Nissan within information to base important decisions.

In light of this, the concept of a Decision Support System (DSS) is discussed and its use illustrated by means of a pilot study. The DSS of the pilot study is done on a selected portion of data, generic enough in fashion to be expanded and adjusted for the complete database in the event of a disaster.

3.1.1 Boundaries of study

Taking destruction to the warehouse, by means of disaster, the focus of the methodology and information provided by the DSS is on the inventory of the PDC.

The study of inventory is in the short term, considering those parts most critical to Nissan and the new demand requirements generated because of disaster.

Mention is made of the background influences and synergy between the stock, resources and activities need to store distribute and control it.

The project is only concerned with the inbound logistics sourcing in the event of an emergency.

3.2 Objectives

In order to achieve the aim, certain aspects need to be addressed, they are:

- Provide a contingency methodology framework, within which to work from
- To allow for crucial and responsive decisions shortly after the disaster
- To ensure suppliers have an understanding and awareness of the situation
- Provide a framework for a Decision Support System to aid Nissan with decisions in crisis

4. Literature Study

4.1 Contingency planning

BNET (2009) defines a contingency plan as: ‘a plan, drawn up in advance, to ensure a positive and rapid response to a changing situation. A contingency plan often results from scenario planning and may form part of an organization's disaster management strategy’.

4.1.1 Need

Unexpected events always occur; they can also disrupt a company’s ability to do business. A contingency plan can prove to be a vital component in the company’s ability to recover.

Contingency preparedness depends on the way a company handles the area of contingency planning.

4.2 Areas of interest

As stated in the problem definition, the areas of disaster to which the contingency plan applies are grouped in the following way:

- Man-made
- Natural

The more resources used the greater the risk to the company and several risks are prevalent where inbound supply is concerned. Man-made emergencies could involve problems with suppliers and incoming stock (suck as strikes and/or damage to the warehouses at Nissan Japan). Natural disasters can also occur to the Parts Distribution Centre, and can prove the move damaging.

4.3 Decision Support tools

4.3.1 Decision Support System

Mukhopadhyay et al (2003) describe the form of information system: 'Decision Support Systems (DSS) deal with the design and the use of cognitively compatible computerized systems for assisting the managers in taking more effective decisions concerning semi-structured and unstructured tasks'.

The DSS is thus a tool allowing the user to directly interact with the chosen database, allowing the user to deliver data to a particular imbedded decision model and to represent the output thereof in a convenient format.

According to Andersen et al (1985) a DSS has four basic subsystems:

- Interactive capability that enables the user to communicate directly with the system
- A data manager that makes it possible to extract necessary information from internal and external databases
- A modeling subsystem that permits the user to interact with management science models by inputting parameters and tailoring situations to specific decision-making needs
- An output generator with a graphics capability that enables the user to ask what-if questions and obtain output in easily interpretable form

4.3.2 Database

The database software utility used at Nissan for inventory management, discussed earlier, is their custom made MS Access database. Microsoft's Excel and Access programs can be used in combination to create a data management system for the plan.

Both provide the capability to:

- Run **powerful queries** and criteria searches
- Use **sophisticated calculations** to obtain information from
- Connect to **external data**
- **Import data** from external sources

Access provides the readily-stored information regarding the parts, while Excel in turn the does the calculations in which to base the decisions.

4.4 Data Assessment

Once the database containing the information gathered from the inventory analysis is developed, an assessment on the parts can commence.

As described in P.P Gajpal et al (1994): 'The criticality of an item is a very important factor to be considered for specifying service levels, especially in the case of spare parts inventory systems'.

Critical to this phase is the development of standards by which the stock is measured against. **Criticality** will determine the priority of the stock to Nissan in the case of an emergency. For different scenarios (partial damage, complete damage), different priorities may be applicable/assigned.

Having completed the criteria in a given situation, the right priorities should be applied.

However here, with multiple criteria involved, the process is extended, with certain criteria weighed against each other by means of Pair-wise comparisons.

4.5 The nature of spare-parts inventory

Inventory, as described by Waters (1992): is ’a list of all the items held in stock’. Further more, the management of Inventory is described by Coyle JJ et al. (2003) as:’ pertaining to issues of how much [inventory] to order, when and where to store the inventory; and what items to order’. It goes on to mention the emerging emphasis of inventory management in increasing customer service level.

Service level and in particular service level measurement β, is the ability of a company to meet demand created for a product within the company, without delay, from the current inventory on hand. This is measured in percentage of what is met without delay in a certain time period.

Measured as

$$\text{Service level } \beta = \frac{\text{current SOH week}_i}{\text{demand for week}_i}$$

Or

$$\beta = 1 - \frac{Expected\ backorders\ per\ time\ period}{Expected\ period\ demand}$$

The information from the various parts is saved as a **stock keeping unit** (SKU). In Nissan’s CRP, the information surrounding the SKU’s is kept. This is discussed further in the report.

Spare-parts form a unique variety of inventory, as independent demand with various types of forecasting required for different parts. Fortuin (1999) goes on to say: 'The logistics of service parts is difficult, as demand is hard to predict, the consequences of a stock out may be disastrous, and the prices of parts are high'.

As described by Ehinlanwo and Zairi:
Products in the after-sales inventory of automobile manufacturers can be subdivided into 4 main areas, they are:

- Parts
- Accessories
- Auto chemicals
- Tyres (not included at the PDC)

Parts are classified as components of the car that replace, either through long or short-term wear, primary to the car functioning. **Accessories** are classified as extras that usually offer aesthetic appeal and would usually be classified as type 'C'. **Auto chemicals** include the chemicals that help to maintain and service the vehicle. These are essentially the stock that will be ranked and assessed for the project.

4.6 Inventory modeling

Distribution Resource Planning (DRP) builds on the Material Resource Planning (MRP) logic, whereby the requirements for an item are calculated with certain differences, they are:

- DRP starts with a demand forecast for a particular item downstream (the dealers) and then works backwards
- The requirements are based on quantity/stock on hand, and the forecasted demand, dealing with inventory based on independent

demand (unrelated to demands for other products – usually found in manufacturing products)

The DRP develops a time base for distributing products, and as stated in Coyle (2003): 'as developing a projection for each SKU'.

Using and adapting the DRP method in the project will allow the PDC to determine the amount of critical parts needed in shorter space of time, while the rest of the critical parts arrive later, either due to shipment lead-times or large production runs at the suppliers. This demand is now focused on as the demand during the lead time (lead time being the time for normal shipment and order quantities to come through).

The tools are summarised in the table that follows.

Table 1 : Tools / techniques used

Tool	Description
Pair-wise comparison	Use of multiple objective decision making. Ranking of criteria against one another to obtain weights for criteria.
Pareto Analysis	80-20 rule. 20% of parts (or inventory) accounts for around 80 % of the annual rand usage. Pareto analysis involves the study of the top 20 %.
DRP	Distribution Resource Planning involves the planning of inventory requirements downstream and then works backwards to find requirements.
Monte Carlo simulation	Used to determine the effects of replicated effects on static stochastic models
What-if analysis	Looks at various scenarios and the effects the scenarios have on the outcomes

4.6.1 Software

Excel® is commonly used in extracting and calculating data in the aid of solving models of this nature, and is a great tool to use. It is used as the interface and computational software for the Decision Support System. Monte Carlo simulation and What-if analysis conducted for the recommendations section make use of Excel's data tables and scenario planning.

Monte Carlo simulation as described by Kruger (2006),'is the specific sequence of replicated events', used in the modelling of stochastic processes (uncertainty).

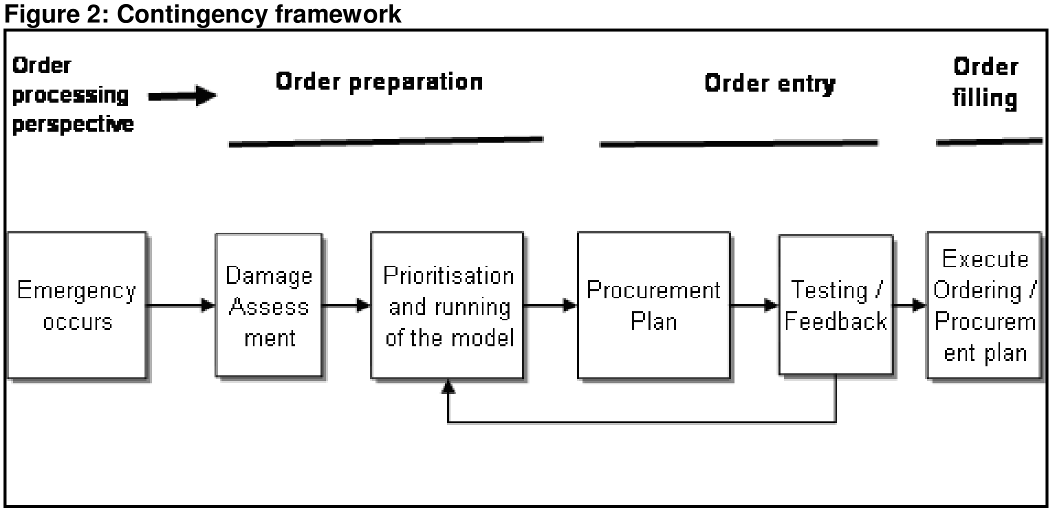
5 Contingency methodology

The methodology for this particular contingency plan provides a simple approach that allows coverage over various possible risks. Sequentially the following steps/phases build up the plan:

1. Damage Assessment
2. Inventory &
3. Needs Analysis
4. Procurement decisions – not in scope, but briefly discussed (see appendix C)

Figure 2 provides the framework with an above head perspective of the typical order-process that the company's After-sales department would handle. It also provides the outline for the Decision Support System to aid Nissan's Inventory Controller in an objective decision.

Figure 2: Contingency framework



5.1 Damage Assessment

The first phase of the contingency methodology can be seen in Figure 3. This phase is the start-up portion, usually where the most time is wasted.

Key to this phase (and highlighted in Appendix C) is the protocol in informing of the disaster and then the assessment of the disaster on inventory in the Risk Committee.

Broken down, the order preparation and order entry components (and how quickly they take place) are used as perspective from normal operations to the contingency plan operations. Under normal conditions order preparation would involve the checking and ordering of stock and a reorder point with regards to the normal inventory model used. However in the emergency event these tasks need a readjustment.

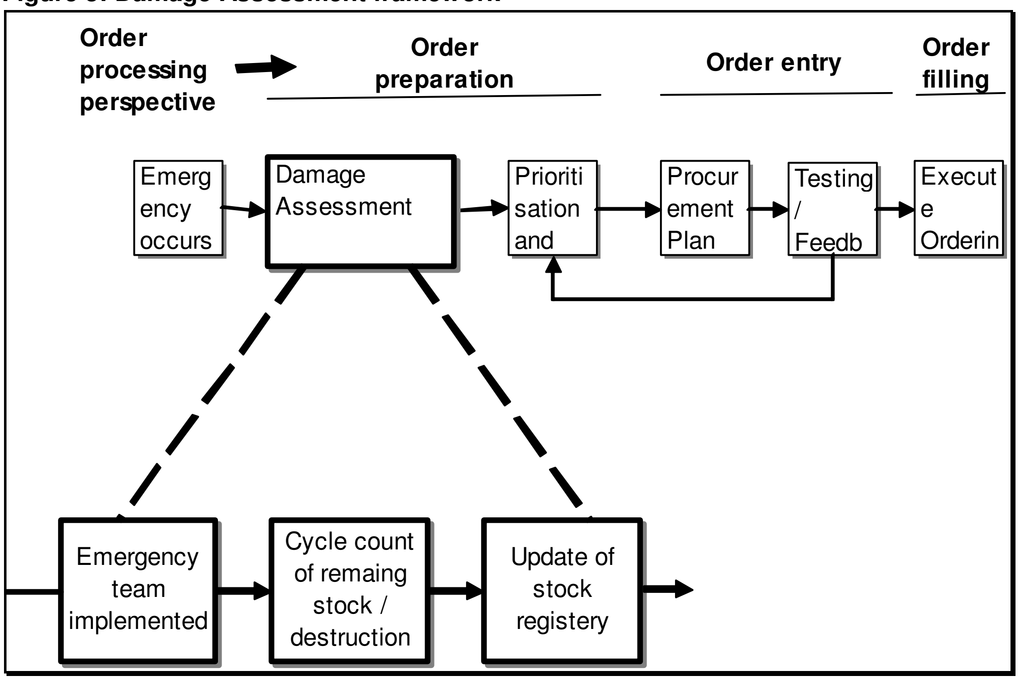
From the ground level, manual input is required to further assess the damage and to make decisions on reordering lost parts in the shortest time possible to meet the demand required by the dealerships. In order to gain the inputs required by the system to aid the Inventory controller the following are to be implemented:

- Assessment of an emergency from ground level, where security at the warehouse notifies the responsible party in the event of an after-hours disaster
- Drawing and/or notifying up the emergency event team, at the best possible time, to deal with the crisis and damage assessment thereof (see Appendix C)
- A cycle-count of the remaining stock (pooling together as many resources as possible to implement the count) and/or to establish if no stock remains at the PDC
- Readiness in dealing with Insurers and re-insurers
- An update of what is damaged and to what extent updated in the database

5.1.1 Who is needed where, and what is the protocol if the situation becomes a disaster?

In order to facilitate what happens next, the emergency/disaster committee makes decisions based on areas of responsibility and move through the hierarchy to obtain approval for decisions made. Working with an emergency committee, allows for the responsive action necessary in the situation and is typically formed as part of disaster management protocol.

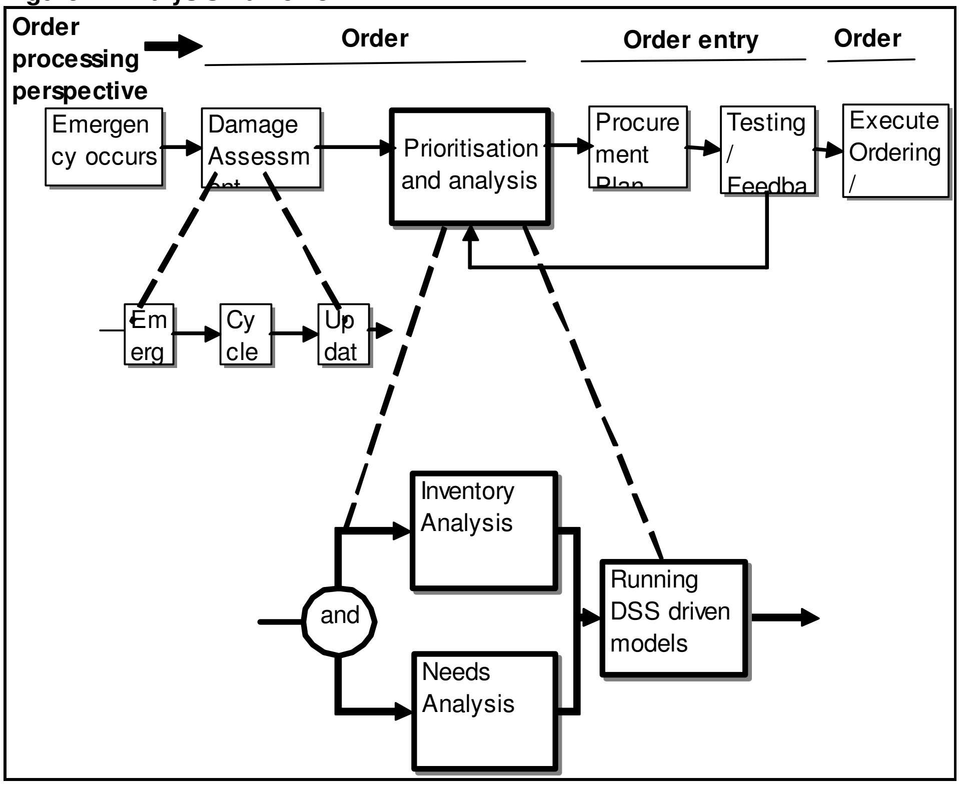
Figure 3: Damage Assessment framework



5.2 Inventory Analysis

The second phase focuses on the current inventory at the **Parts Distribution Centre** (PDC). Information available from the current database, such as the type of stock, where it comes from, costs and lead time, is necessary in the new needs of the PDC. In continuing business by providing its most vital assets to (both dealers and end-users) Nissan will minimise the impact of disruptions.

Figure 4: Analysis framework



5.3 Needs Analysis

In this phase, creating an interface between Nissan, its suppliers and dealerships, is an integral part of the contingency plan. This interface can be used to assess unit relationships that the suppliers and dealerships have with Nissan's part distribution centre and highlight the possible need for new avenues that the PDC have to use in order to procure parts.

What is important is how much is needed now, and then what will be needed later. To determine how much is needed in the short run, while larger orders at cheaper costs are planned in the long-run.

Cognizance must be taken of the various interfaces with suppliers, dealerships and those in management. In Nissan's case, a plan must be ready to use immediately after assessment of the damage done to the stock.

Finding alternative location(s) could be required, and can be deduced with the information gathered in this project and others conducted at Nissan. Using the information, Nissan can understand how much rental space they may need in the interim. A list of warehousing locators is in appendix C.

5.4 Procurement Decisions (not part of scope)

The next phase in the methodology is that of the procurement decisions. In this phase the information supplied from the need and inventory analysis is used to make decisions off of. Techniques such as simulation, optimising and what-if analysis can be performed by Nissan and its inventory analysts. Mention is made of Monte Carlo simulation and what-if analysis in the recommendations.

6. Pilot study

6.1 Acquisition of data and the relationships thereof

Nissan's PDC works off a custom-made CRP system based in MS Access. Although no access to the system was provided (due in large to the sensitivity of data), what is laid out in the following sections highlights the use of the methodology in the form of a pilot study. The logic behind what is done in the pilot study for one part can be applied to the selected whole.

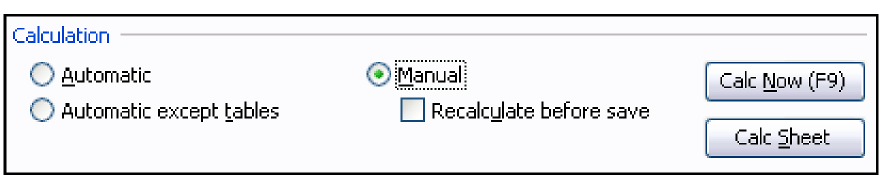
Firstly an indication of how the data is sourced from the access database to excel, in order to do calculations, is shown. The Part information table illustrates what type of data is sourced and on display. With the information supplied the prioritisation of parts is done in the parts criteria section (as depicted in table 2 and figures 7 &10).

The Part information supplied is then also supplied to the inventory model, where calculations are made on the amount of backorders and net stock on hand for the short-term (until bulk-shipment arrives).

6.1.1 Sequence

Once the data is extracted from MS Access, it is stored in the 1st worksheet in the contingency file, from there on each section's information is extracted from that 1st worksheet (named *rank*). The ranking of parts involves excel statistical and logic functions and is completed before the inventory model calculates the expected values. **NOTE**: the calculation settings in Excel are set to manual and to calculate per worksheet, not the whole document, so as not to 'overcook' the operating system.

Figure 5 : MS Excel calculation options



6.2 Decision Support System

6.2.1 Features of the Proposed DSS

This DSS is aimed at helping Nissan decide on what to source in terms of the most important parts from existing and potential suppliers in the database. Through the data-driven models, a set of selection criteria will firstly list and rank the most important parts and view the service level measurement (fill rate) of a particular part, given the situation at hand (the parts particular demand forecast, stock in transit due date and probable backorders).

All of this is made possible through queries run through the interface, with information exchanged via EDI (Electronic Data Interchange).

Figure 6: DSS overview

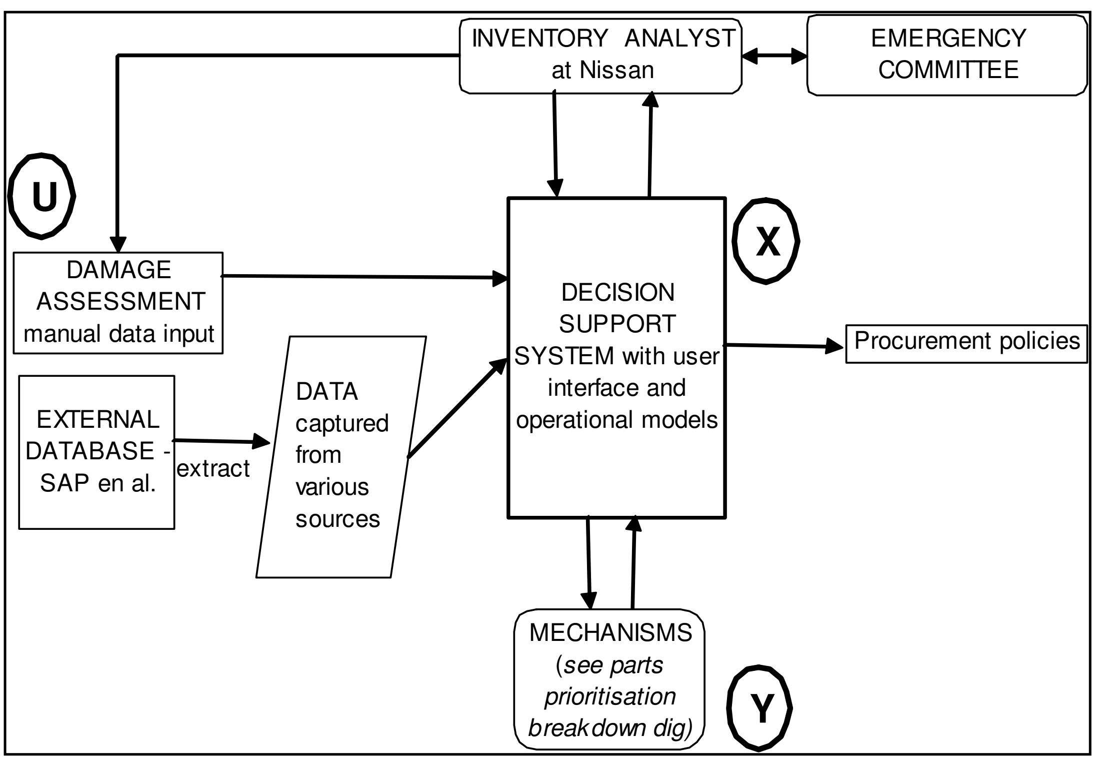
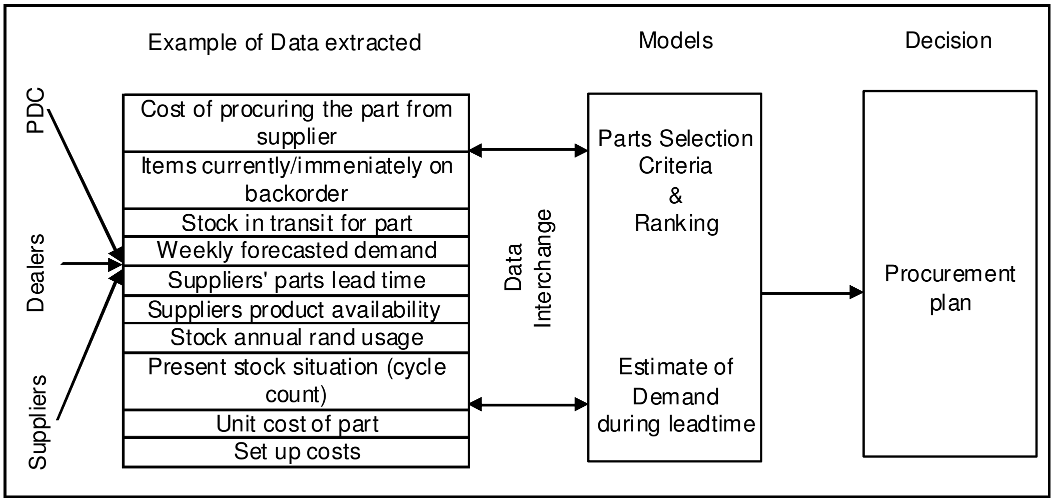


Figure 7: Input data



As seen in Figure 7, the inputs from both manual input and that extracted from Nissan's ERP are then used as inputs for the decision models. The information used from the parts selection model is also used as input (variable) in the next model, and refines the decision making, focusing on a smaller, more critical amount of parts. The visibility of the impact of these parts can be shown in the next model against a backdrop of forecasted demand in the weeks subsequent to the aftermath, as explained in (Winston 2004):'tight management control of ordering procedures is essential for Type A items; individual forecasts should be made for each A item'. The lead time of these particular parts plays a vital role in the recovery of the PDC's supply chain.

Table 2: Example of Part details extracted from database

Part					
Part no.	*Part name*	*Classification*	*WK AV Demand*	*Current SOH*	*SIT*
1191	Spark plug	A_i	100	0	100
HML	*Lead time*	*Backlog*	*Supplier availability*	*Annual Rand*	*Default Supplier*
H	70	-	1	0.10%	Nissan Japan

As can be seen the extracted data includes

- **SOH** (*Stock on hand*) – the stock remaining at the PDC just after the event
- **SIT** (*Stock in transit*) – the stock already order before the event on its way to the PDC
- **Classification/Code** – fast or slow moving part, ranked A-J, whereby A indicates the fastest moving part
- **Lead time** – the usual amount of time it takes to procure a part (from order placed till order received)
- **Annual Rand usage** - percentage of value a part counts in the total rand value of annual sales
- **Particular forecast** – the forecast, forecasted demand weekly
- **Av Weekly Demand** - the calculated weekly average demand for the particular spare parts at the Parts Distribution Centre (PDC)
- **Supplier availability at lead time** – denotes the probability the supplier can supplier desired quantity at the stated lead time (assumed here to be 1)

6.3 Parts Selection Criteria Model

6.3.1 Querying data

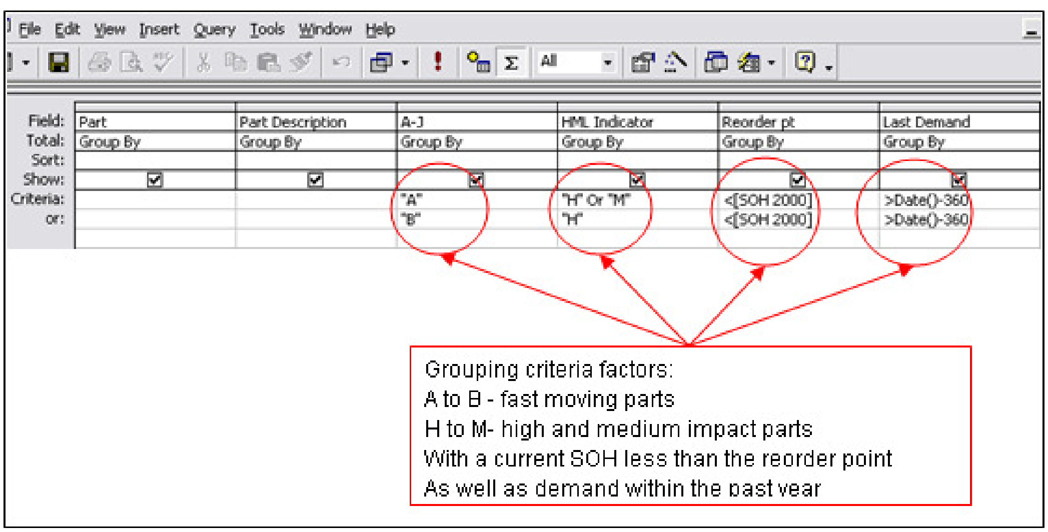
Due to the constraints on time and resources, during an emergency the focus is on the inventory most critical to the supply chain. Through Nissan's CRP database certain attributes are used to sift through those vital and those parts; either obsolete, slowing moving or low impact in nature, that have little effect on the given situation.

The following **Parts Attributes:**

- Fast moving parts (of Nissan's A – J ranking of fast to slow moving parts)
- High impact parts (of Nissan's HML indicator)
- Service-dependant parts (the parts used in the regular servicing of under-warranty cars)

termed 'Criteria group **A**', are used to cut down the considerable amount of parts to a manageable size.

Figure 8: Example of querying from MS Access



Using the querying function in MS Access, what potentially is thousands of parts is shortened to a select list of the important few. This list of parts is exported to MS Excel, and assigned part-related inventory scores to compare it to the other ranking parts, on the following criteria (group **B**):

- average weekly demand
- annual rand usage
- lead time based on current supplier

6.3.2 Inventory score

Given the situation, the criteria may change, or new ones add. These can be adjusted in the Pair wise matrix.

Criteria are rated as shown below, with allocated weights from Pair wise comparison tables, and a consistency index to check the consistency of the weighting procedure. Simple subjective inputs are used, and are valued to the discretion of Nissan's analyst.

Table 3: Pair-wise table

Pairwise comparison matrix	AVG Demand	Annual Rand Usage	Lead time	Supplier availability at lt
AVG Demand	1	5	2	4
Annual Rand Usage	0.2	1	0.5	0.5
Lead Time	0.5	2	1	2
Supplier availability at lt	0.25	2	0.5	1
SUM	1.95	10	4	7.5

Table 4: Criteria weights

i	WEIGHTS	
1	0.51	AVG Demand
2	0.10	Annual Rand Usage
3	0.24	Lead Time
4	0.15	Supplier availability at lt
	1	SUM

The relative weight involved (for criteria **A**) is multiplied with the part's relative performance criteria in group **B**. The highest relative performance (RW for a criterion) from criteria in group **B** is equal to 1:

$$\frac{\textit{largest relative value}}{\textit{largest relative value}} = 1$$

If a parts average demand is the highest, it scores one relative to the others based on being the largest, it's than multiplied with the weight factors for group **A** to allocate its inventory score.

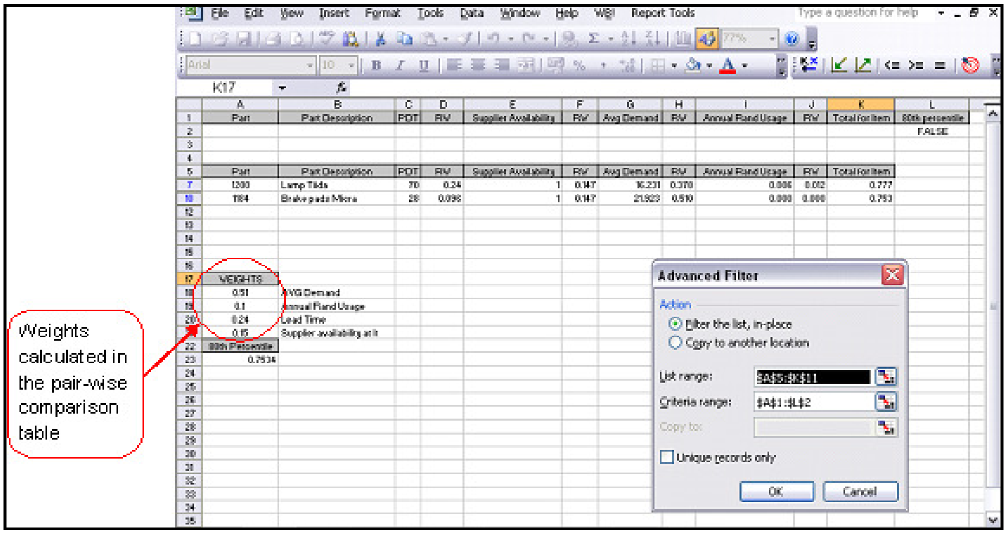
Thus the total composite numerical inventory score possible would be equal to the pair-wise weights multiplied with the relative weights and added together:

$$\sum_{i=1}^{4} (\textit{Weight of criteria } i) * (\textit{Relative Weight of part in criteria } i) = 1$$

Using the criteria, defined in the tables 3 and 4, will allow Nissan to understand what parts, given the current situation, are now deemed the most important. These parts are ranked from Most Important to the Least, using the Inventory Score afforded to it.

Pareto analysis of the 80^{th} percentile rank A1 to A_n likewise B and C for their respective cumulative scores. Use of the PERCENTILE function in excel can calculate the value of the 80^{th} percentile. Use of the filter criteria in Excel allows for a filter of the parts above the 80^{th} percentile. An example of this filter is shown in fig 9.

Figure 9: Example of inventory score query



Those final 20 percent are the parts that make up the highest inventory score can be considered most necessary in retrieving, at a shorter space in time.

Total of composite weights	Class
>=80th percentile	A

Table 5: Parts selection description

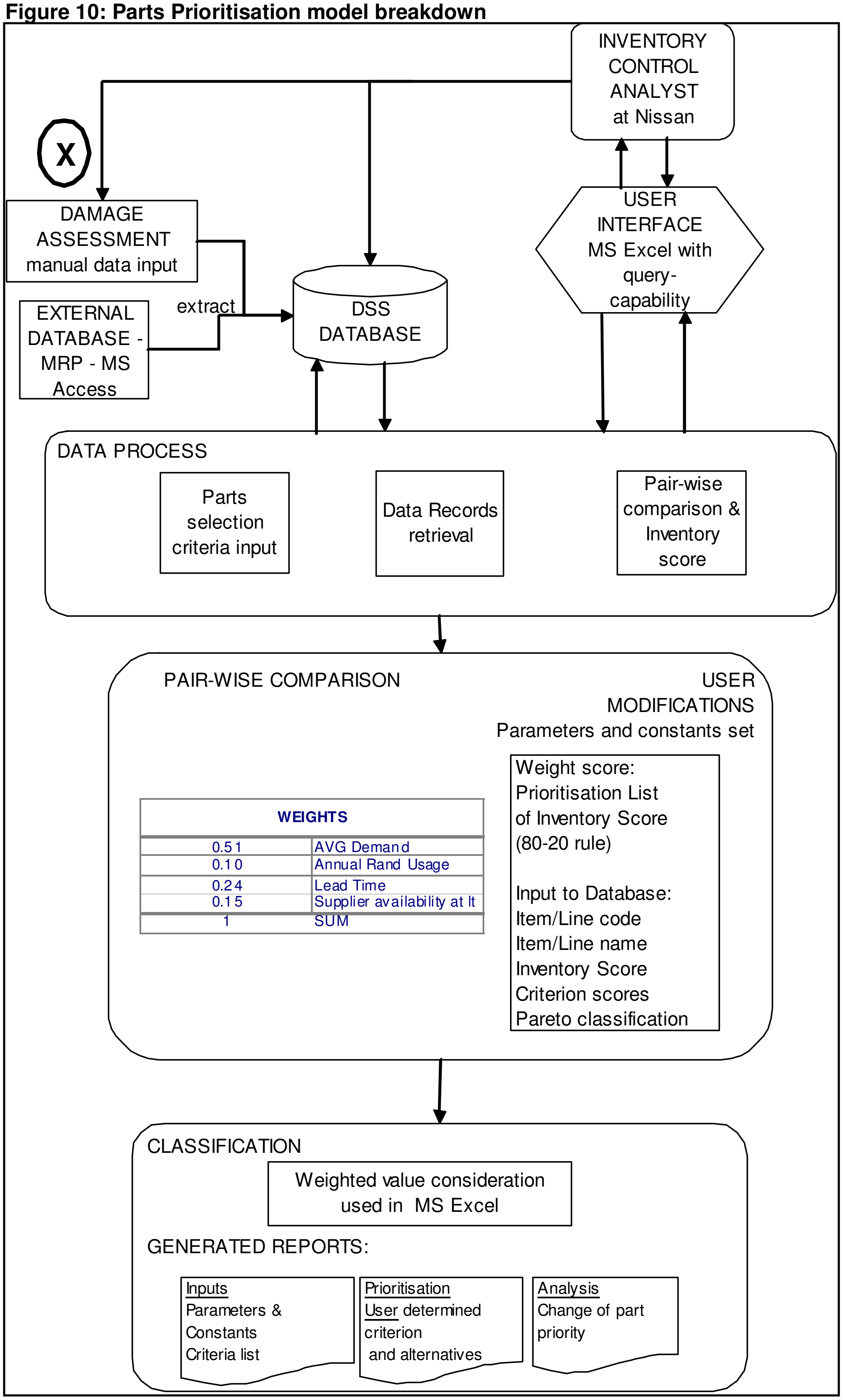
Parts selection abbreviation	Parts selection criteria
A	Av weekly Demand
B	Annual Rand Value
C	Lead time
D	Supplier availability

Table 6: Example of criteria output

		Parts selection criteria					
		A	B	C	D	Inventory Score	ABC
Item name	Item no.	(av. weekly demand)	(%)	(in weeks)	(%)		classification
Spark plug Navara	1844	1506.154	2.2	10	100	X_1	A1
Brake pads	1214	1349.225	1	2	100	X_2	A2
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
Wheel bearing	1111	24.123	0.02	1	100	X_n	C_n

The information gathering process for this model is documented in fig 10.

Figure 10: Parts Prioritisation model breakdown



6.4 Inventory model

6.4.1 Model parameters

Nissan South Africa would need to know that during the period it takes for parts to reach the warehouse during normal lead times, what demand requirements are likely to occur. Those most important parts can then be assigned an amount of demand due to occur during the normal lead time (as such a demand during lead time).

It is within this period that Nissan can decide what to bring back in a shorter span of time, to meet and deal with new demands & backlog, which due to the disaster now can not be met.

The model in fig. 11 is a hybrid of the typical distribution resource plan found in supply chain techniques, to aid in calculating possible demand that will be incurred during the period of 10 weeks. In most cases, the bulk of parts lost will be returned by shipment in a lead time of 70 days (or 10 weeks). The issue is to find out how much is needed to possibly cover demand in the interim by faster means (such as air freight).

The model is run for a pilot study on one part with the following **inputs**

- Stock on hand of 0
- Stock in transit of 50 arriving in transit during the start of week 4
- Forecast for 10 week period
- Average weekly demand of 14 units for the forecast period

Figure 11: Inventory model

	MODEL										
Week	PERIOD										
	0	1	2	3	4	5	6	7	8	9	10
Demand	0	14	14	14	14	14	14	14	14	14	14
NET SOH	0	0	-14	-28	-42	-6	-20	-34	-48	-62	-76
Physical SOH		0	0	0	0	0	0	0	0	0	0
SIT					50						
Air		0	0	0	0	0	0	0	0	0	0
National		0	0	0	0	0	0	0	0	0	0
Backorder		0	14	28	42	6	20	34	48	62	76
New Back.		0	14	14	14	0	14	14	14	14	14

The blocks highlighted indicate the inputs to the model. These input values are obtained from the parts information extracted from Nissan's Access database.

Modeled in Excel with input variables regarding part $_{k}$

- the average weekly demand **Demand** $_{k}$
- stock in transit due for arrival in week X **SIT**$_{kx}$
- the remaining stock on hand data, amended with the cycle count **SOH** $_{k}$

the following is yielded

- Backorders and demand to eventually be met
- Total percentage of service level meet for the period
- Net stock on hand **NET SOH** $_{k}$

as output for the particular part.

Figure 12: Inventory output

Output

Backorder ratio	90.00%	*Amount of demand that went into backorder*
AV. New Back	11	*Average new backorders a week for period*
TOTAL SLM	15.70%	*Total service level measurement for period*
Net result SOH	-73	*Estimated SOH at the end of period*

Output as expected demand (unmet) for period

Calculations for the following outputs are shown in the appendix (A)

- net stock on hand
- accumulated backorders in week
- new backorders in week
- unmet demand (= 1 – service level β)

with an example of stochastic demand

6.4.2 Assumptions

The first assumption is that all demand unmet stays as a backorder, and does not turn into a lost sale. The reasoning here is, that OEM high impact parts especially for cars under warranty are needed to fix/repair with, in order to keep the car under its warranty.

Secondly, the model is static in that the forecast demand is deterministic, (stochastic demand is discussed and applied to the model in the recommendations section of the document), and as such the standard deviation of lead time is not considered in this model.

Thirdly, the time factor for all inputs (Demand, SOH et al) is set as:
start of week $_i$ = *end* of week $_{i-1}$.

Fourthly, the model does not calculate the order quantity, but is merely an indication of demand in the forthcoming period, given the inputs from Nissan's CRP on if and when stock in transit was/is set to arrive before any emergency, and how much stock is currently left.

These types of spare parts are high impact, used on cars mostly under warranty where a backlog is accumulated at the dealers and used up only when parts arrive (in a First in First out manner – FIFO).

The Service Level for each week is measured on whether demand in the previous week was met *in* that week, not preceding weeks.

Lastly, with regards to the model and the project in general, those parts that are recaptured in shorter lead times come damage free, otherwise the model is adjusted again with the amount of parts damaged, as still needing to be recaptured.

6.5 Result

6.5.1 Listing Suppliers of the critical parts

Once values for expected net stock on hand is calculated for critical parts the suppliers of those parts can be viewed by virtue of the extracted data relating a part to its fixed vendor (first-choice supplier in this case). For the pilot study the Net SOH equaled -90 or 90 units short for the end of period. The short term requirements are thus 90 units, and this value is added to the list of important suppliers. The part is listed along with any other parts that the particular supplier may supply to the PDC so as to holistically view critical parts by suppliers.

Listing in terms of supplier first, Nissan can directly view the companies (suppliers) whose parts are vital in the short-term. An example of what is presented can be seen in figure 13 as the list of critical parts' suppliers.

The list groups the parts under selection firstly by their

- suppliers,
- then supplier contact details,
- then various variables concerning the parts
- and then whether a decision/action has been to procure the portion (whether it be through air freight and/or by local supply through overtime production).

The final point is highlighted by the Problem column, stating 'YES' if no decision has been made of behalf of that part. The list also serves to condense the needs analysis in a simple, concise way. It is expected the list could contain around 200 to 300 parts and their respective suppliers.

With the list drawn up, Nissan has a grasp on what is important, and who to get it from. If a supplier can not meet the requirements an alternative can be sought. Using the grouping list (listing in terms of type of parts) alternative suppliers could possibly be found in the list.

Figure 13: List of suppliers

Calculation period ending estimated NET SOH from inventory model

Inventory score calculated from the parts ranking

Supplier	Supplier contact	Part no.	Part Description	Group type	PDT	Supplier Availabili	Estimated short term requirement	Total inventory scor	Rank of invento	Decision ma	Problen
Nissan Japan	Head office ☎	2541	Lamp		70	1	120	1.022	1	☑	
Nissan Japan	Contingency Email addr	1200	Lamp Tiida		70	1	16	0.871	2	☑	
Nissan Japan		622	Lamp Head		70	1	30	0.406	6		YES
Nissan Japan		2500	Brake pads Tiida		28	1	990	0.754	3	☑	
Nissan Japan		1184	Brake pads Micra		14	1	500	0.752	4	☑	
Nissan Japan		1214	spark plug		7	1	200	0.515	5	☑	
Renualt / Niss	Head office ☎										
Renualt / Niss	Contingency Email address +										

7. Recommendations

Each step from the calculated vales for the critical parts to how much is required is laid out as a worksheet in the file and moves on sequentially from the last step.

Parts also should be viewed in terms of the service-dependent parts for a car (ie. those parts required for a Nissan service). The demand for those parts can be grouped in the inventory model to save on time and computational limits, and split up the parts after the calculations are made (eg. All Nissan Tiida's are serviced with 1 air filter, 4 brake pads etc.).

7.2 Monte Carlo Simulation

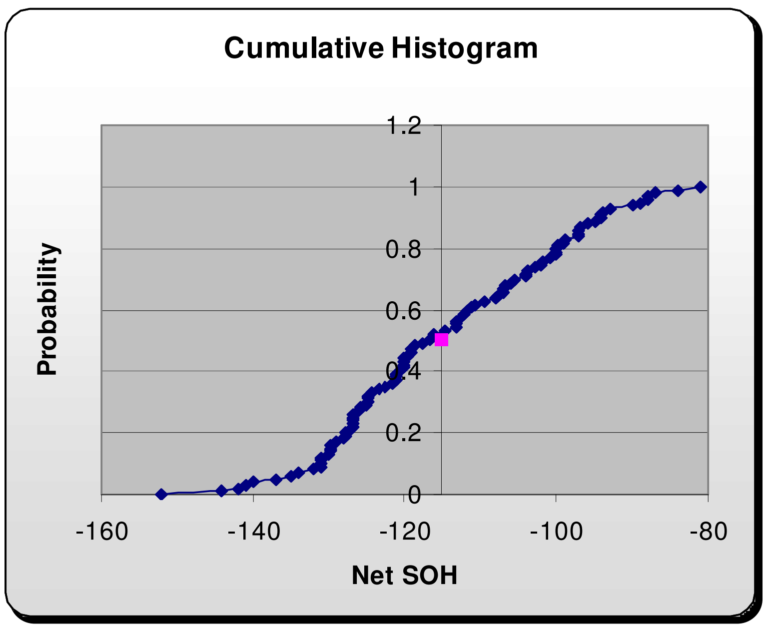
The inventory model considered used deterministic projection of demand, what about stochastic?

When determining demand as stochastic, in order to get a clear picture of the output, Monte Carlo simulation may be a powerful technique employed. With the use of a data table for repetitions of the generated variable for the forecast, results could be observed over the mean, standard deviation, min-max and standard error values from the distribution

The results for a part with a **normally-distributed** forecast with a mean 16 parts weekly and standard deviation of 5, are shown in the following table. The stock situation is the same as it was for the pilot study. The replication run of the simulation is 100.

Figure 14: Monte Carlo output

Net SOH	
Count	100
Mean	-115.74
Median	-115
Standard deviation	16.18368
Minimum	-149
Maximum	-78
First quartile	-126.25
Third quartile	-106.75
5th percentile	-141.15
10th percentile	-107.9
90th percentile	-93.7
95th percentile	-86



The cumulative histogram shown here can usefully express the uncertainty of the stock on hand at the end of the period schematically. In the histogram there is a 0.5 probability that this part will have a net stock on hand of -115 or less at the end of the period.

The use of simulation in determining the short-term requirements should be used for those demand forecasts that can be grouped together. These types are the service-related parts.

7.3 What if Analysis

Depending on whether the suppliers can supply a part in a shorter space in time, and the costs associated with it (order cost setup, overtime production, etc.), the decisions made on what to order in the short-term could increase or decrease the Service level discussed in the literature review. Once all parts' information is obtained, the total scenario planning can take place. In it cost factors are introduced and although no access or information regarding costs was shared, internally the company may weigh up the different scenarios in order to choose when to fly back an amount of parts.

The following Scenario Summary shown in fig. 15 is based on the pilot study done earlier. It indicates the difference in Total Service Level measurement, backorders and costs if an air-shipment were to be flown in. Incidentally, the amount of 115 shown in the Changing cells' rows is the NET SOH calculated from the mean of NET SOH calculated from the Monte Carlo Simulation.
The cost of procurement in the scenario analysis was for a part was arbitrarily taken as

- R50 for air transport in week 2
- R45 for air transport in week 3
- R40 for air transport in week 4

The result is shown on the following page in figure 15.

Figure 15: Scenario Summary

Scenario Summary	DO NOTHING	ORDER_INTERIM WEEK2	ORDER_INTERIM WEEK3	ORDER_INTERIM WEEK4
Changing Cells:				
AIR week2	0	115	0	0
AIR week 3	0	0	115	0
AIR week4	0	0	0	115
Result Cells:				
Total Service Level	21.33%	90.00%	80.00%	70.00%
Backorder ratio	88.6%	9.8%	21.1%	29.3%
Av. New Backorders	9.6	1.2	2.6	3.6
Cost of Procuring part	0	5750	0	0
Cost of Procuring part	0	0	5175	0
Cost of Procuring part	0	0	0	4600

Notes: Current Values column represents values of changing cells at time Scenario Summary Report was created. Changing cells for each scenario are highlighted in gray.

Based on the outputs, the total service level goes up 10% each week the parts are recaptured early. The backorder ratio (amount of demand going into backorder) also decreases the earlier parts are brought in.

In finding a medium between the costs of backlog (not shown here) and the cost of early procurement, Nissan can procure a certain amount of parts to best suit its needs. This is the basis for an optimization study.

7.4 Other factors

Other factors to consider during the contingency plan implementation are

- Plan for the alternative supply sources
- Alternative transport arrangements
- Storage space and how much space is required

Based on this report and those done by other Nissan students, factors such as the temporary storage space and location can be calculated for the interim. This calculated by the amount stock arriving in the period multiplied with cubic capacity / storage space requirements for the parts. Therefore it may not be crucial to store at a warehouse in similar size to the PCD.

Although not in scope, the nature of decentralising could ease the impact of disaster on Nissan, whereby satellite warehouses stock those parts deemed most important.

Parts could also be sourced from the manufacturing plant alongside the PDC (assuming no damage to that portion of Nissan).

8. Conclusion

All the information supplied in the Decision Support System is there as a basis for decisions to be made.

The system should provide information on the most important parts and their demand structure, based on the user's criteria. The use of different scenarios allows Nissan to view the choice of sacrifice in terms of service levels and time. The varying costs and supplier production constraints could then be added, to weigh up the whole picture.

The values determined for the selection and rank of parts, as well as the forecasted 'emergency' demand for a particular part, allows Nissan the opportunity to assess and ease the impact of the disaster. Knowing what is important, and by how much, could lessen the effect of customer service in the short term.

Following the structure laid out here, Nissan can adapt what was done for a pilot study on a larger scale within the methodology.

Once done, changes are needed to respond to future developments; therefore the contingency file should be assessed every 6 months. Included are:

- Changing alternatives / criteria
- Staff assigned to the plan (Contingency committee)
- Interfaces
- Obsolete and excess spare parts (In CRP – MS Access)

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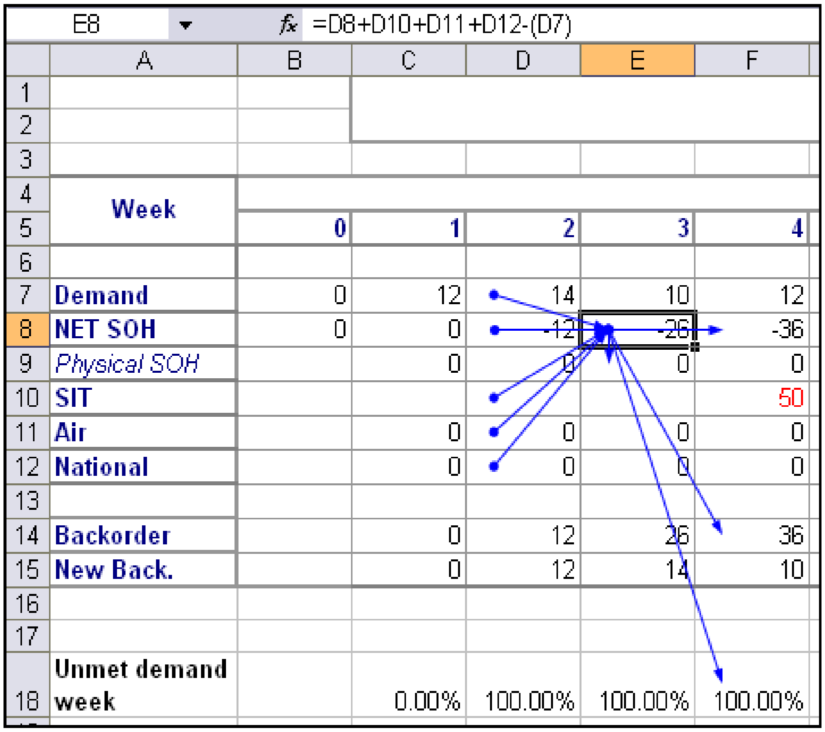
10. Appendix

A Inventory calculations – Net Stock on Hand calculations



E8 =D8+D10+D11+D12-(D7)

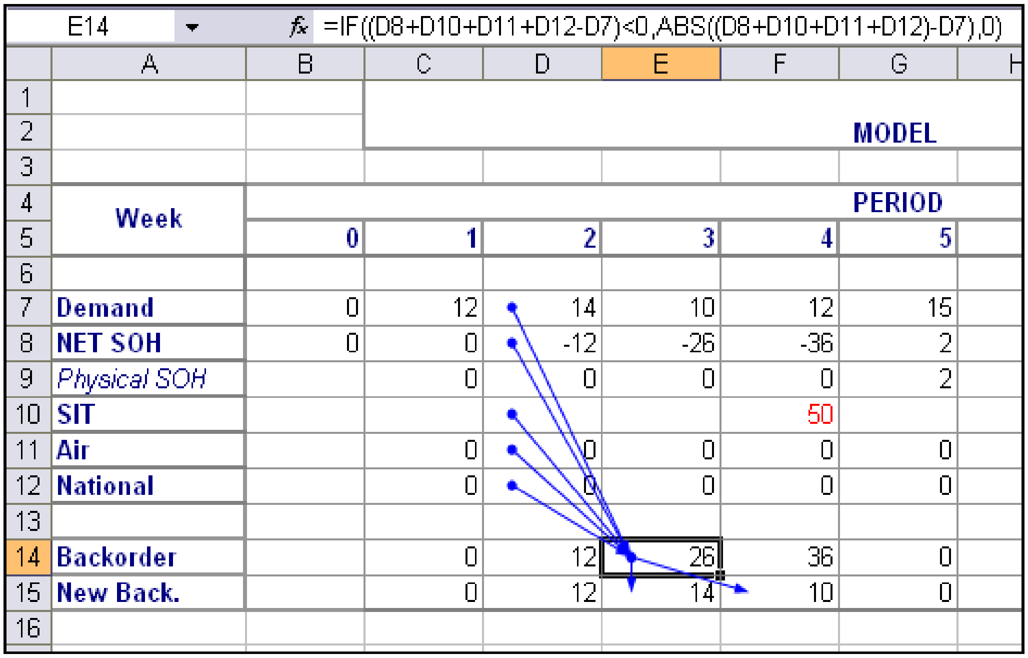
	A	B	C	D	E	F
1						
2						
3						
4	Week					
5		0	1	2	3	4
6						
7	Demand	0	12	14	10	12
8	NET SOH	0	0	-12	-26	-36
9	Physical SOH		0	0	0	0
10	SIT					50
11	Air		0	0	0	0
12	National		0	0	0	0
13						
14	Backorder		0	12	26	36
15	New Back.		0	12	14	10
16						
17						
18	Unmet demand week		0.00%	100.00%	100.00%	100.00%

Net SOH week $_i$ = SOH week $_{i-1}$ + Any arrivals week $_{i-1}$ - Demand week $_{i-1}$

In the diagram, the preceding formulas (or inputs) needed in calculating net stock on hand for week3 are shown as well as the dependent cells on the net stock on hand from week3.

Net stock at end of period = Net stock at end of week 10

Inventory calculations – Backorder calculations



E14 =IF((D8+D10+D11+D12-D7)<0,ABS((D8+D10+D11+D12)-D7),0)

	A	B	C	D	E	F	G	H
1								
2							MODEL	
3								
4	Week						PERIOD	
5		0	1	2	3	4	5	
6								
7	Demand	0	12	14	10	12	15	
8	NET SOH	0	0	-12	-26	-36	2	
9	*Physical SOH*		0	0	0	0	2	
10	SIT					50		
11	Air		0	0	0	0	0	
12	National		0	0	0	0	0	
13								
14	Backorder		0	12	26	36	0	
15	New Back.		0	12	14	10	0	
16								

$$\text{Backorder week}_i = \text{ABS}\left|\text{SOH week}_{i-1} + \text{Any arrivals week}_{i-1} - \text{Demand week}_{i-1}\right|$$

In the diagram, the preceding formulas (or inputs) needed in calculating backorders on hand for week3 are shown as well as the dependent cells on the backorders from week3.

Inventory calculations – Unmet demand per week calculations

E18 =IF(D7>0,IF(AND((D8+D10+D11+D12)/D7<=1,(D8+D10+D11+D12)/D7>=0),1-(D8+D10+D11+D12)/D7,IF((D8+D10+D11+D12)/D7>1,0,1)),0)

	A	B									
4	Week	PERIOD									
5		0	1	2	3	4	5	6	7	8	9
6											
7	Demand	0	12	14	10	12	15	12	12	9	14
8	NET SOH	0	0	-12	-26	-36	2	-13	-25	-37	-46
9	*Physical SOH*		0	0	0	0	2	0	0	0	0
10	SIT					50					
11	Air		0	0	0	0	0	0	0	0	0
12	National		0	0	0	0	0	0	0	0	0
13											
14	Backorder		0	12	26	36	0	13	25	37	46
15	New Back.		0	12	14	10	0	13	12	12	9
16											
17											
18	Unmet demand week		0.00%	100.00%	100.00%	100.00%	0.00%	86.67%	100.00%	100.00%	100.00%
19											
20	SLM		100.00%	0.00%	0.00%	0.00%	100.00%	13.33%	0.00%	0.00%	0.00%

$$\text{Unmet demand \% at start of week}_i = \frac{\text{expected backorders for week}_{i-1}}{\text{demand for week}_{i-1}}$$

$$\text{Service level } \beta = 1 - \frac{\text{expected backorders for week}_{i-1}}{\text{demand for week}_{i-1}}$$

In the diagram, the preceding formulas (or inputs) needed in calculating unmet demand for week3 are shown as well as the dependent cells on the unmet demand from week3.

$$\text{Backorder ratio per part} = \frac{\Sigma \text{ new backorders a week for period}}{\Sigma \text{ demand for period}}$$

$$\text{Total SLM} = \Sigma_i \text{ SLM in week}_i$$

B Monte Carlo output

Net SOH	
Count	100
Mean	-114.69
Median	-116.5
Standard deviation	15.2267
Minimum	-152
Maximum	-81
First quartile	-127
Third quartile	-102
5th percentile	-137.15
10th percentile	-118.8
90th percentile	-94
95th percentile	-88.95

Bin	Frequency	Cumulative %
-152	1	0.50%
-136.7	5	2.97%
-121.4	30	17.82%
-106.1	33	34.16%
-90.8	25	46.53%
-75.5	7	50.00%
-60.2	0	50.00%
-44.9	0	50.00%
-29.6	0	50.00%
-14.3	0	50.00%
More	101	100.00%

	NET SOH
	-85
1	-108
2	-120
3	-124
4	-134
5	-119
6	-88
7	-84
8	-108
9	-112
10	-99
11	-118
12	-128
13	-104
14	-123
15	-107
16	-104
17	-102
18	-125
19	-121
20	-104
21	-131
22	-127
23	-127
24	-121
25	-111
26	-130
27	-125
28	-113
29	-96
30	-130
31	-120
32	-100
33	-100
34	-126
35	-97
36	-106
37	-116
38	-128
39	-107
40	-95
41	-106
42	-130
43	-141
44	-130
45	-100
46	-90
47	-113
48	-94
49	-121
50	-102
51	-116
52	-116
53	-132
54	-120
55	-94
56	-121
57	-88
58	-117
59	-97
60	-97
61	-152
62	-97
63	-112
64	-110
65	-135
66	-129
67	-100
68	-101
69	-127
70	-93
71	-127
72	-89
73	-142
74	-119
75	-122
76	-131
77	-127
78	-144
79	-137
80	-112
81	-127
82	-120
83	-111
84	-81
85	-113
86	-94
87	-140
88	-128
89	-125
90	-131
91	-103
92	-99
93	-113
94	-126
95	-119
96	-125
97	-87
98	-107
99	-131
100	-120

Histogram

0	-152
0.01	-144.08
0.02	-142.04
0.03	-141.03
0.04	-140.04
0.05	-137.15
0.06	-135.12
0.07	-134.07
0.08	-132.16
0.09	-131.09
0.1	-131
0.11	-131
0.12	-131
0.13	-130.13
0.14	-130
0.15	-130
0.16	-130
0.17	-129.17
0.18	-128.18
0.19	-128
0.2	-128
0.21	-127.21
0.22	-127
0.23	-127
0.24	-127
0.25	-127
0.26	-127
0.27	-126.27
0.28	-126
0.29	-125.29
0.3	-125
0.31	-125
0.32	-125
0.33	-124.33
0.34	-123.34
0.35	-122.35
0.36	-121.36
0.37	-121
0.38	-121
0.39	-121
0.4	-120.4
0.41	-120
0.42	-120
0.43	-120
0.44	-120
0.45	-119.45
0.46	-119
0.47	-119
0.48	-118.48
0.49	-117.49
0.5	-116.5
0.51	-116
0.52	-116
0.53	-114.59
0.54	-113
0.55	-113
0.56	-113
0.57	-112.57
0.58	-112
0.59	-112
0.6	-111.6
0.61	-111
0.62	-110.62
0.63	-109.26
0.64	-108
0.65	-107.65
0.66	-107
0.67	-107
0.68	-106.68
0.69	-106
0.7	-105.4
0.71	-104
0.72	-104
0.73	-103.73
0.74	-102.74
0.75	-102
0.76	-101.76
0.77	-100.77
0.78	-100
0.79	-100
0.8	-100
0.81	-99.81
0.82	-99
0.83	-98.66
0.84	-97
0.85	-97
0.86	-97
0.87	-96.87
0.88	-95.88
0.89	-94.89
0.9	-94
0.91	-94
0.92	-93.92
0.93	-92.79
0.94	-89.94
0.95	-88.95
0.96	-88
0.97	-87.97
0.98	-86.94
0.99	-83.97
1	-81

C Contingency file – Risk committee

Parts Distribution Centre Disaster Recovery Plan

Risk Committee committee:

Role	Name	Responsible areas	Contact details
Chairman	General Manager After-Sales	Executive	012-529 6000 082 000 0000 execpdc@nissansa.co.za
Co-ordinator	Senior Manager After-Sales	Organisation	012-529 6000 082 000 0000 seniorpdc@nissansa.co.za
Member	Inventory Analyst	PDC inventory	012-529 6000 082 000 0000 inanalpdc@nissansa.co.za
Member	Inventory Analyst	PDC building	012-529 6000 082 000 0000 invanapdc@nissansa.co.za
Member	Financal Advisor	Finance / Business Planning	012-529 6000 082 000 0000 finance@nissansa.co.za
Member	Inventory Controller	Admin Records, database and computer equipment	012-529 6000 082 000 0000 execpdc@nissansa.co.za
Member	Inventory Controller	Suppliers	012-529 6000 082 000 0000 execpdc@nissansa.co.za
Member	Inventory Controller	Storage	012-529 6000 082 000 0000 execpdc@nissansa.co.za
Member	Inventory Controller	Suppliers	012-529 6000 082 000 0000 invco1pdc@nissansa.co.za
Member	Inventory Controller	Transport / Order processing	012-529 6000 082 000 0000 invco2pdc@nissansa.co.za
Member	Inventory Controller	Quality / Records / SCM	012-529 6000 082 000 0000 invco3pdc@nissansa.co.za

C Contingency file – List of warehousing

List of Warehousing locators / renters

Company	Physical Address:	Contact details
Manhattan Warehousing	77 Voortrekker St, Jacobs Durban	031 461 4652 031 461 4658 utrade@cybertrade.co.za

C Contingency file – Asset List

Responsible member	
Contact details	

Asset	Risk event	Risk rating	Consequences if event happens	Preventive steps to minimize risk/loss prior to event	Recovery steps after event occurance	Support/actions required from other departments
Inventory	Major fire or explosion		Destruction to inventory, either partially or completely	Risk management of parts, issuring for the risk. Sprinkler systems etc. in place	Respond as soon as possible, recover the most important parts to the after-sales department	Manufacturing to possible provide add. parts to the PDC. Finance and Marketing to discuss situation and consult with after-sales
	Striking		No movement of goods (if strike at PDC), parts availability reduced (if strike at supplier)	Trade Union understanding, back-up personnel, 3rd party collaborate planning	Temporary crew to move stock, trade union talks	Nissan SA and its lawyers
	Flooding		As with fire / destruction	As with fire / destruction to warehouse	As with fire / destruction	As with fire / destruction
	Arson		Destruction to inventory, either partially or completely	Secure access to warehouse, continual surveillance.	Checking of surveillance, and security, assessment of what is destroyed and what is to be recaptured	Security and admin, manufacturing to possibly supply parts
	Major theft		Loss of parts, either gradually or quickly	As with Arson	As with arson	Recapture, security etc.

C Contingency file – Inventory grouping

Category of parts	Criteria		Short-term suggested requirements calculation	Long-term requirements decision	Required inputs from database
	Attributes:	*Rank on the following:*			
Most Critical	▪Fast moving parts ▪High - Med Impact parts ▪Service dependant parts	▪Annual rand usage ▪Average weekly demand ▪Lead time on current supplier ▪Top 20 percentile	DRP inventory model used with simulation	Re-assessment ERP based inventory model	▪Real Stock on hand ▪Stock in transit ▪Demand forecast ▪Time horison for decision-making
Critical	▪Fast moving ▪High - Med Impact ▪Service dependant	▪Annual rand usage ▪Average weekly demand ▪Lead time on current supplier	DRP inventory model used without simulation		
Essential	▪Medium - slow moving ▪High - Med Impact	N/A			
Desirable	▪Med - Slow moving ▪Med -Low impact	N/A			
Obsolete / Redundent	Determined obsolete or non-essential	N/A			

Pilot Study