MASTER

Forecasting : a company's fuel?

a study for the effects of medium term forecast accuracy on the supply chain at ICI Holland B.V.

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Preface

I would like to start this preface with thanking everybody that has supported me all through these past nine months; Mr. Dirne and Mr. van Donselaar, my tutors from the university who continuously motivated me to look for better alternatives and applicable solutions.
Also a warm thank you to Mr. Jensen, Mr. Wendels, Mr. Herrebaut and Mr. Vis from ICI who relentlessly supported me in becoming familiar with the ins and outs of the chemical industry.
A special thanks goes out to Cisca Breeuwer for having a great sense of humour when I needed it the most.

The most important learning experience that I have had during this graduation project, was the confrontation that theory and practice are **very** different.
Of course I did not expect to find a ready-to-wear answer in the books, but in this hectic environment of the chemical bulk industry, theory is almost useless.
Especially when it comes to short term forecasting, theoretical models as described in literature need extensive adjustment before they stand a chance of being successfully applied in practice.

KNOWLEDGE IS POWER

ICI Holland is the living proof of that.
The production planning system (MRP) is based on reliable short term forecasting and reliable short term forecasting is based on information.
Therefore it is even more harmful that information is lacking in several crucial areas like production performance, inventory accuracy and customer behaviour.
Also, the accessibility of information is not optimal. For example, a lot of information can be found in the management information system, however, there are only a handful of people in ICI Europe that effectively know how to use it!

All in all, the past nine months have been a very exciting and instructive time and a useful practical conclusion of five years of, mostly theoretical, studies.

Introduction

This report is the result of the work I have been doing the past eight months in accordance to my graduation project at ICI Holland B.V.
The report is written in chronological order; from the assignment determination and company description, via process descriptions and problem analysis to conclusions and finally recommendations.

Chapter one discusses the organisation structures of ICI; worldwide and more detailed on a European level. It describes production processes starting from a helicopter view (ICI Polyurethanes) and narrowing down to the different production plants on the Rozenburg site. After the reader has finished reading this chapter, he should have a pretty good idea of what business ICI is in, the backgrounds on how it is structured, led and built up and some basic knowledge about the involved production processes.

In the second chapter the first draft assignment is specified, along with the relevant context.

The third chapter describes the planning of the logistical part of the Polyurethanes supply chain. It starts with describing the order flow and it ends with the discussion of transport planning and inventory management.

A description of Medium Term Forecasting procedures and an analysis of the effects of MTF on the supply chain are shown in Chapter 4. First, the MTF is discussed and then for every part of the supply chain, the effect of MTF to that part is reviewed.
A fish-bone diagram inventorises all the areas of effect of Medium Term Forecast inaccuracy.

Chapter 5 gives a quantitative analysis of the effects of MTF accuracy on the supply chain, in the form of the calculation of cost consequences of one forecast error in a worst case scenario and the calculation of the actual effect of MTF accuracy on end product level.

After four months the final assignment was determined and the result can be found in Chapter 6. This final assignment will be used as an evaluation tool, the goals that are stated in this assignment should be reached.

Chapter 7: the in depth analysis for possibilities of improvement of the Medium Term Forecast method. This Chapter only discusses the possibilities of improving the forecasting method itself; the required facilitating conditions are discussed in Chapter 8.

An evaluation of the possible adjustments is shown in Chapter 9, resulting in proposed strategies. Chapter 10 gives a proposal for implementation of these strategies and the report ends with a discussion of the most important conclusions and recommendations in Chapter 11.

The working procedure was not explicitly described; it was one of extensive interviewing, gathering the right data in the right form, analysing the data and very much of using common sense.

Chapter 1: The ICI Group

1.1 ICI in brief

The ICI (Imperial Chemical Industries) Group is one of the largest chemical companies in the world, with international strengths in paints, materials, explosives and industrial chemicals.
ICI operates its main businesses on an international basis. In addition, regional businesses in countries such as Australia reinforce the Group's world-wide competitive strengths. The business areas are supported by a powerful research and technology base and by manufacturing and engineering expertise which ensures continuous improvements in products and processes.

ICI has 78000 employees world-wide, over 2500 products and manufacturing sites at about 200 locations in more than 30 countries. Also, ICI has prominent positions in:
* decorative paints and industrial coatings
* blasting services
* acrylics
* ozone benign refrigerants
* pure terephthalic acid (PTA)
* polyurethane chemicals and systems
* polyester films
* PET polyester polymer
* catalysts
* surfactants
* titanium dioxide pigments
* chlorine, one of the basic building blocks of the chemical industry
* petrochemicals for the production of plastics, fibres, fertilisers and a range of organic chemicals

1.2 Vision

ICI is a science-based chemicals company that aims to produce consistently outstanding performance through market leadership, technological edge and a world competitive cost base.
The company's vision is to be the industry leader in creating value for customers and shareholders. It aims to achieve this by:

* market-driven innovation in products and services
* winning in quality growth markets world-wide
* inspiration and reward of talented people
* exemplary performance in safety and health
* responsible care for the environment
* relentless pursuit of operational excellence

1.3 ICI Polyurethanes

ICI's Polyurethanes business is a leading international producer of polyurethane chemicals and systems based on MDI (diphenylmethane diisocyanate). As well as MDI, ICI Polyurethanes produces TDI (toluene diisocyanate), flexible and rigid polyether and polyester polyols, and fully formulated polyurethane systems. TDI and MDI are isocyanates which when reacted with polyols such as polyester polyol and polyether polyol form either a rigid or flexible polyurethane foam used by manufacturers in other industries, such as automotive, construction, refrigeration and shoe soling industries.
Tailoring products to customers' needs, the business produces materials for:
* insulation in construction and refrigeration,
* seat cushioning in vehicles and furniture,
* other automotive components,
* shoe soling,
* construction boards made from wood and agricultural by-products,
* adhesives

ICI Polyurethanes has reduced the environmental burden of its manufacturing processes and products through energy conservation, the elimination of CFCs and positive contributions to recycling and waste management programmes. Recent developments include:
* Eco-Binding technology, which recycles waste by producing fibreboard from agricultural by-products such as sugarcane fibres, rice straw and wheat straw,
* Vacpac technology for vacuum panels, which provides high levels of thermal insulation and is used by freezer manufacturers,
* Waterlily comfort cushioning, the first MDI-based technology for flexible slabstock foam that offers comfort, support and durability.

The business has over 40 locations in 34 countries, serving customers in more than 70 countries. The main production plants are at Geismar in the USA (through Rubicon, a joint venture with Uniroyal) and Rozenburg in Holland. A new £ 123 million MDI plant at Rozenburg was be opened at the end of 1997 and will enable the business to meet growing global demand and improve customer service at reduced cost.

Nitrobenzene is used to manufacture aniline, a key raw material in the manufacture of MDI. At Wilton in the UK, a new 400,000tpa (tonnes per annum) nitrobenzene plant is scheduled to come on stream in 1997 together with a doubling of aniline production to 300,000tpa.

ICI's manufacturing plants are supported by a network of regional development centres (RDCs), each of which focuses on a specific industry. In addition, a number of technical service centres are able to respond to national market needs.

1.4 ICI Rozenburg

1.4.1 Introduction

One of the two present Polyurethane plants is situated in the Botlek-area in Rozenburg. The production site harbours several plants:

* the MDI 1 plant; produces three different kinds of MDI:
  - Mixed Isomers (also called Motherliquor)
  - Polymeric MDI (also called DNR)
  - Pure MDI (also called MPR)
* the MDI 2 plant; additional capacity, opened at the end of 1997
* the Polyol plant; produces different kinds of polyols
* the Variants plants: plant 1 and the Variants Extension plant 2; products arisen from the reaction of different MDI's with eachother or from the reaction of an MDI with a polyol
* the Formulations plant; modified polyols production

For a more detailed picture of the reactions that take place in these plants, see annex 1.

In this section, each factory will be discussed in a separate paragraph. The MDI 1 and 2 factories will be discussed in the same paragraph, because these factories are basically the same; MDI 2 is in principle an extension of capacity of the MDI 1 factory. The same goes for the two Variants plants.

1.4.2 The MDI plants

The production of MDI is a continuous (meaning 24 hour a day, seven days a week production; continuous input and continuous output) process and takes place in several steps. First, two intermediate products are made: DADPM and phosgene. DADPM is the result of the reaction between aniline and formaline, where hydrochloric acid is added to speed up the reaction process. Phosgene is made from chlorine and carbon monoxide, which are supplied through pipelines. In the next step DADPM and phosgene react and make MDI precursor. This precursor MDI is split into three different products: pure MDI (MPR), mixed isomers (motherliquor) and polymeric MDI (DNR).
Pure MDI and mixed isomers are diisocyanates. See annex 1 for details of the actual reactions. Figure 1 on the following page shows the detailed flows of products.
A by-product of the reaction is hydro-chloric acid gas, which is partially re-used and partially sent back to the supplier (Akzo) by pipeline. Further, the MDI is purified and concentrated and stored as final product in tanks. Customers receive the product as 'Suprasec' in tank trucks or drums.

1.4.3 The Variants plants

The production of Variants is a batch production which ideally takes place on customer order. In reality, this is not possible because of the unreliable production process and the highly variable demand patterns and therefore they work with short term forecasts.
When there is enough demand and there are no problems with the supply from the MDI plants, there is a 24 hours a day production, seven days a week.
If demand is low or supply not sufficient, there is a two shift system, meaning 16 hours a day production and no production in the weekends.

Variants are formed when an MDI reacts with another MDI or with a polyol. It is also possible that an MDI reacts with a polyol, MDI or external raw material and is stored as a prepolymer. Lateron it will be mixed with an MDI and this will make an end product. Customers use the variant to make it react with a polyol (polyester or polyether), which gives the final product; polyurethane foam. Polyurethane foam can be divided into two different kinds: flexible and rigid foam.

Flexible foam is formed by the reaction of a prepolymer with a polyol with long chains. Rigid foam arises when a prepolymer reacts with a polyol with short chains. Extra rigidity can be obtained by a reaction of a prepolymer with a branched polyol.
Also, certain additives can be brought into the reaction to influence for instance colour or the speed of reaction.
End products may be shoe soles, pillows, seat cushions, steering wheels, car bumpers, etc.

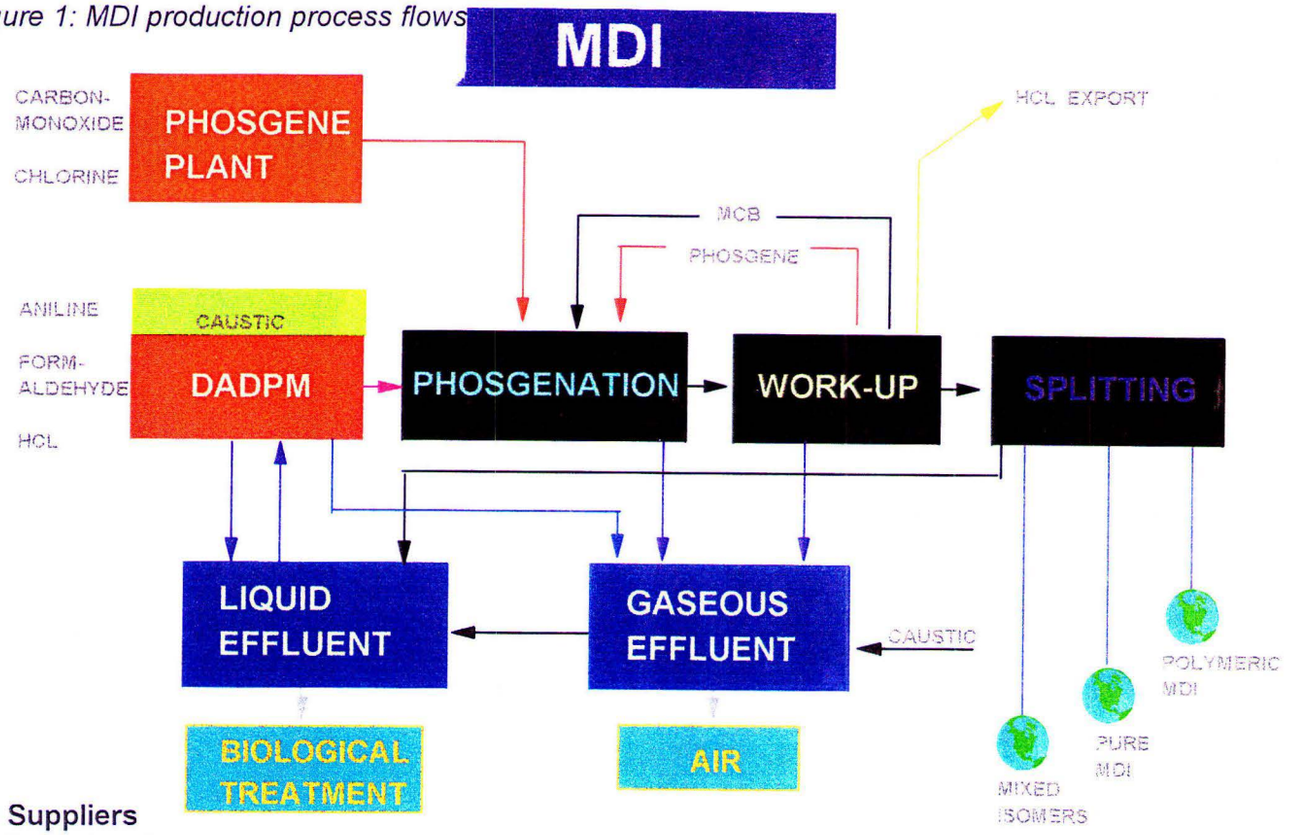
1.4.4 The Polyol process

In the polyol process, alcohols or amines (dependent on the desired end product) react with propylene oxide and ethylene oxide. The reaction takes place after the addition of a catalyst. When the reaction is finished, the catalyst is neutralised with acid. The polyol is dried and filtered, after which the product is stored in tanks. Sometimes additional substances are added to the polyol to achieve a certain effect in end-applications. Polyols are delivered to customers in tank trucks or drums by the name of 'Daltocel' or 'Daltolac'.

1.4.5 Formulations production

Formulations are modified polyols. Dependent on the desired properties of the end product, certain substances are reacted to a polyol. The outcome makes a formulation.
Formulations are for external customers only; they are not used as a raw material for other ICI plants.
Customers use the formulations to react them to an MDI or a Variant and thus to make polyurethane products.

Figure 1: MDI production process flows



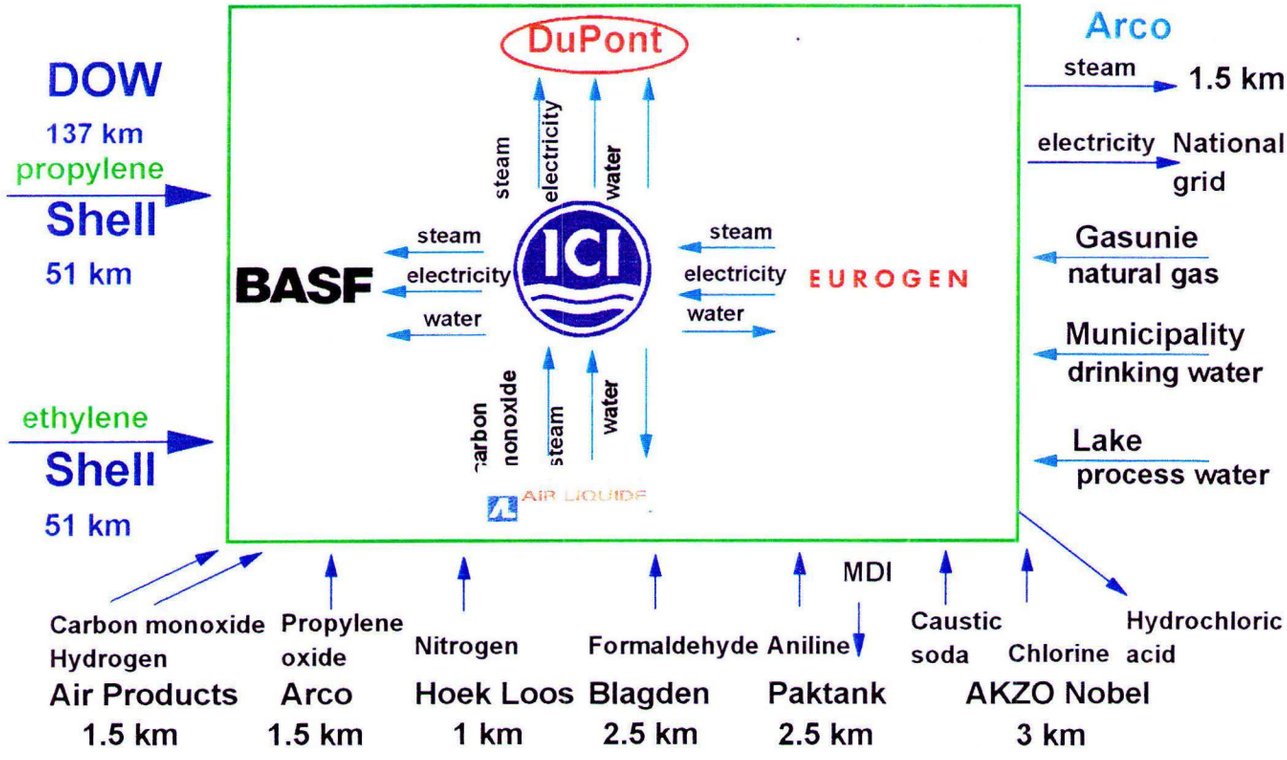
1.5 Suppliers

ICI Rozenburg's raw materials are either supplied by other ICI plants (such as ICI Wilton which supplies aniline) or by external suppliers. An overview of the main suppliers is pictured in Figure 2. This overview shows a rectangle which serves as a system border for the Rozenburg site. At this site ICI is situated, but Dupont, BASF and Eurogen also have residence here. The parts of the site that are now their property, were hived off by ICI.

The suppliers outside the rectangle are the suppliers that are not on the Rozenburg site. Several of these suppliers supply us by pipeline. These are:

* AKZO: chlorine and hydrochloric acid
* ARCO: propylene oxide
* Air Products: carbon monoxide
* Cryoton: nitrogen
* Gasunie: natural gas
* Municipality: drinking water
* Lake: process water
* Eurogen: steam

Figure 2: Internal and external suppliers of ICI Rozenburg's polyurethane plant



1.6 Hauliers

Transportation can be divided in bulk and drum transport. Hauliers both in drum and bulk transport have their own geographic working area. Hauliers are:

-Bulk transportation:

* *Den Hartogh*: serve Greece, Spain, Portugal, France, Denmark, Germany, Benelux, Austria, Switzerland and Eastern European countries.
* *Hoyer/RTT*: serve England, Ireland, Italy, Scandinavia (Denmark excluded) and Turkey.

-Drum transportation:

* *De Rijke*: serve Greece, Spain, France, Denmark, Germany, Benelux, Eastern European countries and Portugal.
* *P&O Ferrymasters*: serve England, Ireland, Italy, Scandinavia, Austria and Switzerland.

The tariffs of tank trucks are accounted by lumpsum, that means that costs are accounted per freight to a certain destination. Sometimes extra costs are added for cleaning, nitrogen blankets (protection against pollution during loading), extra drivers (for urgent delivery) etc.

The hauliers that serve us now, have been doing so for years. It is a very specialist line of work; specific equipment is demanded and very little hauliers are available. The ones we have right now are chosen because of their relatively low prices, good service and good performance. Performance is evaluated four times a year and when the yearly contract negotiations take place, the past performance from both parties is also taken into account.

If one of the hauliers is not available when we need them, there is always the other haulier ready to cover for him. It never happens that we have to turn to a third party for transportation.

Tariffs are either based on a one way or a two way travel. This depends on the kind of material that is transported and if the carrying tank trucks are dedicated or not. For instance, in MDI transport, trucks are dedicated. This means that in these trucks only MDI can be transported. If trucks are dedicated, tariffs are based on a two way travel, because the haulier has to go back with an empty truck. In case of general purpose transportation, different products can be transported in the same truck, and tariffs are thus based on a one way ride; hauliers can take other materials back. However, if the destination is not particularly far (for instance Benelux), it is often more convenient to ride an empty truck back, than to go through the trouble of loading and taking another charge back. So taking a load back after a delivery is only interesting if the delivery destination is far enough away.

1.7 Customers

ICI's customer directory is quite stable. They are mostly large companies which use our products to make products of their own, for example car seats, shoe soles or dash boards. Because our end products are the raw materials for other large companies, the amount of customers does not change too much. The decision to build for example an automotive plant is not made every day.
There are smaller customers however, who only order a few drums. But this customer directory is also stable.

Chapter 2: First draft assignment and context

2.1 First draft assignment

After one month of research a first draft of an assignment was determined. This assignment is a starting point for the research to be done until the interim reporting takes place after three months. After this interim meeting the definite problem definition will be determined as well as the direction in which a solution is sought.

The first draft of the assignment is defined as follows:
-The monitoring and analysis of the effect of medium term forecast quality on the Rozenburg supply chain. This supply chain concerns all logistical activities from the supply of raw materials (internal as well as external) to the distribution and delivery of end products to customers.

The system to be considered begins where raw materials are purchased and transported to the various plants and it ends where end products are distributed to the customers. The chemical and physical characteristics of the production processes are not considered, because these are beyond the scope of my research. Only the logistical characteristics are of importance.
Considering the research borders, a distinction between *information* flows and *physical* flows will have to be made. This distinction is necessary because the research borders for the physical flow are narrower than the borders for the information flows. That is, relevant information flows at customers and suppliers are included.
The physical flow begins when we receive raw material from suppliers and it ends when we deliver our end products to the customer.
A visualisation of this scope of research is shown in figure 3 on page 9.

2.2 Context

If necessary, this version of the assignment can still be adjusted. The research will concentrate on the Medium Term Forecast (MTF). This MTF is a forecast that is made to predict sales volumes. This prediction is done on a customer/product level, meaning that every order of every customer is forecasted separately.

The MTF is a rolling forecast which gives a four week forecast from which the third and fourth week are updated every week. The first week is 'frozen' and can not be changed. The MTF is the most important forecast for the production planning system; MRP1. This new planning system was introduced together with the new computer-system (SAP/R3); the first of April 1997.
The difference with the old computer system is that the SAP system is an integrated system; data from Finance, Production, Sales, Purchasing etc. are all in the same form, with the same codes and names. That makes it very easy to interchange data.

The medium term forecast is used by the order scheduling department to plan production with. The production planning is based on MRP1; a planning mechanism that translates the forecast to a proposed production schedule, considering inventories, lead times and the Bill Of Material (BOM). Raw materials are assumed to be always available and inventory and forecast figures are assumed to be accurate. It is clear that for MRP1 to perform well, one of the conditions is that the forecast is accurate.

Not all Rozenburg plants work with medium term forecasts. The MDI plants for instance do not work with MTF. The plant is making the same flow of products 24 hours a day and it is more a matter of keeping the MDI plant running than of planning the outcome.

Also, the outcome can only be influenced in a very limited way, by manipulating the split. By manipulation, just a small shift in the percentage of mixed isomers and pure MDI in the diisocyanates can be obtained.

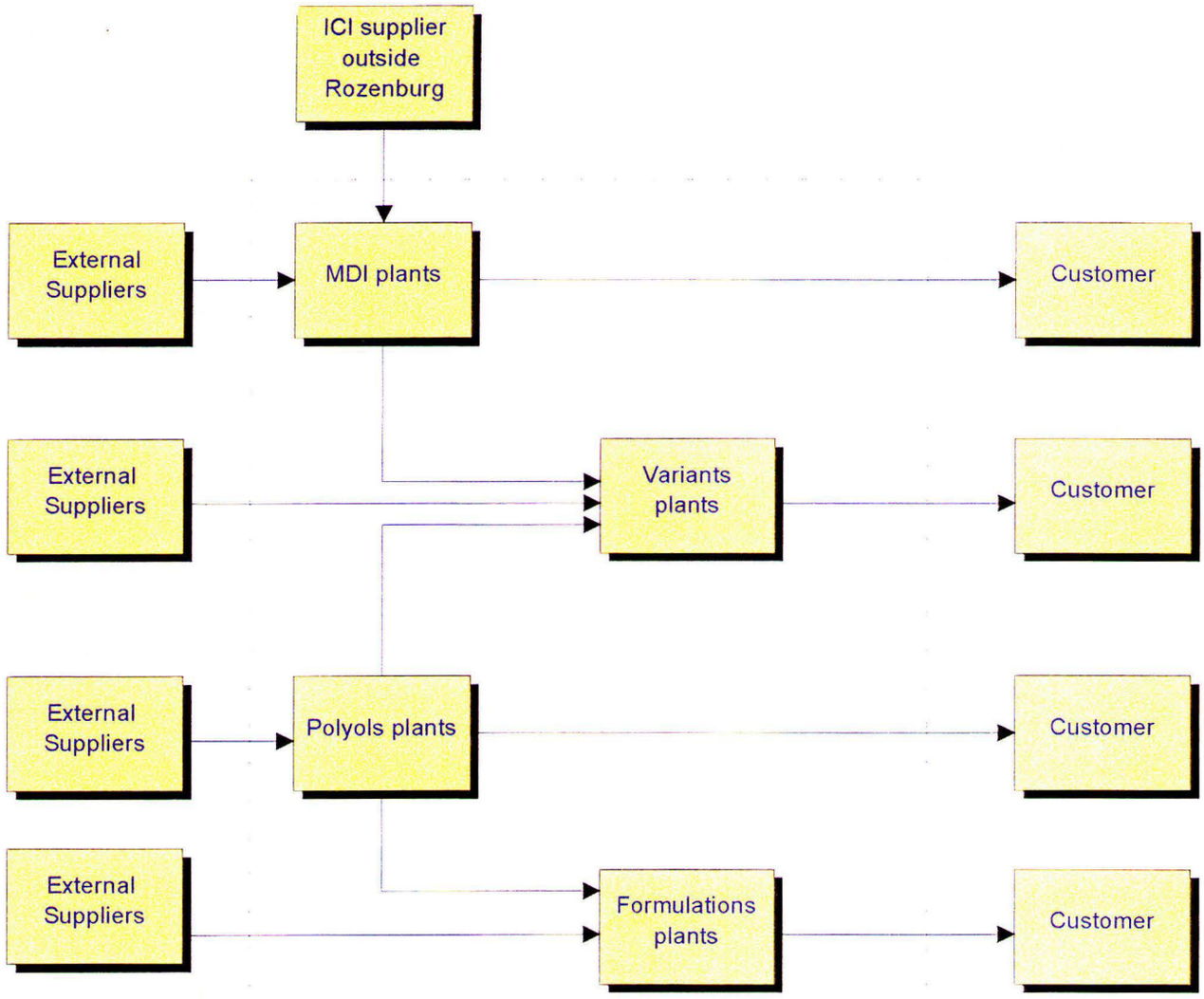
The Variants plants however, do use medium term forecasts. So do the polyols and formulations plants. The Variants plants will be the centre of attention in my research, because this is the largest plant with the largest forecasted quantity.
The MDI and Polyols plants are involved as supplying plants.

Sales departments will have to be involved, because they make the Medium Term Forecasts.
It is crucial to have their support and faith, because if not, a possible implementation of any recommended improvements in their working area will turn out to be very difficult.

Customers will have to be involved. Not only because they are the ones that file claims and complaints, but also because they are important suppliers of data that are needed to make a good Medium Term Forecast.
For example information about the customers' production processes, technological developments and production progress is needed to make a good MTF. This information can only be supplied by the customer.

A visualisation of the research system borders can be found in Figure 3 on page 9.

Figure 3: Research system borders concerning the Polyurethanes supply chain



Chapter 3: Description of logistical processes in the Polyurethanes Supply Chain

3.1 Introduction

In the previous chapters, descriptions of the different elements of the supply chain have been given.
In this chapter, relevant features of the logistical processes of the Polyurethanes Supply chain are described. The word *processes* should be emphasised, because this chapter will mostly handle planning and tuning issues in and between the different areas. Descriptions of these processes are necessary to fully understand the impact of forecast inaccuracy.

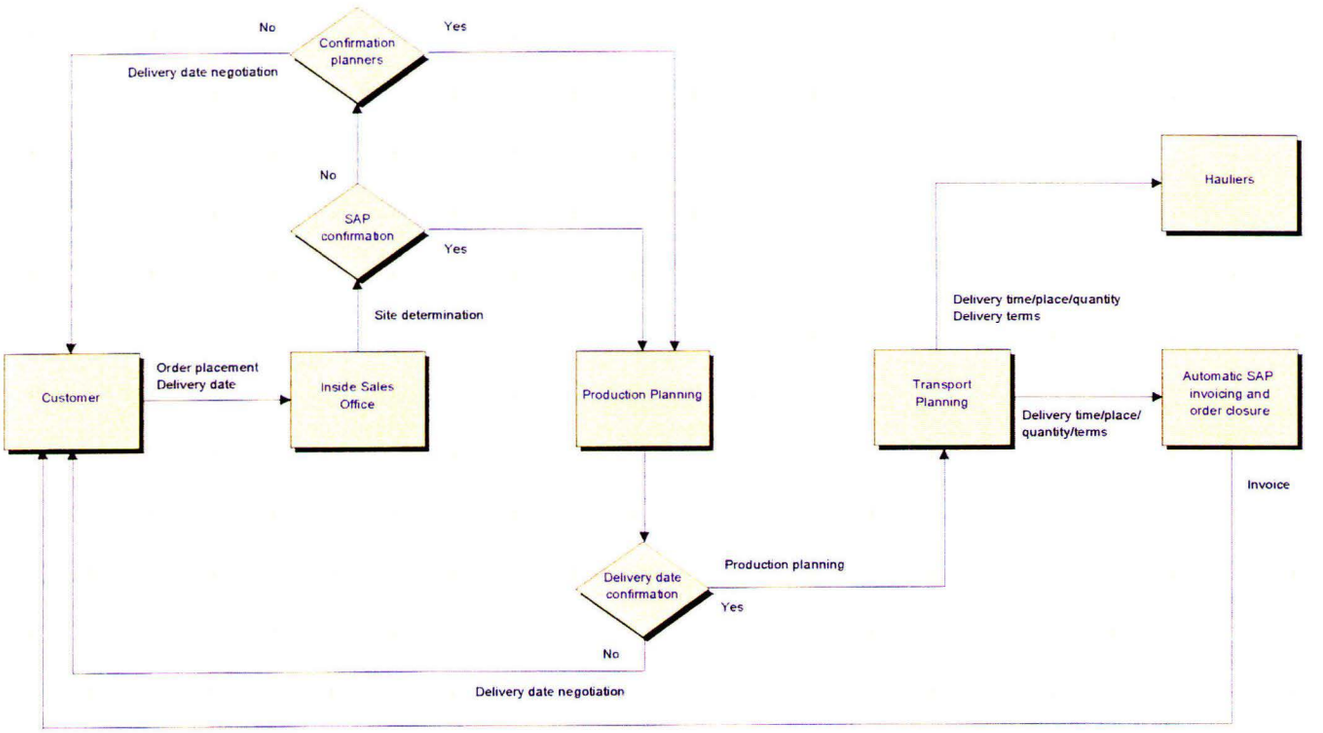
3.2 Order flow and acceptance procedure

From order entry until order acceptance, the procedure is as follows (also see figure 4).
An order enters at the inside sales offices. These harbour the sales representatives who process orders, handle complaints and claims and who remain in contact with the production plants. The outside sales offices take care of the actual sales activities, like the acquisition of new customers or accounts.
The inside sales offices check the availability to promise (ATP) element from MRP1in the SAP computer system to see whether the order can be accepted. To check this, the site where the order is to be produced has to be determined. That is dependent on the customers preference (some customers wish to be supplied from a specific plant), the capabilities of the plant and geographical elements.
If the SAP system indicates that an order cannot be accepted, the sales office contacts the production planners of the relevant production site. If they do accept the order, the sales office can confirm this to the customer. If not, the sales office has to negotiate a delivery date with the customer. When the customer is not willing to change the delivery date, ICI will try anything to make the order in time. If there is no chance of making it in time, the choice is to the customer; either accept a longer lead time after all or go somewhere else.

If the SAP system confirms (based on Medium Term Forecast!), the sales representatives can accept the order. The order is then brought into the SAP system, so that the production planning department of the producing plant can start planning the order. However, the availability to promise element in SAP is based on MTF and not entirely on actual orders, meaning that the ATP is not necessarily correct. Therefore, the planners may decide that it is not possible to produce the order within the requested time limit. If that is the case, they will discuss this with the sales department. Then again, the sales departments discuss this with the customer.

If the planning department accepts the order with connected lead time, a production planning is made and sent to the transport planning department. They send data about delivery time, place, quantity and terms to the haulier and into SAP system. Then the transport planners close the order and, automatically, SAP generates an invoice which is sent to the customer.

Figure 4: Order flow



3.3 Process features

Chemical and physical features of the Polyurethanes production process are not relevant for my research and therefore I will not describe them.
I will start by naming the relevant features of the **Variants plants**.
The Variants plants make batch production in batches ranging of about 5 to 12 hours. The size of the batch can differ from 5 to 40 tonnes. If there are enough raw materials and orders, the Variants plants runs 24 hours a day (3 shifts), 7 days a week. In slower times this can fall back to two shifts a day (16 hours), 5 days a week.
At the moment, the *reactors* of the plants have an available capacity of 6000 hours a year, based on 24 hour a day, 7 days per week production. The *blenders* of the plant run 16 hours a day, 5 days a week which results in an available capacity of about 2800 hours a year. The plants have in total three blenders and five reactors. In tonnes this means that the Variants plants make 45.000 tonnes of end product per year.

Capacities of the Variants plants are not universal. Most products can be made on two and sometimes even three reactors. There is one preferred reactor choice and the production planning department will try to schedule production in such a way that products can be made on the preferred reactors.
Almost all batch sizes are flexible. A reactor contains two mixing elements; one in the top of the reactor and one about half way. The minimum batch size has to be large enough to fully cover the lower element and the maximum batchsize is restricted by the tank capacity.

Set up times reactors of the Variants plants are negligible. So after the production of one batch, the next one can start almost immediately.

The **MDI plants** are a different story, because they produce continuously. With continuous production, 24 hours a day production is meant, 7 days a week, with a continuous input of raw materials and a continuous output of end products.
About once a year there is a total (planned) shutdown of the MDI plants (not both at the same time) in order to check everything thoroughly.
The MDI 1 plant makes about 90.000 tonnes of precursor a year. Through several production steps this precursor is split into three different flows; polymeric MDI, pure MDI and mixed isomers. Eighty percent of the precursor flow is converted into polymeric MDI (DNR), and depending on the split, the remaining twenty percent consists of 55-60 percent pure MDI (MPR) and 40-45 percent mixed isomers (mother liquor).
The MDI 2 plant makes about 160 tonnes of precursor a year and the split between the pure MDI and the mixed isomers can be manipulated more carefully. To what extent the split of pure MDI and mixed isomers can actually be manipulated, has not been determined yet, because the MDI 2 plant is not yet producing at its maximum production rate. An important feature of both MDI plants is that the split can be manipulated, but it is never sure that you will exactly get the desired proportions.
Also, the MDI production process is, as opposed to the Variants production process a very unreliable process. The plants can go down at any moment for an unknown period of time. This period can vary from one day to several weeks, depending on the extent of the problem. The timing of these shutdowns can not be predicted, neither can the duration.

Another major supplier of the Variants plant is the **Polyols plant**. This plant produces about 50.000 tonnes a year in batches, 24 hours a day, 7 days a week. There are flexible and rigid polyols, the flexible ones are made in 14 hours in batches of 35 tonnes and the rigids are made in 12 hours in batches of 15 tonnes. These polyols are not only meant for the Variants plant, they can also be sold to the customers directly, or be used in the production of formulations.

3.4 Procurement procedures

Purchasing of raw materials for the Variants plants is initiated by SAP's MRP mechanism. MRP calculates raw material requirements considering end product demand, Bill Of Materials (BOM), available inventory, required safety stock levels, lead times and demand data and generates a proposed purchasing order.

The split in the MDI plant is planned 'by hand'; the optimal split is determined according to the actual orders that have come in and related raw material requirements for the MDI plants.

For the raw materials that are supplied by pipeline, MRP does not do the purchasing. ICI gives the respective supplier a monthly forecast about what they expect to consume. With the pipeline suppliers, there is always enough raw material (if there are no problems at the supplier!). You can compare it with drinking water; you can take it from the tap at anytime you like and you will get the bill afterwards.

Further, there are the so called monthly orders. These are used if MRP does not perform for a certain reason. A reason can be that the lead times are too long to work with or that there is limited storage capacity (amount advised by MRP can not be stored). So orders for products that have these problems must be created otherwise; by monthly orders. For example, in January the Variants plants is expected to consume 300 tonnes of product X. The order scheduling department knows that total consumption will be 300 tonnes, but the exact timing of consumption cannot be determined yet. For the 31st of January (=end of the month!) an order of 300 tonnes is placed at the supplier. The supplier knows that ICI will be taking 300 tonnes over January, so he makes sure that he has material available from the 1st of January. The supplier will not keep the entire 300 tonnes in stock from the beginning, because he knows that ICI will not be needing all of it at once. Usually the supplier roughly divides the total order by four and produces this amount every week.

3.5 Production planning

For the MDI plants there is no production planning process, because they will produce virtually the same product continuously anyway. The split that divides the MDI flow into three flows can be slightly manipulated.
Depending on the demand for these three flows, the Variants plant production planners decide what split is desired. Usually, even with manipulation of the split, the demand of the three flows is not the same. One flow (at the moment this flow is MPR) is then very highly demanded in comparison to the other flows.
To prevent high stock levels, the sales departments are involved to manipulate demand. As a last resort, the highly demanded flow of product can be put on allocation. That is, the MDI flow is split in such a way that stock problems are minimalised. The highly demanded product is then used as efficiently as possible. This usually comes down to the fact that the most important customers are served first.

For the Variants plants however, there is a planning. The official way of planning production should go according to MRP1.
MRP1 is based on a realistic forecast, accurate inventory figures and the assumption that raw materials are always available. Also, MRP1 does not perform a capacity check; especially a problem with the restricted capacity of some reactors.
Practice has indicated that forecast is inaccurate, inventory records are inaccurate and raw materials are not always available. That means that MRP1 does not support the production planning process enough.
Therefore, the planners have their own way of planning the production.
Inventory is checked manually instead of relying on SAP system figures.

From SAP, data about actual orders from customers are recovered. Considering inventories, maximum tank levels (preventing overflow), consumption obligation (concerning expiry dates of the MDI products), split restrictions and capacities of reactors, the production planners make a plan for the coming day about what to make on which reactor and when. All these elements are not (fully) incorporated in MRP and this makes the job of the order scheduler very complicated. The order scheduler can not rely on the production orders that were proposed by MRP to make a production planning.

The production orders as made by the planners are given to the plant and the transport planners so they can arrange timely transportation.
In case of restricted capacity or raw materials and in case of rush orders from customers, the procedures are the same, with the difference that the raw materials and capacities are on allocation. This means that the demand manager has to make an additional decision about which products can be made first.
Allocation in times of supply shortage is one of the responsibilities of the demand manager. The other is to contribute to achieving an optimum balance between supply, demand and inventory.

3.6 Transport planning

The starting point of the planning of the transportation process is the print out that the planners get from the production planners. This print out is based on the actual production orders and it contains data about the loading and releasing dates and places of certain products of certain customers. These data are given to the hauliers and they arrange their own schedule. A rush order is arranged the same way, only with additional costs.

3.7 Inventory management

Stock can be kept in two ways: bulk or packed. In case of bulk storage, product is kept either in tank trucks (immediately ready for transportation) or in shore-tanks. In case of packed storage, product is stored in drums which are put in warehouses. Drumming is outsourced to De Rijke, which has full responsibility for it. Both warehouses and shore-tanks can be heated if certain products require this.

At the moment there is no clearly defined inventory management strategy, there are merely several rules that are taken into consideration. The most important rule is that it is not allowed to have more that two months of demand on stock.
Another constraint is that the storage tanks must not overflow. This is especially an issue when demand is low or not well proportioned and MDI has to be consumed, resulting in over-production of the Variants plant. In case of unbalanced demand for the three MDI's, there has to be maximum production of a certain highly demanded flow of end product. A consequence would be that you are stuck with the remaining two flows that need to be stored or consumed by the Variants plant (and then stored). To avoid this problem, the highly demanded end product has to go on allocation or the market has to be manipulated in such a way that also the two remaining flows can be sold.
At the moment, pure MDI is a very much asked for product. That means that polymeric MDI and Mixed isomers are also produced and cannot be sold completely. With polymeric MDI that is not too big a problem, because it only expires after a year. Mixed isomers however, have an expiry date of at most three weeks and if there is no storage capacity left, the Variants plants are forced to consume it. So the shelf life issue can cause problems with storage capacity (tank overflow), both for the storage of MDI plant end products as for the Variants plant end products. The shelf life of the end products of the Variants plants ranges from nine months to a year. Within ICI however, this shelf life is halved, because ICI assumes that the customer also keeps the product in stock for a certain time.

Chapter 4: Qualitative analysis of the effects of Medium Term Forecast inaccuracy on the Rozenburg supply chain

4.1 Introduction

In the previous chapters, the relevant environment and processes of the supply chain were described according to the boundaries of my assignment.
The purpose of this chapter is to show what the effects of Medium Term Forecast inaccuracy are on the different elements of the Rozenburg supply chain; the physical flow of products through the organisation as well as information flows with suppliers and customers. In this chapter it will be determined in which areas MTF inaccuracy has impact and how.
Of course, the Medium Term Forecasting method itself will be described as well.

4.2 Medium Term Forecasting method

For ICI good forecasting is of vital importance, because realistic forecast is the basis on which the entire planning system of the plant is built. Crummy forecast makes erroneous production planning and this is obviously not wanted.

In this paragraph, I will go into the way the medium term forecast (MTF) is made.
The Medium Term Forecast is a rolling forecast of sales volumes which gives a weekly forecast for four weeks ahead and which is updated every Wednesday of the week. The first of the four forecasted weeks cannot be changed in order to protect the planning departments from nervousness.
The MTF is made on customer/product level.
The MTF is made by the inside sales people and based on the following elements:

* *Information about future demand from the customers themselves*
  This information should be obtained by the inside sales persons by making a weekly phone call to the customer and to ask them for their forecast for the coming weeks
* *Historical data*
  Historical data about the last few weeks are put in a spreadsheet by the inside sales people and this information is used to seek for a pattern in historical demand that may indicate future demand patterns
* *Additional information*
  With additional information is meant the information that is given to the inside sales people by the outside sales people (=account managers) and the technical service managers (technicians that support the customer in using our products in their production system)

A combination of these three elements together with the experience of the inside sales people makes the MTF. Inside sales people are mainly order processors and have not been especially trained to make forecasts. They have been assigned to make the MTF because they are close to the system where the MTF must be entered and because they are close to the customer.

There is no formal way of making the MTF; every sales person has his/her own way of making the MTF and so the quality of the MTF is likely to differ from person to person and from sales office to sales office.

4.3 Effects of MTF accuracy on the different supply chain elements

4.3.1 Production processes

A worst case scenario of the implications of medium term forecast on production would be that due to false forecast no raw material inventory is available and a plant is forced to shut down.
Important to realise is that the order scheduling department is burdened by Medium Term Forecast inaccuracies. At the moment the biggest problem is that the MTF is so inaccurate that it can not even be used. That means that the order scheduling department is forced to make to order, which is not efficiently possible in this particular environment; demand is too variable and high and lead times are too short.
If forecast is inaccurate, the production schedule may need to be changed, because other (quantities of) products are required. This can lead to different raw material and capacity requirements. When an order was not forecasted, there is less time to plan, produce and distribute the product; the lead time for these activities is smaller.

4.3.2 Inventory Planning

The effect of forecasting on inventory is easy to imagine; if too much or too little demand is predicted, inventories will respectively be too low or too high. For example, if an order was predicted but was not actually ordered, raw materials have been reserved for production. These raw materials need to be stored.
Especially in the polyurethanes business, stock keeping is critical, because products mostly have an expiry date of about three months and storage capacity is limited and expensive.

Also, since the Hillhouse Variants plant in England was closed, ICI Rozenburg covered its demand. Now demand for certain capacities is so high that it cannot be fulfilled. That means that there is no capacity to build up and maintain stocks. For the products that go over these capacities, an MTF is extra important, because the MTF must be used to prioritise customer orders. This prioritisation influences the customer service levels and these are an important competitive edge.

4.3.3 Suppliers

When demand is not realistically predicted, supply also may need to be adapted. Urgent deliveries of raw materials can be necessary or maybe deliveries are cancelled, because there is no need for the material or there is no storage available.
When an order was not forecasted but is placed after all, there may not be enough raw material and a rush order must be placed at the supplier.
The suppliers we have now are mostly regular suppliers; they have been supplying us for a long time. If one of the suppliers is not able to deliver, we can always turn to another supplier for help. Of course, extra costs are then involved, because service is usually not as good as with our regular suppliers and due to specialisation our regular suppliers are also cheaper.
Further, if modifications often take place, this is seen as deteriorated performance on our part and that can be used against us in the yearly contract negotiations with our suppliers. The exact effect of medium term forecast accuracy on these contract negotiations is hard to prove, but it has to be mentioned though.

4.3.4 Hauliers

For hauliers, about the same thing goes as for suppliers. That is, extra costs arise in case of urgent deliveries (for example extra drivers, extra cleaning activities, no return freight possible).

If deviations from plan (that was based on MTF) occur often, this can influence our performance towards the haulier. That is, if we constantly ask the haulier for rush transportation, he may use this in the yearly contract (price) negotiations.

4.3.5 Customers

Customers have two ways in which they are influenced by forecasting.
The first is of course the fact that they are the ones that supply the most important information in making a Medium Term Forecast.
Further, they are influencing the performance of their supplier through the accuracy of their own forecast. If the customer is not able to give ICI a reliable forecast, the lead time from ICI to the customer and the delivered quantity are also less reliable. So for customers forecasting is like a two-edged sword.
If the forecast is continuously wrong and our lead times to the customer are not reliable, this will be taken into consideration with the yearly contract negotiations.

4.4 Limitations to the effects of MTF accuracy

It will have to be realised that there are limitations to the effect of MTF accuracy on the supply chain. Even if the MTF is one hundred percent accurate,
that still does not mean that the MRP1 planning system will run perfectly.

MTF accuracy is not the only condition that is required by the production planning system. MRP1 also assumes that **raw materials** are always available and that **inventory** figures are accurate.
The first assumption is already violated by the behaviour of the supplying MDI plants. These plants have a very unreliable production process; each plant can go down (=stop producing) at any moment for any period of time. Occurrence of such shutdowns cannot be predicted and the same goes for the duration of such downtimes.
These characteristics of the MDI plants also influence the performance of the Variants plants; even a Utopian MTF does not solve this.

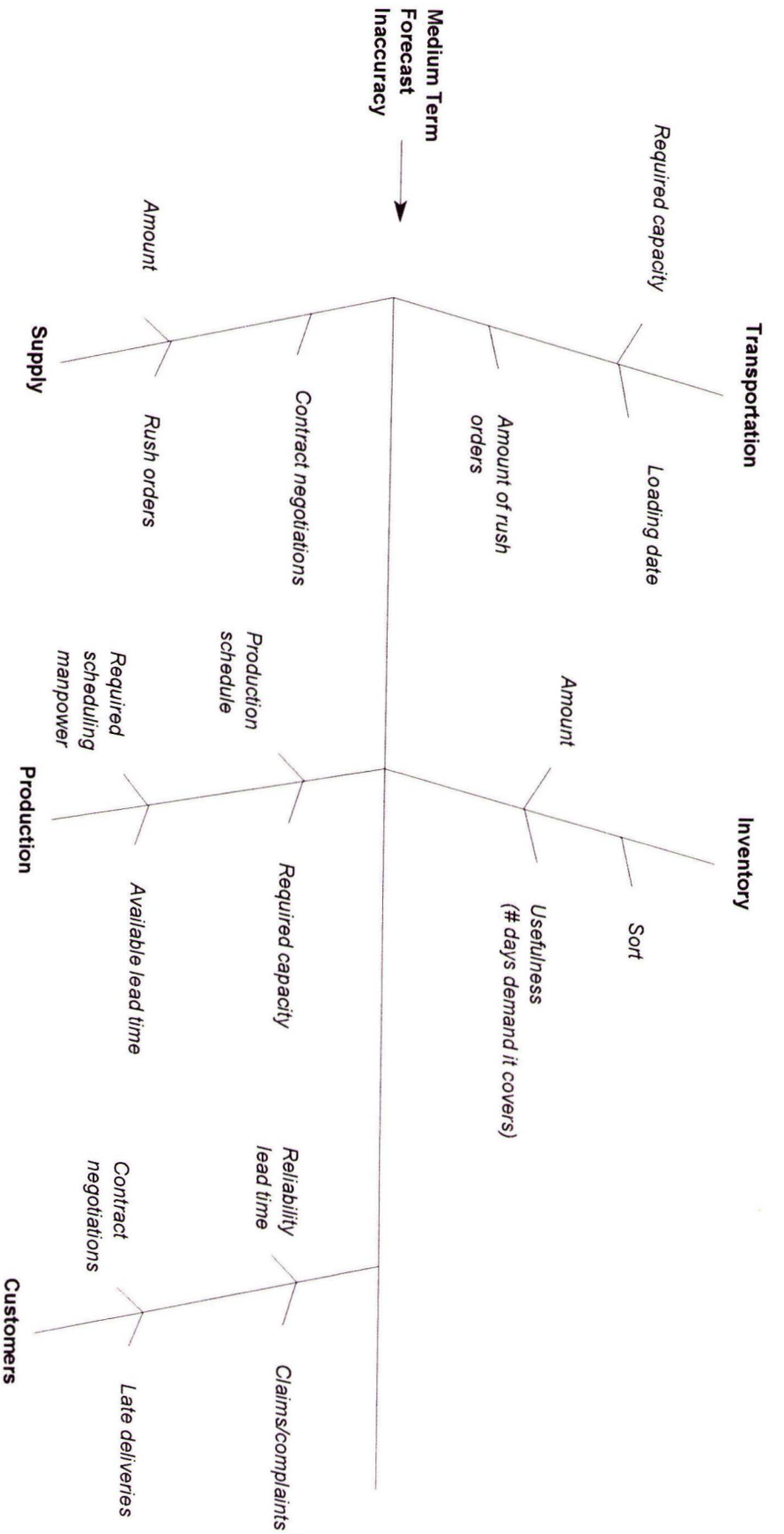
The second assumption is also violated; inventory figures as they are at the moment are far from accurate. It happens frequently that the SAP system indicates that there is a certain amount of raw material available, when in reality stockout is about to occur.

Also, a very important limitation of MRP1 is that it does not perform a **capacity** check. With the strict capacity limitations that may occur at the reactors of the Variants plants, this is not convenient!

4.5 Conclusions and remarks

* In figure 5 on page 18, the effects of medium term forecast inaccuracy are summarised in a fish-bone diagram. This is not a standard fish-bone diagram however, because in this case the *input* (being MTF accuracy) influences the different branches instead of the branches representing the influences on the *output*
* There is a 'double' relationship with the customer; that of supplier (of data) combined with the normal customer relationship
* MTF has within ICI the most effect on the production planning and purchasing departments; distribution is done on customer order
* MRP1 does not give enough support for the production planning department; too many of MRP1 inherent assumptions are violated; one of them is indeed the accurate forecast
* Improvement of MTF does not solve all problems!

Figure 5: Fish-bone diagram of the elements of the supply chain that are influenced by Medium Term Forecast inaccuracy



Chapter 5: Quantitative analysis of the effects of medium term forecast inaccuracy on the supply chain

5.1 Introduction

The purpose of this chapter is to determine if MTF inaccuracy can lead to additional costs, in what area these costs arise and how.
A worst case scenario of the effects of MTF inaccuracy was calculated to show what the effects can be and in order to show where to most substantial costs arise.

MTF inaccuracy measurements on customer/product level have been determined in order to evaluate the forecasting performance of the sales offices. However, the real impact of the MTF inaccuracy is on an end product level; SAP makes an iteration that adds up all customer/product level forecasts to one forecast on end product level. So the actual effect of the forecast accuracy is expected to be dampened because positive and negative deviations of forecast from different customers can counterbalance against each other.

To show the effect of MTF accuracy on production planning, the inaccuracy of a fastmover and a slowmover on an end product level was computed. The costs of having to cover for the remaining forecast inaccuracy with inventory are used as a performance indicator for the current forecasting method.

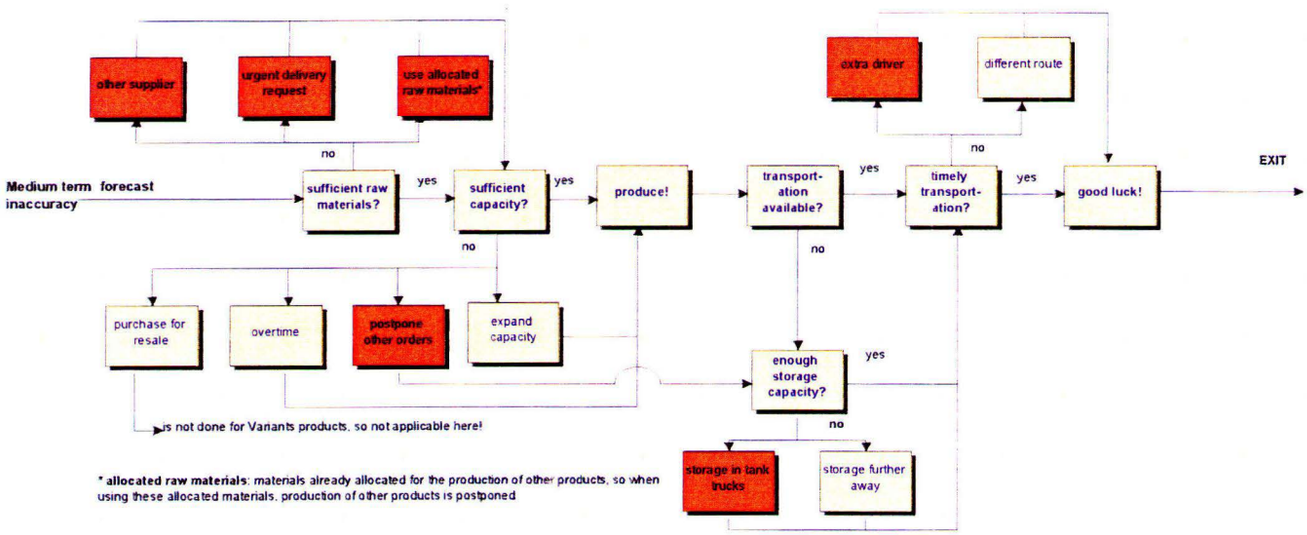
5.2 Analysis of MTF inaccuracy impacts

Chapter 4 was concluded with the summary of the elements that are influenced by MTF inaccuracy. This summary was visualised in the fish-bone diagram in figure 5. In this figure, the link between the supply chain elements is not visible. It also does not show how the negative effects of MTF inaccuracy can be tackled.
To clarify this, a flowchart is constructed and shown in Figure 6 on the next page. The flowchart begins with the input of a certain Medium Term Forecast inaccuracy. It shows the problems that arise in the different areas of the supply chain when MTF is not accurate and how these problems can be handled.
The flowchart handles only the *physical flow* of products, *information flows* and possible consequences of forecast inaccuracy there are not yet covered in this chart!
The flowchart is based on four crucial questions that need to be checked when the MTF is wrong:
1. Are there sufficient raw materials available?
A deviation of actuals to plan (MTF) can cause a deviation in raw material requirements.
2. Is there sufficient capacity available?
A deviation of actuals to plan can change capacity requirements.
3. Is there transportation available?
If there is no transportation available the product will have to be stored until there is.
4. Is there enough storage capacity available?
Storage capacity is needed if end products are waiting for transportation or when orders are postponed to give priority to other orders (then the raw materials need storage).
5. Is there timely transportation available to transport the end products to the customer?
If an order was not forecasted, transportation can not be planned in advance. The lead time of the order can be too small to be able to produce and transport in time. Transport may need to be rushed to deliver the product on time to the customer.

If all these questions are answered with 'yes', production and transportation can proceed without problems and then the deviation of the forecast will have no cost consequences for this physical flow of products.

If a question is answered with 'no' a problem arises and each problem has several options to tackle it. Each option has its own cost consequences. The options that are in red are the options that are usually chosen by ICI.
Notice that when there are not sufficient raw materials, there are three options in red. This means that for ICI all three options are common:
* If additional raw material is needed unexpectedly, a rush order is placed at the supplier
* Another supplier is chosen in case the raw material is an MDI, because a rush order is not possible with the MDI factory; it is already producing at its maximum capacity
* The option of using raw materials that are allocated to other products is used when the suppliers can not deliver the material, not even with a rush order

Figure 6: Flowchart to check consequences of MTF inaccuracy on the physical flow of products through the supply chain



5.3 Input decisions

As mentioned in the introduction, an example of a worst case scenario will be calculated in order to give an impression of what could happen if everything goes wrong. It also helps to determine in which areas the highest costs arise.
A worst case scenario is bad in two ways; the MTF is particularly inaccurate and the circumstances are very bad.
To have a practical example of the effect of MTF inaccuracy, the worst case scenario is applied to one customer/product combination.

5.3.1 Worst case scenario description

In the beginning of paragraph 5.3 it was mentioned that the worst case scenario was bad concerning circumstances. Bad circumstances in this case mean that things that under normal circumstances *could* go wrong, in this case also *do* go wrong. Related to the flowchart, that means:

- not enough raw materials available
- not enough production capacity available
- no timely transportation possible
- not enough storage capacity available

Notice that it was not mentioned that there could be no transportation available. That is because that never happens. Transportation may cost more to get it on time, but it never happens that there is *no* transportation available and we have to wait for it.
So the question 'transportation available' is here actually redundant; it is put in the flowchart in order to be complete.

5.3.2 Selection of customer/product combination

The customer/product combination that is chosen is the product X2700 and the customer Bertrand Faure France.
Bertrand Faure France was chosen because it is a large important customer and it is handled (and thus forecasted) by the French sales office. This sales office is believed to be not too impressive in forecasting. Bertrand Faure France is situated in Magny Vernois, France.
In annex 2 a calculation of the mean and standard deviation of forecast error is given for all products that Bertrand Faure is supplied with from ICI Rozenburg.
Suprasec X2700 was chosen because it has the highest mean and standard deviation of forecast error and thus Suprasec X2700 is forecasted the most inaccurate.
Suprasec X2700 is a Variant made of MPR, MI-15, Arcol 1374 and Arcol 3450.
MPR (Pure MDI) and MI-15 (Mixed isomers) are end products of the MDI plant, Arcol 1374 is an Arco Chemicals product from Belgium and Arcol 3450 is an Arco Chemicals product from Marseilles.

5.3.3 MTF inaccuracy input

Considering the flowchart in figure 6, the MTF inaccuracy is the input of this flowchart.
So the MTF inaccuracy of Bertrand Faure France's product X2700 serves as an input for the flowchart in this worst case scenario.
Taking the mean of the forecast error is not worst case enough. To have a good example of a worst case scenario, the mean plus twice the standard deviation was chosen; that is, actual demand was much higher than forecasted.
Mean plus twice the standard deviation of X2700 is 55138 kilos of un-forecasted product.
So the consequences of having to produce 55 additional tonnes of X2700 will be computed.

5.4 Worst case cost calculation

Using the flowchart with the in paragraph 5.3 mentioned input, a cost calculation was made. The detailed calculation is shown in annex 3; the outcome is shown below.
As you can see in this summary of cost elements, also costs related to information flows are incorporated.

Worst case cost consequences of one medium term forecast error:
(the MTF error being an extra 55 tonnes of Suprasec X2700 for Bertrand Faure France)

-Urgent delivery request:	fl. 6.000,00
-Using allocated raw materials:	fl. 296,00
-Using allocated capacity:	fl. 615,00
-Storage in trucks:	fl. 0,00
-Timely transportation:	fl. 3.150,00
-Handling of claim:	fl. 301,00
-Claim small customer:	fl.10.000,00
-Arranging rush orders/transportation:	fl. 25,00
-SAP alterations	fl. 100,00
-Allocation	fl. 40,00
-Customer	fl. 21,00
TOTAL:	**fl.16.905,64**

These total costs can only be considered in ceteris paribus situations. That is, in a situation where all other circumstances are kept the same. So if there is also another product with a certain forecast inaccuracy, it may well be so that some of the effects counterbalance against each other.

There are three cost elements that together make up the larger part of the total costs: costs of rush transportation inwards (urgent delivery request to suppliers), costs of rush transportation outwards (urgent delivery to customers) and claim costs.

A short remark has to be made about consequences of MTF inaccuracy that are hard to quantify. An example of such consequence is that if MTF inaccuracy constantly initiates the need for rush transportation inwards and outwards, ICI's performance towards hauliers and suppliers will deteriorate.
If ICI constantly places rush orders, hauliers and suppliers will definitely use this as a pressure in the yearly contract (price) negotiations.
Indirectly, inaccurate forecasting then costs ICI money. The exact amount that is involved can not be specified.

5.5 Inaccuracy calculation

Before a start can be made on the calculation of actual effects of medium term forecast inaccuracy, the inaccuracy as it is at the moment must be determined.
There are two different inaccuracies that can be calculated:

1. Absolute MTF inaccuracy per sales office
2. Relative MTF inaccuracy per sales office

The *absolute MTF inaccuracy* measures the mean and standard deviation of forecast error per sales office over a certain period.
Forecast error is defined as: Requested quantity minus MTF.
The MTF that is measured is the last adjusted MTF.
These forecast errors are measured on a customer/product level.
The absolute MTF inaccuracy is shown in annex 4.
If the mean and standard deviation of forecast error are low, the forecast is accurate.

Notice that the Nordic sales office is performing well and the Benelux sales office is performing badly on this measure. However, this inaccuracy measurement cannot be used to evaluate the sales offices; the size of the sales offices is not incorporated! So another measurement is introduced: the relative MTF inaccuracy.

The *relative MTF inaccuracy* compares in a period the total delivered quantity per sales office to the total forecast deviation per sales office (=sum of all forecast errors).
The relative MTF inaccuracy incorporates the size of the sales offices by incorporating the total delivered quantity.
This measurement can be used to evaluate the sales offices' performance.
The relative MTF inaccuracy is shown in annex 5.
If the total forecast deviation is close to zero, the forecast is accurate.
Notice that when incorporating the size of the sales offices, the Benelux sales office is performing well and the Nordic sales office is performing badly!

In order to calculate the chance of a forecast error of a certain size to occur, a frequency distribution of forecast error was determined. This is done by putting all deviations of all sales offices over a period of four weeks into one file and measuring frequencies of forecast error in ranges from -100.000 to +100.000 kilos. The result is shown in annex 6.
Notice that the frequency distribution is bell shaped, indicating a normal distribution of forecast error.

5.6 Analysis of cost consequences of medium term forecast inaccuracy

The above paragraphs show what *could* happen if all goes wrong.
What is also of importance to know, is how much can be gained from introducing a new forecasting method. In order to determine this, a performance indicator for forecasting must be chosen. The performance indicator will be the costs of the inventory that is needed to cover for the remaining forecast inaccuracy. There are several ways to cover for remaining forecast inaccuracy; inventory, capacity reservations, lead time negotiations. Inventory is the most logical choice in this situation, because reserving capacity costs ±fl. 900,- an hour; very expensive. Lead time negotiations are not an option, because in this business lead time is a crucial competitive edge; ICI wants to keep lead time as small as possible.

First, the costs of necessary inventory in the current situation are determined. Costs of keeping inventory with the new forecasting method can of course only be determined after a new forecasting strategy is proposed.
The calculation will be done for two products: a fastmover (Suprasec X2700) and a slowmover (Suprasec 2020). Each calculation will be discussed in a separate paragraph.

5.6.1 Fastmover calculation

First, the fastmover will be handled. The Suprasec X2700 is chosen as an example, because this is by far the 'fastest' fastmover of all Variants products, it has by far the highest peaks and falls and because the planners indicate that they believe that the forecast inaccuracy of this product is very high.

Annex 7 shows the detailed calculation of the forecast error and it shows a frequency distribution of forecast error. For inventory purposes, only the positive deviations are of importance. The maximum positive deviation is here 160 tonnes. Assuming that this is not an outlier, 160 tonnes of inventory will be needed to cover for the remaining forecast inaccuracy.
For the X2700 there is 200 tonnes of storage capacity available on site; enough to cover for the 160 tonnes. The most important costs of keeping inventory then are the interest costs: 160.000kilo*fl.2,52*7/365*10%=fl.770,- per week.

5.6.2 Slowmover calculation

Annex 8 shows the forecast inaccuracy of a slowmover: Suprasec 2020. S2020 is an average slowmover.
When studying the possibility of keeping inventory, it turned out that due to the very limited capacity of the reactor on which S2020 is made, there is no capacity available to keep an inventory and maintain it. In other words; capacity on this reactor is so limited that it can never cover the demand of the products that are made on this reactor.
This limitation of capacity is mainly caused by the fact that the ICI Variants plant in England has closed. ICI Rozenburg has been covering for this demand.
So in this case, there is also no possibility of keeping inventory.

This means that an MTF should be useful for estimating raw material requirements and for deciding which orders are fulfilled and which are not. The prioritisation of orders mainly depends on the customer.
However, the MTF as it is shown to the production planners is on *end product level*; it does not show for which customer the material is! The MTF is entered in the computer system on customer/product level though, meaning that it is known which MTF belongs to which customer. It is the SAP system that makes an iteration of adding up all MTF's per product.

Therefore, data about how the MTF on product level is built up are available, they are just not used.
That means that the MTF as it is now, can not be used to prioritise orders.
Concerning service levels towards customers, it is very important to ICI to know beforehand which orders are coming and which of those need to be fulfilled.

An option could be to implement an extra action before the MTF is added up by the system. The demand manager could do a rough capacity requirement check on the MTF, and if the MTF takes up more capacity than available, a choice of which customers to deliver can be made before the MTF is shown to the production planners. That means that when an MTF arrives at production planning, it is already checked that there is enough capacity to handle it. When using this system, you can inform the customer that when his order was not forecasted, it probably cannot be granted.
In the hypothetical case that suddenly all customers start forecasting perfectly and capacity remains too limited to cover demand, principal choices need to be made. Choices about which part of the market to serve and which part to ignore.

If this option is to be implemented, the MTF is supposed to be quite accurate, because you are relying on it when prioritising customer orders; sales may be lost unnecessarily.

The benefits of improving the MTF for this purpose are very hard to quantify. The customer service objectives that are the reason for this improvement are of such importance to ICI though, that improvement is desired anyhow.

5.7 Conclusions and remarks

* There are important non-quantifiable reasons that indicate the usefulness of MTF
* Interest costs for keeping inventory of Variants end products are not particularly high
* Forecast inaccuracy on a customer/product level is extremely high and the forecast error seems to be normally distributed
* Forecast inaccuracy on an end product level (for the X2700 and S2020) is also quite high but this frequency distribution does not indicate a normal distribution of forecast error
* Even when the required inventory levels show that there is not too much to gain in improving the MTF, ICI will probably decide to start in investing in improvement anyway for the following reasons:

-determining the raw material and capacity requirements
-prioritising customer orders when there is limited capacity/raw material
-working towards cash targets (little cash tied up in inventories)

* One of the more important reasons to use MTF could be to use it in the prioritisation process. However, this is not possible with the MTF as it is now, while the data are available. That means that the data that are collected when making the MTF are not used optimally

Chapter 6: Final assignment

6.1 Introduction

Since the start of the project, processes, structures and restrictions have become clearer and problems could be determined more specifically.
In the light of these new findings, a final, more detailed assignment could be formulated. This final assignment will be used as a guideline for the last part of the project and as a tool to evaluate it.

6.2 Final assignment formulation

The new part of the assignment was defined as follows:

* Developing a satisfying way of improving the Medium Term Forecast method where necessary and possible and finding a way of dealing with the remaining Medium Term Forecast inaccuracy.

Coping with remaining forecast inaccuracy can be done in different ways. Stocks, excess capacity, using additional lead time and lead time negotiations with the customers are all ways to cover for forecast inaccuracy.

Considering the time horizon of this project, it is not possible to determine a strategy to improve the Medium Term Forecasting method for every single end product. Also, it is very likely that not all products need a different forecasting strategy, so first all products will be clustered.
The classification can be based on several criteria: demand pattern, amount of customers, lead time etc. Choosing and combining criteria gives x classes, for each of which a strategy concerning Medium Term Forecast method will be defined. This strategy will contain statements about if and how the MTF in this particular class should be improved.
For every class one or more alternatives for improvement will be given and every alternative will have a performance indicator attached to it.

The amount of inventory that is needed to cover for the *remaining* forecast inaccuracy when using the new forecast method will function as the performance indicator of that forecast method. For every alternative method of forecasting, this performance indicator will be quantified so that the different forecasting methods can be compared.
It is to be expected that for certain classes of products the investments for improving the forecast method will be so high that it is smarter to cover for forecast inaccuracy with inventory. In this case, the desired stock level will be determined when using the current forecasting method.
Stock levels that are needed to cover (remaining) forecast inaccuracy will be determined according to desired customer service levels. These customer service levels are set by ICI's management and are fixed; they cannot be seen as variable.

Chapter 7: Analysis and improvement of Medium Term Forecasting method

7.1 Introduction

Chapter 5 showed that the MTF on both customer/product as product level (for the `X2700 and S2020) was very inaccurate, what the consequences of an inaccurate MTF can be and what it costs to cover for the remaining forecast inaccuracy.
In order to evaluate whether it is justified to invest in the improvement of MTF, a new forecasting method needs to be developed and tested. Chapter 9 will discuss the benefits of the new method in terms of inventory requirements. This chapter and the following Chapter 8 will handle the *possibilities* for improvement.

The MTF can be improved in two areas:

* The forecasting method itself
* Facilitating conditions for making a forecast

The facilitating conditions will be discussed in Chapter 8, this chapter will handle the analysis and improvement of the forecasting method itself.

Chapter 4 described how and by whom the MTF is made.
It showed that the medium term forecast is made in a very subjective way; there is no basic forecasting method that the inside sales people can use to make an MTF. The inside sales people are not trained in forecasting and as a consequence they now make the forecast based on feeling and experience.
In this chapter I will develop a new forecasting method that will support the inside sales people in making their forecast.

It is likely that not all end products of the Variants plants will need the same forecasting method. Therefore, the products are first clustered into several categories; each with its own strategy.

Because the scope of my research is limited to the Variants plants, I will only describe how the products of this plant can be forecasted.

Products that are made to be sold in drums and IBC's (Intermediate Bulk Container) are excluded here, because they represent a small part of demand. An inaccurate forecast of these products does not have a great effect on inventory, capacity and raw material requirements.
Of five products there was no historical data found, meaning that these products are to be considered new. That leaves twenty-two end products with historical data available to study.

7.2 Product clustering

One cluster is the cluster of five new products (entirely new or just no historical data available; entirely new means that the product is not a replacement for another product). For these products you are entirely dependent on the customer; history cannot give any hints about the future.
The strategy for new products will be discussed below.
When a product is new but replacing an old product, the demand pattern of the old product can be used as an expected demand pattern for the new product.

For each of the remaining twenty-two (bulk) end products of the Variants plant a file was constructed that describes its demand pattern. This file was constructed in the hope that it would give an idea about possible clusters.
All files consist of the following elements:

* All customer orders from April 1997 to present
* Monthly sales figures from as far back as possible (differs per product) to present
* Both these demand data visualised in respectively a graph and a histogram
* Estimates of total yearly demand
* The amount of customers and the responsible sales offices

An example of such a file along with an explanation can be found in annex 9.
Remark: all data that were used in determining the demand patterns were captured from ICI's management information system: Navigator

From the demand patterns different clusters of products can be deducted; clusters of end products with the same characteristics.
There are two clusters, each of which can be divided in two sub-clusters:
(because of certain very limited capacities)

1. Products that can be made to order
    A. Sufficient capacity
    B. Limited capacity
2. Products that may be forecasted by Time Series Analysis
    A. Sufficient capacity
    B. Limited capacity

Also, there is the mentioned cluster of new products (or products with no historical data); these all go over capacities that are more than sufficient:
3. New products
All three categories will be described in the following paragraphs.

Remark: the following clusters are based only on the studied products of the Variants plants!

7.2.1 Products that may be made to order

When analysing the demand patterns, the first consideration should be whether all products really need Medium Term Forecasting. In case of a large part of the products (11 of 22) it is not necessary to go through all the trouble to make a very accurate MTF; these products can be made to order.
All eleven end products that fall in this category have the same characteristics:

* Rather low (< 600 tonnes) yearly demand
* Demand does not occur every week and when it occurs, it is always the same quantity which is smaller than 30 tonnes
* There are only one or two small (< 20 tonnes) peaks
* Lead times are small; six of the eleven products can be made on the In Line Blender, meaning that the lead time is one minute per tonne and the batchsize is almost infinitely flexible. For all other products the lead times are no more than half a day and the batchsize flexibility is always enough to cover for the small peaks that may occur

Looking at these characteristics, one would expect that these products could easily be kept in stock; total demand is not too high and maximum weekly demand is low as well. However, there is no bulk storage in the form of shore tanks available for these products. This means that if you want to keep these products in stock, they will have to be stored in tank trucks.

Tank trucks have a capacity of 25 tonnes and cost fl.140,- per day. So if you want to keep the 11 products in stock, for each product at least one tanker, it will cost; fl.140,-*365days*11 products= fl. 562.100,- per year, just on storage costs for these products. Also, there would occur interest costs: fl. 2,52*25.000kilos*11*10%=fl.69.300,- a year. In total that gives: fl. 631.400,-; for ICI that is an unacceptable amount.

These products represent such a small part of total demand and put such an equally spread, small burden on capacity, that it is expected that they can easily be made to order. The total capacity of the reactors on which these products are made, compared to the capacity that they use is:

Table 1: Required capacity versus total available capacity for products that can be made to order

Product/Reactor	Available capacity (year)	Required capacity for product in question (year)
X2530/In Line Blender	3000 hours	25 hours
S2082/V2015	6000 hours	300 hours
X2412/In Line Blender	3000 hours	20 hours
S2015/V2103	6000 hours	480 hours
X1040/In Line Blender	3000 hours	40 hours
S2528/In Line Blender	3000 hours	10 hours
S2525/In Line Blender	3000 hours	200 hours
S2021/V2015	6000 hours	56 hours
S2332/V2009	6000 hours	400 hours
X2008/V2009	6000 hours	185 hours
X2420/In Line Blender	3000 hours	75 hours

This would indicate that demand for these products can be squeezed through between regular production. However, since the take-over of demand of the ICI Hillhouse plant in England, capacity on some reactors is very limited. Then it is too risky to make these products to order and an MTF is needed anyway.
So actually, this category should be divided into two sub-categories:

A. Products that can actually be made to order (sufficient capacity)
B. Products that need an MTF for restricted capacity reasons

7.2.1.1 Sufficient capacity

All the products that are made on the In Line Blender fall in this category; six products. Even when products can be made to order, a rough check is needed to check raw material requirements.
This can be done based on an MTF. This MTF may not have to be as accurate as the MTF's that are used for production planning purposes, because it is merely used for a rough check. The possibility of not having to improve the MTF for this purpose and to use the current MTF will be studied.

The effect of MTF inaccuracy on raw material requirements is expected to be less than it is on production (end product level). For five of the most important raw materials for the Variants end products, I calculated how the inaccuracy of the MTF (as it is now) influences raw material requirements.

If the compensation percentage is 100%, that shows that all positive deviations are compensated by the negative deviations. Meaning that there is always enough raw material and possible even too much.

When the compensation effect is 0%, there were no negative deviations to cover for the positive ones; a shortage of raw materials occurs.
A compensation percentage of 72 % means that 72% of positive deviations are compensated by negative deviations, leaving the 28% of positive deviations from forecast that are left to influence raw material requirements; a raw material shortage occurs.
The shortages that occur depend on the size of the (remaining) positive deviations.

The compensation percentage was calculated three times for three following weeks. Annex 10 shows the calculation that led to the compensation effects shown in table 2.

Table 2: Compensation effects of MTF inaccuracy on raw material requirements

	Compensation percentage		
Product	**Week 1**	**Week 2**	**Week 3**
MPR	58%	51%	28%
Suprasec X 2185	72%	68%	100%
MI-15	100%	31%	85%
Cereclor S52	0%	100%	0%
Arcol 1374	24%	0%	36%
Daltocel P720	14%	32%	57%

Suprasec X2185, MPR and MI-15 are the three most important raw materials for the Variants plants. These raw materials are used in many end products and they represent 70% of total raw material requirements of products in this category.

The other mentioned raw materials represent a much smaller part of total raw material requirement, but those are needed for production too. If the compensation percentage for all raw materials was high, then the MTF as it is now can be used to estimate raw material requirements with. Unfortunately, that is not possible so another way to estimate raw material requirements must be found.

One possibility would be to improve the MTF for this product category anyway; not for inventory reduction reasons but merely to be able to estimate raw material requirements. Another possibility would be to estimate the raw material/capacity requirements based on the long term forecast. But no proper decision rule could be found to divide the long term forecast up into short term.

If it is decided that for this category it is necessary to improve the MTF, then a forecasting strategy must be determined. For these products, it is not really the quantity that is important, but the timing of the order. The time between two orders is quite variable; there is no pattern. That means that for these products the forecasters rely on the customer to give them a good indication of when the order is expected to be placed. In practice, forecasting for these products will come down to calling the customer every week. With a maximum of three customers per product for this category, this is not too big a job.

The performance indicator that can be used when it is decided that the MTF needs to be improved, cannot be inventory. Not because it is not possible to build up inventory, but because it is not possible to keep it (remember the tank trucks). Again, the main reason for improving the MTF for this category would be to estimate your raw material requirements more accurately. So the required inventory level of raw material would be a suitable performance indicator.
This performance indicator can not be used yet, because the benefits of the new forecasting method (involving the customer) cannot be determined.

7.2.1.2 Limited capacity

Five of the studied products belong in this category, meaning that they are made on reactors that have such limited capacity that demand for this can never be met.
If the products go over such limited capacity, then the MTF can be used to prioritise orders. Not all orders can be accepted, so if you want to serve your customers well, you will want to let them know as soon as possible whether they can be delivered or not.

As mentioned in paragraph 5.6, an option could be to implement an extra action before the MTF is added up by the system.
The demand manager could do a rough capacity requirement check on the MTF, and if the MTF takes up more capacity than available, a choice of which customers to deliver can be made before the MTF is shown to the production planners. That means that when an MTF arrives at production planning, it is already checked that there is enough capacity to handle it.
When using this system, you can timely inform the customer if his order can be accepted or not. Customers that give a forecast this way make a better chance of having their order accepted.
In the hypothetical case that suddenly all customers start forecasting perfectly (and capacity remains too limited to cover demand), principal choices need to be made. Choices about which part of the market to serve and which part to ignore.

If this option is to be implemented, the MTF is supposed to be quite accurate, because you are relying on it when prioritising customer orders; sales may be lost unnecessary. How accurate depends on the customer service level that is desired.

Also, an MTF may be useful to do a rough raw material availability check, because this check is not incorporated in the MRP1 system.

Forecasting for these products is more a matter of determining when the order is going to come in than of determining the size of the order; the order quantity is always the same (any small peak can always be covered by the batch size flexibility). Historical data show that the time between the entry of two orders is very variable; there is no pattern. That means that the customer must be involved.
Consistently making a call to the customer every week is then the only thing to do.

The performance indicator for any new forecasting method can of course not be the required inventory level; there is no possibility of keeping inventory because of capacity restrictions. In this case a logical performance indicator could be the customer service level, because this is expected to improve by the prioritising process.

The benefits of improving the MTF for this purpose are very hard to quantify (performance indicator!). In this case, it concerns quite a low amount of products (and related forecasts), so improving the MTF for this small amount will not have a great effect on total forecast accuracy.

7.2.2 Products that may be forecasted by Time Series Analysis

The eleven products that fall in this category all have the same characteristics:

* Clear seasonal effects
* High yearly demand (>1000 tonnes)
* Varying demand quantities per week
* Significant peaks and falls in the demand pattern that can clearly be identified and quantified and which are not seasonal, for example:

1. Unexpected events that only have a *temporary* effect on sales volumes:
-strikes (roadblocks France)
-wars, political circumstances (shoes for the Russian war in Tsjetsjenia)
-shutdown at customer
-shutdown at competitor
-shutdown at own plants (problems and eventual closure of ICI Hillhouse, England)
-the approval of a letter of credit (mostly customers from Middle-East or Eastern Europe)
-weather conditions

2. Predictable events that have a *lasting* effect on sales volumes:
-new laws for environmental protection or safety laws (prohibition on using polyurethane insulation in refrigerators)
-new product introduction of the customer
-mergers, take-overs, bankruptcies
-entrance to new market (China)
-government subsidies

A more detailed description of these peaks and falls and their influence on demand can be found in annex 11.

Products that fall into this category all have at least one year of historical data.
For this category of products goes the same as for the other category; there are products that are made on reactors with very limited capacity. For these products goes another forecasting strategy than for the other products that are made on reactors with sufficient capacity. So again, there are two sub-categories:

A. Products that can be forecasted by TSA (sufficient capacity)
B. Products that are made on reactors with very limited capacity

7.2.2.1 Sufficient capacity

Eight products that are made on reactors with sufficient capacity fall in this category.
The possibility of using theoretical models that use historical data to predict the future will be studied.
Forecasting models as described in literature were checked for usefulness in this situation. It turned out that Time Series Analysis was the only theoretical forecasting method that can be considered in this environment. This does not necessarily mean that TSA is the *right* forecasting method in this situation, it merely means that TSA may be applicable. Testing of the method will be done in Chapter 9.
It will be discussed how TSA should be done in theory and how it may be used in practice.

The following theoretical forecasting models were described in Silver and Peterson's publication about inventory management and production planning (*Lit. 1*). They use historical data to predict the future and were all tested for usefulness in this environment.

* ***Exponential smoothing:*** There is an obvious seasonality which rules out the possibility of using exponential smoothing. Also, some products have periods in which they have no demand; that is hard to incorporate in exponential smoothing procedures; even when these 'empty' periods are seasonal.

* ***Regression techniques*** are also not suitable for these kind of demand patterns, because in regression it is assumed that one or more variables can predict the future of another variable, in this case that would be demand. For instance, population growth curves can (partly) predict the future need of diapers. In the bulk chemicals business, there is no such strong indicator of future demand so regression techniques cannot be used. It is especially difficult because ICI is a supplier of very basic raw materials; we are very far from the end user.
* ***Auto-Regression techniques*** can also not be used, because no proof could be found that demand in a certain period is dependent on demand in the previous period(s). In some months, like September, it can be seen that when demand has been low the previous month, August, that there is relatively high demand in that month. However, this phenomenon is not structural but seasonal; for many countries August is the holiday month and plants are down then.
* ***Time series analysis (TSA)*** is a method that may be applicable. All products in the rest category have significant seasonal patterns and some have increasing or decreasing demand levels, which time series analysis can take into account.
Time series analysis is a forecasting method that bases the forecast on historical data.
Sales data are analysed for trend and seasonality as follows:

-determine on which aggregation level the data are available and on which level they need to be analysed
-determine the cycle for seasonality; of how many periods does this cycle consist
-calculate a moving average over the amount of periods in a cycle; these moving averages represent trend
-subtract the moving averages from the actual sales data; this gives seasonality factors
-average the seasonality factors per period in order to obtain one seasonality factor for each period

Now a TSA forecast can be made based on trend and seasonality factors.

In theory, TSA could be applied to the 'raw' sales data. However, the peaks and falls as described in annex 11 must be taken into account because they distort the figures.
That is because peaks and falls will be seen as seasonal by TSA, when in fact they are not. The peaks and falls as described are incidental and do not regularly occur in the same period.
So, temporary peaks and falls must be filtered out from historical data before trend and seasonal effects are determined. Lasting changes in sales data must be incorporated in trend determination.
The forecast made by a TSA must be adapted with predictable peaks and falls, also described in annex 11.
In annex 12 two examples of the effect of peaks and falls are shown; one for a fastmover (Suprasec X2700) and one for a slowmover (Suprasec 2020).

Steps in making a TSA forecast per product:

1. Filter out all incidental peaks and falls from historical demand data
2. Use a 52 week moving average to determine trend
3. Subtract the trend from the actual sales data to obtain seasonal indices
4. Average seasonal indices per week to determine one seasonal index per week
5. Execute trend fitting: y=a+b*x and determine a and b
6. Determine the periods for which you want to make a forecast
7. Fill in the formula y=a+b*x to determine trend
8. Add the seasonal factors to the forecast

9. Go through the checklist in annex 13 (to be explained later) to check for any expected events that may change sales volumes, quantify them and adjust your forecast to them

Evaluation of the proposed forecasting method will be done based on the need for inventory to cover for remaining inaccuracy. Inventory requirement will be determined considering the service level that was set by management.
This service level requires that 97% of all orders is delivered FCD. FCD stands for Fully Conforming Delivery and it means that 97% of all orders is delivered to the customer on time and in full (=OTIF) with all the right documentation.
The detailed method is described in Chapter 9.

7.2.2.2 Limited capacity

In principle, the same things go for this category as for the products that are mentioned in paragraph 7.4.1.2, with the difference that the demand for these products is much higher and much more variable. So for these products it is more important to have a good MTF, because they cover a far greater part of demand (and raw material requirements) and because demand is far more variable (can cause more problems because of peaks).

So again, an MTF for these products can be used to estimate raw material requirements and to prioritise orders. For this MTF, both size and timing of the order are of importance. This means that for these products, a TSA can be used to make a forecast.
Only the performance indicator for the forecast can now not the required inventory and related costs, performance of the TSA forecast can be measured by increased customer service and better estimates of raw material requirements. These can not be quantified though, so it is hard to prove the use of investing in improving the forecast for these products.

7.2.3 New products

All new products are made on reactors with sufficient capacities.
With new products, products are meant that are completely new; they do not replace other products in the same application. Products that replace others in the same application should be classified according to the demand pattern of the old products.
This category also contains products that have no historical data at all.
When considering the five products that fall in this category, there is no possibility to make a prediction for the future based on historical data. That means that one relies completely on data from the customer and common knowledge about the industry and environment of the customer, such as knowledge of seasonality and peaks and falls (as defined).
In this case, you will have to concentrate on involving the customer in forecasting and to gather as much knowledge about environment and industry as possible.
Involving the customer can be done by:

* Negotiating a longer lead time, so production can be done to order
* Convincing the customer of putting more effort in making a reliable forecast for us
* Convincing the customer to give ICI (more) information about their inventory levels, if possible even partnering in the form of Tank Telemetry
* Also, a continuously bad forecast on the customers' part can be taken into consideration at the yearly contract (price) negotiations

It is clear then that in making the MTF for this cluster, the focus should be on the customer. Details about how exactly to involve the customer should be determined by a co-operation between the outside sales representatives, sales managers and customer service managers, since this is probably very customer specific.

The performance indicator can be determined as soon as the demand pattern is identified; then these products can probably be assigned to one of the clusters above, or new clusters with new strategies may arise.

7.3 Summary of results

In short, the following clusters were identified with corresponding performance indicators and forecasting methods:

Table 3: Product clusters and corresponding forecasting strategies

Cluster	# Prod.	Capacity availability	Cluster No.	Performance Indicator	Forecasting strategies
Products may be made to order	6	Sufficient	1A	Raw material inventory	Customer involvement
	5	Limited	1B	Customer service	Customer involvement
Products may be forecasted by TSA	8	Sufficient	2A	End product inventory	Time Series Analysis
	3	Limited	2B	Customer service	Time Series Analysis
New products	5	Sufficient	3	?	Customer involvement

7.4 Conclusions and remarks

* The three clusters that are mentioned in paragraph 7.4 are the clusters that exist at the moment (August 1997) for the products of the Variants plants in Rozenburg. It is expected that over time, demand patterns, product portfolio and situational factors like capacities will change. Therefore, it is necessary to re-evaluate the clusters every six months to incorporate any major changes.
* When forecasting, we are still very dependent on the customer; history does not give too much support
* Capacity restrictions lead to sub-clusters and the necessity of different performance indicators
* Cluster 2A is the only cluster that has a recommended forecasting strategy that can be evaluated for usefulness in quantitative terms. This is because the performance indicator that goes with this method (end product inventory requirement) is well quantifiable
* The other performance indicators are either very hard to quantify (Customer service) or cannot be determined yet (Raw material inventory)
* Recommended actions for the clusters are as follows:

  Cluster 1A: Do not bother in trying to improve the MTF; the only purpose would be the better estimate of raw material requirements and considering the small amount of orders, the benefit will be small

  Cluster 1B: Improvement of MTF could be justified with the argument that it would improve customer service

  Cluster 2A: The outcome of the calculation of the corresponding performance indicator should indicate whether investment in improvement of MTF is justified.

  Cluster 2B: Improvement can be justified by the possible increase of customer

service. This cluster contains products with high sales volumes and high peaks and falls; it is also important to have a good raw material requirement estimate for products in this cluster

Cluster 3: Because products in this cluster have not been forecasted yet, there is no question of *improvement* of the forecasting method

Chapter 8: Facilitating conditions for environment

8.1 Introduction

The previous chapter described how the medium term forecasting method can be improved. There are also facilitating conditions of the environment that need to be fulfilled. This concerns conditions that are necessary to be able to make a good forecast; all the right information must be available at the right time in the right place and all involved parties need to be committed in making a good forecast.
Involved parties are the forecasters themselves, outside sales representatives, technical service managers, customers, customer service managers, managers of sales offices and indirectly the order scheduling department.

Also, the success of improving the MTF depends strongly on the awareness of the inside sales people of MTF inaccuracy and its consequences and on their motivation to do something about it.
Especially because it will take quite some time and effort to make the necessary inventorisation of peaks and falls and to continuously contact the customer.

The inside sales people rely on the information of others (customers, outside sales representatives, technical service managers, etc.) to identify and quantify peaks and falls, trend and seasonality. Therefore it is important that all in forecasting involved parties are aware of the MTF inaccuracy and its consequences.

Paragraph 8.3 gives certain information requirements. These requirements arise when it is decided to improve the forecasting method.

8.2 Information and motivation issues

The following problems concerning motivation and information issues related to medium term forecast were observed:

* The people who make the MTF, the inside sales representatives, do not always have sufficient information to do a good job; they need data about market developments, changes in customer production, new contracts, holiday periods etc.
* There is not enough or no contact at all between the inside sales people and the customer. A reason for this may be that the outside sales representatives do not want the inside sales to 'steal away' their customers and therefore shield the inside sales people from any contact with them.
* There is no solid basis of how to make a forecast; the sales people do the forecasting 'by the nose'. They do not have a tool available that guides them in making a forecast; no extensive history records, no supporting software. They are not trained in how to make a reliable forecast so they have to figure out a way to do it themselves. This way, forecasting is very dependent on personal ideas and therefore very different, even within the same sales office.
* The inside sales representatives are not aware of the effect of their forecast on production planning. They do not know how much work arises at Rozenburg (or any other plant for that matter) when their forecast is wrong, so they do not realise how important their job is.
* The inside sales people are not aware of their own inaccuracy.
* The motivation of the inside sales people to make a good forecast is very low. This is mainly caused by the fact that they do not know their own inaccuracy and the effect of it.

* Because inside sales have such little information and tools available, they only look at the most recent history (no more than four months) to make their forecast. Seasonal effects cannot clearly be identified this way.
* The outside sales representatives are very important information suppliers for the inside sales people, because they provide information from the customer. There may be a conflict of interest though, because outside sales have a sales target, on which they are evaluated. For production plants the most important thing is that the forecast is accurate; the quantity is not so important. As long as it is accurate, production can plan efficiently.
For the outside sales people, it clearly is important how high the sales are. If the forecast given by the customer is significantly lower than the sales target, outside sales will probably try to make sales volumes meet the target and forecast is wrong.
* Outside sales representatives also do not know how inaccurate the forecast actually is and what the consequences of it are. That is important for them to know though, because they are key suppliers of information that is needed to make a good forecast.
* Customers do not make an effort in giving the sales representatives reliable forecast. This can happen for several reasons:
    - The customer thinks that a forecast is an obligation to buy
    - They do not realise that it is in their own benefit; they only see the effort they have to make, not the reward in for instance more reliable lead times
    - Customers have the tendency to forecast higher than necessary in order to make sure they will get enough material
    - The customer is afraid that ICI is going to use the knowledge they give us about their production process against them (for instance in yearly price negotiations)
    - They do not want us to know what their inventories are, certainly not when we are not their sole supplier (then we would know how much and when they order at the competitor)
* Of course, there are always customers who really do not know what their production in the coming four weeks will be.
* The product range changes constantly; new products come and old ones go very quickly. However, it is often the case that when an old product goes, the new one that takes its place has the same application. That means that demand patterns for the new product will be virtually the same. But for completely new products, you rely entirely on the customer to make a forecast; there are no historical data available.
* Demand patterns can be distorted because of problems at other factories. For instance, if the ICI Hillhouse production plant goes down, ICI Rozenburg is expected to cover that demand too. This demand was not supposed to be covered by Rozenburg, but they do have to cover for it. So if you look back in history data, this kind of demand will have to be filtered out to get a reliable picture of actual Rozenburg demand.

8.3 Information structuring

The problems mentioned in paragraph 8.2 are about information and motivation.
When the information flows are structured and complete and when all involved parties are committed to making a good Medium Term Forecast, the facilitating conditions for implementing the proposed forecasting method are improved.

Information availability and motivation are not independent variables. An important step in motivating people is making them aware of the problems. Awareness can be created by providing explanatory information.
Because motivation is expected to be increased when information flows are correct and complete, I will start with handling the information flows.

The first step in structuring the information flows is determining the need for information. Some information will have to be brought across only once, other information will be continuously needed.
The first kind of information can be provided by training, information meetings, brochures etc. The second kind of information may be transferred repeatedly by for example weekly or monthly meetings, written reports, meetings with customers, etc.

The information requirements that are deducted from the above mentioned observed problems are as follows:

1. One time information requirement:
For the *inside sales representatives:*

A: Creating awareness of how inaccurate the MTF is at the moment
B: Enlightenment on the effects of this inaccuracy on all parts of the organisation (especially the effect on customer service; Fully Conforming Delivery (FCD), On Time In Full (OTIF) delivery, lead times, etc.)
C: Responsibilities and authorities of inside as well as outside sales representatives in order to prevent overlap and to facilitate a good working relationship
D: Information on how to make an MTF; where do you get the needed information and how do you use the information you have

For the *outside sales representatives:*

E: Creating awareness of how inaccurate the MTF is at the moment
F: Enlightenment on the effects of this inaccuracy on all parts of the organisation (especially on customer service; FCD, OTIF, lead times, etc.)
G: Realisation that it is important for the inside sales people to be in touch with the customer as well; that this is not a threat to their own relationship with the customer
H: Awareness of how important it is to co-operate with inside sales and to provide them with all the information they need to make a good MTF
I: Responsibilities and authorities of inside and outside sales people, in order to prevent overlap and to facilitate a good working relationship
J: Medium Term Forecast should not be used a sales target for outside sales representatives

For *customers:*

K: Explanation that giving a forecast to ICI is not an obligation to buy, neither will it be used against them lateron
L: Customers must be convinced that it is in their own benefit to give a reliable forecast, by informing them of how short and reliable our lead time towards them could be if their forecast improves

2. Continuous information requirement:
For the *inside sales people:*

M: All available historical data; preferably also visualised in a graph.
N: Information of the Technical Service managers about technological changes at the customers, like new product introduction, new production processes, unplanned shutdowns, production problems at customers, etc.
O: Information of outside sales representatives about new product introduction, removal of old products from product range, planned shutdowns of customers as well as competitors, holiday periods, strikes, expansions, problems with production at customers
P: Information from the production plants about shutdowns and production problems at ICI

Q: Information about coming orders and inventory levels at customers (if customers are willing to give this information!)
R: Feedback about how good the MTF is; is it improving?
S: Written report from marketing managers about business developments and important changes at important customers

For the *customers:*

T: Feedback about how good their forecast is and how it affects the lead times towards that particular customer

All *other involved parties (management, order scheduling, customer service):*

U: Feedback about how the forecast is improving (or not)

Now that the need for information is determined, it is time to determine how the information should get to the right place in the right form, at the right time. Information transfer can be done in countless ways; meetings, brochures, training, reports, telephone calls, etc.
In the following table I will propose ways to transfer information for every specified information need.

Table 4: Information management

Information need	Information transfer	Transfer frequency	Information supplier
1A,1E	Enlightenment session forecast inaccuracy	Once	Customer service managers
1B,1F	Enlightenment session forecast effects	Once	Customer service managers/Order scheduling
1L,1K	Enlightenment session forecast necessity and benefits	Once	Sales office managers
1C,1I,1G,1H,1J	Enlightenmentsession responsibilities/authorities of all sales people	Once	Sales office managers
1D	Training in forecasting techniques	Once	External expert
2M	Navigator report that shows history in one overview*	Weekly	Report *input* is delivered by inside sales themselves
2N	Written report that includes all relevant changes *	Monthly	Technical Service Managers
2S	Written report about business developments*	Monthly	Marketing managers
2O	Short (oral) update about contracts etc.	Weekly	Outside sales representatives
2P	Telephone call	At occurrence	Order scheduling
2Q	Update about stock levels by phone or by Tank Telemetry	Weekly	(Key) Customers
2Q	Short phone call by inside sales to the customer	Weekly	(Key) Customers
2R,2U	Inaccuracy measurement	Monthly	Customer service manager Rozenburg
2T	Inaccuracy measurement	Every six months, difficult ones; every two months	Outside sales representatives

* already available records

The information requirements mentioned in this table should be fulfilled when the decision to improve the forecast is taken.

Information needs 2M to 2P should be especially emphasised in the peak and fall removal forecasting process. Key customers are customers that have a high contribution to the total forecast inaccuracy.

Motivation at sales offices to make a good forecast is so low, that I argue for the use of the monthly MTF inaccuracy measurement as a Key Performance Indicator (KPI) for the inside sales people. If sales people are not held accountable for the quality of the MTF, I fear that they will not be too eager to spend time on forecasting. This is mainly caused by the fact that sales does not suffer the consequences of a bad forecast.
By making Medium Term Forecast inaccuracy one of their KPI's, the sales people will be forced to put an effort in it.

8.4 Conclusions and remarks

* The first and most crucial steps in improving the MTF are the increasing of motivation and the structuring of information flows
* The accurate gathering and keeping of information is crucial; especially in using historical data to make a forecast
* The success of the implementation of the proposed forecast method relies for a major part on the commitment of the sales offices to make a good Medium Term Forecast
* The sales offices are still quite dependent on the customer to make a good forecast

Chapter 9: Evaluation of possible forecasting methods

9.1 Introduction

This chapter will handle the analysis of the (possible) benefits of the proposed forecasting methods. The only new forecasting method that can be evaluated quantitatively at this time is the Time Series Analysis (see Chapter 7) for products from cluster 2A.

Chapter 5 already determined the required inventory level in the current situation for a fastmover (Suprasec X2700).
The fastmover was chosen from the group of products from cluster 2A.
This chapter will give the same calculation in two new situations where:

1. Forecasting is done by the inside sales people and peaks and falls identified and removed
2. Forecasting is done by Time Series Analysis and peaks and falls are (of course) removed

Because it is not yet possible to make a good TSA (see Chapter 8), the forecast as it would be when using TSA is simulated by a 4-week moving average.
Clear seasonal patterns are filtered out of the demand pattern, assuming that TSA would detect them.

There are two situations calculated and not just one, in order to see whether *besides* peak and fall removal, the forecast should be made by the inside sales people or by TSA.

Correct data are available from week 25 to week 51 in 1997, so in total 27 observations of forecast inaccuracy were made (per product). That is not very much, but at the moment it is all that is available.

Other proposed forecasting methods cannot be evaluated for several reasons (mentioned in Chapter 7), so the use of these methods cannot be determined quantitatively (yet).

9.2 Evaluating the use of peak and fall removal for the fastmover Suprasec X2700

Annex 7 shows the calculation of forecast error after the peaks and falls are removed from the demand pattern of X2700. This demand pattern is compared to the MTF that was made by the inside sales people and forecast errors were determined.

The peaks and falls are marked in red. In week 34 and 35 a seasonal fall was detected; holiday period.
In week 46 a fall was detected that was not predictable; caused by the haulier strikes in France. This fall was removed from the demand pattern.

The maximum positive deviation after peak and fall removal is now 60 tonnes; 100 tonnes less compared to the current forecasting situation (see paragraph 5.6). The savings in interest costs that are made by not having to keep 100 extra tonnes in stock are:
100.000kilos*fl.2,52*10%*7/365=fl. 483,- per week.

Annex 7 shows a detailed description of how the forecast with peak and fall removal must be done by the inside sales people and how much time is spent on each action.
In total, the time that is spent on making a forecast for the X2700 is: half an hour per customer per week.
The X2700 has five customers, resulting in the weekly forecasting costs of:
fl.100,-*0,5*5=fl.250,-.

The forecasting costs before were 1.5 hours for (on average) 15 customers; about five minutes per customer. Costs: fl.100,-/12*5=fl.41,- for the five customers per week.
The **additional** costs for the new forecasting method are: fl.250,--fl.41,-=fl.209,- per week.
So the savings of removing peaks and falls are fl. 483,- per week in interest costs and the additional forecasting costs are fl. 209,- a week. The net savings are thus fl. 274,- a week; not a huge saving, especially since the (non-recurrent) costs of training and informing the sales people are not even incorporated.

However, there are several non-quantifiable reasons for investing in medium term forecasting that are important to ICI:

* With a good MTF raw material requirements are better predictable
* ICI's strategy incorporates the goal of having as little cash tied up in inventory as possible; every decrease in inventory is appreciated
* Customers can be notified beforehand on whether their order will be delivered in time or not; a good MTF contributes to a good customer service

ICI may decide to invest in MTF for these reasons.

Remark: other products in this category all have smaller peaks and falls than the X2700, meaning that the filtering process for these products will be even less beneficial. Forecasting costs for these products are about the same; the amount of customers ranges from three to six.

9.3 Evaluating the usefulness of TSA in addition to peak and fall removal for the Suprasec X2700

At the moment, it is not yet possible to correctly evaluate the TSA for usefulness. This is due to several factors:

* Weekly data are only available from April 1997 on; that is not even one year which is quite little for trend determination and insufficient to determine seasonal factors
* Peaks and falls cannot be filtered from historical data; they were not registered then
* TSA strongly relies on the good filtering of peaks and falls, which in turn relies strongly on the performance of the inside sales people. The motivation of the inside sales people therefore also determines the success of the TSA.

When there are more data available to use in making a TSA, it is possible to evaluate the usefulness of TSA into detail.
The time that is necessary to test the TSA depends on how accurate an evaluation is desired. Time Series Analysis performs the best if a lot of historical data are available. Because a 52 week moving average is required, one will need at least a year to *make* a TSA. This means that TSA forecasting can be started in April 1998.
You can start evaluating this forecast as soon as data about actuals are available; after one week. However, for determining seasonal factors, it is desirable to have as much seasonal factors as possible. If you start with one year history, there is only one seasonality factor per period (week) available. For two factors per period, another year of history is required. Considering that ICI will want to know the applicability of TSA as soon as possible, a testing phase of six months to a year is more practical.

Steps in evaluating the TSA for usefulness:

1. Calculate the forecast error by subtracting the TSA forecast from the actuals
2. Calculate the mean and standard deviation of forecast error; for more than 20 weeks (n>20), you may assume that the frequency distribution is normal.
3. Determine the desired service level (in this case this is set by management:97%)

Assumption: I have to assume that if an order is not forecasted, it is not delivered FCD. In practice, an order that is not forecasted is usually delivered *in time* anyway, but the effort that is put in is considerable, meaning it costs ICI money.
Also, TSA predicts *total amounts* per product, not separate orders. So I have to assume that if 97% of demand was forecasted, that also at least 97% of all orders were forecasted.

4. Calculate the total demand over the n periods
5. Determine the part of the total demand that needs to be covered by either forecast or inventory; in this case that is 97% (based on the service level). Three percent of demand is allowed to be not covered.
6. Say three percent of total demand is 3 tonnes. Then calculate the chance that the forecast error is larger than 3 tonnes, assuming a normal frequency distribution
7. The level of the safety stock should then be: $k*\sigma_l$ where k is the chance that the forecast error is larger than the specified portion of total demand and σ is the standard deviation of forecast error over the lead time
8. Calculate the costs of keeping the safety stock by multiplying the safety stock level to the costs of keeping stock. The costs of keeping stock are determined by interest costs and storage costs (depreciation costs of shore tanks)
9. Make an estimate of the total time that is invested in making the MTF by TSA: the forecasting costs
10. Compare the forecasting costs and the stock keeping costs to the costs you have if you don't change the forecast.

Remark: if there is a structural over-prediction in the TSA, all demand will be forecasted, but that does not mean that the TSA was accurate. Therefore, a last check must be done:

11. As a last check, the chance for over-prediction (being the chance that the forecast error is negative!) must be determined and evaluated for acceptability

The outcome of this evaluation will indicate whether TSA should be applied in practice or not. If TSA turns out to be not accurate enough to use, it is clear that history does not give enough indication about the future to base a forecast on.

To be able to make a quick estimate of the usefulness of TSA *now* and to avoid to complicated calculation with several assumptions, the TSA is simulated by using a 4-week moving average. Clear seasonal patterns (for instance in week 34 and 35) are filtered out of the demand pattern, assuming that TSA would have covered those. The period of four weeks has been chosen by trial and error; four weeks was the most suitable period.
Again, this is done for the Suprasec X2700.

Remark: as mentioned in Chapter 4, the first week ahead is 'frozen' for making the forecast; the MTF may only be made for two or more weeks ahead. So the 4 week moving average for week 40 is based on the sales data of week 35 t/m 38!

Annex x shows the result of the 4-week MA forecast for the X2700. The maximum remaining forecast inaccuracy to be covered by inventory is now also 60 tonnes.
That is, TSA as opposed to the inside sales people's 'best guess' is not expected to make a large contribution in improving the MTF.

9.4 Conclusions and remarks

* Based on savings made in inventory costs, TSA itself is not recommended
* The filtering process of peaks and falls that was initially meant as a preparation of data for TSA turns out to be the most beneficial action for improving the MTF
* The gathering of information and the interpretation of it are the most important factors in improving the forecast
* Non-quantifiable reasons for improving the MTF are very important to ICI

Chapter 10: Implementation proposal

10.1 Introduction

As mentioned in the introduction of Chapter 7 there are two areas of improvement: the forecasting method itself and the facilitating conditions for the environment.
For both areas, different proposals are made, described in Chapters 7 and 8.
Evaluation of the proposals was done in Chapter 9.
This chapter will discuss which proposals should be implemented and how.

Based on the calculations in Chapter 9, improvement of MTF for items from cluster 2A will not lead to major savings in inventory requirements.
However, ICI wants to invest in improving MTF anyway (for reasons mentioned in Chapter 9), starting with the products from Cluster 2A and 2B. So a proposal for implementation of the strategy will be given after all.

10.2 Implementation of facilitating conditions and peaks and falls analysis

Chapter 9 indicated that the most profit is to be gained with the removal of peaks and falls. An additional TSA does probably not give any significant additional savings. Therefore it is recommended to start with implementing the peak/fall incorporation and related facilitating conditions and in six months to a year, test the TSA in detail for usefulness.

Chapter 8 already described in detail (in the information table) how the facilitating conditions for making an MTF need to be implemented. The information table also contains the information strategy that is required to identify and quantify the peaks and falls.
Annex 13 gives a manual for the inside sales representatives that can help them to make an MTF step by step. It shows how demand is built up, what is predictable and what is not, where to pay the most attention to and how much time it will all take.
Especially the information flows need attention.

A start of implementation can be made by doing a pilot implementation project. A pilot project can show clearly how the proposed actions influence forecasting accuracy and can indicate any unexpected problem areas.
If the pilot project succeeds, the implementation of forecasting strategies can go ahead for all sales offices.

The French sales office has already indicated that they are very willing to improve their forecast, but that they do not know how; they have asked Rozenburgs customer service manager for help.
That means that the French sales people are motivated to work on their forecast and will co-operate with the implementation of changes.
Also, the French sales office has been visited and sales people have been interviewed about Medium Term Forecast.
This makes the French sales office a good candidate for the pilot project.
A customer service team from Rozenburg will go to Paris to inform and train the sales people and to set up the required information structure.

The project will start with trying to improve the forecast of key customers; customers who contribute the most to forecast inaccuracy.

If the implementation succeeds for these products, then it can be considered to implement the same motivation and information recommendations as described in Chapter 8 also for the clusters other clusters, peaks and falls analysis excluded.

10.3 Practical issues concerning implementation

Someone must be responsible for clustering the products into the different categories. It is not impossible that during this process, other categories appear. Especially because the product assortment is quite variable.
The clusters need to be revised twice a year in order to keep up to date with new products, rejected products and changing demand patterns.
New clusters may arise and existing ones may disappear. The business modeller will be responsible for the update of the clusters.

Chapter 11: Conclusions and recommendations

11.1 Introduction

In this final chapter I will discuss the most important conclusions I have drawn and the recommendations that are in line with those.
The recommendations are extensively described in previous chapters and I will inventorise them in short in the paragraph 11.3.

11.2 Conclusions

The most important conclusions I have drawn are as follows:

* The MTF as it is being made now is very inaccurate on a customer/product level
* The effect of MTF on production is less, but still significant (end product level)
* The cost savings (in terms of inventory requirements) to be gained in improving the forecasting method are not very high; investment in the improvement of MTF is not a necessity from this point of view
* However, this conclusion is based on quantifiable costs of keeping inventory only! Non quantifiable benefits of an improved forecast (such as better estimate of raw material requirements and timely prioritisation of customer orders) are also of great importance to ICI
* Motivation at the sales offices to make a reliable MTF is very low
* Information about the effects of MTF inaccuracy is not common knowledge; especially at the sales offices
* The 'double' relationship with the customer makes it hard to persuade them to co-operate in making a good forecast; the customer is powerful, certainly if ICI is not the only supplier. Still, ICI is very dependent on the customer for making a good forecast, especially when it comes to entirely new products
* The one theoretical model (TSA) that may be applicable in this environment, has proven not to be any better than the inside sales people's best guess
* Success in making a good Medium Term Forecast relies strongly on the effort and motivation of the forecasters themselves; the inside sales representatives. This is mostly determined by the fact that they are responsible for acquiring, studying and interpreting the necessary information and that information is crucial in making the MTF
* It is very likely that the situation in terms of capacity availability, demand patterns and product portfolio will change in time; the forecasting strategies and defined clusters should be reviewed regularly to be updated
* Because the reasons for improving the forecast are mostly non-quantifiable, it will be more difficult to explain to the involved parties (especially the inside sales people of course) why the need for improvement is so high and to convince them to co-operate

11.3 Recommendations

* Before anything, it must be communicated throughout the organisation (especially the sales offices!) how inaccurate the Medium Term Forecast is at the moment and why there is a need for improvement. If there is no notion of the possible consequences of MTF inaccuracy, nobody will feel an obligation to do something about it. The importance of these issues should be communicated as described in table 4.

* Motivation at sales offices to make a good forecast is so low, that I argue for the use of the monthly MTF inaccuracy measurement as a Key Performance Indicator (KPI) for the inside sales people. If sales people are not held accountable for the quality of the MTF, I fear that they will not be too eager to spend time on forecasting. This is mainly caused by the fact that sales does not suffer the consequences of a bad forecast.

By making Medium Term Forecast inaccuracy one of their KPI's, the sales people will be forced to put an effort in it.

* Of course, one of my recommendations is that the strategies as described in chapter 8 (information management table) and 9 (pilot project) will be implemented.
* Recommended strategies for the clusters are as follows:

Cluster 1A: Do not bother in trying to improve the MTF; the only purpose would be the better estimate of raw material requirements and considering the small amount of orders, the benefit will be small.

Cluster 1B: Improvement of MTF could be justified with the argument that it would improve customer service. In this case improvement should be sought in contacting the customer more intensively for the timing of orders.

Cluster 2A: TSA is not recommended, peaks and falls analysis can be used to bring down MTF inaccuracy. Reason for implementing it would be cash targets, better raw material and better capacity requirement estimates.

Cluster 2B: Improvement can be justified by the possible increase of customer service. This cluster contains products with high sales volumes and high peaks and falls; it is also important to have a good raw material requirement estimate for products in this cluster. The forecasting strategy is the same as for cluster 2A.

Cluster 3: Because products in this cluster have not been forecasted yet, there is no question of *improvement* of the forecasting method. Strategy would be to intensify the relationship with the customer; the main source of information.

Literature

1. "Decision systems for inventory management and production planning" by Edward A. Silver and Rein Peterson, Second Edition 1979
2. "Introduction to probability and statistics" by William Mendenhall and Robert J. Beaver, Ninth Edition 1994
3. "Forecasting, methods and applications" by Spyros Makridakis, Steven C. Wheelwright and Victor E. McGee, Second Edition 1978
4. "Forecasting techniques in logistics" by Sander de Leeuw, Karel van Donselaar and Ton de Kok, First Edition 1997
5. ICI Factbook 1997

Forecasting: a company's fuel?

Annexes

by Miranda van den Oetelaar
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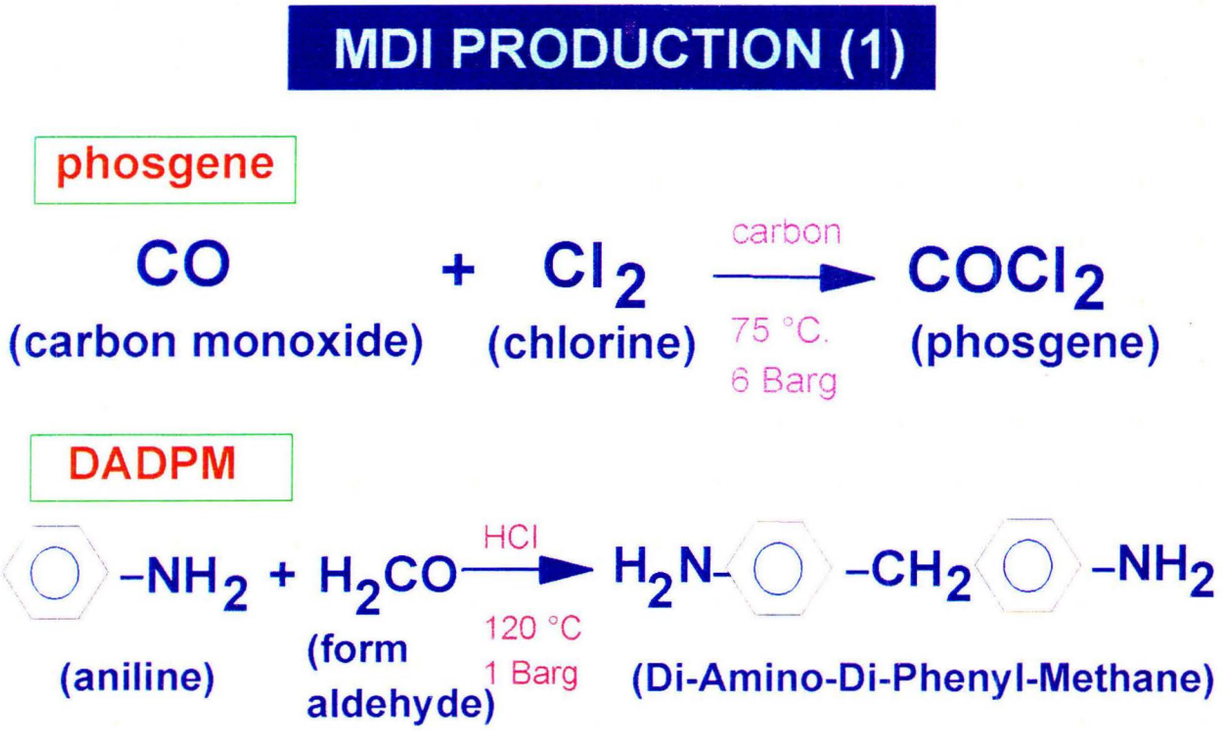
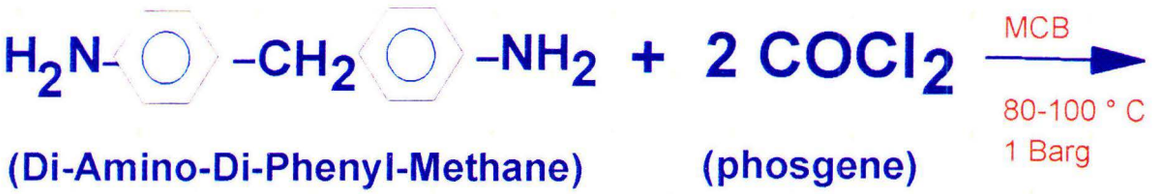
Annex 1: MDI production process reactions



MDI PRODUCTION (2)

phosgenation



(Di-Amino-Di-Phenyl-Methane) **(phosgene)**

Di-Isocyanate-Di-Phenyl-Methane (MDI)

Annex 2: Forecast error of Bertrand Faure France (last adjusted MTF)

Actual deliveries versus MTF

	Week:	23		24		25		26		27	
		MTF	orders	MTF	orders	MTF	orders	MTF	orders	MTF	orders
Product:	X1040	20000	20000	0	0	0	20000	20000	0	0	19900
	X2701	20000	0	20000	38480	20000	39240	40000	67520	0	19360
	S2030	0	20240	20000	0	0	0	0	20060	20000	0
	X24	20000	0	20000	0	0	0	0	0	0	0

28		29		30		31		32	
MTF	orders	MTF	orders	MTF	orders	MTF	orders	MTF	orders
0	0	0	0	20000	20000	0	0	0	0
40000	38900	0	54100	40000	20000	20000	20000	0	0
0	20120	0	0	22000	0	0	0	0	0
20000	19920	0	0	0	0	0	0	0	0

Deviations: Actual deliveries minus MTF

	Week:	23	24	25	26	27	28	29	30	31	32
Product:	X1040	0	0	20000	-20000	19900	0	0	0	0	0
	X2701	-20000	18840	19240	27520	19360	-1100	54100	-20000	0	0
	S2030	20240	-20000	0	20060	-20000	20120	0	-22000	0	0
	X24	-20000	-20000	-20000	0	0	-80	0	0	0	0

Mean and standard deviation of forecast error

Product:	M	s
X1040	1990	11335
X2701	9796	22671
S2030	-158	16669
X24	-6008	9655

Annex 3: Calculation of worst case cost consequences of MTF inaccuracy

For every one of the five questions from the flowchart (figure 6), options and related cost consequenses in a worst case situation are as follows:
(All costs are rounded to whole guilders)

Primary process costs:

1. Sufficient raw materials?

    As mentioned above, all three options are valid in this case.
    -To the option of *'other supplier'* are no extra costs attached, because we have an agreement with our competitors that we help each other out. This option goes for MDI products only, because in case of external suppliers it is more common that an urgent delivery is requested.
    -An '*urgent delivery request'* is not possible in the case of MDI (our own factory) and in case of other products it only leads to additional costs if an extra driver (or some situation like that) is involved. For X2700 the raw materials are either from Marseilles or from Belgium. Because Belgium is very nearby, an extra driver is not of much use then. From Marseilles the price for an extra driver will be about fl. 2.000,-. But for 55 tonnes, you will need three tank trucks and therefore also three extra drivers. This will cost ICI; **fl.6.000,-.**
    -When using '*allocated raw materials*' the consequence is that other orders are postponed, which in turn has the consequence of having to keep certain not needed raw materials in stock. How many raw materials need to be stocked depends on the amount of postponed orders. The X2700 consists for 75% of Arcol 1374. The only other product that contains this raw material is the S2535 (56%). In order to get enough Arcol 1374 to make 55 tonnes of X2700, 73 tonnes of S2535 need to be postponed; two batches. S2535 also contains 27% of MI-15; also a raw material for X2700 (15%). So 73 tonnes of S2535 gives ±20 tonnes of MI-15, of which 8 tonnes are used for making the 55 tonnes of X2700. That leaves 12 tonnes to store.
    S2535 also contains 16% of X2185; 12 tonnes need storage. Further, X2700 and S2535 both contain the same very small (<0.5%) percentage of Arcol 3450. It is assumed that this can be kept in a small drum, with negligible storage costs.
    The X2700 is further made of 10% MPR (5 tonnes). To get these 5 tonnes, 5 tonnes of S2020 need to be postponed (99,9 % MPR); exactly one batch.
    So eventually, two times 12 tonnes of raw material need to be stored.
    In cases like this, storage is done in tank trucks which costs ICI fl. 140,- a day, per postponed product. Assuming that the raw materials can be used again the next day, storage costs are **fl. 280,-.**
    Interest costs for 24 tonnes of raw material are:
    24000kilos*fl.2,52per kilo/365*10%=**fl.16,-** per day.

2. Sufficient capacity?

    Since expansion of capacity on the short term is not possible (worst case!), purchase for resale is not done for the Variants and overtime is not possible for the reactors on which X2700 is made, only the postponing of other orders is an option.
    -X2700 is made in 20-40 tonnes batches. For 55 tonnes, two batches are made; two times 12 hours of reactor capacity. In this time, at most 80 tonnes of production could have been planned, meaning that 80 tonnes of raw material need to be stored.Assuming two different kinds of raw materials in a product; 4 tanktrucks are needed. This costs **fl. 560,-** in storage costs. Interest costs are **fl. 55,-** per day.

3. Immediate shipment to customers?

   If for some reason the end product can not be shipped to the customer immediately, it will have to be stored. If an order is not forecasted and has to be rush produced and transported, it is possible that transportation is not available immediately and the product has to be stored for a while. These storage costs have to be taken into consideration. I have to remark though that this is hardly ever the case, because a product can almost always be transported immediately, the price of rush transportation then is just higher. This is covered in item 5.
   Because X2700 needs about five days to 'grow' to an end product, immediate shipment to the customer is in principle never possible. But of course, if inventory is sufficient, there can be an immediate shipment from stock.

4. Enough storage capacity?

   Because there is virtually always immediate shipment to the customer, the issue of sufficient storage capacity is usually not addressed.
   -The option '*storage in tank trucks'* is possible though, but then with another cause. The batch size of X2700 is (only in emergencies) flexible between 20 and 40 tonnes. If you have an additional demand of less than twenty tonnes, you will have to make at least twenty. All the additional material you are forced to make has to be stored. If there happens to be no storage capacity available at that time, the material has to be stored in tank trucks.
   The rental of a tank truck (25 tonnes contents) is **fl.140,-** a day.
   Also, when storing, you will have to consider interest costs. Estimating the interest percentage at 10%, the interest costs are:
   (value of stored material * # days stored / 365 * 10%).
   In this case we are talking about two batches of 28 tonnes, so storage due to batch size requirements will not be necessary.

5. Timely transportation available?

   It never happens that there is *no* transportation available; our four hauliers cover all the demand we might have. For accuracy reasons this question should therefore be: is there *timely* transportation available? If an urgent delivery is necessary (worst case, so here it is), the most common choice for ICI is hiring an extra driver. Different routes are not so convenient.
   -If an extra driver is hired, that will cost us fl. 1.050,-; the price for a two way ride to Magny Vernois, where Bertrand Faure France is situated. Again, for 55 tonnes three tanktrucks and three extra drivers are needed: **fl. 3.150,-**.

Other costs

The costs that are mentioned above the primary production process and of course these are not the only forecasting related costs. There are:

1. *Control*; bad forecasting results in 'fire extinguishing', meaning all extra activities that are done in order to handle modifications that originate from forecast inaccuracy. These control costs include costs of handling claims and complaints, claims itself, arranging urgent deliveries, storage capacity and transportation and the SAP-alterations that have to be made.
2. *Communication;* employees have to communicate a lot more when forecast is not accurate; for example the allocation of material in case of no raw material availability or determining the necessity and use of urgent deliveries/transportations.

1. Control costs:

-*Claims:* in case things go very wrong, there will be a claim from a customer. The most important reason for a customer to file a claim, is when because of ICI's faults the customer's production goes down and they are not able to produce for a certain amount of time. Depending on the damage done to the customer (like the number of days the production was down and the costs of one day's production lost) the amount of the claim can range from **fl.10.000,-** for a smaller customer to **fl. 4 million** for a customer like BMW. This last situation is almost never the case though, because these kind of customers will get priority; ICI will think twice before not supplying them! But a claim from a smaller customer is not unrealistic and has to be accounted for. About forty times a year a claim of a certain amount is filed.

-*Handling of claims and complaints*: It is not likely that insurance is involved in case of losses due to forecasting inaccuracy, because we are not insured for these kind of events.

Usually, a claim or complaint comes in at the sales office, they send it over to the production sites to have it checked for validity, the results are sent back to the sales office and they inform the customer. In case of a complaint, the handling of it takes in total two hours (by sales and production personnel) in which a ten minute phone call with the customer is included. If there is a claim, meaning there is a demand for indemnification, there is even more time spent on negotiation with the customer and handling credit notas.

Handling costs of complaints are:

2hrs*fl.150,-+ 10minutes*fl.0,15=fl.301,50.

Remark: Not all late deliveries and other faults on our part lead to a complaint though. In at most 20% of the deviations, a complaint is filed.

A claim is researched more thouroughly, in total an entire day may be spent on it. However, if it is caused by forecast inaccuracy, it is clearly our fault and research does not have to take any longer than the time for a complaint: two hours. So the amount spent on claim handling is **fl. 301,-** per claim.

-*Arranging rush orders/transportations* usually takes no more than a single phone call, so I estimate that *in total* no more than fifteen minutes are spent on this: fl.100,-(hourly personnel costs)* 1/4= **fl. 25,-.** Transportation is always available; if one haulier is not available, the other will cover. The thing is that if we rush order, the costs of it are ours. This usually comes down to the costs of an extra driver, which are already incorporated.

-*SAP alterations:* when the forecast changes, the production plan changes too and therefore the data in SAP need to be changed as well. These SAP alterations take up a lot of time; approximately 60 minutes or **fl.100,-** spent on total personnel costs. These sixty minutes are the amount of time spent on SAP alterations by all supply chain employees, thus including transportation planning, production planning, order processing and purchasing employees. The estimate of sixty minutes of actions taken per forecast deviation is an estimate made by the employees themselves.

-*Allocation:* when orders have to be postponed, the choice about which orders that will be is made by the demand manager. He reviews customer status (how important, how much delay, consequences of delay at customer, etc.) and discusses his decision with planning. The more critical the postponement is, the more time it will take the demand manager to make a decision. In a normal case it will take him about 15 minutes. That 15 minutes include the phone calls made to planning (from the Everberg site to Rozenburg; fl.0,4 per minute), these calls take about 7 minutes. So, 15 minutes of the time of the demand manager: 0,25*fl.150,-=fl.37,50. The phone call costs: 7*fl.0,4=fl.2,80. Altogether the allocation process of one deviation costs: **fl.40,-**.

-*Customer:* customers who's orders are postponed have to be notified of such. This too should not take more than a single phone call, but that will be a longer call than usual, because the customer will not just stand there and listen that his order is delayed. He will at least need an explanation and will try to get his order after all.Phone call: 8*fl.0,15+ 8* fl.150,-/60= **fl.21,-**.

Medium Term Forecasting costs:

An estimate of what the forecasting costs are right now:

-*MTF:* every sales person spends about one and a half hours a week on making an MTF. In total, 30 employees are involved in making the MTF, this comes down to: 30*1.5=45 hours a week spent on forecasting, one forecast is made a week, so 45 hours are spent by all sales people in Europe to make one forecast for all their customers. Let's say that they all cost the same an hour, which is fl.100,- an hour. Fl.100,-*45= fl.4.500,-.These are only the costs of the time spent on forecasting. Because a lot of the time, about a fifth of it, is spent on communicating with the customer (usually by phone), also telephone costs have to be taken into consideration. These are:
1/5*45hrs*60min*fl. 0,15/min= fl. 81,-. This number is based on the Dutch rate of telephone costs during daytime within the country. The total costs of forecasting as it is done now add up to fl. 4.581,- per weekly forecasting operation for all Europe. Yearly this is: **fl. 238.212,-** spent on forecasting for Europe.

Annex 4: Absolute forecast inaccuracy per sales office

Mean and standard deviation of forecast error (in kilos) of a forecast made in a certain week by the respective sales offices

	Mean		Standard deviation		M+2std		Average Ranking
Sales office	Week 1	Week 2	Week 1	Week 2	Week 1	Week 2	
Benelux	754	30	10238	9125	21230	18280	9
Eastern Europe	280	365	6218	8421	12716	17207	4.5
France	-1573	1162	7471	6679	13369	14520	3
Mid Europe	-337	457	8760	7642	17183	15741	4.5
Iberia	646	1862	7208	9062	15062	19986	7
Italy & Greece	956	1448	9595	7740	20146	16928	6
Middle East	2305	1458	10302	7749	22909	16956	8
Nordic	196	-484	4509	4702	9214	8920	1
UK & Ireland	-776	-663	6641	7283	12506	13903	2

Annex 5: Relative forecast inaccuracy per sales office

	Week 1		Week 2		Week 3	
Sales office	**Total quantity**	**Total deviation**	**Total quantity**	**Total deviation**	**Total quantity**	**Total deviation**
Belgium	248543	231221	272941	159168	279128	209328
Eastern Europe	583753	617848	477285	505805	422037	305477
France	208762	202772	492405	381740	933124	797609
Germany	591670	666463	689294	430933	1001705	918576
Iberia	106182	64702	297690	256310	492500	417390
Italy&Greece	296283	316858	910607	772503	914200	982939
Middle East	270330	248574	681456	477333	352360	328735
Nordic	185773	138677	85630	134742	49285	178985
UK/Ireland	849569	697043	740956	645001	1109852	765413

Annex 6: Frequency distribution of forecast error on customer/product level

Frequency distribution of forecast error

Range	Frequency	%
< -100000	0	0
-90000 to -99999	0	0
-80000 to -89999	0	0
-70000 to -79999	3	0.05
-60000 to -69999	7	0.11
-50000 to -59999	0	0
-40000 to -49999	5	0.08
-30000 to -39999	9	0.15
-20000 to -29999	124	2.05
-10000 to -19999	96	1.59
-1 to -9999	733	12.15
0	4071	79.63
1 to 9999	721	11.95
10000 to 19999	127	2.11
20000 to 29999	91	1.51
30000 to 39999	18	0.3
40000 to 49999	12	0.2
50000 to 59999	5	0.08
60000 to 69999	1	0.02
70000 to 79999	3	0.05
80000 to 89999	1	0.02
90000 to 99999	3	0.05
>100000	3	0.05
	+	+
	6033	100%

Annex 7a: Forecast error of X2700 at current situation

X2700	Ordered quantity	MTF inside sales	Forecast error
Week			
25	181	180	1
26	109	140	-31
27	140	120	20
28	137	160	-23
29	155	100	55
30	119	120	-1
31	125	140	-15
32	100	100	0
33	140	80	60
34	40	40	0
35	78	100	-22
36	157	140	17
37	200	160	40
38	320	160	160
39	260	160	100
40	240	200	40
41	200	120	80
42	173	180	-7
43	100	220	-120
44	218	140	78
45	120	120	0
46	77	200	-123
47	140	140	0
48	160	160	0
49	260	180	80
50	200	180	20
51	139	140	-1

Frequency distribution of forecast error:			
Range:	Frequency	Chance	
<-150	0	0.0	
-140 to -149	0	0.0	
-130 to -139	0	0.0	
-120 to -129	2	7.4	
-110 to -119	0	0.0	
-100 to -109	0	0.0	
-90 to -99	0	0.0	
-80 to -89	0	0.0	
-70 to -79	0	0.0	
-60 to -69	0	0.0	
-50 to -59	0	0.0	
-40 to -49	0	0.0	
-30 to -39	1	3.7	
-20 to -29	2	7.4	
-10 to -19	1	3.7	
-1 to -9	3	11.1	
0	5	18.5	
1 to 10	1	3.7	
11 to 20	3	11.1	
21 to 30	0	0.0	
31 to 40	2	7.4	
41 to 50	0	0.0	
51 to 60	2	7.4	
61 to 70	0	0.0	
71 to 80	3	11.1	
81 to 90	0	0.0	
91 to 100	1	3.7	
101 to 110	0	0.0	
111 to 120	0	0.0	
121 to 130	0	0.0	
131 to 140	0	0.0	
141 to 150	0	0.0	
151 to 160	1	3.7	
>161	0	0.0	

Annex 7b: Forecast error of X2700 with peak and fall removal, forecast by Inside Sales

X2700	Ordered quantity	MTF sales	Forecast error
	After peak and fall		
Week	removal		
19	19		
20	55		
21	57		
22	100		
23	20		
24	135		
25	181	180	1
26	109	140	-31
27	140	120	20
28	137	160	-23
29	155	100	55
30	119	120	-1
31	125	140	-15
32	100	100	0
33	140	80	60
34	40	40	0
35	78	100	-22
36	157	140	17
37	140	160	-20
38	180	160	20
39	160	160	0
40	180	200	-20
41	160	120	40
42	173	180	-7
43	100	220	-120
44	180	140	40
45	120	120	0
46	150	200	-50
47	140	140	0
48	160	160	0
49	200	180	20
50	200	180	20
51	139	140	-1

Frequency distribution of forecast error:			
Range:	Frequency	Chance	
<-60	1	3.703704	
-50 to -59	1	3.703704	
-40 to -49	0	0	
-30 to -39	1	3.703704	
-20 to -29	4	14.81481	
-10 to -19	1	3.703704	
-1 to -9	10	37.03704	
0	0	0	
1 to 10	0	0	
11 to 20	5	18.51852	
21 to 30	0	0	
31 to 40	2	7.407407	
41 to 50	0	0	
51 to 60	2	7.407407	
>61	0		

Annex 7c: Forecast error of X2700 with TSA including peak and fall removal

Week	Ordered quantity After peak and fall removal	MA Forecast	Forecast error
19	19		
20	55		
21	57		
22	100		
23	20		
24	135		
25	181	135	46
26	109	135	-26
27	140	158	-18
28	137	142	-5
29	155	141	14
30	119	142	-23
31	125	135.25	-10.25
32	100	137.75	-37.75
33	140	134	6
34	140	124.75	15.25
35	140	121	19
36	157	126.25	30.75
37	140	130	10
38	180	144.25	35.75
39	160	144.25	15.75
40	180	154.25	25.75
41	160	159.25	0.75
42	173	165	8
43	100	170	-70
44	180	168.25	11.75
45	120	153.25	-33.25
46	150	153.25	-3.25
47	140	143.25	-3.25
48	160	137.5	22.5
49	200	147.5	52.5
50	200	142.5	57.5
51	139	162.5	-23.5
52	40		

Frequency distribution of forecast error: X2700

Range:	Frequency	Chance	
<-60	1	3.7	
-50 to -59	0	0.0	
-40 to -49	0	0.0	
-30 to -39	2	7.4	
-20 to -29	3	11.1	
-10 to -19	2	7.4	
-1 to -9	4	14.8	
0	0	0.0	
1 to 10	3	11.1	
11 to 20	5	18.5	
21 to 30	2	7.4	
31 to 40	2	7.4	
41 to 50	1	3.7	
51 to 60	2	7.4	
>61	0		

Total # obs.: 27

Annex 8: Forecast error of Suprasec 2020 with current forecasting method

Week	Ordered quantity	MTF sales	Error
14	18	40	-22
15	17	20	-3
16	9	40	-31
17	0	20	-20
18	0	40	-40
19	0	20	-20
20	36	60	-24
21	8	20	-12
22	27	20	7
23	20	20	0
24	9	20	-11
25	19	20	-1
26	20	10	10
27	19	0	19
28	29	0	29
29	20	10	10
30	0	0	0
31	40	40	0
32	0	10	-10
33	50	0	50
34	0	0	0
35	0	0	0
36	20	30	-10
37	30	0	30
38	20	20	0
39	19	0	19
40	20	0	20
41	20	10	10
42	10	0	10
43	38	40	-2
44	0	0	0
45	20	40	-20
46	30	30	0
47	20	0	20
48	0	0	0
49	37	40	-3
50	10	10	0
51	15	40	-25
52	0	0	0
1	0	0	0
2	40	20	20
3	33	0	33

4

Frequency distribution of S2020 forecast error

Range	Frequency	Chance
<-50	0	0.0
-40 to -49	1	2.4
-30 to -39	1	2.4
-20 to -29	6	14.3
-10 to -19	4	9.5
-1 to -9	4	9.5
0	12	28.6
1 to 10	5	11.9
11 to 20	5	11.9
21 to 30	2	4.8
31 to 40	1	2.4
41 to 50	1	2.4
51 to 60	0	0.0
>61	0	0.0
Total # observations:42		

Annex 9: Example of demand pattern file

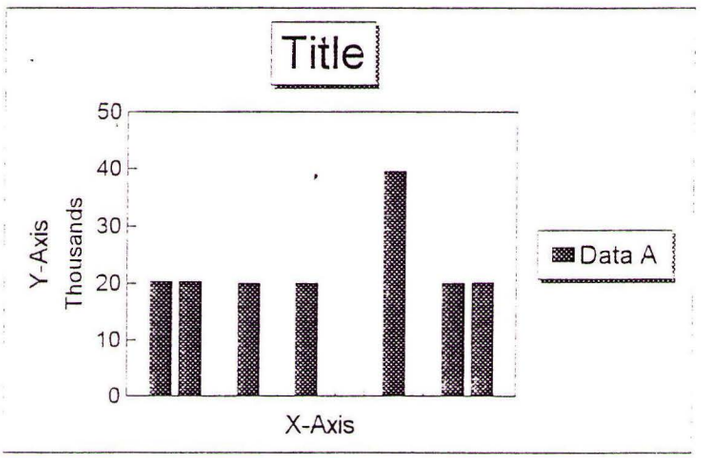
Sales orders for Plant: PU Rozenburg with a minimum Required delivery date: 1997-03-28

Required Delivery Date	Promised Delivery Date	ro Line	ateri Type	Material Code	Material	Customer	Plant Code	Order Ref	Sales Organisation Code	Total Quantity Kg
01-Apr	01-Apr	MDI	BULK	100226	SUPRASEC X 2530 @BULK	SOMMER INDUSTRIE	RZ10	768	S080	20000
16-Apr	22-Apr	MDI	BULK	100226	SUPRASEC X 2530 @BULK	HP CHEMIE PELZER GMBH	RZ10	1464	S030	20000
06-May	06-May	MDI	BULK	100226	SUPRASEC X 2530 @BULK	HP CHEMIE PELZER GMBH	RZ10	3151	S030	20000
				100226	SUPRASEC X 2530 @BULK	SOMMER INDUSTRIE	RZ10	2473	S080	20000
22-May	22-May	MDI	BULK	100226	SUPRASEC X 2530 @BULK	SOMMER INDUSTRIE	RZ10	4355	S080	20000
05-Jun	05-Jun	MDI	BULK	100226	SUPRASEC X 2530 @BULK	SOMMER INDUSTRIE	RZ10	5248	S080	20000
11-Jun	11-Jun	MDI	BULK	100226	SUPRASEC X 2530 @BULK	HP CHEMIE PELZER GMBH	RZ10	6029	S030	20000
16-Jun	16-Jun	MDI	BULK	100226	SUPRASEC X 2530 @BULK	SOMMER INDUSTRIE	RZ10	6287	S080	20000
20-Aug	20-Aug	MDI	BULK	100226	SUPRASEC X 2530 @BULK	HP CHEMIE PELZER GMBH	RZ10	10074	S030	20000
09-Sep	09-Sep	MDI	BULK	100226	SUPRASEC X 2530 @BULK	HUKLA-WERKE GMBH	RZ10	10758	S030	22160
01-Oct	17-Oct	MDI	BULK	100226	SUPRASEC X 2530 @BULK	HUKLA-WERKE GMBH	RZ10	13785	S030	24000
15-Oct	17-Oct	MDI	BULK	100226	SUPRASEC X 2530 @BULK	HP CHEMIE PELZER GMBH	RZ10	14335	S030	20000

Report Description:

Report: C:\TOOLKIT\VRAAG.IMR

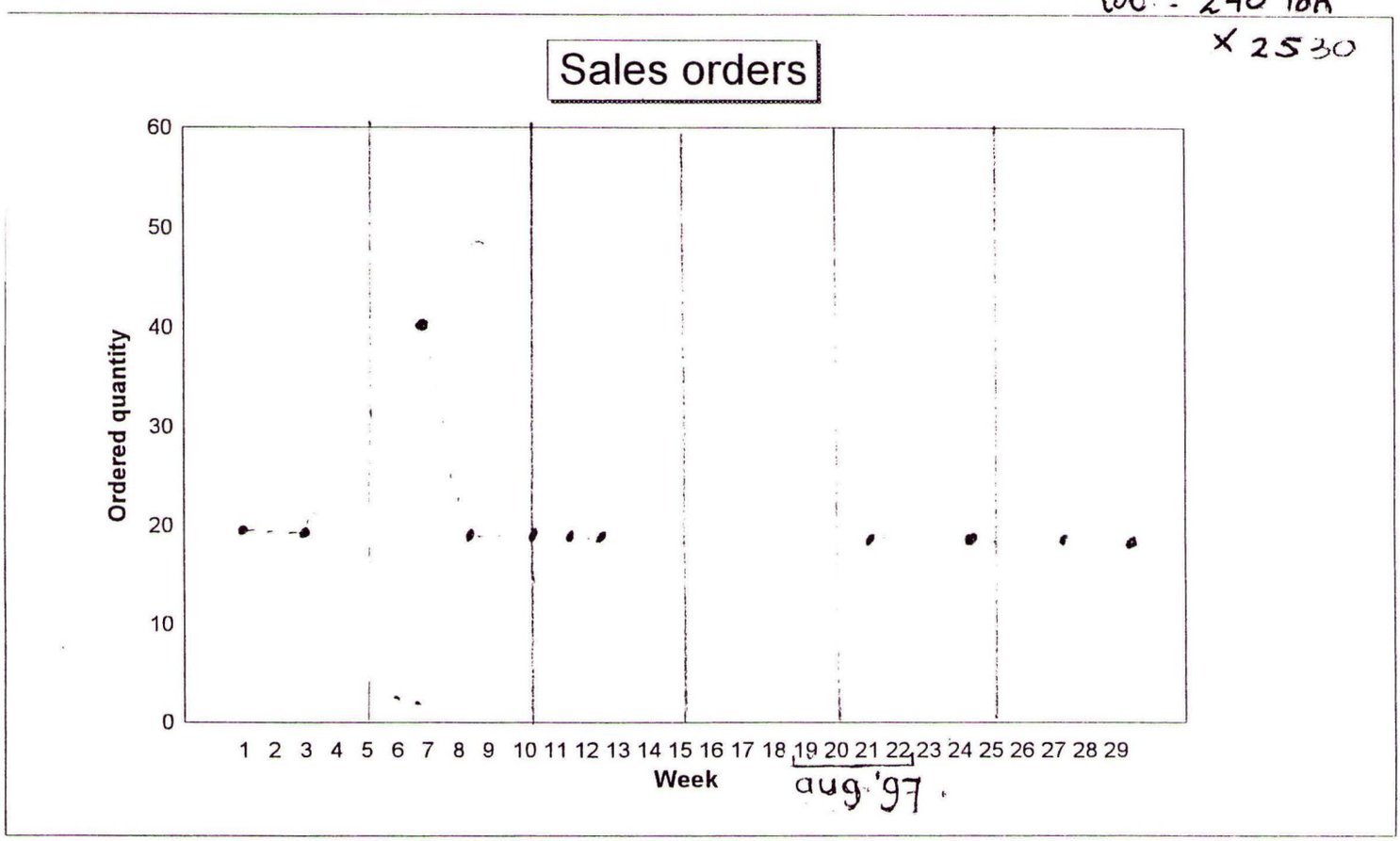
Year	Month	Material	Total (Volume Actual) No.1
1996	1	SUPRASEC X 2530 @BUL	20300
1996	2	SUPRASEC X 2530 @BUL	20260
1996	3	SUPRASEC X 2530 @BUL	0
1996	4	SUPRASEC X 2530 @BUL	19960
1996	5	SUPRASEC X 2530 @BUL	0
1996	6	SUPRASEC X 2530 @BUL	19960
1996	7	SUPRASEC X 2530 @BUL	0
1996	8	SUPRASEC X 2530 @BUL	0
1996	9	SUPRASEC X 2530 @BUL	39480
1996	10	SUPRASEC X 2530 @BUL	0
1996	11	SUPRASEC X 2530 @BUL	20020
1996	12	SUPRASEC X 2530 @BUL	20040



Material	100226	SUPRASEC X 2530 @BULK	
Material type	BULK	Finished Product in BULK	
Unit of meas.	KG	**Base unit**	KG

Cl/Cc/Plnt/SLoc/Batch D	Unrestricted use	Qual. inspection	Reserved
Total	**21.740,000**	**0,000**	**0,000**
NL01 PU Holland	**21.740,000**	**0,000**	**0,000**
RZ10 PU Rozenburg	[illegible]	0,000	0,000
RZ20 De Rijke Bottlek	[illegible]	0,000	0,000
B100 Roadtankers	21.740,000	0,000	0,000
RZB1038	500,000	0,000	
RZB1039	19.880,000	0,000	
RZB1041	280,000	0,000	
RZB1045	260,000	0,000	
RZB1046	320,000	0,000	
RZB1049	340,000	0,000	
RZB1050	160,000	0,000	

tot : 240 ton
× 2530



Annex 10: Compensation; effects of positive and negative forecast deviations on customer/product level on raw material requirements

	Total positive deviations			Total negative deviations			Compensation percentage		
Product	**Week 1**	**Week 2**	**Week 3**	**Week 1**	**Week 2**	**Week 3**	**Week 1**	**Week 2**	**Week 3**
MPR	146816	261809	184956	-84810	-134103	-51348	58%	51%	28%
Suprasec X 2185	138857	103123	97959	-99945	-69880	-108203	72%	68%	100%
MI-15	56901	77901	36367	-56971	-24305	-31056	100%	31%	85%
Cereclor S52	1458	1458	1610	0	-2916	0	0%	100%	0%
Arcol 1374	62790	65895	89760	-15000	0	-32685	24%	0%	36%
Daltocel P720	18178	30623	19479	-2527	-9940	-11056	14%	32%	57%

Annex 11: Detailed description of events that influence sales volumes

There are different events that have an influence on sales levels, some have a lasting (L) effect, others have only temporary (T) impact. Also, not all events are predictable.
First the unpredictable events will be mentioned and described, than the predictable events will be inventorised.

Unpredictable events:
* *Unplanned shutdowns of customers* (T) cannot be predicted, but you can prepare yourself for a demand peak immediately after the shutdown, when the plant is running again. Also, knowledge of shutdowns at customers in the past, planned or unplanned, can and must be used to identify structural demand patterns.

* The same goes for *shutdowns at competitors (T)* (for this range of end products; BASF and Bayer). However, if the competitor plans a shutdown, they will probably have enough stocks to cover for demand during the downtime. That means that the shutdown of that particular competitor will not influence our own sales levels. It will though if the shutdown was not planned. Than the competitor did not have any time to build up stock and therefore cannot meet demand. This demand will have to be met by other suppliers; us!

* In the beginning of November of 1997, a shift in sales volumes may also be noticed. The cause were the road blocks all around France, that were upheld by *striking* (T) truck drivers. Countries like Spain and Portugal could only be reached by boat or aeroplane and France could not be reached at all. Customers from those countries could order only small quantities (because of the increased transportation costs) or nothing at all. After the strikes, sales volumes increased to make up for losses.

* *War and political circumstances (T/L)* influence sales. A rather strange example is that during the time that Russia was in war with Tsjetsjenia and Afghanistan, the sales of Suprasec 2980 were quite high. S2980 is used in the Footwear sector to make shoe-soles. By the time those wars ended and army boots were no longer necessary, demand dropped dramatically.

Predictable events:
* *Planned shutdowns at customers (T)* can be predicted, that is, if the customer is willing to give us that information. If they are reluctant, a pattern may be deducted from the past demand figures of that particular customer.

* If ICI itself has a *planned shutdown (T)*, that should not influence demand patterns, because stocks have been built up to cover for demand. When ICI has an unexpected shutdown, two things can happen; customers can go to the competitor and sales will be lost, or customers can wait and a peak in sales level can occur when the plant is up and running again. When Variants end products are considered, the last option is likely to occur. Namely, when it comes to Variants products, ICI has very little competition. There are no competitors that make the exact same products. However, a competitor can offer a system that is used in the same application. For instance, ICI delivers X2700 to customers that make mattresses. The customer adds an MDI to this X2700 and together this makes the raw material for the mattress. There are no competitors that make the exact same product as the X2700, but there are companies that can deliver a *system* that also can function as a raw material for making mattresses. That is, they make two other products that can also be combined to make a mattress; just like the X2700 and the MDI can. So ICI does not have any competition on an end product level, but on system level. Fortunately,

this goes only for the application of very few Variants end products. For the larger part of the materials and corresponding systems, ICI is the only supplier of the customer.

* Another cause of a sudden peak in demand can be the *release of a new product (L)*. In the automotive industry this can be the release of the newest BMW model, in the footwear industry this can be the introduction of the latest Nike Air. If a product is suddenly introduced into the market, the distributors will need a starting inventory to be able to serve the customer. This can lead to sudden high demand that is placed on us.

* Also, *weather circumstances (T)* are important. If it suddenly starts to freeze for a longer period of time and construction cannot go on, that will first result in a downfall of demand and then, when the temperature goes up, the demand will be extra high. This is actually seasonal demand, but of course in Holland it is hard to predict how long and how intense it will freeze. Of course, there is always a discussion whether the weather is predictable or not!

* *Governmental issues* (L) like the introduction of a new law (safety, environmental), the granting of subsidies or approval of Letters of Credit can influence sales volumes for a longer or shorter period.

* Further influences are mergers, take-overs, bankruptcies and entrances to a new market (China).

Annex 12: Example of the effect of a peak in sales volumes

The table below gives an idea of how such demand patterns look. The weeks in June and July and the first week of September are normal weeks. The last three weeks of September (marked in red) are weeks in which a peak occurred. This peak was caused by the fact that one customer, Recticel, who is in the mattress business, had a big mattress sale. This caused a doubling of demand for Suprasec X2700 from Recticel in September which in turn caused a peak in total demand.
The table shows the total amount of orders that were placed and the amount of that that was from Recticel and the total quantities that those orders represented.

Week	Total amount of orders placed	Total quantity ordered (tonnes)	Amount of orders from Recticel	Total quantity ordered by Recticel (tonnes)
17-23 June	6	105	3	50
24-30 June	5	95	2	40
1- 7 July	8	160	4	80
8-14 July	7	140	3	60
15-21 July	5	100	4	60
1- 7 September	8	160	4	80
8-14 September	10	200	6	120
15-21September	14	280	7	140
22-28September	13	260	9	180

The total amount of customer orders per week is not very high; usually between 5 and 10.
It needs to be mentioned that X2700 is a very fastmoving product; all the other products have even less orders in a week.
Another example of a demand pattern from the TSA category is the demand pattern of Suprasec 2020.

Week	Total amount of orders placed	Total quantity ordered (tonnes)	Amount of orders of Petri	Total quantity ordered by Petri
1- 7 June	1	20	1	20
8-14 June	1	10	1	10
15-21 June	2	20	2	10
22-28 June	1	20	1	20
29 July-4 August	2	40	2	40
12-18 August	3	50	2	40

This table shows that the total amount of orders placed is usually one or two orders, equalling ten to twenty tonnes of S2020. In the two weeks of August in which a peak occurred (marked in red), the total amount ordered doubled, because Petri ordered double the usual quantity.

Annex 13: Forecasting manual for inside sales representatives

A. Demand patterns:
Demand is built up by the following elements:
1. Trend
2. Seasonality
3. Unexpected events that cause temporary peaks or falls in demand
4. Sudden but predictable events that cause lasting rises or falls in demand

ad. 1: Trend
-trend can be described as a gradual and **lasting** increase or decrease of sales volumes

ad. 2: Seasonality can be described as
-a **temporary** increase or decrease of demand that always occurs in the same period; for example: holiday periods, ski and other weather dependent seasons sale (discount) periods, end of the year/beginning of the year, etc.

ad. 3: *Unexpected* events that only have a *temporary* effect on sales volumes:
-strikes (roadblocks France)
-wars, political circumstances
-shutdown at customer
-shutdown at competitor
-shutdown at own plants (covering demand of other plants)
-the approval of a letter of credit (mostly customers from Middle-East or Eastern Europe)
-weatherconditions

ad. 4: *Predictable* events that have a *lasting* effect on sales volumes:
-new laws for environmental protection or safety laws (hypothetical: prohibition on using polyurethane insulation in refrigerators)
-new product introduction at a customer
-mergers, take-overs, bankruptcies
-entrance to new market (China)
-government subsidies

B. Steps in making a Medium Term Forecast:
The following steps must be taken in order to make a good Medium Term Forecast.
The steps are designed for making a forecast for *key customers*;it takes too much time to make a forecast like this for all customers. Moreover, it is not necessary, because the key customers are the ones that contribute the most to the forecast inaccuracy, meaning that their forecast need improvement the most.

The numbers between the brackets are the expected amount of minutes that are spent on the respective step for each key customer *per week*.

1. (5min) Look at the historical data in the X file; what is the normal quantity that is ordered by the customer? Use this quantity as the basis of the MTF.
Take into account any seasonal factors (under A1) you know of.

2. (incl. in 1.) What are the maximum and minimum ordered quantities? Keep this in mind in making the MTF!

3. (5min) Make sure that you have read the visitation reports of the outside sales representatives to your key customer; pay extra attention to indications of events mentioned under A4!

4. (1min) Stay up to date about the latest findings of the Technical Service managers at your key customer; either by reading the monthly TS reports or by calling the Technical Service managers once a month.

5. (5min) Call the outside sales representatives once a week to make sure that you are up to date of the newest developments at the customer.

6. (5min) Go through the checklist on page 1 and check whether you have taken all expected peaks and falls into account.

7. (10min) Last but certainly not least:
CALL THE KEY CUSTOMER EVERY WEEK AND DEMAND A FORECAST!!!
When calling the customer you will have to realise the importance of making a good MTF and try to bring over this idea to the customer; it is very important to both ICI *and the customer* to have a good Medium Term Forecast!
It is important that you call the customer every week at the same day, preferrably also at the same time. This way the customer knows that you will be calling and can prepare an answer.
Remark: compare the forecast of the customer to the one you already had in mind; if there is a difference, ask the customer why.

8. If the customer does not order every week, *timing* of the order is more essential than quantity! In this case, it is even more important to push the customer in co-operating in the forecasting process. In this case you can use the historical data also to estimate the timing of the order placement.

9. Even when the customer does not give you a forecast immediately, keep on calling them every week at the same time to ask for one.

In total it will take about half an hour a week to make a good forecast for one key customer.

C.Data recording:
In order to have a clear overview of all important historical data, events that are mentioned under items A3 and A4 should be recorded with the following details:
* Description of the event and on which customer/product it has an effect
* The time (=week-number) when it took place
* The effect that this event had (or still has) on sales volumes; try to quantify this as accurate as possible

Actual sales data will be shown and visualised in a simple graph in the X file. They will be based on the standard Navigator reports, so no additional effort will be necessary in keeping historical data in the form of actual sales volumes.