How to Order from the Orient?

Improving Purchasing and Inventory Management at Promocionales Pacífico de Mexico.

Bachelor Assignment Report of 2005-2006 Internship

by
Taco Wychert Potze

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University of Twente, Enschede, the Netherlands

Supervisor(s):
Dr. P.C. Schuur
Ir. S.J. Maathuis
E.J.M Koolen (extern)

Management Summary

This is a Bachelor Assignment Report for the study of Industrial Engineering and Management at the University of Twente, The Netherlands. Our internship took place during the 1st of September 2005 until the 23d of December, 2005 at Promocionales Pacífico de Mexico located in Mexico City, México.

The importance of purchasing is getting more and more attention in many industries these days. Purchasing is PPM’s core business and top management must realise that every dollar not spent on purchasing is a dollar extra profit.

We identified three major problems at PPM relating to purchasing and inventory management:

1. The customers of PPM are not satisfied with the current service
2. Decreasing inventory turnover
3. Overspending on purchasing budget

After analysing the purchasing process at PPM we set the following objectives, mainly in the order stage of the purchasing process:

1. Improve timeliness of purchasing to provide better services for customers.
2. Match purchase quantities and demand to increase inventory turnover time
3. Reduce purchasing and inventory costs by minimizing the average inventory level

To get a better understanding of requirements of customers we suggest implementing an exponential smoothing forecasting model to predict future demand. Next, to control inventory PPM should implement an appropriate Inventory Control System (R, s, S system). This combination checks every week if the stock level is bellow or at a reorder point. If so, a replenishment order should be placed to raise the stock level to a certain level.
Whether or not a reorder point exists depends on the forecast and the amount of safety stock needed for the item. We propose a Customer Service Approach to establishing safety stock using a certain fill rate. The fill rate approach gives a better idea of the on-time delivery performance and is therefore often used in practice.
To minimize holding and shipping costs, we propose an Economic Order Quantity model, which minimizes total costs. Because of the current shipping cost method (base on the flete) order costs can differ a lot. PPM should therefore use CFR (Cost and Freight) prices instead of the current FOB (free on board) prices. Instead of using the value of the shipment, the volume could also serve as a base to calculate order cost.
In section 3.5, we have schematically drawn the flowchart of the proposed purchasing and inventory model. Although the system seems rather complicated in the beginning it is actually easy to understand and to implement.

Purchasing can add a lot of value to organisations because of its impact on an organisation’s financial, logistical and operational performance. At PPM it seems this potential added value is not recognized yet.
The CCO his first task is therefore to market the purchasing function to the senior management. If they can be convinced of the benefit of a renewed purchasing function, a great opportunity can be seized. After the top management, the sales and operational departments should also be involved since the set up of a purchasing function is a joint undertaking and success should be communicated as such.
Since the current information system of PPM, ASAP, is not capable of delivering the information needed, a new application has to be created that does fulfil the needs of the purchaser and includes the methods and models we discuss in this research. We have created a timeline where PPM develops an application in half a year with the help of an external party to write the application.

For the scope of this research, the (R, s, S) inventory model seems to fit well. The model depends on good forecasts and safety stock models. Since data from the ASAP system was limited and the new models are not evaluated in this research we urge PPM to evaluate the models after implementation. In addition, when more data regarding seasonal demand is available, forecast models should be further researched. We have added some further research suggestions in the end of this report.

In the last chapter, we evaluate our personal and professional performances. Professionally we have learned a lot, both doing our internship and writing our report. We found that what management wants is not always what they need. And what the company needs is not always what the University wants.
In the end, we had a great experience in Mexico and hope we were able to add value that helps PPM to reach their ambition “*Become the number one promotional company in Mexico*.”

Preface

After living in Brazil for a year, I really wanted to go back to Latin America to learn to speak Spanish, learn more about the Latin-American culture and to gain more work experience. The University of Twente offered me the opportunity to do both my Minor as my Bachelor at ones in this internship.
Through Stephan Maathuis of the International Management Faculty, I came into contact with Rik Koolen of Promocionales Pacífico. After that, things went rather fast and my internship was set up within a couple of weeks.
My initial assignment was to improve the current purchasing situation and write an implementation plan to implement the solution into the information system that Promocionales Pacífico used. This was more easily said than done. The internship turned out to be a lot of work dealing with many complex problems. Also finishing this report took me some time due to the start of my Master degree in Industrial Engineering and Management. In the end, I hope PPM finds the solutions helpful. I hope I have benefit to the company. I could never have done it without the support of colleges, family and friends which some of them I would like to thank especially.

In the first place I would like to thank Rik Koolen for offering me the opportunity to do an internship at Promocionales Pacífico and to open his house for me as well. I hope he finds this research both reliable and useful in practice.

I would like to thank Peter Schuur and Stephan Maathuis for being respectively my first and second supervisors.

Many thanks also for the CEO of Grupo Pacifico, Lic. Stephan Toonen, to give me and many other students the opportunity to gain work experience in his companies.

Next, I would like to thank my colleagues and friends of Promocionales Pacifico, Judith Cabrera en Miguel Vega for everything they have done for me, both inside and outside the company.

I would like to thank my parents and family for their support during my stay in Mexico. I would like to thank my uncle Michel Kemper for his attention given to the IT part of my internship and I want to thank Adinda for supporting me during the writing of this report.

Last, but certainly not least, I would like to thanks Tessa de Kort, my partner in internship, living and travelling in good times and bad.

Many thanks for all your support,

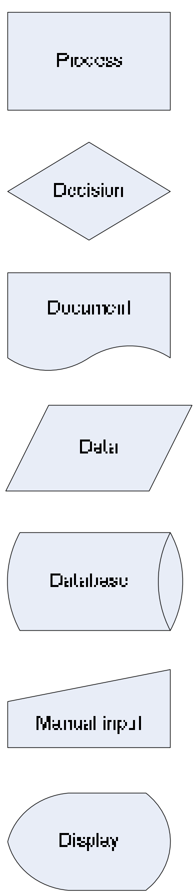
Taco Potze
t.w.potze@student.utwente.nl

Enschede, November 2007

List of terms and abbreviations

ASAP	=	Accelerated SAP, PPM´s ERP system
CCO	=	Chief Commercial Operations (daily operations)
CEO	=	Chief Executive Operations
CFO	=	Chief Financial Operations
CFR	=	Cost and Freight (incoterm)
DBV	=	Distribution By Value
EOQ	=	Economic Order Quntity
ERP	=	Enterprise Resource Planning
FOB	=	Free on Board (incoterm)
Logyx	=	PPM´s fiscal warehouse
MAD	=	Mean Absolute Deviation
MAPE	=	Mean Absolute Percentage Error
MOQ	=	Minimum Order Quantity
MOV	=	Minimum Order Value
MSE	=	Mean Squared Error
PPM	=	Promocionales Pacifíco de Mexico SA de CV
ROS	=	Replenishment Order System
SKU	=	Stock-keeping Unit
USD	=	United States Dollar
VDP	=	Vanguard DesisionPro (forecasting software program)

Basic Flowchart shapes



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1. Problem Identification

This is the Bachelor Assignment Report of Taco Wychert Potze of the faculty Industrial Engineering and Management at the University of Twente, The Netherlands. This research involves improving the inventory and purchasing management at Promocionales Pacífico de Mexico SA de CV located in Mexico City, Mexico.

In this first chapter, we first describe the background of the company Promocionales Pacífco de Mexico (PPM). We look at PPM's organization chart, its' objectives and the competing environment. Next we identify three main problems of PPM and summarize these into our research objectives. We conclude this chapter with a research approach, which states our research questions, research strategy, demarcations and assumptions.

1.1 Background Promocionales Pacífico

Promocionales Pacífco de Mexico SA de CV (PPM) was founded in 1998 by the Dutchman Stephan Toonen in Mexico-City and is part of Grupo Pacífico. Promocionales Pacífco is Grupo Pacífico's largest company.
The core business of Promocionales Pacífco is to sell high volume promotional items and business presents also called premiums. The promotional items are used to boost the sales of the client's products. For example if a consumer buys five flacons of Unilever's Dove lotion he gets a bathing set for free or for a 'small' extra payment (sometimes PPM's clients still make a profit on the sales of the promotional items).

Figure 1.1 - Article PM0022.10, Bathing Set

The business presents differ from 'luxurious' wine sets to simple ballpoints:

Figure 1.2 - Article IT2658.14 – Wine Set

Figure 1.3 - Article PM0011.04 – Blue Pen

On all the items a client's company logo can be printed. PPM's has its own print shop with many different techniques of printing.

In this report, we call each individual item on stock a Stock Keeping Unit (SKU). A SKU is a unique item, unique in colour, size, function and value. The current SKUs at PPM are 299 products. There are 247 products in the catalogue of which some are available in different colours and sizes.

PPM sells mainly to two different parties. Both are business to business. The first group of clients is the distributors. They resell the products to their own clients. The second is the 'final customers'. They sell or give the products away their customers or relations. For all clients customized products can be designed and produced. The minimum order quantity for these special productions is very large so only bulky customers can buy customized products.

The top of the organization chart of PPM is as follows:

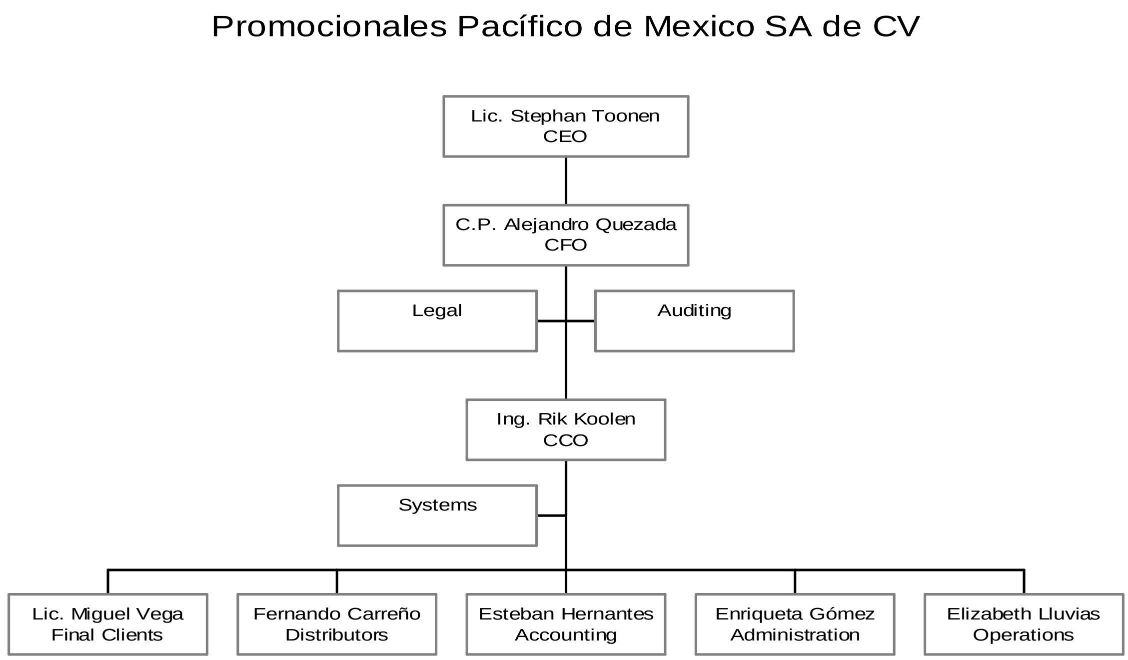


Figure 1.4 - Organizational Chart PPM

Since the CEO and the CFO are working almost fulltime on a project, we report directly to the Chief Commercial Operations (CCO) of PPM, Mr. Koolen. He is in charge with all the daily operations of PPM. As we notice in the organizational chart, there is no separate purchasing department.

1.2 Strategic and Operational objectives

The vision of PPM is "*To become the number one company in promotional items in Mexico.*". To become so, their strategic objective of PPM is also stated in its 2005 business plan:

"Promocionales Pacífico de Mexico provides high quality promotional items for a reasonable price. With the help of experienced, high-volume buying offices in the Orient, specialized in obtaining low prices while guaranteeing quality, combined with the one-stop-shop approach, quality and service are guaranteed. PPM provides clients with promotional items suited to their specific needs."

The strategic goal of PPM is to become the number one company in promotional items in Mexico. PPM is already in the top six of the companies on the promotional market, but has only a market share of 0.5% in turnover.
The operational goals of PPM are to increase turnover by 30% every year. Another operational goal is to spend less than 65% of the total turnover on purchasing (FOB), shipping, duty, interest and warehousing.

1.3 Competing Environment

PPM is now seven years active in the promotional items market. At first, there was not much competition, but the success of a few companies has created more and more competition.
New entrants to the market mainly compete on price. To stay competitive PPM must keep its prices as low as possible. But to stay ahead of competition, PPM should focus on two competitive advantages.
The first is a *superior service level*. PPM is a well-organized and innovative company with many products in large volumes on stock and highly trained and coached employees. They have to make sure customers are being served according to their wishes. The second competitive strength is *larges volumes*. Through long-term relationships with the trading companies and smart purchasing strategies, PPM has large amounts of products on stock. If the competition cannot offer the customer the amount of products the customer wants, PPM should be able to deliver these large volumes.
By offering fair prices at a superior service level and having almost a monopoly in the large volumes market, PPM can keep its margins high and grow in turnover.

1.4 Problem Identification

The CCO of PPM contacted us with the question if we could improve the inventory situation at PPM. During a number of interviews with the CCO he elaborates on three major problem indicators:

1) The customers of PPM are not satisfied with the current service. Not all products in the catalogue are always available when the customer would like to order them. Almost no customer is willing to place a backorder. The customers complain initially to the sales persons. Next the sales employees complain to the CCO.
A study; "*The path to professionalize and restructure the operational processes at Promocionales Pacifico de Mexico*" (Brussen and Raijmakers, 2004) has shown a number of potential problems in the company relating to logistics.
They summarize their findings in the figure bellow and write: "*All the clouds in the figure represent problems or opportunities at PPM, mainly in the area of logistics. The clouds in red represent the areas of attention on first sight. … The other red ones can be seen as recommendations for further research in the near future.*"

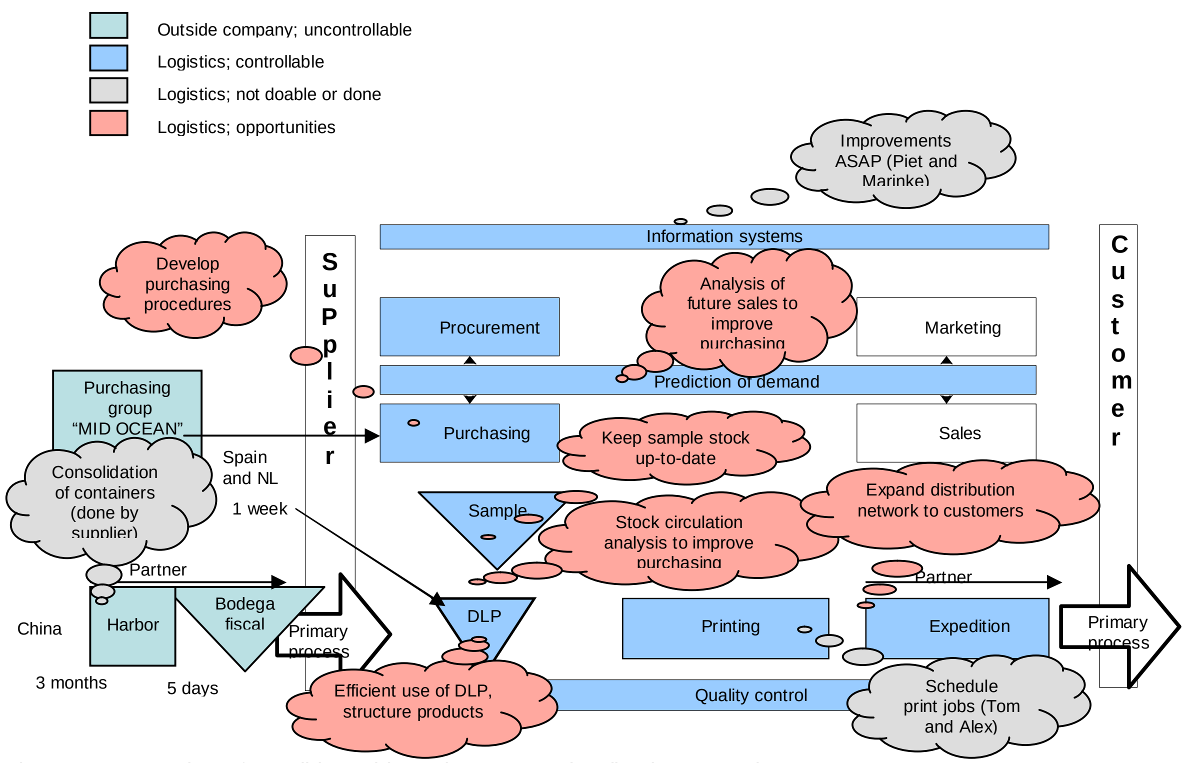


Figure 1.5 - Overview of possible problems (Brussen and Raijmakers, 2004)

Brussen and Raijmakers have proposed solutions in their research especially in warehousing and supply chain management at PPM: "*A selection of problems to solve was made based on feasibility, possible advantages, time and of course the requirements of the internship. The focus moved to supply chain management, because of the many opportunities and advantages that could be realised.*"

2) Decreasing inventory turnover. The following data is available regarding turnover and inventory at PPM:

Year	Annual Turnover (Million USD)	Turnover Growth	Average Inventory (USD)	Average inventory Growth	Inventory Turnover (times/year)
2002	3.9	-	-	-	
2003	5.3	+36%	545.000	-	9,7
2004	6.6	+25%	1.016.000	+186%	6,5
2005	9.3	+41%	2.061.000	+203%	4,5

Table 1.1 – PPM inventory data

Where:

$$\text{Inventory turnover} = \frac{\text{Annual turnover}}{\text{Average inventory}}$$

As we can see in table 1.1, the inventory growths much faster than the growth of turnover in the company and the inventory turnover time is decreasing.
Since inventory is holding a lot of dollar usage of the company, not enough money is available to pay creditors or to buy new stock. When many invoices are open at one specific trading company, it occurs that no new credit is given until the old bills are being paid.

3) Overspending on budget of purchasing. The operational goal of the company is to spend less than 65% of the total turnover on purchasing (FOB), shipping, duty and warehousing.
The following data shows more specific the increase in average inventory level of each month in 2003, 2004 and 2005.

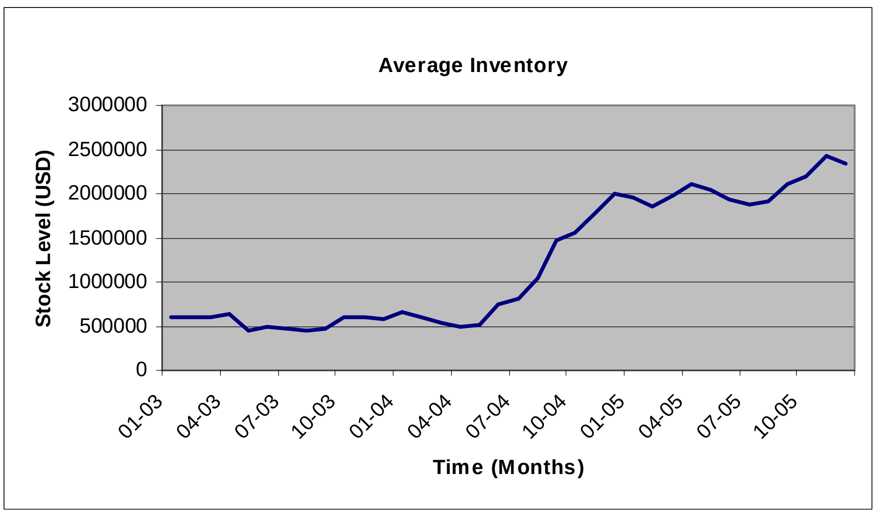


Figure 1.6 – Average Inventory Level (USD)

In figure 1.5, the average inventory level seems to fluctuate around 500.000 USD until half of the year 2004. Next it increases rapidly and showing an increasing trend after the leap.

We can conclude the three identified problems into the following objectives:

4. Improve timeliness of purchasing to provide better services for customers.
5. Match purchase quantities and demand to increase inventory turnover time
6. Reduce purchasing and inventory costs by minimizing the average inventory level

In other words, our objectives is to improve the alignment between demand and purchased quantities, order items on time and do all of this as efficient as possible. In the next section we describe the approach we take to accomplish our objectives.

Research questions

We divided the main objectives and research phases into smaller sub research questions that helps us to identify the problem, analyze it, create solutions, choose among alternative solutions and implement them.

This results in the following research questions:

How is the current purchasing process and inventory managed?

- What does theory say regarding purchasing and inventory management?
- What are the currently methods and procedures at PPM?
- Which bottlenecks in PPM's current purchasing and inventory processes should be improved?

How can we improve purchasing and inventory management at PPM?

- What says literature regarding inventory management?
- Which improvements should we make to reach our objectives?

How to implement our chosen improvements in the organization?

- Who should be responsible for the implementation?
- How fits purchasing as a part of the organization?
- What does the implementation roadmap looks like?

1.5 Problem Approach

We base our problem approach on the Standard Business Administration Problem Approach (Algemene Bedrijfskundige Probleemaanpak) with some changes to adapt the standard approach to fit our research. Our approach includes the following phases:

Problem Identification
- Background of the company, objectives, competitive environment
- Global problem identification and describtion
- Formulation of research questions
- Planning of the solving process and demarcations

Problem Analysis
- Cause of the problems and its consequences
- Analysing the current situation using Van Weele's purchasing model
- Bottlenecks in the current situation and scope of our research

Alternatives
- Forecasting Model
- Inventory Control System
- Safety Stock Model

Implementation and Further Research
- Change of the current situation as a result of the choosen alternatives
- Roadmap of Change
- Sugestions for Further Research

Personal Evaluation
- Evaluate our own research process and professional evaluation

Figure 1.5 - Research Approach

In this chapter we have done the problem identification section of our study. We have identified three objectives, we would like to improve the timeliness of purchasing, match purchase quantities and demand and we want to reduce purchasing and inventory costs. To solve these problems we have divided the research into main and sub research questions.
To analyse the problem we look into literature that helps us to model the current situation at PPM and

to identify the main bottlenecks. Using interviews we are enable to model the purchasing and inventory processes and define the scope of our research.
After we have identified the major bottlenecks and the extent of our research, we do another literature research to find solutions for the bottlenecks found in our analysis. Using literature, we are able to define alternative solutions for the problems that currently exist in the purchasing and inventory process at PPM.
In the next stage, we write a roadmap for PPM of how the current situation should be changed as a result of the chosen alternatives. In the end, we advise PPM what further research is needed and we evaluate our personal and professional performance.

Enterprise Resource Planning: ASAP

At the beginning of 2004 an Enterprise Resource Planning (ERP) system was introduced at PPM. The system is called ASAP (Accelerated SAP) and is highly customable. The system was slowly adopted due to resistance of PPM's employees. But in 2005 the system became fully operational. Historical data is available since the beginning of 2004, but is 99% accurate since 2005 according to the system administrators. In this research we therefore use data since January 2005.

Demarcations and Assumptions

1. We demark this research to the direct purchasing cost of goods, not services and work, neither on the indirect purchasing cost (office supplies, cleaning etc.)
2. In this research focus only on the products that are in PPM's catalogues. The Final Clients department of PPM also works with 'special production'. Products custom made for the final clients. We do not include these products into this project.
3. We assume that are no joint replenishment orders.
4. We assume there are no backorders (this is not registered yet in the ERP system)
5. We do not hold into account any products manufactured incorrectly, since this percentage is close to zero.

2. Problem Analysis

In this chapter, we describe the causes of the identified problems at Promocionales Pacífico. Next, we discuss the consequences of these problem causes. We will use a literature-based model to see how the problems relate to each other and where the main bottlenecks exist. After analysing the current situation and its problems, we will define to reach of our research.

2.1 Causes of the problems

From the start, in the late '90, PPM always purchased and shipped the goods <u>after</u> an order had been placed. Goods were shipped from suppliers stock by air from China or Europe. Doing so PPM minimized the risks of having inventory and also save on warehousing costs. Items could theoretically be delivered to customers after two weeks.
Unfortunately, there were many problems with shipping and the Mexican customs. This could delay deliveries by weeks, resulting in a loss of orders and customers.
Besides these transportation issues, competition had started to grow in Mexico, as described in the previous chapter. Low priced competition was steadily increasing after the new Millennium. PPM had to lower its prices by cutting costs to stay competitive.

2.2 Consequences

In 2004 PPM found a solution to the transportation and costs problems by changing the means of shipping from air to sea transportation. Doing so PPM could solve both the delivery issues since they could sell straight from their stock and save on costs since shipping by boat is much cheaper.

The downside of this change is that the average lead-time (the time it takes a product to arrive in PPM's warehouse after it has been ordered) for a product has increased enormously. In this report we refer to the old purchasing situation as to the *Order to Customer* strategy and the new purchasing situation as the *Order to Stock* strategy.
Currently the average replenishment lead-time after placing an order with a trading company until the goods arrive in the LOGYX Fiscal Warehouse is 12 weeks.

2.3 Current Situation

To analyse the current purchasing and inventory situation at PPM we use the 'Race Car' purchasing model (Van Weele, 1998). This model provides a good framework for purchasing and inventory management.

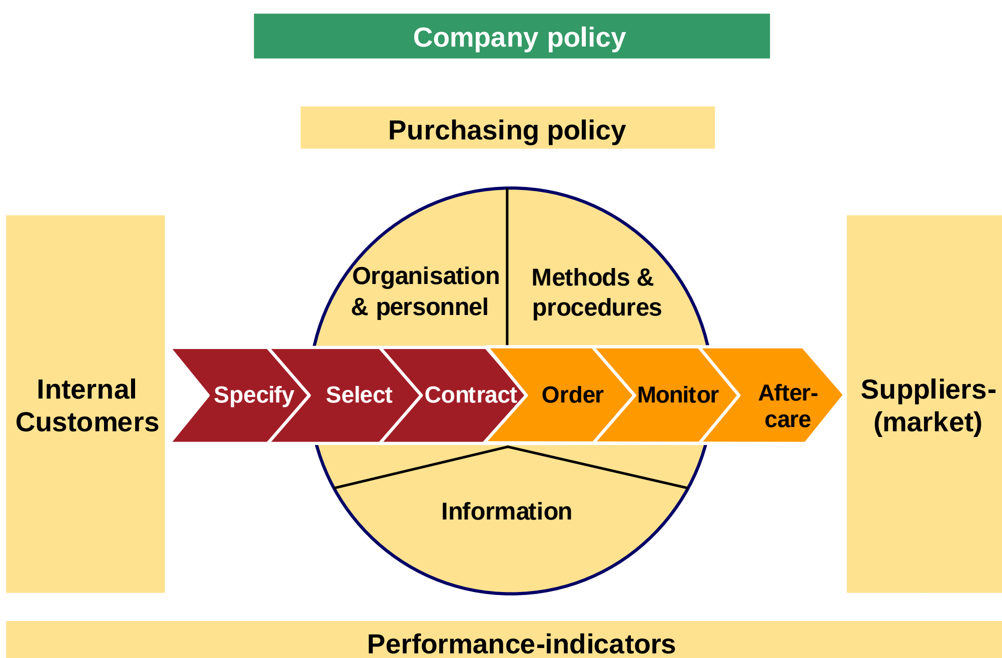


Figure 2.1 - Van Weele's Purchasing Model (Race Car Model) or purchasing function

The purchasing process is the most important section of Van Weele's purchasing function. Besides this

process we need to take a look at the organizational aspects on the purchasing function.
The purchasing process can be laid out in six main steps. The first three steps are the tactical function, the last three the operational function.
We use definitions from the reader for Purchasing Management of the University of Twente (Telgen et al, 2005) to describe the six stages in the purchasing process. Next, we look at how the process is being done at PPM and which issues exist.

2.3.1 Tactical purchasing function

1. Specifying

Specifying is the perhaps the most important step of the process. (Telgen et al, 2006) In this phase is defined what is going to be purchased. It is therefore the basis for all further steps. The specification phase also has most impact on total costs. Before selecting a supplier, specifications have to be drawn up to decide which products will be in the catalogue. This can be done by creating a Programme of Requirements. The Programme of Requirements determines which products are bought and used trough out the entire purchasing process to follow, this stage is therefore the main cost driver.
Currently at PPM two catalogues a year are made. In the existing situation the specification of the products is officially done by the CEO, CFO and the CCO. However, since the CEO and the CFO are working fulltime on another project, the CCO makes most specification decisions.

- It is unclear on what requirements these products are specified. There is no Programme of Requirements;
- No input from distributor and final clients sales departments, nor input from clients, nor market research is used to make a decision.

2. Selecting

In the selection phase, the choice is made which trading companies are being invited to submit their offers of the specified products. Important issues are prices, quality, service, lead-times, and the amount and duration of credit that is given.
All suppliers should be evaluated on the selection criteria set up in this phase. This is called supplier management.
Currently PPM is using only a handful of suppliers. In practice, PPM does not ask suppliers for offers of products, they order the product straight away from the suppliers. This is understandable since PPM has experience with the company and therefore has more trust in the order. On the other PPM needs to remember that every dollar not spend on purchasing is a dollar extra profit.

- Products and/or Prices of different providers are not compared;
- No supplier management.

3. Contracting

Contracting is the stage where contracts are signed between the company and the suppliers. Terms and conditions, agreed pricing and discounts are being discussed as well as legal details. The contract contains all agreements related to the deal. Not only on what is to be supplied, also the way in which logistic, after sales and the financial part are dealt with are described.
At PPM the contract are signed by the CEO and the CFO, the CCO handles al the details. No bottlenecks are currently known in this process.

2.3.2 Operational purchasing function

4. Ordering

Ordering is the actual requesting of a delivery. Most orders are being frequently repeated. In the tactical stage the questions are: *What and where to order?* In the ordering stage we need to answer the questions: *When and how much to order?*
The current order phase of the purchasing process at PPM is that the CCO gets inventory reports every last day of the week and every last week of the month from PPM´s logistics supervisor (Mrs. Mancilla). Here is an example of an ‘Inventory Report’ for July 2005.

REPORTE DE INVENTARIOS AL 29 DE JULIO DE 2005

PEDIMENTO	CODIGO	COSTO UNITARIO	INVENTARIO INICIAL	ENTRADAS		SALIDAS		AJUSTES	INVENTARIO FINAL			INVENTARIO ASAP	DIFERENCIAS
				PIEZAS	COSTO	PIEZAS	COSTO	PIEZAS	COSTO	PIEZAS	COSTO		
3093-2000043	IT2393.06	0.59	15,000	0	0	0	0	0	0	15,000	8,850		15,000
3093-3000020	IT2622.11	0.98	330	0	0	330	311	0	0	0	0		0
3093-3000907	4213.SC	1.00	10,800	0	0	0	0	0	0	10,800	10,800		10,800
3093-4000445	IT2743.14	1.07	4,700	0	0	0	0	0	0	4,700	5,029		4,700
3093-4000554	KC5937.16	0.94	2,500	0	0	0	0	0	0	2,500	2,350		2,500
3093-4000554	KC5939.16	0.94	3,500	0	0	1,500	1,410	0	0	2,000	1,880		2,000
3093-4000636	IT2726.04	0.78	395	0	0	0	0	0	0	395	308		395
3093-4000636	IT2729.05	0.78	4,800	0	0	0	0	0	0	4,800	3,744		4,800
3530-4006713	KC1713.04	0.04	15,000	0	0	1,000	40	0	0	14,000	560		14,000
3530-4006713	KC2523.06	0.20	6,750	0	0	0	0	0	0	6,750	1,350		6,750
3530-4006713	KC2524.22	0.20	6,200	0	0	4,600	920	0	0	1,600	320		1,600
3530-4006713	KC2524.23	0.20	3,000	0	0	0	0	0	0	3,000	600		3,000
3530-4007921	KC1907.05	0.63	1,200	0	0	100	63	0	0	1,100	693		1,100
3530-4008699	KC2509.04	0.50	1,800	0	0	600	300	0	0	1,200	600		1,200
3530-4008840	KC2201.17	0.73	1,300	0	0	0	0	0	0	1,300	949		1,300

Figure 2.2 – A sample of the (Spanish) Inventory Report for the month of July 2005

Basically what the report says is what article is mentioned, how many pieces are arrived at the warehouse, how many have left and what the current stock level is. In practice, this is a lot of information to process for a human. And that is exactly what the CCO currently needs to do before making a purchase decision; processing all this sales and purchase information of hundreds of articles to make a replenishment decision.

- No mathematical based purchasing methods or procedures
- No forecasting
- No graphical representation of inventory

5. Monitoring
During the monitoring phase the goods are monitored from the moment they are purchased. This logistical monitoring is the first main task during this stage in the process. This stage also includes the handling of the incoming invoices and related payments. The second task is to evaluated if the operational process is going according to the agreed standards set in the contract with the supplier.
During transport to one of PPM´s warehouses or the LOGYX warehouse the goods are monitored by the forwarder and by PPM´s Logistics Supervisor (Mrs. Mancilla). The Logistics Supervisor also deals with the customs and other transportation issues that might occur. Currently no major bottleneck exists in the monitoring, but one task of the Logistical Supervisor is not being used at PPM, this is:

- Evaluated whether the operational process is going according to the agreed standards set in the contract with the supplier

6. Servicing (or Aftercare)
Servicing is necessary when situations occur during the operational purchasing process that need to be resolved. Servicing can take place during both the ordering as the monitoring stage. Servicing usually takes care of incidental problems. The main focus is not to complain, but to research why and where things went wrong and to decide how things can be done better in the future. Sometimes it is necessary to evaluate the over-all performance of a supplier and re-negotiate the contract or look for a new supplier.
On arrival at PPM in the LOGYX warehouse in Mexico products are checked if they are according to the specifics. If the goods are not perceived as correct, the trading company is notified. Arrangements with the trading company are made. Usually a discount is given on the next order.
Since the trading companies check the quality of the manufactured goods before shipment, the quality of the supplied units is on average very well and no bottlenecks are known in the servicing stage.

2.3.4 Support elements

The purchasing function is more than just the purchasing process. A number of elements are needed to support and to facilitate the purchase process described above. These elements can also be seen in Figure 2.1.

Clients and Suppliers
"*Clients of the purchasing function are all employees that make use of the products and services purchased*" (Telgen et al, 2006). So instead of regarding only customers as clients, all internal employees should also be regarded as clients. The supplies are a key part for the purchasing function, they supply all goods and it is therefore very important to keep a good relationship with them.
Currently two bottlenecks in the clients and suppliers element exist:

- The two sales departments nor the operations department is seen as a client. Currently these departments are left out the purchasing function.
- The CCO of PPM is to occupied to maintain a close relation with the suppliers

Organization and Personnel
Telgen et al write the following in their reader for Purchasing Management: *"The quality of the people working on purchasing tasks largely defines the quality of the purchasing functions. It is important to determine the purchasing tasks and assign them to the right people."*
The CCO and PPM´s Logistics Supervisor deal with the entire purchasing function. In spite of their efforts many issues remain in purchasing and inventory management.

- Insufficient capacity to run entire logistical process.

Information Services
The purchase process depends on the input of information. Information regarding sales, stock levels and forecasts are very important. But also information regarding the competition, trends in sales and historical sales are needed. There is also a system necessary for supplier management.
The ASAP system contains a lot of real-time information. But reports are very limited and the lack of graphics and historical data makes it very hard for a purchaser to make good decisions.

- Insufficient and unclear format of information

Internal Methods and Procedures
The methods and procedures are important to take the steps in the process. It tells the purchaser when to take a new step and when to revise a step taken in the process. Methods can be used for specifying new products, evaluating supplier proposals and placing orders. Procedures prescribes the way of working to standardise methods throughout the organisation. A procedure describes which actions have to be done by whom to maintain a certain level of quality and efficiency. The design of methods and procedures is an important part of implementing a professional purchasing function.

- Currently no formal purchasing methods or procedures are used within PPM

Purchasing Policy
"The purchasing policy states the way an organisation wants to profile itself towards external parties, such as suppliers, by providing principal guidelines. These guidelines are in line with relevant corporate policies and reflect the organisation's opinion on economic, organisational, idealistic and ethical subjects." (Telgen et al, 2006)
All together a Purchase Policy takes all the factors in account for a smooth running purchase process. The Purchase Policy needs to fit into the goals and mission of the company.

- PPM does not have a Purchasing Policy

Performance Indicators
"Performance indicators are those measurable indicators of the purchasing function that have been identified as representative for the purchasing performance as a whole." (Telgen et al, 2006) Useful indicators could be inventory turnover time to measure inventory performance or the amount spend on shipping to monitor transportation cost. These indicators should let the purchaser and the management know if there is need to change factors in the purchasing function.

- PPM does not use any performance indicators

2.4 Summary of Bottlenecks in Current Situation

With the help of Van Weele's framework for the purchasing function, we have identified a number of bottlenecks in the current purchasing situation.
We believe that the problems in the Order stage of the purchasing process are directly responsible for the problems we have identified in chapter 1. We believe that focussing on the Order stage has highest priority and by resolving these issues first we can reach our objectives and add most value to the company in the limited time we have available.
The other issues have less priority and should be solved after further research (see also Chapter 5). The scope of solving issues in the Order stage is broader than just the purchasing process, we have summarized all identifies issues in the figure bellow and coloured the problems that will be discussed blue in this figure;

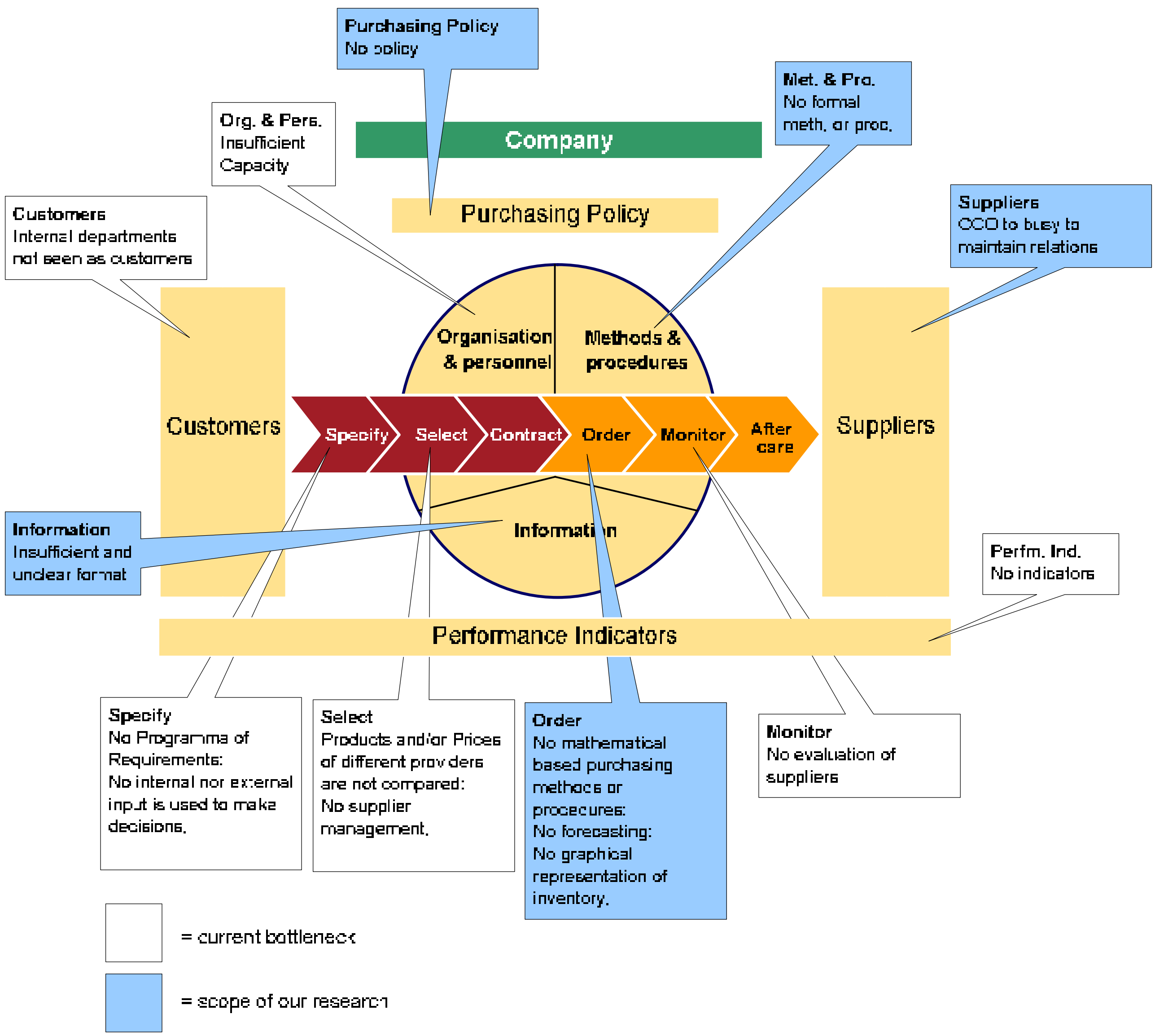


Figure 2.3 - Van Weele's Purchasing Model with identified bottlenecks at PPM and the scope of our research

In the next chapter, we conduct another literature research to find out which models and alternatives are suggested at the order stage of the purchasing process to improve inventory and purchasing management. We then chose the best solutions among these alternatives.

3. Alternatives

Many facets of live, including when products of PPM are sold to customers, are naturally unpredictable. This means that the result of management and a purchase function can never be guaranteed. Using the same conditions and the same function on different days may well lead to different outcomes. This does not mean that we should stop trying to manage our purchasing and inventory. It means that we must find *robust* policies and methods. A robust policy is not a 100% optimal policy, but is one that works well most of the time. Using a set of organizational and mathematical models holding probability into account we aim for a policy that works effective in most situations.

In chapter 2 we have used the Race Car framework of Van Weele to identify the bottlenecks in the purchasing process of PPM. Next, we have divined the range of our research by focussing on the Order stage of the purchasing function.
In this chapter, we formulate alternative solutions for the Order stage and decide what alternative fits best for our objectives. Recall that we want to improve the timeliness of purchasing, match purchase quantity with demand and reduce purchasing and inventory costs

Ordering is the actual requesting of a delivery. Most orders are frequently repeated. In this section, we resolve three issues:

1. *How often the inventory status should be determined*
2. *When a replenishment order should be placed*
3. *How large the replenishment order should be*

Nevertheless, the first thing we need is a forecast model for planning and control of our inventory.

3.1 Exponential Smoothing Forecasting Model ($\hat{w}_L$)

In an optimal situation, a replenishment order arrives precisely when the inventory level is zero. This can only be done when the lead-time is also zero. As soon as the period of the lead-time is longer, a forecast for the coming period is needed. The lead-time (L) at PPM is standard 12 weeks.
Forecasting has a long history and can be of great importance for an organization. It can be used to prepare an organization for future events. Forecasting can be based on a combination of observations in the past and future events. Forecasting is not only based on historical input but also on human judging.
To write a Forecast Model we use the framework suggested by and Silver, Pyke and Peterson (1998).

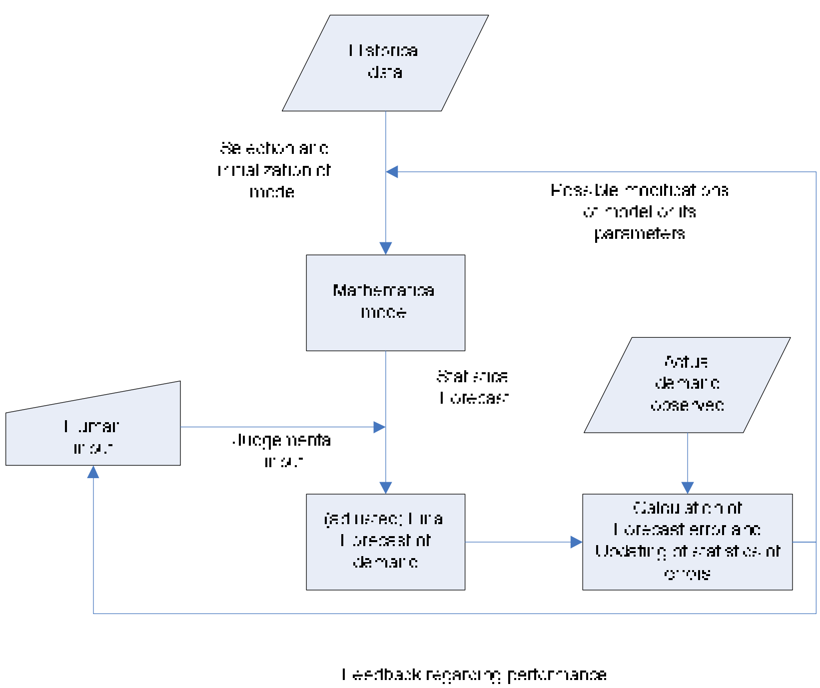


Figure 3.2 – Forecasting Framework, (Silver, Pyke and Peterson, 1998)

The framework clearly shows that human input as well as a mathematical model is used in the process of creating a forecast. Both inputs get feedback from the actual demand of the forecasted period. Since PPM is not using any mathematical model yet nor and calculation of the forecast error, we determine both.
To create an appropriate mathematical model we need to consider the following seven factors (Bowerman and O´Connell, 1993):

1. Desired forecast form
2. Time Frame
3. The pattern of data
4. The cost of forecasting
5. The accuracy desired
6. The availability of data
7. The ease of operation and understanding

The data we want to use to predict the forecasts are the exits of all products out of the LOGYX warehouse instead of the sales data. The difference is that samples are not being sold, but are removed from the warehouse. For now this data is usable but, actually sales data is preferable.
In this study we had a problem with point 6, the availability of data. The sales history data is available since the beginning of 2004 in the ASAP system (99% correct at the beginning of 2005).
Next the ASAP system is a rather old software programme for which not much modules are available. Data can be exported to a text file, but needs to be converted to be useful.

Since we only have two years of data (two demand cycles) and only data of a few products, we have decided to analyze data using two statistical software packages. We have chosen two popular and often used packages: Vanguard DecisionPro (VDP) and the statistical software of Minitab. VDP calculates the forecasts with over 20 different forecast models. Including: moving average, exponential smoothing and seasonal models. To find the best fit VDP calculates the Mean Absolute Percent Error (MAPE). The model that results in the lowest MAPE could be chosen as best fitting model and is displayed with its results. A sample can be seen in Annex 2.1.
Subsequently, we tried a number of forecast models on the data. We used simple moving average and single and double exponential smoothing models in the program MiniTab (see Annex 2). With both programs the single exponential smoothing model gave the best results (the lowest values of MAD and MAPE, see Annex 2).
VDP nor Minitab finds any trends or seasonal demand patterns due to the shortage of data. The demand seems to be level, fluctuating about a constant base level and is sometimes even completely random.
Since we wanted to make a simple model and we have only a limited time available to complete this research we use only one forecast model for all PPM's articles. Although not optimal for each product, single exponential smoothing gives good enough results for our main purpose, which is to estimate the reorder point.
We recommend PPM to use multiple models in the future when more data is available (see Further Research). With other models, trends and seasonality can be hold into account that makes reorder point calculations more precise.

Exponential Smoothing Model
Considering all factors and suggestions made by VDP and Minitab, we use (simple) exponential smoothing as a mathematical model to estimate demand during the lead-time. The model for exponential smoothing uses a constant alpha (α), times the demand in the current period plus (1- α) times the forecast for the current period:

$$\hat{W}_L = \sum_{t=1}^{L} a\ (D_t) + (1-a)(F_t)$$

<u>Where:</u>

$\hat{W}_L$	=	is forecast demand over a replenishment lead time of L weeks, in units
L	=	lead-time of 12 weeks
F_t	=	forecast for the current time period, in units
D_t	=	demand in the current time period, in units
Alpha or α	=	smoothing constant. $(0 \le a \le 1)$

To initiate the forecast we assume $F_1 = D_1$.
Higher values of α place more weight on the more current time periods. To calculate the optimal value for α we have to measure the forecast errors. We can do this again by calculating the mean squared error. In an optimal situation each item on stock has its own value of α, and so it's own forecast model. According to Silver, Pyke and Peterson the value for α is likely in the range of 0.01 to 0.30. We initially set α at a compromising value of 0.10. Latter on PPM can change this value according to their wishes.

For purpose of establishing the safety stock of an individual item (to provide an appropriate level of customer service), we need an estimate of the standard deviation (σ_L) of the errors of forecasts of total demand over a period of duration R+L (the review period plus the replenishment lead time). We first estimate σ_1, the standard deviation of errors of forecasts of demand for one unit period. Next we discuss the conversion of the estimate of σ_1, to an estimate of σ_L.
Silver, Pike and Peterson suggest to use the Mean Square Error to measure variability. To calculate the MSE of each item, we use the formula:

MSE = $\frac{1}{n}\sum_{t=1}^{n}(e_t)^2$

Where:

n	=	total number of observed time periods
e_t	=	forecast error, in units ($e_t = x_t$ – avr. $X_{t-1,t}$)
t	=	time period

MSE is directly related to σ_1. To find the standard deviation of the errors of forecasts σ_1, we use a simple relation between the true value of σ_1 and the true MSE:

$\sigma_1 = \sqrt{\text{true MSE}}$

Since the replenishment lead time *L*, is different than the forecast update interval we need to convert σ_1 to σ_L. This is complex since the relationship between σ_1 and σ_L depends on the underlying demand model, the forecast updating procedure and the value of the smoothing constant. Silver, Pyke and Peterson have found that the following model captures, empirically the required relationship:

$$\hat{s}_{R+L} = (R+L)^c \hat{s}_1$$

Where:

$\hat{s}_L$	=	estimate of the standard deviation of forecasts errors over a lead time *L* basic periods (*L* does not have to be an integer)
$\hat{s}_1$	=	estimate of the standard deviation of forecasts errors over one basic period
c	=	coefficient that must be estimated empirically
L	=	lead-time of 12 weeks
R	=	Review period of 1 week, discussed in section 3,3

In this study we assume that in an L period the forecast errors in consecutive periods are independent and each has standard deviation σ_1. Therefore we use as value for *c* as suggested by Silver, Pyke and Peterson of c = 0.5 which gives us the following:

$$\hat{s}_{R+L} = (R+L)^{0,5} \hat{s}_1$$

Equals: $\hat{s}_L = \sqrt{(R+L)}\ \hat{s}_1$

3.2 The Form of the Inventory Control System

If demand is deterministic the reorder point can be calculated easily and a replenishment order arrives exactly whenever the inventory level is zero. But in most practical situations demand is probabilistic. We use the follow factory physics law which can also be used for nonmanufacturing examples (Hopp and Spearman, 2000):

Law (Variability Buffering): *Variability in a (production) system will be buffered by some combination of:*

1. *Inventory*
2. *Capacity*
3. *Time*

If demand is unpredictable (variable) customers go elsewhere if a product is not on stock. So time cannot be used as a buffer. Likewise, since products cannot be buffered by capacity because of the long lead-time the only available buffer to protect from variability is inventory. To manage inventory appropriable, we use an appropriate inventory control system which we discuss in the next section.

Silver, Pike and Peterson (2006) discuss four types of control systems. The first two are continuous; this means that the stock status is always *real-time* known. With period review the stock level status is only reviewed once in a certain time period. The last control system is a mixture of the second and the third system.

1. **Order-Point, Order-Quantity (s, Q) System (continuous review)**
   A fixed order quantity is order when the stock level drops under a reorder point.
2. **Order-Point, Order-Up-to-Level (s, S) System (continuous review)**
   A variable replenishment order is placed when the stock level goes under a reorder point. The replenishment order is just enough to bring the order up to level.
3. **Periodic-Review, Order-Up-to-Level (R, S) System (periodic review)**
   Every R units of time the stock level is checked and raised to the order level S if needed. This method is used often if the company does not have a computer system or when a container needs to be filled with item to keep the costs low.
4. **(R, s, S) System (combination (s, S) and (R, S))**
   This combination checks every R times if the stock level is bellow or at the reorder point. If so, a replenishment order is placed to raise the stock level to point S.

We can summarize this is as:

Lot size	**Inventory status review**	
	Periodic	**Continuous**
Fixed	(R,s,Q)	(s,Q)
Variable	(R,s,S) or (R,S)	(s,S)

Tabel 3.1 – Order systems for a single stockpoint (Silver, Pyke and Peterson, 2006)

Currently purchase orders are placed ones a week. There is no need to have more reviews during the week; the lead-time would change only a few days, a small percentage. So we review the stock levels periodically, with a period (R) of 1 week. Since we use a periodic review system the first two controls system can not be used. The third control system is also not correct since we do not place orders on a regular basis, neither order up to a fixed level since demand is variable.

So we use the fourth (R, s, S) System. It has been shown (Scarf, 1960) that this system under quite general assumptions produces a lower total of replenishment, carrying and shortage costs than does any other system.

3.3 Decision Rules for the (R, s, S) Control System

In the (R, s, S) inventory control system, every *R* units of time we check the inventory position. If the inventory position is below the reorder point *s*, we order enough to raise it up to level *S*. If the position is above s, nothing is done until at least the next review point *R*.

3.2.1 The Review Interval (R)

Currently the CCO checks inventory level every week. Since the lead-time is 12 weeks, the review period can be rather long. A day more or less would only make a marginal difference, but shortages should be noticed early so a replenishment order can be placed. Reviewing inventory one time every week makes sure shortages are notified, but the purchaser is not continuously working on placing orders and checking inventory. Checking inventory one day of the week fits PPM. The purchaser can subsequently calculate any reorder points and contact the trading companies to place the orders. The Review Interval (R) is therefore set at 1 week.

3.2.2 The Reorder Point (s)

Reorder point; additional products are only ordered if the inventory positions falls below the reorder point. Once a purchaser places an order, a lead-time elapses before the order is available at PPM. Therefore, the purchaser must place an order when the inventory is still adequate to protect PPM over a replenishment lead-time. Every review interval the purchaser needs to calculate whether a reorder point exists. We calculate the reorder point as follows (Silver, Pyke and Peterson, 1998):

Reorder point, s $= \hat{w}_L + SS$

And

Safety Stock, SS $= k\,\sigma_L$

<u>Where:</u>

$\hat{w}_L$ = forecast (or expected) demand over a replenishment lead time (L), in units, see section 3.1

σ_L = standard deviation of errors of forecasts over a replenishment lead time (L), in units, see section 3.1

k = safety factor

Determination of a *k* value leads directly to a value of s through use of these two relations.

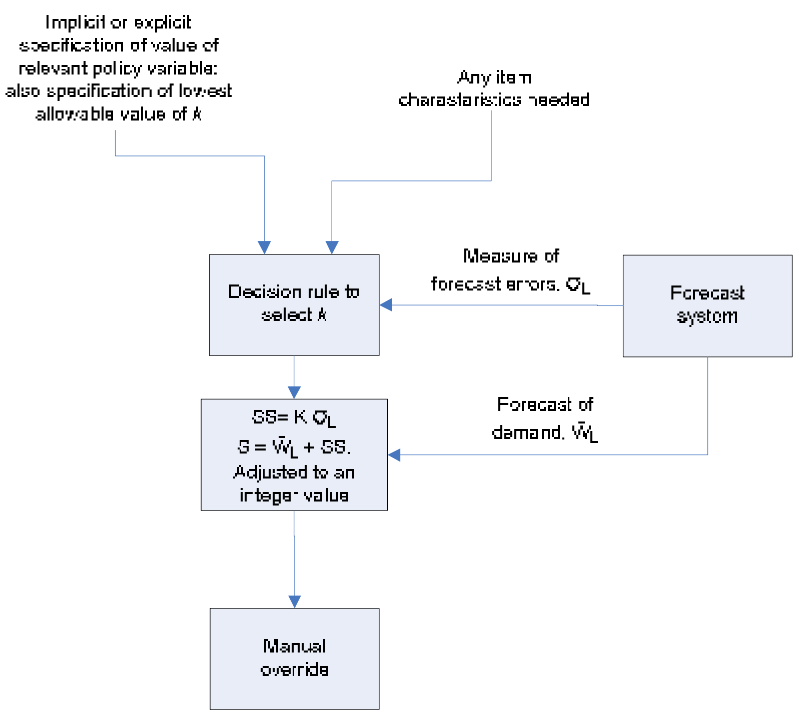


Figure 3.3 – General decision logic used in computing he value of *s*, (Source: Silver, Pyke and Peterson, 1998)

The question is how to choose safety factor k? In the next section, we discuss the customer service approach and its performance measures.

3.3 Safety Stock (SS), The Customer Service Approach

A definition of safety or buffer stock is: "*The amount of inventory kept on hand, on the average, to allow for the uncertainty of demand and the uncertainty of supply in the short run.*" (Silver, Pyke and Peterson, 2006)

At PPM the future rate of demand is probabilistic. To create a buffer for the variability in our forecast model we need extra inventory. This extra inventory is the safety stock. This stock should guarantee that stock is available with a certain probability so customer service is improved. On the other hand will the extra stock increase the aggregated inventory level and so it is the cost of keeping inventory on hand. A decision regarding the quantity of safety stock is made in one of these four ways:

1. Safety Stock established through the use of a Simple-Minded Approach
2. Safety Stock based on Minimizing Cost
3. Safety Stock based on Customer Service
4. Safety Stock based on Aggregate Considerations

In the end the management of safety stock is a tactical choice for a company. A decision must be made to focus more on the easy of use of the system, minimum cost, maximal customer service or a combination of them.

In section 1.5 we have discussed PPM's competitive strengths. An important strength is its high service level, safety stock based on customer service seems appropriate. The aggregated consideration model could also be used, but this is usually based on an individual budget for each SKU. This budget is not available. We do not calculate the safety stock based on minimizing cost since our focus is on customer service. We could use the first method; safety stock established through the use of a simple-minded approach, but we prefer to base the safety stock on customer service to focus on our competitive strength.

There are four common ways to measure service when safety stock is based on customer service:

- Specified probability (P_1) of no stockout per replenishment cycle – Cycle Service Level
- Specified fraction (P_2) of Demand to be satisfied routinely from the shelf – Fill Rate
- Specified fraction of time (P_3) during which net stock is positive – Ready Rate
- Specified average time between stockout occasions

The *fill rate* (the P_2-measure according te Silver, Pyke and Peterson, 2006) is the long run fraction of demand that is delivered immediately from stock on hand. It gives a better idea of the on-time delivery performance and Is therefore often used in practice. The fill rate approach seems the best approach for PPM.

According to the fill rate approach, one should choose the safety factor *k* such, that the customer service level equals some given target value. For example, the probability that the central depot will not be out of stock during a replenishment cycle should be 0,95. A stockout is defined as an occasion when the on-hand stock drops to the zero level.

We denote the target fill rate by f. The actual fill rate can be found as follows (Van der Heiden, 2007). Subsequent replenishment cycles have more or less identical behaviour, so we can simply focus on the expected fill rate in a replenishment cycle. The total demand in a replenishment cycle equals *Rm*. As a replenishment order arrives at the start of a replenishment cycle and demand occurs furring the remainder of the cycle, the demand that cannot be met during a cycle is identical to the backlog at the end of the replenishment cycle, just before next replenishment arrives (we assume that the probability of a positive backlog at the start of a cycle is negligible).

So the actual fill rate equals the ratio the expected backlog at the end of a replenishment cycle and the mean demand during that cycle, Rm. Backlog only occurs if the replenishment was raised to the order-up-to level S (see section 3.4), which should cover all demand during a period R + L. So we have backlog if:

$D(L+R) > S$, and the amount of backlog is:

E [Backlog] = σ_L G(k)

<u>Where:</u>
G(k) = ø(k) – k [1-Φ(k)]
σ_L = standard deviation of errors of forecasts over a replenishment lead time (L), in units, see section 3.1

The fraction of demand that is *not* satisfied immediately form stock on hand is approximately equal to the ratio of expected backlog at the end of a replenishment cycle and the total demand during a replenishment cycle, so:

Fill rate = 1 - E [Backlog] / Rm

This formula is valid for high fill rates, because we ignore the possibility that the backlog is already negative at the start of a replenishment cycle.

3.4 Order-Up-To Level (S)

The last key issue for a purchaser is how large a replenishment order should be. The key time period over which protection is required is of duration R + L, instead of just a replenishment lead time L. See the example in the figure bellow where S = 50 units and where two orders (called X and Y) are placed at times t_0 and t_0 + R, and arrive at times t_0 + L and t_0 + L + R.

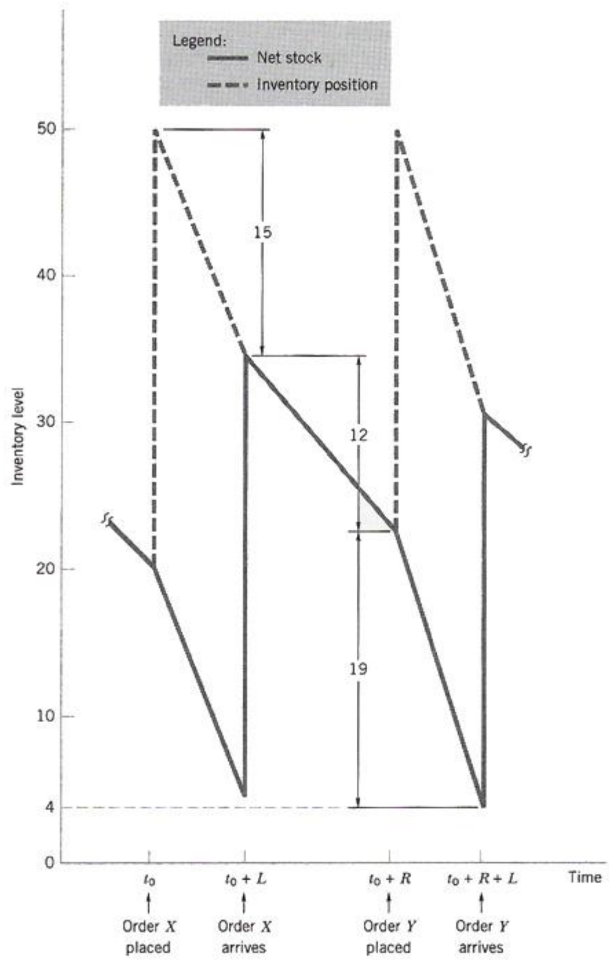


Figure 3.4 The Time Period of Protection in an (R, S) System (Source: Silver, Pyke and Peterson, 2006)

A stockout could occur toward the end of the period if the total demand in an interval of length R + L exceeds the order-up-to level S. Of course, this does not mean that we would necessarily take no action if at time t_0 a stockout appeared likely by time t_0 + L. PPM should expedite any already outstanding order or try to get the current order (that placed at time t_0) delivered as quickly as possible.

To minimize holding and shipping costs, we use an Economic Order Quantity (EOQ) model which minimizes total costs. EOQ models are in practice not often used as an automated replenishment system, but they can show a purchaser, which quantities could be purchased to minimize costs.
There are a number of constructs that lead to the basic EOQ model (Silver, Pyke and Peterson, 2006). These assumptions are sometimes far away from the reality at a company, but the EOQ model can be adjusted to fit into a companies purchase policy. The nine constructs we discuss are:

1. The demand rate is constant and deterministic
For the demand we use the exits of the Logyx fiscal warehouse. Every exit from the warehouse means that a customer has placed an order. At the beginning of this section we have seen that the demand varies for a number of items and is not deterministic for short periods. This demand rate changes every time the system is updated.

2. The order quantity need not be an integral number of units, and there are no minimum or maximum restrictions on its size.
There are minimum restrictions. Because this is different for each article and supplier each article has its own minimum order quantity (MOQ). The standard minimum order value (MOV) is 5.000 USD. Using this MOV we can calculate the MOQ:

Minimum Order Quantity, $\quad MOQ = \dfrac{5000}{p}$

p = Purchasing price of an item (Free On Board, FOB), in USD

3. The unit variable cost does not depend on the replenishment quantity.
Quantity discounts are used, but differ from product, time to time and supplier. We use the following formula for average quantity discounts:

1x MOQ	=	100% of unit variable cost
2x MOQ	=	96% of unit variable cost
4x MOQ	=	93% of unit variable cost

The standard EOQ model does not hold quantity discounts into account. We need to extend the basic EOQ model with a model where quantity discounts allowed.

4. The cost factors do not change appreciably with time (low inflation)
Inflation in China is very low, but changes do occur. All the costs factors are variable constants and we need to keep this in mind during the implementation of the economic order quantity model.

5. The replenishment lead-time is zero durations
Lead-time is 12 weeks, for the EOQ model this creates no problems.

6. No shortages are allowed
Shortages are not allowed and need to be strongly avoid. That is why there is a safety level for the stock.

7. The planning horizon is very long
We assume that the article life cycle is long enough to use an EOQ model. If an item has reached its end of life the purchaser should eliminate the product from the purchase program.

8. The item is treated entirely independently of other items, joint replenishment is ignored
Joint replenishment does occur. PPM sometimes waits with purchasing until a complete container can be filled. This saves shipping cost. But in this research we do not include joint replenishment (see also our recommendations).

9. Costs Involved in Inventory Models
1. Unit Variable Cost (v)
2. Order Costs (A)
3. Carrying costs per year (r)

Order Costs (A)
The order costs exists of two components. The first is the time the CCO spends on each order. The second component is the freight costs of the goods shipped by container. Since the time the CCO spends on each order is very little compared to the freight or shipping costs, we neglect these first costs.
The current order cost calculation is not suitable for our EOQ model. We need standard order cost for each product known in advance. Instead PPM calculates the variable order cost after a shipment has arrived. Shipping costs are not standard, nor can costs be known in advance. First of all PPM uses 3 types of containers:

Container	Content	Total Price*	Price in USD/m^3
20´	33.2 m^3	$3200	$96.39
40´	67.7 m^3	$4300	$63.52
40´ High Cube	76.3 m^3	$4600	$60.29

Table 4.8 - Container Costs * Average price, depending on port of origin

When PPM uses a larger container the cost of a m^3 is much less than a small container. So shipping the same amount of products could vary in price a lot.
The second issue has to do with the part of the container that is divided over the goods. The price of the whole container (see Table 3.6) is divided over the total value of the different products. In the first case a certain amount of article A is shipped with relative low priced goods;

Example 1, High Order Costs Item A:

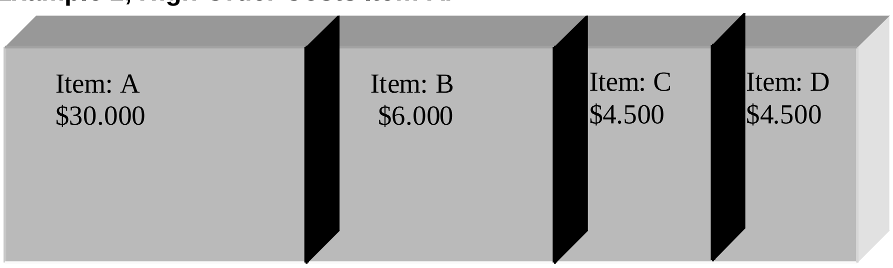


Figure 3.4 - Model 20´ Container with 4 SKUs

The total value of the container is $45.000 of which $30.000 belongs to Product A. In the first case, goods A will receive 66.7 percent of $3200. In this case, shipping cost for product A would be **$2134.4**

In the second case the same amount of article A is shipped, but this time with more expensive products:

Example 2, Low Order Costs Item A:

Figure 3.5 - Model 20´ Container with 4 SKUs

The total value of the container is $108.000 of which $30.000 belongs to Product A. In the second case goods A will receive only 27.8 percent *flete* of $3200. Shipping costs for product A would be **$889.6**

We have shown how order costs can differ a lot. So we can not give each SKU a fixed order cost *A*.

PPM could use CFR (Cost and Freight) prices instead of the current FOB (free on board) prices. Instead of using the value of the shipment, the volume could be taken as a base to calculate shipping cost. In doing so the CFR price paid for the article is the *unit variable cost*, or *v*. Using the CFR price, PPM can calculate in advance how much the shipping will be and use the economic order quantity model to minimize cost.

Carrying costs per year (r)
The cost of warehousing is expensive in Mexico due to extra safety measurements against robberies and thefts. PPM pays 0.70% for warehousing and 0.05% for insurance a year for the value of the inventory in the warehouse.

With this data, we can calculate the economic order quantity for each product. For the Economic Order Quantity (or Q_{opt}, optimal replenishment order) we use the standard EOQ model of Silver, Pyke and Peterson:

EOQ = $\sqrt{\frac{2AD}{vr}}$

Where

A	=	fixed costs component, in $
D	=	demand rate of the item, in units/units time
r	=	carrying charge, in $/$/unit time
v	=	unit variable cost of the item, in $/unit

Since we use a model with quantity discounts with a double breakpoint, we have three different values of v. The calculation of this Q_{opt} is show in Annex 1.

And

Order-Up-To Level, S = EOQ + SS

Where:

EOQ	=	Economic Order Quantity
Safety Stock, SS	=	k σ_L (see section 3.2)

In the end the economic order quantity is just a trade-off between holding costs and ordering costs. This model does not hold into account the product life cycle or the future demand. It is still up to the purchase to decide the volume to buy.

3.5 Conclusion

We are convinced that the (R, s, S) Inventory Control System is best suitable for PPM. Although the system seems rather complicated in the beginning it is actually fairly easy to understand and to implement. On the next page, we have schematically drawn the flowchart of the model. In our Recommendations we discuss how to improve the proposed (R, s, S) Inventory Control System and its models in the future.

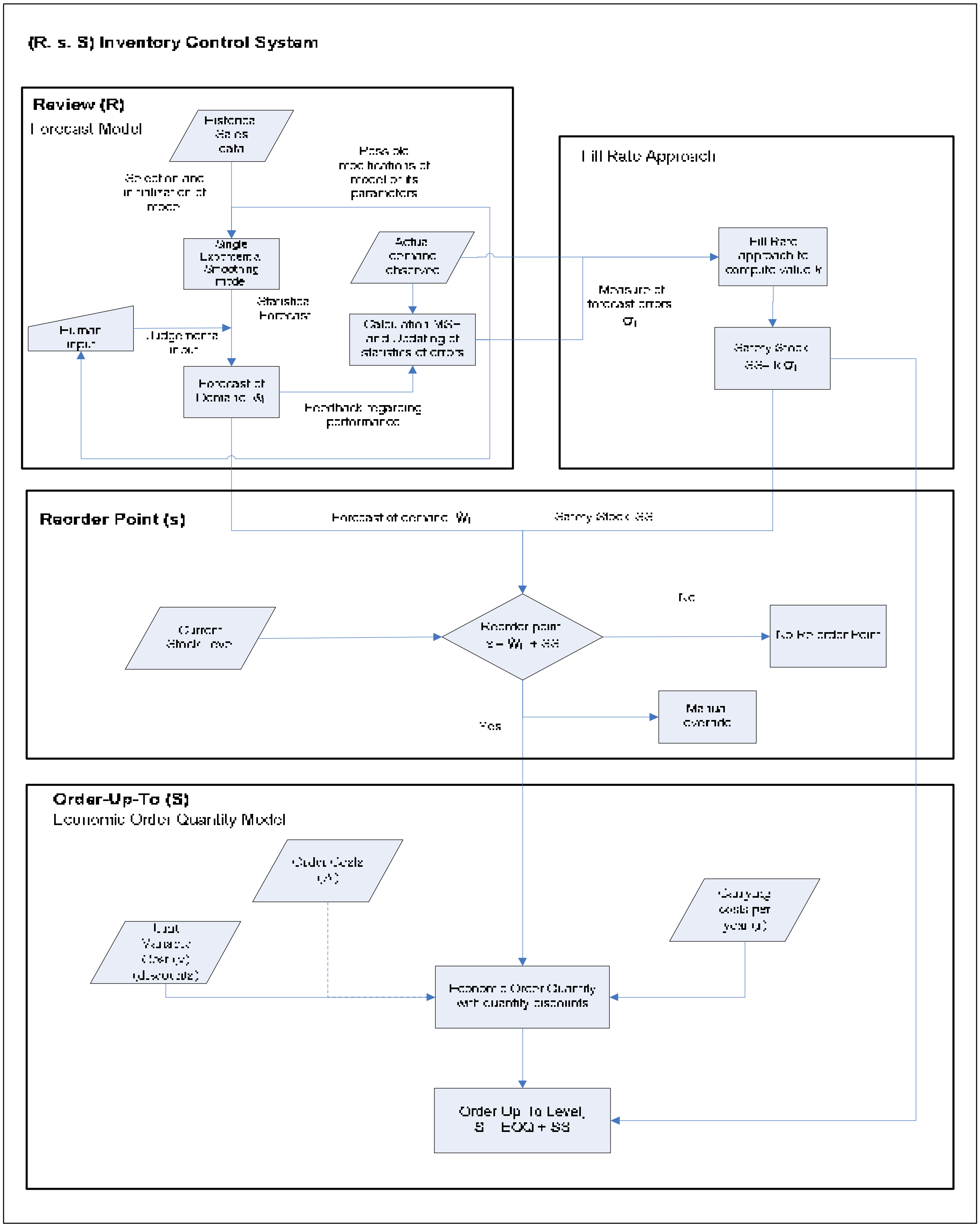


Figure 4.5 – Flowchart of proposed (R, s, S) Inventory System

4. Implementation and Further Research

The importance of purchasing is getting more and more attention in many industries these days. Management realises that costs can be cut in this area especially after realising the amount spent on (direct and indirect) purchases. The share of purchasing spend in the overall revenue is increasing because of developments such as 'back to core business' and outsourcing. Purchasing is PPM's core business and should get all the attention it deserves. Top management must realise that every dollar not spent on purchasing is a dollar extra profit.
We have shown is this research that many problems faced by customers, sales persons and management are related to the limited purchasing function of PPM. By implementing the new purchasing strategy and models we have discussed in chapter 3 we are convinced many of PPM's problems can be solved. In this chapter we provide a general roadmap to successfully implement this new strategy, policies and methods.

4.1 Marketing the purchasing function

Purchasing can add a lot of value to organisations because of its impact on an organisation's financial, logistical and operational performance. At PPM it seems this potential added value is not recognized yet.
The CCO his first task is therefore to market the purchasing function to the senior management. If they can be convinced of the added value a renewed purchasing a great opportunity can be seized. In this report, we have identified problems and shown a way to solve these with improvements in the purchasing function. This implementation should start at the top of the organization and then be managed downwards. After the top management is convinced, the sales and operational departments should also be involved since the set up of a purchasing department is a joint undertaking and a success should also be communicated as such.

4.2 Informational Services

In the previous chapter, we have discussed a number of models for the order stage of the purchasing process. These models make sure that the right products are being bought from the right supplier, at the right time and in the right quantity.
Since the current information system of PPM, ASAP, is not capable of delivering this information, an new application has to be created that does fulfil the needs of the purchaser and includes the methods and models we have discussed. We have created a timeline where PPM develops an application in half a year with the help of an external party to write the application. We suggest PPM to take the following milestones into account:

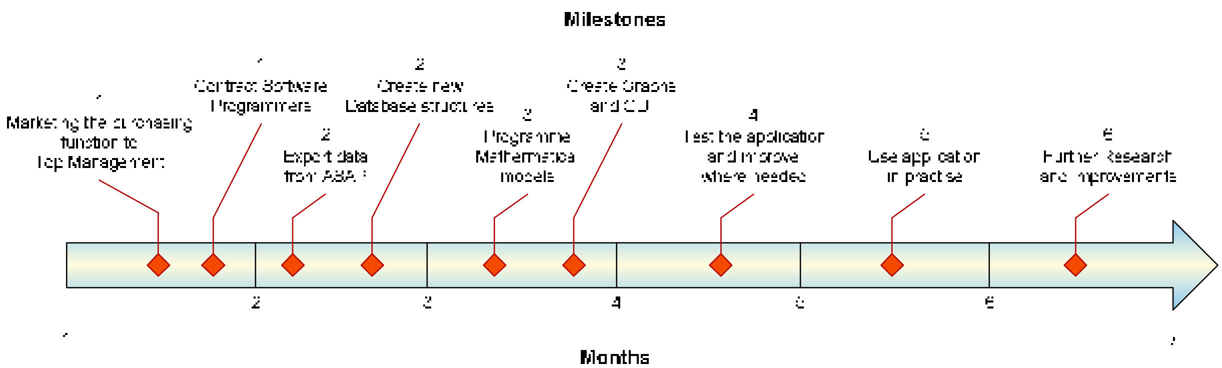


Figure 4.1 Timeline of implementing the information service application

During our internship at PPM we were asked to develop an informational system to determine reorder points and quantities for replenishment orders. We have created a basis to do so with fully documentation and further recommendations for PPM. More information can be found in the Annexes.

4.3 Recommendations and Further Research

For the scope of our research, the (R, s, S) inventory model fits well. The model depends on good forecast and safety stock models, discussed in the next sections. In this section we give PPM recommendations and suggestions for further research to improve purchasing and inventory management at PPM additionally.
Of all models, the forecast model was the hardest model to design. The forecast is used to determine the reorder point. We would like to make to following recommendations to improve the forecast model.

4.3.1 Forecast Model

Multiple Mathematical Forecast Models

The simple exponential forecasting model only tells us, when we should reorder looking at the lead-time of 12 weeks. An optimal situation we be that a number of forecast models are used for each SKU. With the MSE an optimal forecast model could be chosen for each item.
Right now we have chosen for one standard model for all articles. We have done this in the first place because limited data was available. We only had one or sometimes two annual cycles, making it hard to use a seasonal model. Second is that the calculation of an optimal model (and in this model again an optimal value for α and β) is very complex. For this research we did not have the time to research or implement this.
Since our simple exponential smoothing model does not have a trend or seasonal plots. The forecast is always level. This means that in some cases the forecast is too much and in other cases too little. We recommend PPM that when more data is available to design a number of forecast models. This should be around the beginning of 2008.

Use Error Measurement to Optimize Forecast Model

The exponential smoothing model uses a value of alpha, α to put more or less wait on historical data. Using the error measurement an optimal value for α can be chosen.

Use more Indicators

The forecast models we have discussed are all based on historical data. There are many more indicators of how demand in the future will be. Product life cycles, market trends, salespersons information and more can also be hold into account to make a forecast. In this research we have not hold any backorders into account since they are not registered. We recommend PPM to The forecast model should definitely hold these backorders into account.
The CEO also came with the idea that if large volumes of a product are sold to a client, then its competitor will never buy this product again, neither the original customer for its next year products. This all has to do with the product life cycle, the value of the product and many more factors. Using these factors, the future demand of PPM's products could be more accurate than it is now. But now the forecast is not used as an order quantity model, only as an input for the reorder point model.

4.3.2 EOQ Model

An operational goal is to spend less than 65% of the total turnover on purchasing (FOB), shipping, duty, interest and warehousing. With the EOQ model the purchaser can easily see, using basic minimum order quantity and quantity discounts information, if it would pay off to buy more of a product. Maybe buying 2 times the MOQ would save PPM thousands of dollars. Or maybe it would only save a few hundred. In the last case it would still be a better choice to order the smaller quantity even though money can be saved. Because the risk of putting items on stock is not measured. Neither is the product life cycle in this model or advantage that can be made out of joint replenishment orders. The order quantity model is only a model that advices the purchaser on the volume to buy. All the models, graphs and historical information will give the purchaser a clear, but in the end it is up to the purchaser to make the final purchase decision.

In order for the EOQ model to work precisely, we recommend PPM to use CFR (Cost and Freight) prices instead of the current FOB (free on board) prices. Instead of using the value of the shipment, the volume could be taken as a bases to calculate shipping cost. In doing so the CFR price paid for the article is the *unit variable cost*, or *v*. Using the CFR price, PPM can calculate in advance how much the shipping will be and use the economic order quantity model to minimize cost.

In the end the EOQ model does not hold into account what the forecast for the coming period (not only the lead time) is. It would be wise for PPM to create a forecast for a longer period of time and mach this demand with the order quantity. At the moment due to the limited data available this was not an option yet, the EOQ-model we have designed gives the purchaser a good advice, but should never be followed blindly since product life cycles and many other factors are not held into account.

4.3.3 Purchasing Process

In this research, we have focused on the operational part of the purchasing process. We recommend PPM to further research the improvements that can be made in the first part in the purchasing process, the tactical procurement. As said before, specifying is the perhaps the most important step of the process. (Telgen et al, 2006) In this phase is defined what is going to be purchased. It is therefore the basis for all further steps. The specification phase also has most impact on total costs. Further research can be done at designing and implementing a purchasing policy.

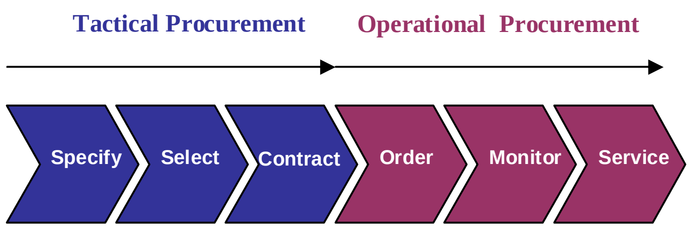


Figure 4.2 - Model Purchasing Process

After the management of PPM is convinced that the implementation of a purchase department and purchase function is necessary for the company, one of the first things that needs to be done is to write a purchasing policy. As written in the previous chapter, PPM's purchasing policy should reflect the organisation's opinion on economic, organisational, idealistic and ethical subjects. Since one of PPM's core competences is its high service level, the purchasing policy should be accordingly and mention that shipments should be of a high quality. This could next be set up as an performance indicator, for example that any shipment should contain less than 3% broken peaces.

Next the management of PPM must set up new methods and procedures for the purchasing department. This report provides a framework to set up these procedures based on the research of various purchasing models. The decisions have to be made by a purchasing professional which should be employed by PPM.

4.3.4 Setting up a Purchasing Department

We recommend PPM to set up a new department especially for the purchasing function. The value added by this department will be a great benefit for PPM. The department should minimal exist of a purchasing professional. He or she will be responsible for the entire purchasing function and process for both the core direct purchasing of goods and the indirect purchasing of goods. Beside the purchaser, Jacqueline Mancilla, PPM´s logistics supervisor should continue being responsible for the monitoring and aftercare of all shipments. She will also be responsible for the monitoring and keeping score of suppliers trough a Balanced Scorecard method. The last person in the purchasing department should focus more on marketing, find new interesting problems to update catalogues more often, keep track of product life cycles so products that are not selling can be removed form the catalogue and function as an assistant of the purchasing professional. Market research will be of great benefit for the company to stay ahead of competition. We can show the new purchasing department in a section of the organizational chart:

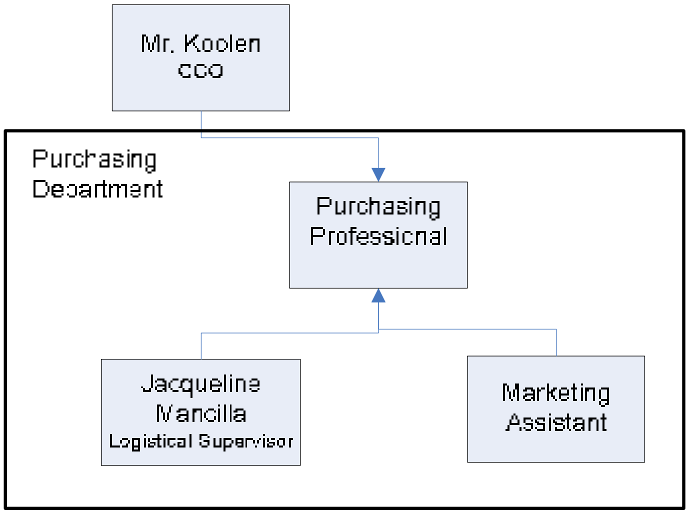


Figure 4.3 – Organizational Chart of Purchasing Department

Currently, wishes of customers are known to the salespersons, but not to the management or purchasing department. PPM uses a push strategy to sell their products. By listening more to customers and salesmen PPM can try to change to a pull strategy. Although this is very hard with a lead time of three months, we think the effort is worth it. Maybe purchases as the business card holder, IT2393.04, of which thousands, after many years, still exist on stock can be prevented.

4.3.5 Out of Scope Further Research

To increase the service of PPM's furthermore, we also though of some alternative studies.

1. Reduce the lead-time

By reducing the lead-time products could be delivered sooner to customers. Reducing the lead-time could occur in two ways. The first way is to choose different suppliers than the ones PPM uses now. PPM is searching for suppliers on the local Mexican market, but prices in the Orient are still much lower than in Mexico itself. Some products (like domino sets) need to be bought on the local market, for these products the lead-time is no longer an issue. PPM still sources in Mexico but for now, China offers much better prices. The second option is to reduce the lead-time of the current suppliers.

2. Make customers Order more early

The promotional campaigns in which the customers use the purchase products of PPM are planned months before the actual campaigns takes place. Still products are only ordered at PPM some weeks before the campaign starts. If PPM does not have the products on stock the customer must either settle for other products or go to another supplier. Since PPM is not always able to deliver the products the customer wants, the customers are learning t order more early. Especially larger customers who sometimes want special designed products start discussing this with PPM months before their campaign actually takes place. This gives PPM the time to source these products and make sure they can be delivered on a certain date.
When other customers would tell PPM also months in advance, PPM would be able to deliver this items according the the agreement

In the end we are convinced that PPM is doing an excellent job. Turnover is decreasing greatly every year and the company is becoming more and more professional. With the help of a purchasing department, PPM's customer service will increase even more. Benefiting not only customers, but also smooth up processes inside the company and reduce costs.

5. Personal Evaluation

Unfortunately we did not have enough time to actually complete the implementation and evaluate of the proposed control system and models. At the time of writing we do not know if they are actually performing better as the old inventory and purchasing management methods. We will therefore only discuss our professional evaluation on our internship at Promocionales Pacifico de Mexico.

5.1 Research process evaluation

Problem Identification

Our first weeks in the company we used to oriented ourselves in the company. There was a lot to learn about the business of PPM, its market, its culture, customers, partners, logistics and much more. All these we have not included in this research since our main objective was to improve the purchase policy for PPM. We did not fully knew what was expected of us, what the current problems were and of course how we could solve these. By talking a lot with the CCO and the heads of the sales departments we found out what the current problems where. Using this information, we could write the first chapter of this research project.

In the first chapter, we have identified a number of problems at PPM which all related to the current purchasing process. However only *after* our software application was implemented we got a first clear glance on the purchasing of PPM in the last two years. The graphics in the application made us see how purchasing had been done in the past and which mistakes could have been prevented.

Problem Approach

Since we did not have much experience with research projects we did not look for problem identification structurally enough. Later on while writing this report we had to change some research questions.

We found out that the basis of the whole project, the problems, research questions; goals and approach are of great important to the success of a project. In the future, we will focus more on this basis than we have done in this research.

The data collection went well. We had enough support of the IT department of PPM. They were enthusiastic with helping me with my project, although sceptical in the beginning, after I had proven myself intelligent enough they would support my ideas. Since the ERP system of PPM runs on a DOS based platform it was hard to get some specific data as annual demand. I calculated many things in Excel which took up a lot of my time, but was necessary to analyze the current purchase problems.

Alternatives

In the alternatives phase of our project we knew more about different theories and models by reading more specific books regarding purchasing, inventory models and forecast. With this, the problems we identified in the previous phases and the goals we had in mind we really got started and choose some models that would be appropriate for PPM. After learning more about the models, making changes to them we good go to the next phase.

Decisions

Choosing among alternatives was a hard task. Of course we wanted a theory and models that fit best for the organization. But we also realized that if we choose models to complicate, it would cost us too much time to implement them well. Besides, the models had to be able to provide PPM with a quick insight into their purchasing process and inventory policy. We felt that if we made the model too complex, the persons at PPM would lose their interest and continued in their old way. So by choosing more simple models we had enough time to implement them into the current ERP system and to show the benefits to PPM.

Implementation

The implementation of the application was a lot of work. We did not have much experience with programming and none with Visual Basic .NET. Asking advice to our uncle Michel Kemper who has been a programmer for Shell he told us that our deadline of end December 2005 was almost impossible for a program this complex. Still, by working hard (10 hours a day) in the next months we were able to write and implement the program. We are proud of the result and think that it is very suitable for PPM. In the future the program should be easy to adapt and the be expend for further functions.

The control part is in the hands of PPM and especially the CCO. We hope that this research gives him a good idea of the possibilities for PPM in the area of purchasing. We really felt the need for a change within this area and hope we have contributed to that. We hope that the application will be of a good use in PPM and that it takes a little of the CCO his shoulders regarding purchasing since he has many more tasks to fulfil within PPM.

Personal Goals

Let me say first that there will be a more detailed evaluation of my personal goals and achievements available in my Minor Report and in a separate personal evaluation report.
Overall, I had a great experience in Mexico. Doing my internship at Promocionales Pacifico has taught me how it is to actually be a part of a company and what problems they have in practice. It was great talking to the managers of PPM, they have discussed many issues with me which has given me a lot of new thoughts, ideas and motivation for my years to come at the University of Twente.
To perform my first real research was great. I know now that there is still a long way to go and that I still need to learn many things. On the other hand, I noticed that the last years of studying really paid of and changed they way already of how to look at an organization from an industrial engineering point of view.
The Mexican (corporate) culture was great to experience and also taught me a lot about our own Dutch culture.
Finally my Spanish has improved a lot which will certainly be an advantage in the future in personal life and in business.

Annex 1 Formulas Used

Mean Square Error

We calculate the mean square error or MSE to compute the standard deviation of forecast errors (σ1) for the purpose of control and to set safety stock levels as discussed in §2.3.

MSE = $\frac{1}{n}\sum_{t=1}^{n}(e_t)^2$

Where:

n = total number of observed time periods

et = forecast error, in units

t = time period

To calculate the standard deviation of the errors of forecasts σ1, we use:

σ1 = $\sqrt{\text{true MSE}}$

Mean Absolute Deviation

The forecast error method of mean absolute deviation or MAD is used in the statistical program Minitab:

MAD = $\frac{\sum_{t=1}^{n}|e_t|}{n}$

Where:

n = total number of observed time periods

et = forecast error, in units

t = time period

Mean Absolute Percentage Error

The method of mean absolute percentage error or MAPE is used in the forecasting software Vanguard DecisionPro. We discuss Minitab and DecisionPro in more detail in section §4.2.

MAPE = $\frac{1}{n}\sum_{t=1}^{n}\frac{|F_t - D_t|}{D_t}$

Where:

Ft = forecast for the time period t, in units

Dt = actual demand in the time period t, in units

n = total number of observed time periods

t = time period

Expanded EOQ Model with Quantity Discounts

Standard EOQ model of Silver, Pyke and Peterson:

Qopt or EOQ = $\sqrt{\frac{2AD}{vr}}$

Where

A = fixed costs component, in $

D = demand rate of the item, in units/units time

r = carrying charge, in $/$/unit time

v = unit variable cost of the item, in $/unit

Since we use a model with quantity discounts with a double breakpoint, we have three different values of v:

v0
v0(1 – d1)
v0(1 – d2)

Where:
v0 = basic unit cost without a discount
dx = discount at breakpoint x, as decimal fraction

Of the three calculated EOQs we check if they fall between the allowed breakpoint values of Qbx:

$0 \leq Q_{opt1} < Q_{b1}$,
$Q_{b1} \leq Q_{opt2} < Q_{b2}$ and
$Q_{b2} \leq Q_{opt3}$

Where:
Qoptx = optimal replenishment order quantity, in units
Qbx = quantity at breakpoint x, in units

If the Qopt is less than the left end point than the left end point is the Qopt, if Qopt is larger than the right end point the right end point is the optimal replenishment quantity.

To determine the best replenishment quantity out of the three Q optimal calculated we calculate the minimal total relevant costs:

For Qopt1 TRC (Q) = AD/Q + Q v0 r/ 2 + D v0
For Qopt2 TRC (Q) = AD/Q + Q v0(1 – d1) r/ 2 + D v0(1 – d1)
For Qopt3 TRC (Q) = AD/Q + Q v0(1 – d2) r/ 2 + D v0(1 – d2)

Where:
TRC (Q) = total relevant costs per unit time

Where TRC (Q) is minimal the Qopt, or economic order quantity is chosen.

Annex 2 Vanguard DecisionPro

Sample results of Vanguard DecisionPro for article KC3003.13 with weekly data:

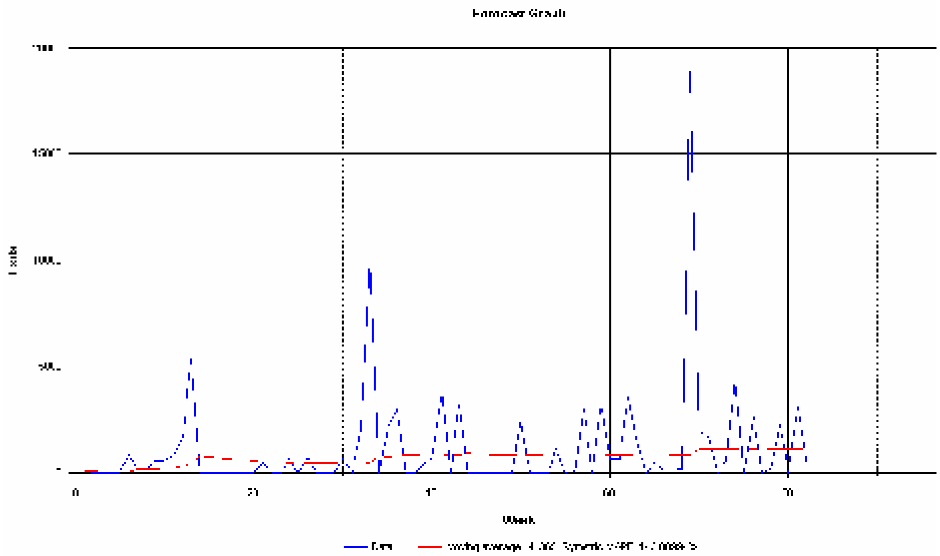


Figure Annex 2.1 - Forecast Graph KC3003.13 in weeks

The figure above shows a symmetric MAPE value of 143%. And a forecast which does not seem accurate at all. We ask Vanguard Software for an explanation. Rob Suggs of Vanguard Consultancy wrote us:

“You are correct--this data is not suitable for time series forecasting. The Symmetric MAPE is 143%. This means the data is basically random. Looking at the graph, it looks like the software correctly determined that the distribution is lognormal and correctly estimated the aspects of the data that are consistent and can be extrapolated. So, I think the software is doing the best job that any time series forecast software could do. Its just that your data is basically random and therefore, unpredictable. If you used monthly data (and more of it), the software might be able to find reliable patterns. However, you will need years of data instead of just a part of one year (fraction on a single cycle).”

Sample results of Vanguard DecisionPro for article KC3003.13 with monthly data:

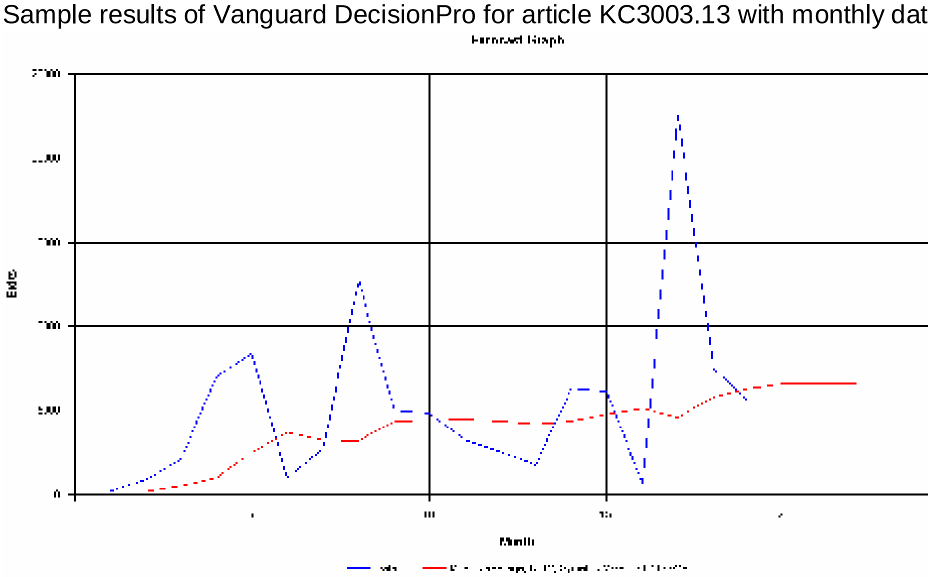


Figure Annex 2.2 - Forecast Graph KC3003.13 in Months

As we can see, the monthly data follows a nicer trend, so forecasting is more accurate.

Annex 3 Minitab

Examples of the results in Minitab 14 of the articles KC3003.13 and IT2497.04. Both with an A classification. They are among the most important products of PPM. The best results are displayed in red.

Model:	MAD	Forecast
Moving Average, N=3	1568	1844
Moving Average, N=4	1599	1440
Moving Average, N=5	1497	1175
Moving Average, N=6	1542	1411
Single Exponential Smoothing	**1342**	**1362**
Double Exponential Smoothing	1645	952-551

Table Annex 3.1 KC3003.13 - Week

Model:	MAD	Forecast
Moving Average, N=2	5294	15130
Moving Average, N=3	4745	10307
Moving Average, N=4	4432	9310
Moving Average, N=5	4001	8715
Single Exponential Smoothing	**3799**	**5968**
Double Exponential Smoothing	4721	9.297-10.221

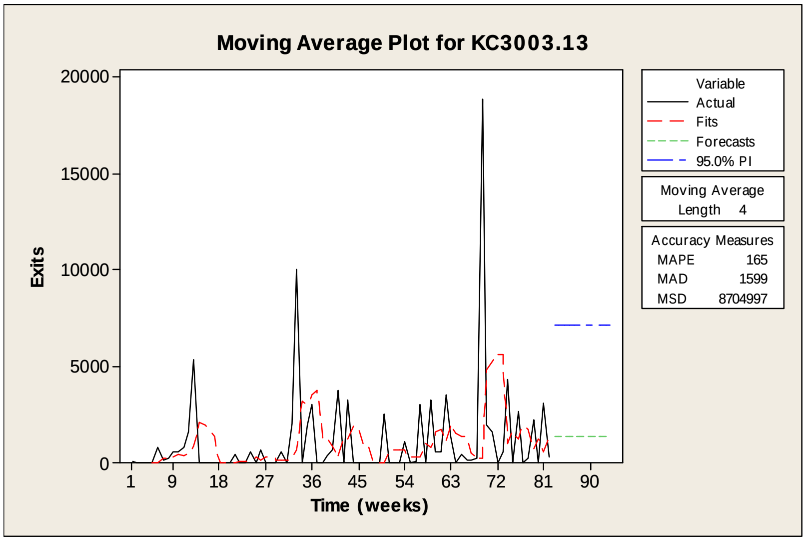
Table Annex 3.2 KC3003.13 - Month

Model:	MAD	Forecast
Moving Average, N=3	2637	0
Moving Average, N=4	2494	0
Moving Average, N=5	2603	965
Moving Average, N=6	-	-
Single Exponential Smoothing	**2546**	**1722**
Double Exponential Smoothing	2956	0

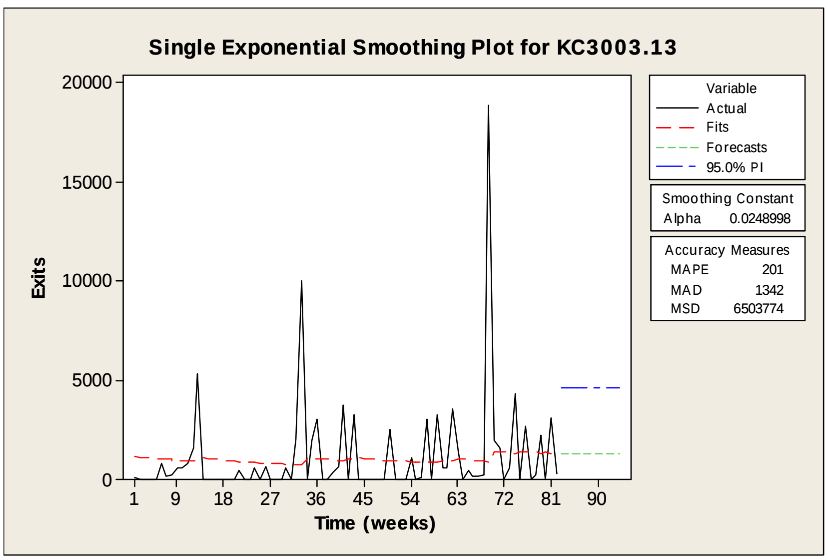
Table Annex 3.3 IT2497.04 - Week

Model:	MAD	Forecast
Moving Average, N=2	9465	3907
Moving Average, N=3	9632	3816
Moving Average, N=4	9583	3891
Moving Average, N=5	-	-
Single Exponential Smoothing	**7021**	**7476**
Double Exponential Smoothing	8553	5343

Table Annex 3.4 IT2497.04 - Month



Graph Annex 2.1 KC3003.13 – Week – Moving Average



Graph Annex 2.2 KC3003.13 – Week – Single Exponential Smoothing

Annex 4 Calculation of ABCD Classification

Although we ended up not using the ABCD classification in this research, we will still mention it in this Annex so it can be used in further research.
First, we have created a Distribution by Value or DBV curve where the percentage of total of SKU is set out against the percentage of the total annual dollar usage of an item.
The annual demand *D* of each item was unfortunately not directly available. Therefore, we use the demand from January until half September in the year 2005 of each SKU.
Each item or SKU has its own Value *v* and Demand *D*. Using this data we have created the table 3.1 with cumulative percentages.

SKU	Value (*v*)	Cumulative % of SKUs	Demand (*D*)	Annual Usage Value (*Dv*)	Cumulative Usage	Cumulative % of Total $ Usage
KC1203.16	$1.34	0.7%	34976	$46,867	$46,867	2.5%
KC3003.13	$0.84	1.8%	52980	$44,503	$91,371	4.9%
IT2236.04	$1.41	2.5%	31150	$43,921	$135,292	7.3%
IT1904.13	$9.13	2.6%	4766	$43,513	$178,806	9.6%
IT2497.04	$0.55	4.2%	77120	$42,416	$221,222	11.9%
etc.	...	...	...	...	...	...

Table 4.2 - SKUs by Descending Dollar usage

Using the cumulative percentage of total SKUs at PPM and the cumulative percentage of dollar usage we can create the Distribution by Value Curve for PPM's items:

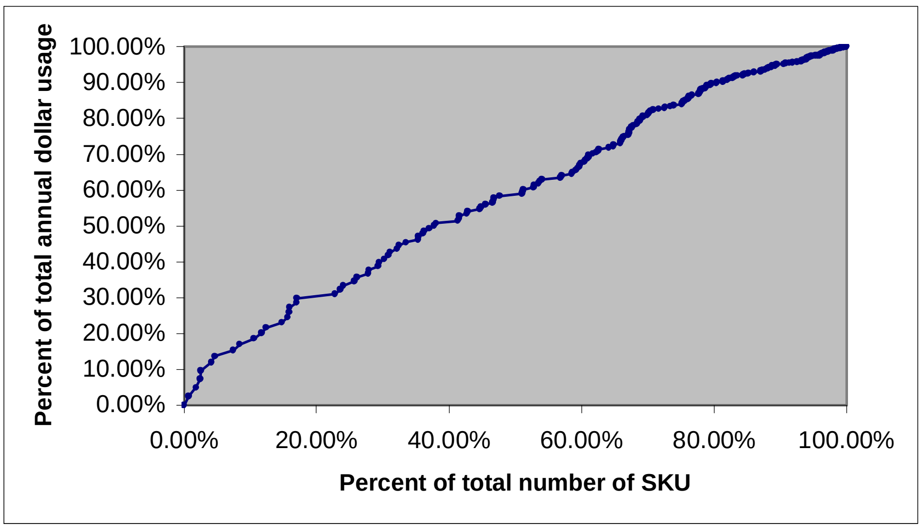


Figure 4.1 - Distribution by Value Curve of SKUs at PPM

Winstons says that the first 5-20% of the SKUs accounts in most cases for 55 to 65% of the total annual dollar usage. These items should be rated A. But we see that in our case this is not true. 60 percent of the total dollar usage is hold by 60 percent of the total SKUs. The division is much more 'equal' in our research. In this case it is hard to give products an A, B or C rating.

For example: IT1999.04, a Plastic Thermo Mug in the color Blue. Since the value is only 0.53 USD this product does not easily score high in Table 3.1. It is actually number 190 in the table. But talking to vendors we discovered that the article IT1999.04 is indeed a very important product for PPM. It is being order almost every week. Margins are good and most customers will buy more products besides the Mug. Therefore its availability is very important and IT1999.04 should be a class A product in our classification. More products as IT1999.04 exist.

So to gain a better ABC classification, we have made another list based on the number of customer transactions (or the exits out of the Logyx Warehouse) which we show next.

Listing	SKU	Exits
1.	KC3003.13	44
2.	IT2497.04	38
3.	KC1203.16	34
4.	IT2190.04	34
5.	KC1050.17	33
Etc.	Etc.	...

Table 4.3 - SKUs by Exits Logyx

IT1999.04 is now on the 11th place in the table, its importance is clearly shown now. But we can not give the articles an A, B or C classification just by exits from the warehouse since dollar usage is an important criteria as well.

Now to make a better ABC Classification based on both the dollar usage and the Exits from Logyx we gave all products in both tables a unique score from 0 to 299 next we added the two scores into a new table 4.5.

Score	SKU	Exits
299	KC3003.13	44
298	IT2497.04	38
297	KC1203.16	34
296	IT2190.04	34
295	KC1050.17	33
294	...	...

Table 4.4 - Scores SKUs by Exits

Score	SKU	Dv
299	KC1203.16	46867
298	KC3003.13	44503
297	IT2236.04	43921
296	IT1904.13	43513
295	IT2497.04	42416
294	...	...

Table 4.5 - Scores SKUs by Dollar value

Score	SKU	Classification
597	KC3003.13	A
596	KC1203.16	A
593	IT2497.04	A
585	KC1050.17	A
576	KC5608.16	A
571	...	...

Table 4.6 - Total Scores SKUs

The total score list was checked manually by Judith Cabrera, a distributors vendor who has been with the company almost since the start. She checked if products on the list where really descending by importance. Ten changes where made, most of them where products rather new in the catalogue but selling good already.
Next we gave products with a score of over 400 an A classification, products with a score between 200 and 400 a B classification and products with a score lower than 200 a C classification. Our example item IT1999.04 is now on the 31st place in the table, clearly an A classification.
This is a manual classification to get our model working. In the end the purchaser or the management will have to judge the stockout probability themselves.
There are a few exceptions in this classification. Products that have no lead-time (bought in Mexico) or products that are discontinued do not need to have a safety stock. Therefore we gave them the separate classification D.

Annex 5 Prototype ROS

5.1 Prototype ROS

We haven created a spreadsheet where we have implemented the chosen models in Chapter 4. We designed a prototype with an Interface with 5 tab-panels. We called our prototype program simply **PROS** (Prototype Replenishment Order System). The purpose of the PROS was to create a GUI that could be approved by PPM's management.

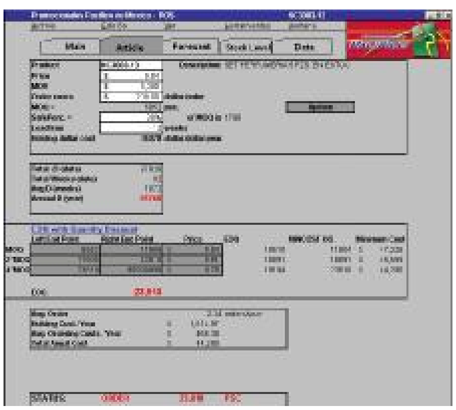
1) Main

The first Main tab contains most information and is most important to the ROS.

All the articles are displayed in a column with their Status, EOQ, On-Order, On-Hand Stock, Net stock, Inventory, Position and Late (weeks ago an order should have been placed).

When clicked on the update button. The tables will be updated with new information out of the ASAP system and new calculated Status and EOQ.

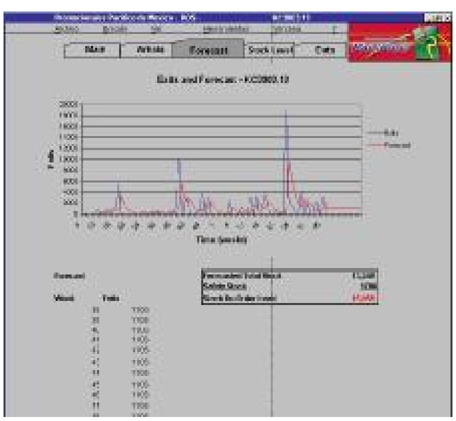
There can be chosen out of 4 windows with more detailed information regarding the currently selected Article. Double click on an Article will go straight to the Article screen.



2) Article

The Article tab gives detailed information regarding the selected Article, or an article number can be typed in so information will be displayed.

Information regarding the Articles Price, Minimum Order Value, Order costs, MOQ , Safety Percentage, Lead-time, Holding dollar cost, Total Demand (data), Total Weeks (data), Average Demand (weeks), Annual Demand (year). Also the Economic Order Quantity (EOQ) with Quantity Discount



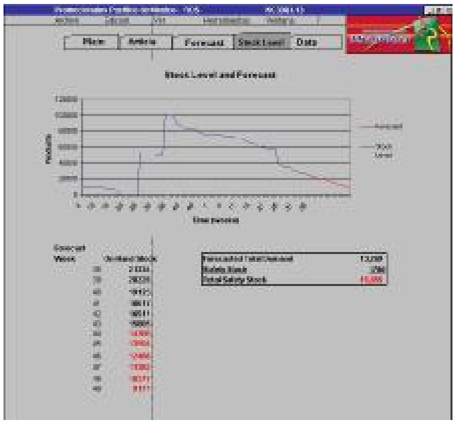
3) Forecast

The Forecast tab shows a graph of the exits of the LOGXY warehouse. In the same graph a forecast is shown for the coming 3 months.

Trends and seasonality can be seen more easily in the graph.

The total Demand for the next 12 weeks is shown with the Safety Stock. This together gives the Stock Reorder Level.

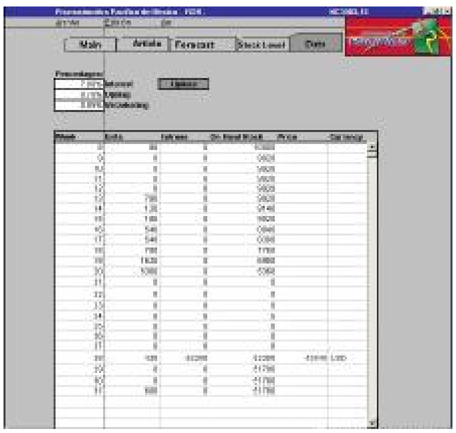
In the table the forecasted exits of the warehouse are showing.



4) Stock Level
The Stock Level tab shows a graph of the stock level of the selected product. In the same graph a forecast is shown for the coming 12 weeks.
Trends and seasonality can be seen more easily in the graph.

The total Demand for the next 3 months is shown with the Safety Stock. This together gives the Stock Reorder Level.

If the forecasted Stock Level in the forecasted months becomes less than the Stock Reorder Level, the Articles Status becomes ´Reorder´ and a Late is given in weeks for every week the Stock is under the Stock Reorder Level.



5) Data
Here the percentages paid for Interest, Warehousing and Insurance can be updated.

The last screen contains the Article data used to perform the Forecasts and the calculation of the Economic Order Quantity

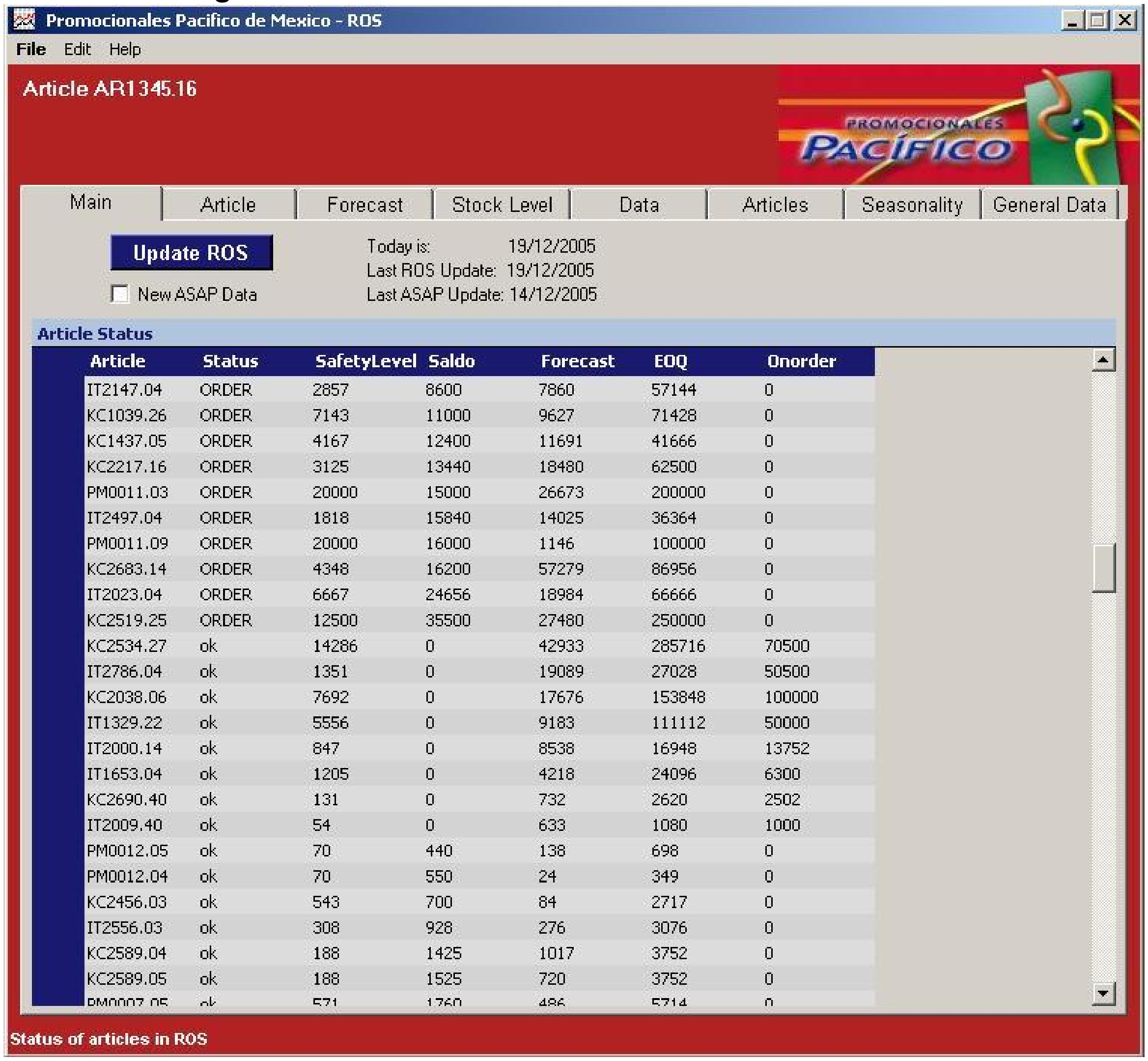
The prototype ROS, its Interface and its function were approved by the CCO on the 10th of October.

5.2 Alternative importations and languages

After the prototype we started thinking about the structure of the program. The two persons in charge of the ASAP system are, Sr. Rodolfo Mortera and Sr. Giovanni Alva.
They explained that it is very hard to directly access the data in ASAP, also because there are multiple users and tables may be locked etc. After discussing the possibilities with them we came to the conclusion that the best way to set up the ROS was exporting the data from the ASAP system and next import the data into the ROS system using a text file, XML file or a Database.

Annex 6 Replenishment Order System

6.1 Main Page – Idle

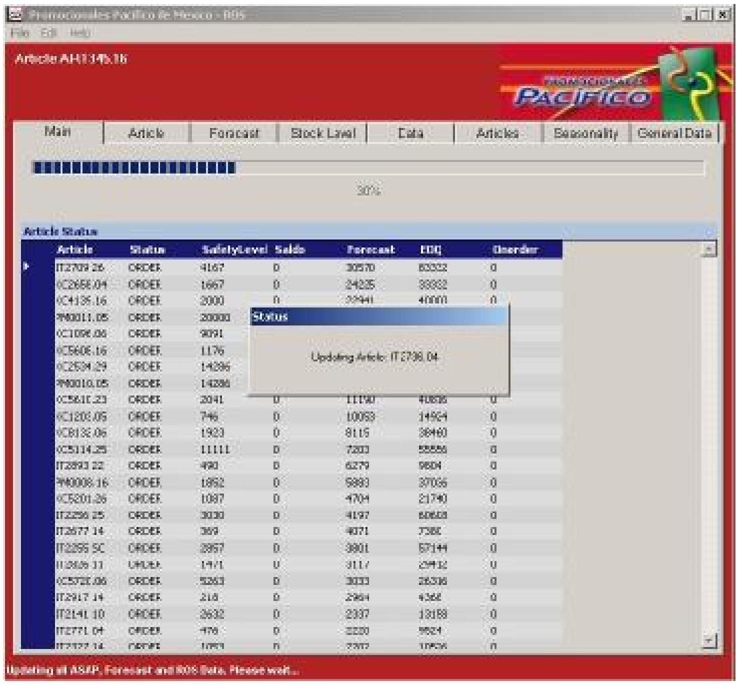


In the Main screen the most important data for purchasing is displayed. In the Status table is shown:

- The Article name
- Status (ORDER, ok or Discontinued)
- Safety Stock Level
- Current Stock Level or Saldo
- The Forecasted quantity for the next three month
- Economic Order Quantity
- Products that are On Order

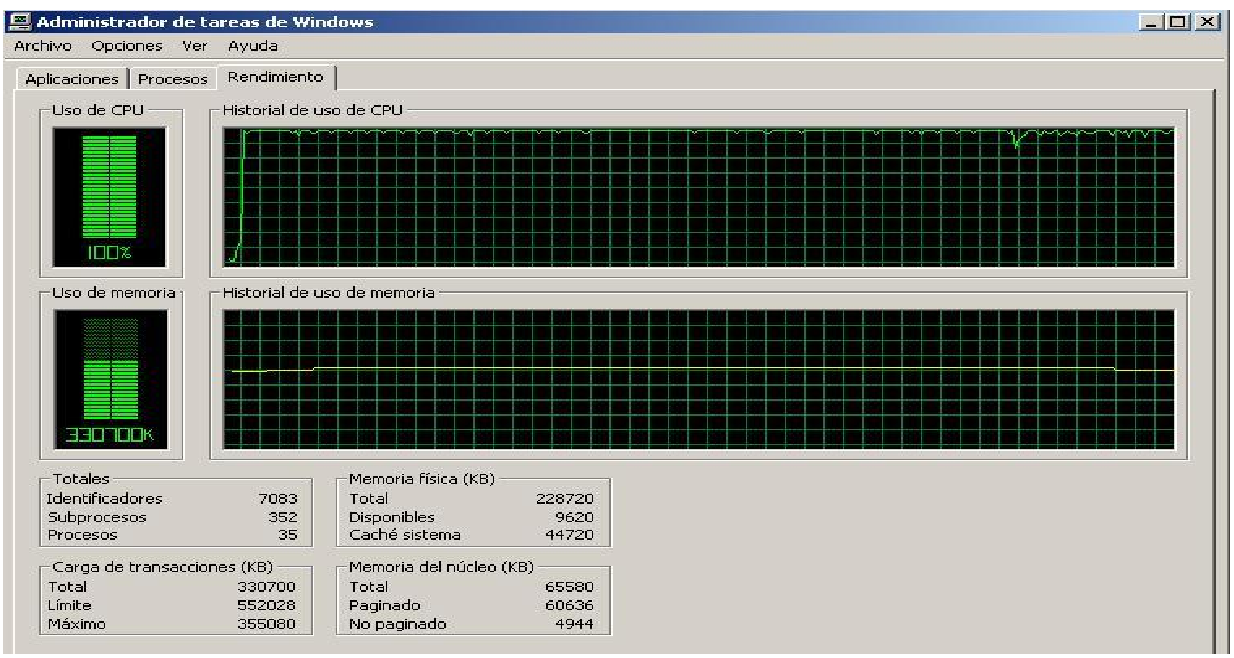
The products are ordered by Status, Saldo and Forecast, so the products with the highest priority are shown at the top of the table.
The current date and the latest ROS and ASAP updates are given. If the ASAP has been updated the user receives a message asking him to update ROS first. Also after every change in General or Article data the ROS needs to be updated first!
With the 'Update' button the ROS is updated, if the user wishes to use new available ASAP data he should check the checkbox as well.
Backups are made automatically every time the ROS is updated.

6.2 Main Page – Updating



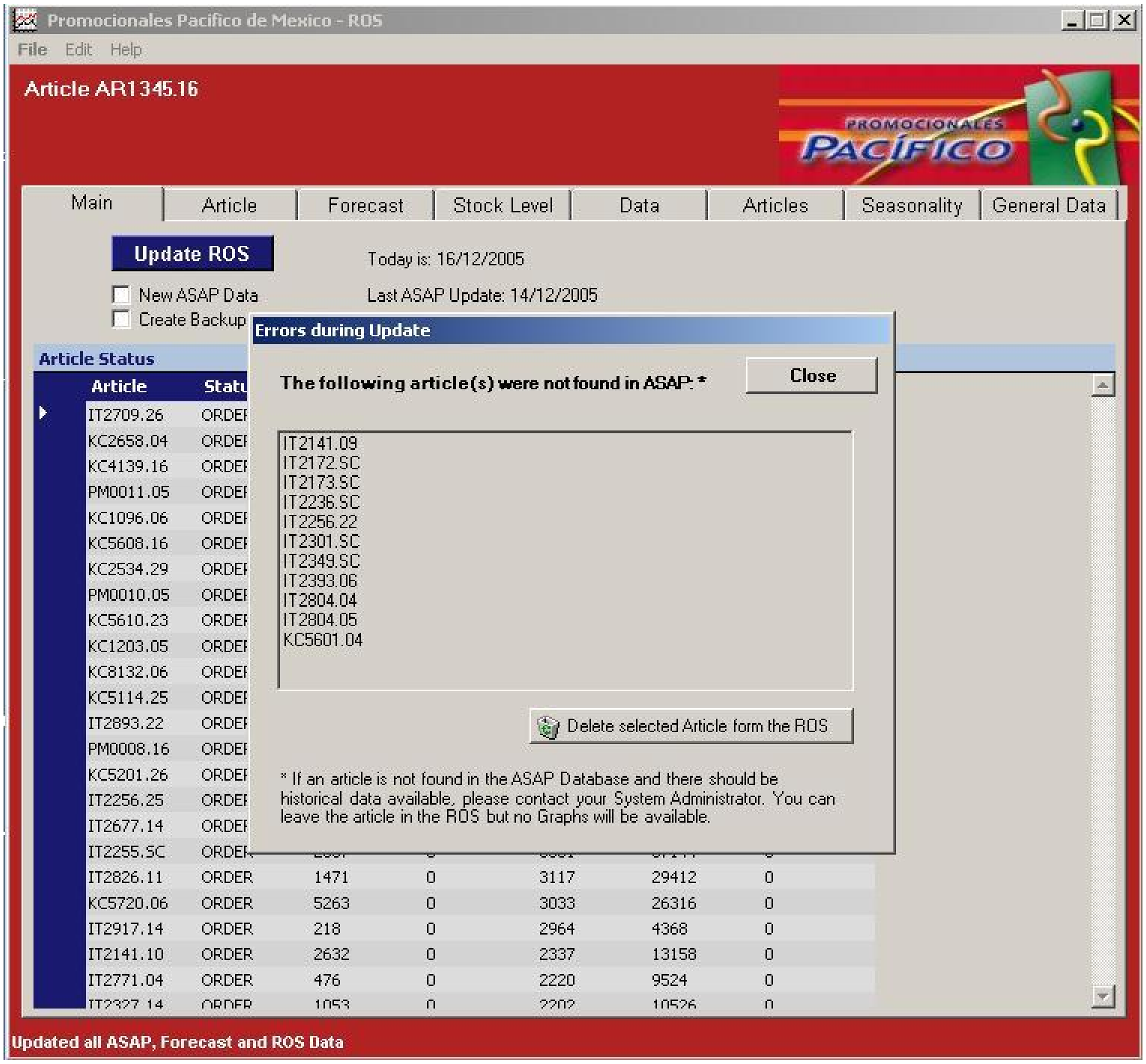
When clicked on the ‘Update’ button a status bar is shown with the remaining percentage for the upload. In the Status frame information is being displayed regarding the current process being updated.

6.3 System Resources during Updating



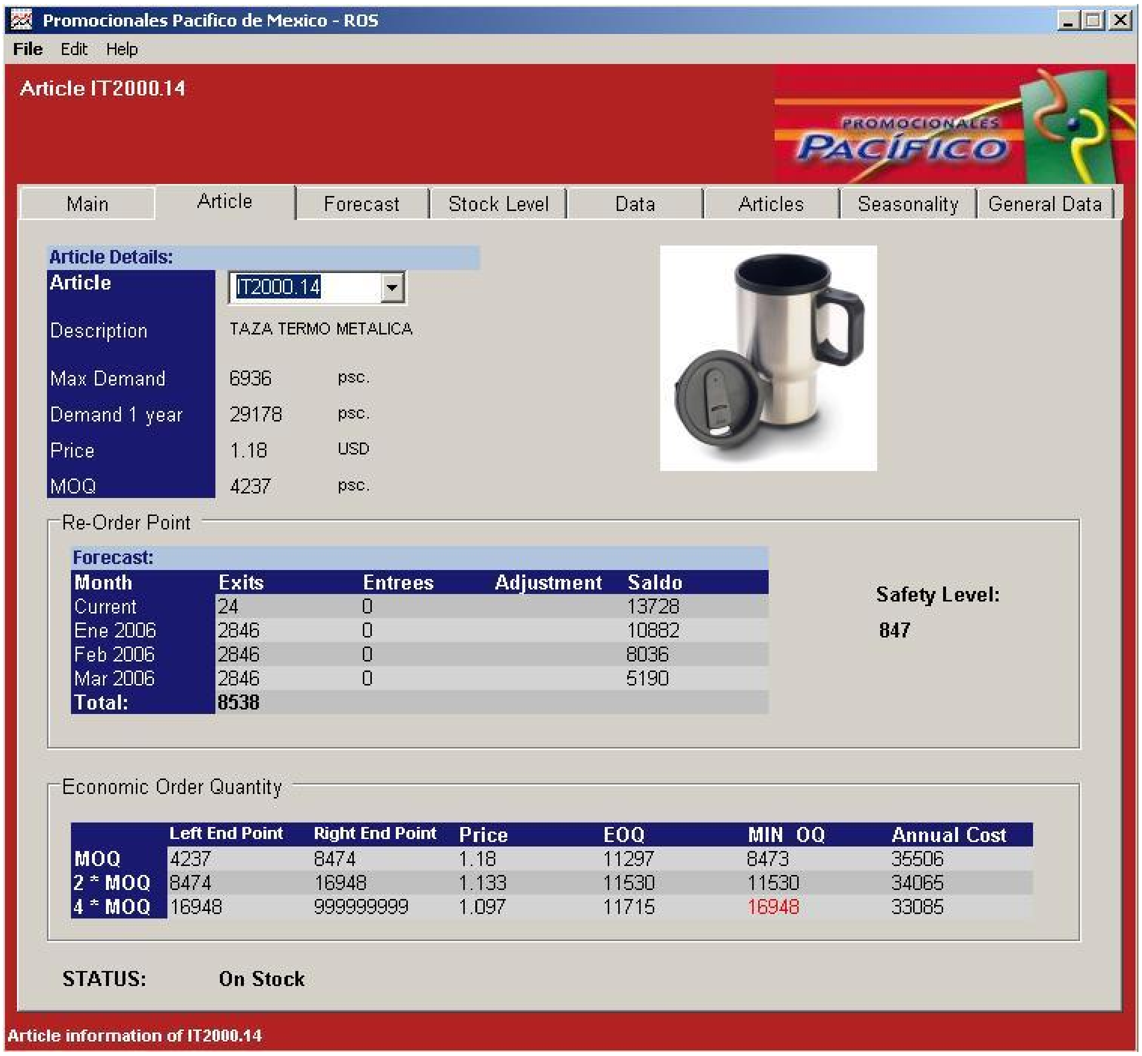
An Update takes about 3 to 10 minutes, depending on the users PC, the chosen update options and the number of articles in the ROS.
During an update the CPU is used maximal, but the user will still be able to use his PC to surf the Internet or the check his email. The extra memory usage is minimal as can be seen in the ‘*Historial de uso de memoria*’.

6.4 Main Page – Error Message



After updating is completed a message will be displayed that the update was successful or the Error frame will display the articles of which no information was found in the ASAP table. This means that either the Article name is wrong or there is not historical data available yet in ASAP because the article is new. In case of a wrong spelled name, the user can go to the Articles tab page and update the article. In case of a new article an error will be displayed every time the user updates until data is found in the ASAP table. If historical data of the article should be available the user should contact the System Administrator.
An article can directly be deleted from the ROS if the user decides to.

6.5 Article Page



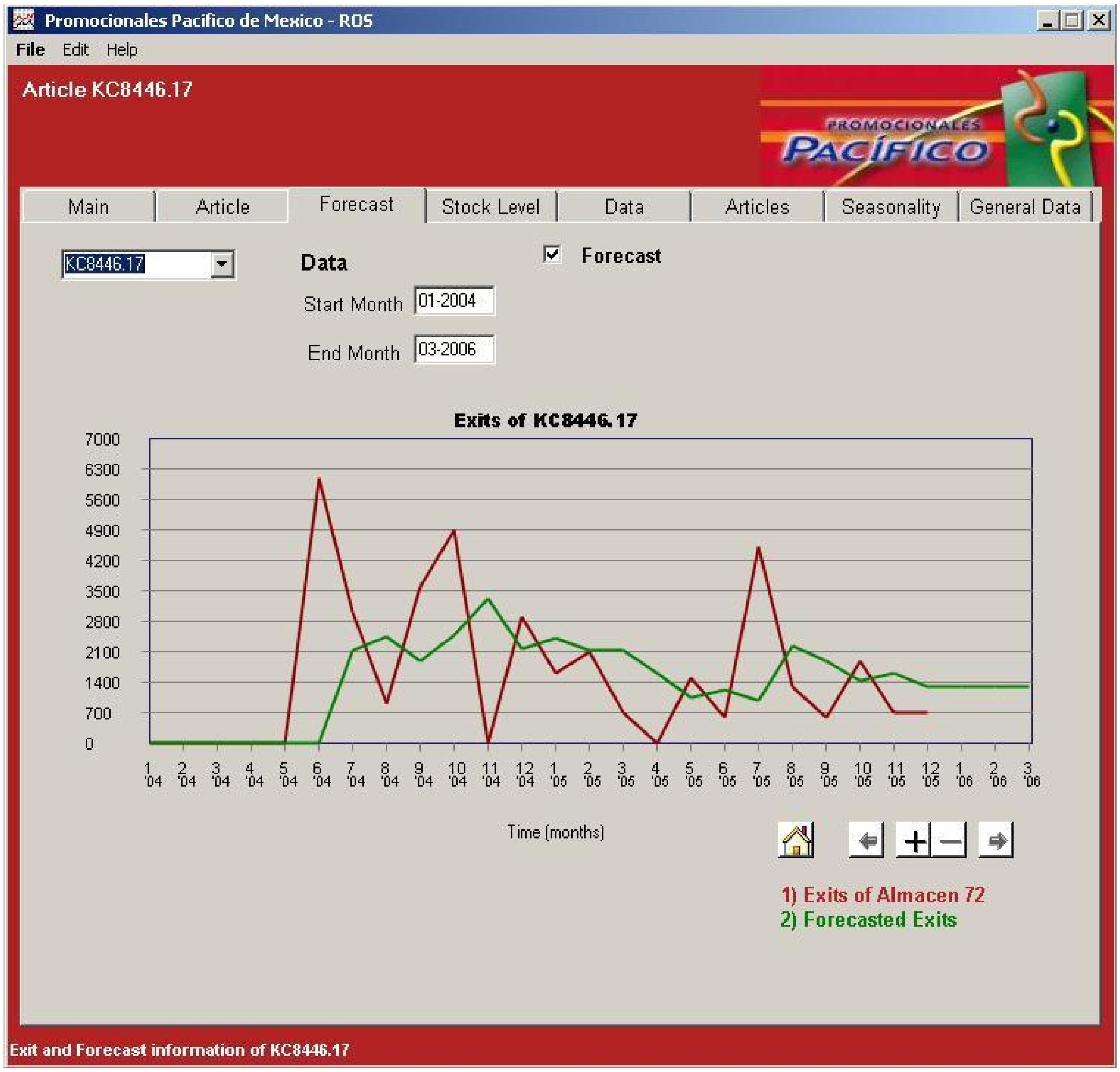
The Article Tab page displays information about the selected article:

1) An image of the article downloaded from PPM´s image server and shown
2) The description of the article as saved in ASAP
3) The Maximum demand in one month during the history of the article
4) The Demand as used for the EOQ calculation (Nine month history and the three forecasts)
5) The FOB price of the Article as insert by the user
6) The Minimum Order Quantity (MOQ) as insert by the user
7) The Safety Stock Level as set by the user

The calculations of the Reorder Point based on the Safety Stock Level. If the current or forecasted stock level is below the safety level, the text is color red and the ‘ok’ status of the article changed to ‘ORDER’.

The EOQ model with quality discounts is displayed. The user can see the EOQ for all quantities and the price that should be paid for the article. The minimum EOQ (with the minimum annual cost) is displayed in red.

6.6 Forecast Page



In the Forecast tab page the selected Article's exits of the Logyx warehouse and the smoothed and forecasted exits are graphically displayed. The user can set the time (X-axis), the values and scale of the Exits (Y-axis) are dynamic.
Double click on the graphic will display the Y-value of the clicked location.
In our forecast model we use (simple) exponential smoothing to calculated the demand for the next periods. The forecast for the next period using exponential smoothing is a smoothing constant α times the demand in the current period plus (1- α) times the forecast for the current period. Higher values of α place more weight on the more current time periods. The alpha α can be set in the General Data tab.

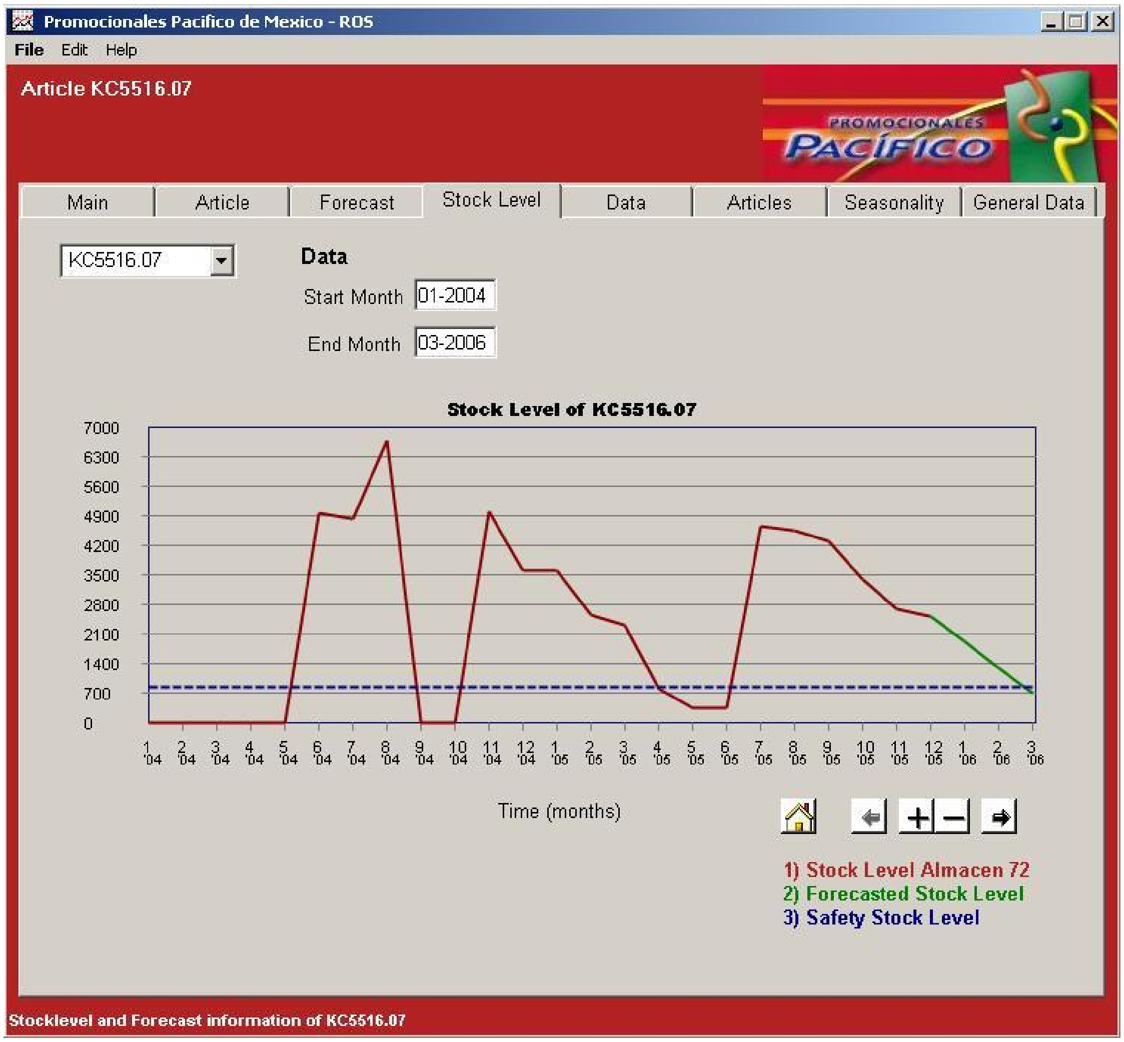
$$F_{t+1} = \alpha (D_t) + (1- \alpha)(F_t)$$

Where:

F_{t+1}	=	forecast for the next time period, in units
F_t	=	forecast for the current time period, in units
D_t	=	demand in the current time period, in units
α	=	smoothing constant. $(0 \le a \le 1)$

To initiate the forecast we assume $F_1 = D_1$.

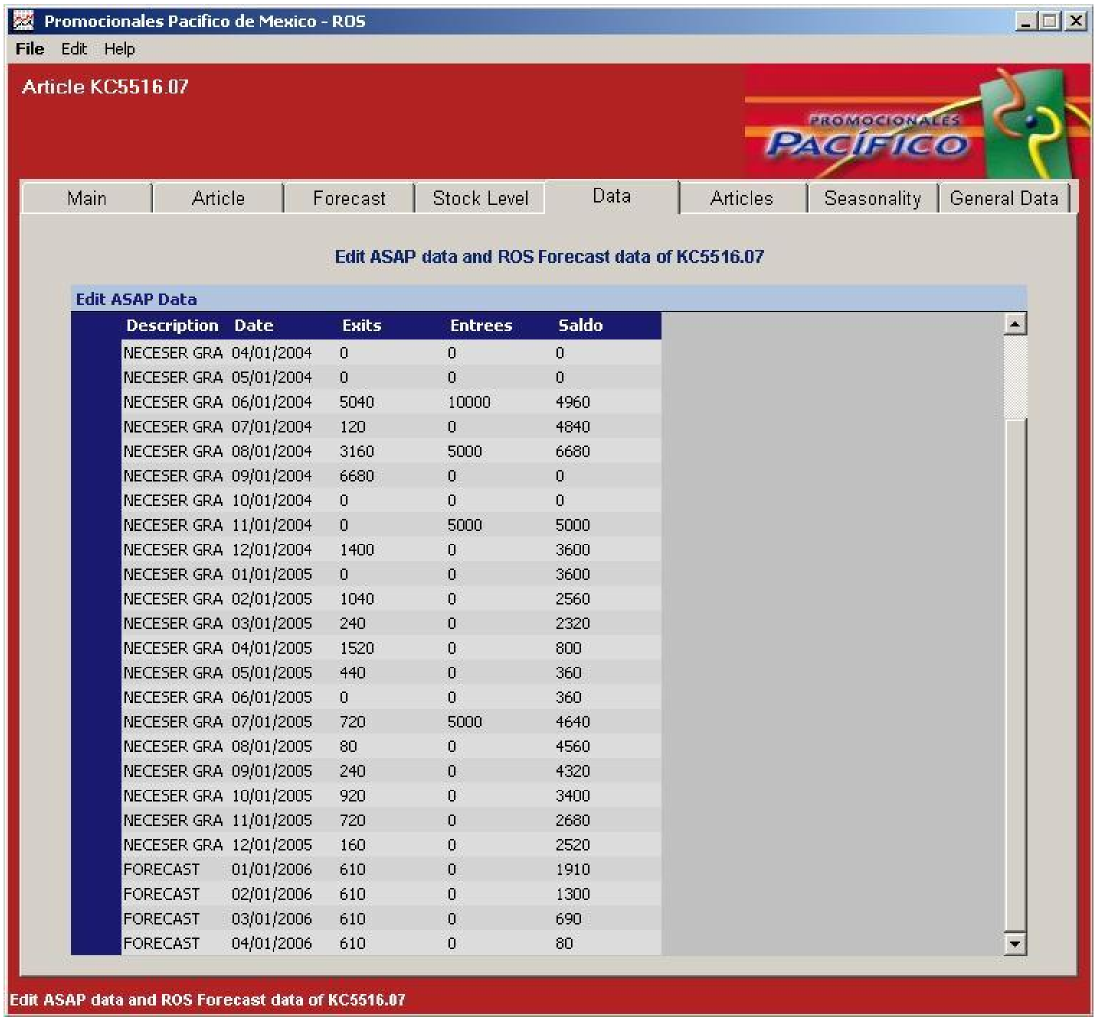
6.7 Stock Level Page



The Stock Level tab pages works basically the same as the Forecast tab page. Only here the history and forecast of the stock level are displayed.

The blue line is the article's safety stock level. If the current or forecasted stock level crosses this line the status of the article is changed from 'ok' to 'ORDER'.

6.8 Data Page



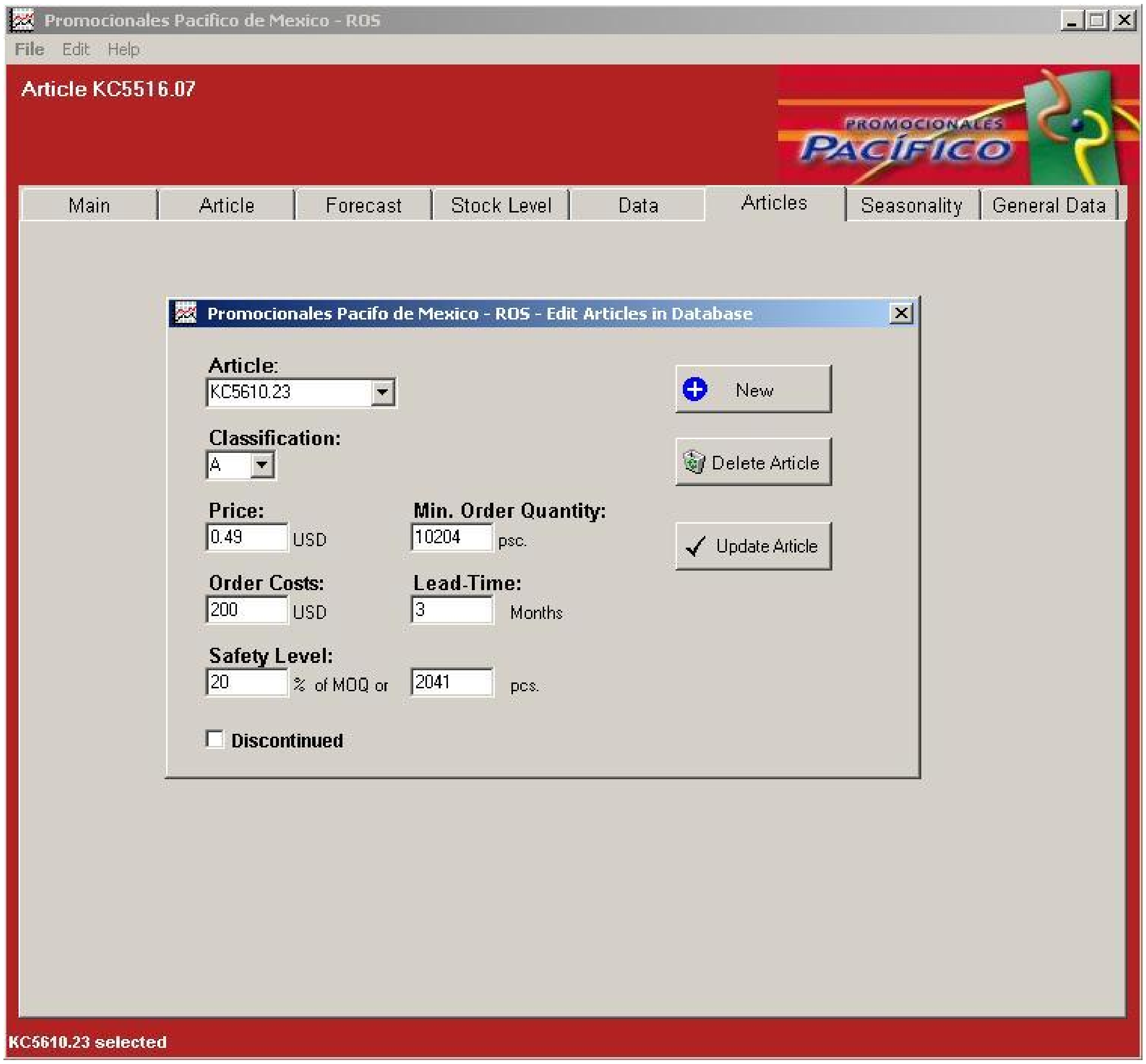
Description	Date	Exits	Entrees	Saldo
NECESER GRA	04/01/2004	0	0	0
NECESER GRA	05/01/2004	0	0	0
NECESER GRA	06/01/2004	5040	10000	4960
NECESER GRA	07/01/2004	120	0	4840
NECESER GRA	08/01/2004	3160	5000	6680
NECESER GRA	09/01/2004	6680	0	0
NECESER GRA	10/01/2004	0	0	0
NECESER GRA	11/01/2004	0	5000	5000
NECESER GRA	12/01/2004	1400	0	3600
NECESER GRA	01/01/2005	0	0	3600
NECESER GRA	02/01/2005	1040	0	2560
NECESER GRA	03/01/2005	240	0	2320
NECESER GRA	04/01/2005	1520	0	800
NECESER GRA	05/01/2005	440	0	360
NECESER GRA	06/01/2005	0	0	360
NECESER GRA	07/01/2005	720	5000	4640
NECESER GRA	08/01/2005	80	0	4560
NECESER GRA	09/01/2005	240	0	4320
NECESER GRA	10/01/2005	920	0	3400
NECESER GRA	11/01/2005	720	0	2680
NECESER GRA	12/01/2005	160	0	2520
FORECAST	01/01/2006	610	0	1910
FORECAST	02/01/2006	610	0	1300
FORECAST	03/01/2006	610	0	690
FORECAST	04/01/2006	610	0	80

The Data tab page displays the (by ROS edited) description, date, exits, entrée and stock level data of the selected article. The displayed data is of January 2003 until the last forecasted month.

f the description is the true description of the article then it is real data of ASAP. When the description is FORECAST then the values are forecasted exits or expected entrees with their forecasted saldos.

The Date is written in the SQL Server as MM/dd/YYYY, because the days are blank, the Server sets them automatically to 01, the first of the month. But the Exits and entrees are of the whole month and the saldo is at the end of the month, either 30 or 31. So the dates have to be read as end of month dates.

6.9 Articles in ROS Page



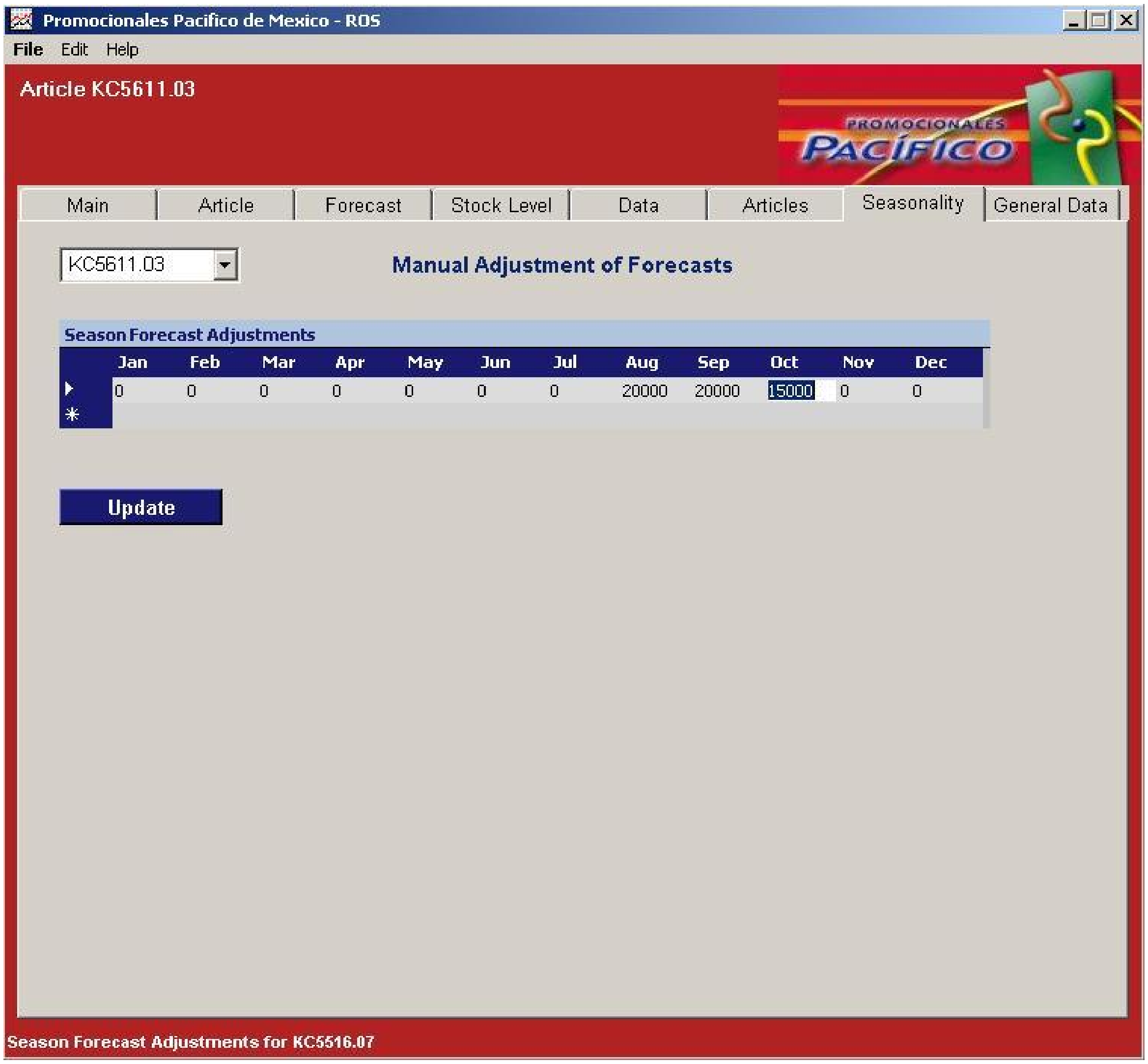
When clicked on the 'Articles' tab pages a new frame is displayed.
In this frame new articles can be added and articles in the ROS can be deleted or updated. The information that can be changed by the user is:

- Article name
- Classification (A, B, C or D)
- Price (FOB)
- Minimal Order Quantity (MOQ)
- Fixed Order Costs (Administration and freight)
- Lead Time (in months)
- Safety Level in percentage
- Safety Level in pieces

Discontinued (checked is true)

If the users adds a new article that is not found in the ALM72.txt text file (ASAP data) a warning is given.
Every time information article is changed, the ROS needs to be updated first for the changes to have effect on the calculated ROP, EOQ and status.

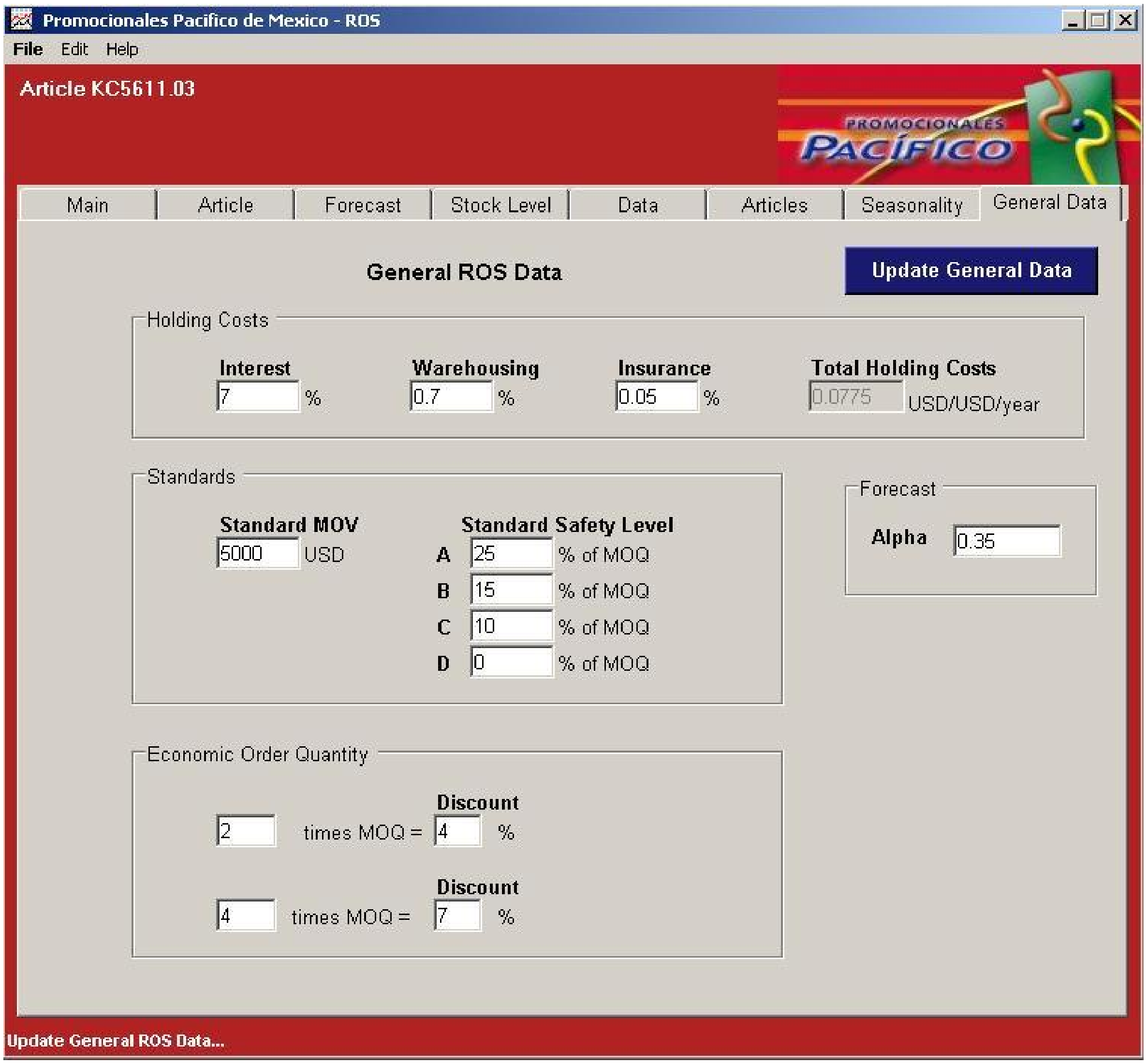
6.10 Manual Forecast Adjustments (Seasonality)



A forecast can be manually overwritten for each month and product. Expected orders can be added to the system as well as seasonal forecast adjustments.

After every change the table must be Updated and the ROS must be updated as well!

6.11 General Data



In the last tab page the General Data that is used for all calculations can be edited and updated. Information is:

- Interest (the percentage that is paid to the bank for loans a year)
- Warehousing (percentage)
- Insurance (percentage)
- Total Holding Costs, USD a USD a year (automatically calculated)
- Standard Minimum Order Value
- Standard Safety Levels for A,B,C and D classified articles
- Value of Alpha (higher values of α place more weight on the more current time periods)
- And for the quality discounts, the breakpoints and their respective discounts

When any of the General Data is changed, the General Data and the ROS need to be updated before the new values are used in the calculations!

Annex 7 ROS Dataflow

Schematically our dataflow can be shown as follows:

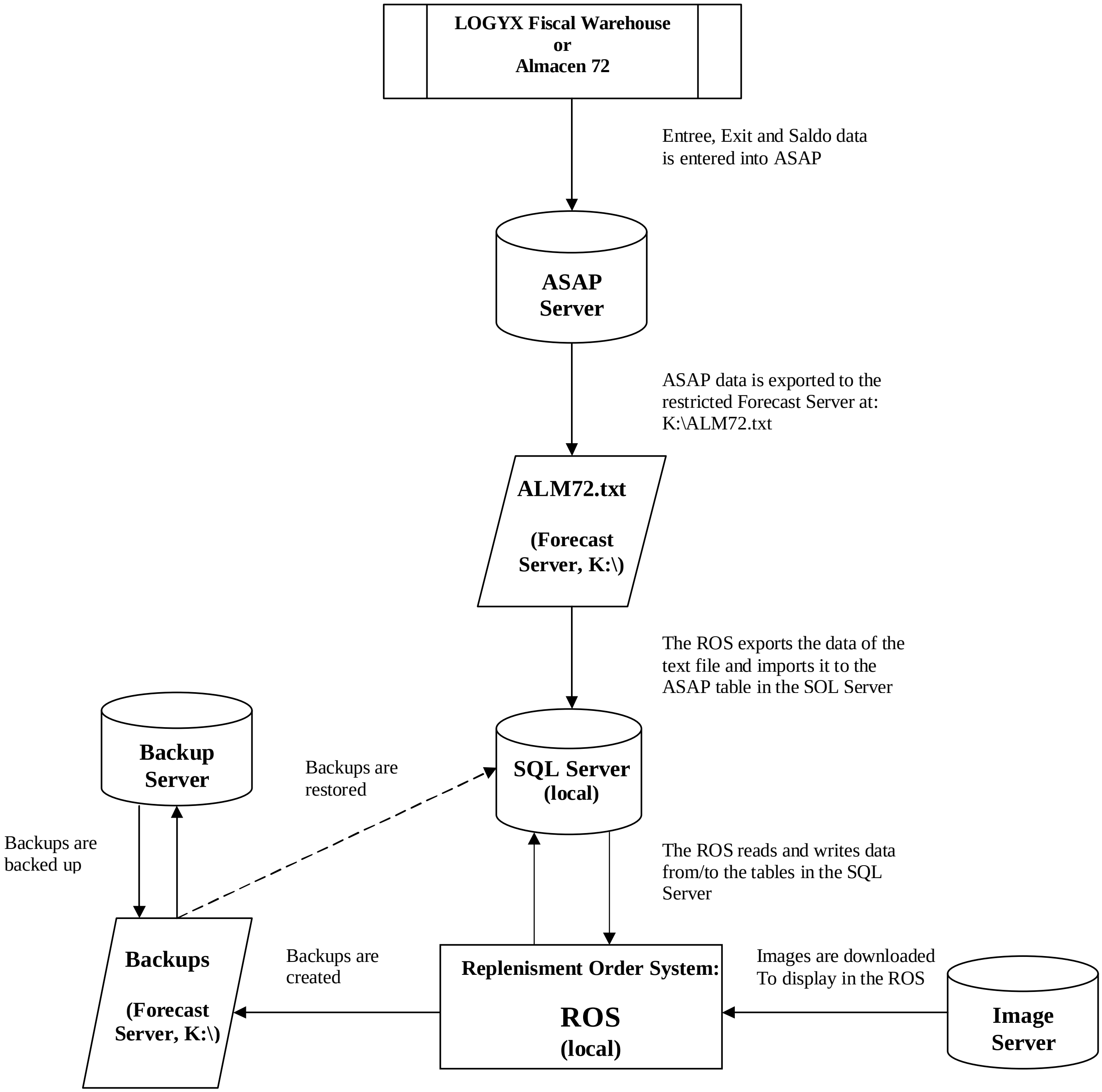


Table Annex 7.1 - Dataflow ROS

7.1 Text file, ALM72.txt

Every time an update is required the ASAP data is exported by the System Administrator to a text file. The text file is placed on a restricted server called Forecast Server or K:\. Only the system administrator and the ROS user have access to this server. The text file ALM72.txt contains the following information:

Article name	Description Article	Date (ddmmyy)	Exit	Entree	Saldo	Price	Currency (usd or mxp)	On Order	Back Order

Right now the Price, Currency and Back Orders are not yet registered in the ASAP system and therefore set to 0. See the recommendation section for more information.
An example registering the arrival of 10.000 pieces of IT2277.09 at 16 November 2004 is:

```
IT2277.09,RELOJ DESPERTADOR,16/11/04,0,10000,10000,$.00,0,0,0
```

The current ALM72.txt file contains almost 8000 entrees. The ROS imports all the lines of the text file and inserts them into the ASAP table in the PPM database at the SQL Server.

7.2 Backups

With every update of the ROS a backup is made of two tables of the SQL Server: the ARTICLELIST and SEASON table. All the other tables can easily be re-created by the ROS and the ASAP table can be imported from the ALM72.txt file again.
The backups are saved on the Forecast server at:

- K:\backup\backup_ppm_articlelist.txt and
- K:\backup\backup_ppm_season.txt

A backup of the Forecast server is made after every work day. If the local computer on which the ROS and SQL server run crashes, the two back up files can easily be imported at the (re-installed) SQL Server so no data will be lost.

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