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European logics of shapes

a study of the design of an integral physical distribution structure for DSM Engineering Plastic Products Europe

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European Logistics of Shapes

Study on the design of an integral physical distribution structure for

DSM Engineering Plastic Products Europe

Jean J.M. Nijssen,
August, 1993

Abstract

This thesis describes the first stage of a study on the design of the physical distribution system for semi-finished products of DSM EPP in Europe. In this stage the company's customer service objectives are described, the actual physical distribution is analyzed and first investigations are done towards the distribution structure. Within the actual settings a physical distribution structure is proposed with national warehouses. Recommendations for further investigations are given.

Executive summary

This report describes the first stage of a study on the design of the physical distribution system for semi-finished products of DSM Engineering Plastic Products in Europe. This project was done within the framework of the curriculum of the Industrial Engineering and Management Science study at the Eindhoven University of Technology.

DSM Engineering Plastic Products is a division of the Dutch multinational DSM. It has been established in mid 1990, after a merger of two individually operating companies; Erta and Polypenco. The division's has a decentral structure, with geographically organized business units.

DSM EPP's core business is the production and sales of semi-finished engineering plastic products (called 'shapes'). They are divided into three major product groups. The production of shapes takes place in 5 production plants, located in four different countries in central Western Europe. Both Erta and Polypenco have strong market positions in central Western Europe, with own sales departments and own distribution centers.

For the distribution of shapes, different customer groups are distinguished; distributors, who are actually wholesalers, machine shops owned by DSM EPP and others. The customers are delivered either from production, or from the distribution centers. In general, all customers that are located in a country where DSM EPP has a distribution center, are delivered by that distribution center. Deliveries from production take place to customers outside these countries, that often are authorized distributors.

A problem is that Polypenco and Erta still operate relatively independent. In production several processes of the two groups already have been combined. In sales and distribution however they still act separately. Both companies have their own physical distribution structure, with distribution centers that only deliver customers of the own brand.

The competitive strategy of DSM EPP is to be a leader in logistic service. The company wants to provide daily shipments to its customers, with next day deliveries. The management wants to develop a concept for the design of an integrated physical distribution system that makes this possible. In the first stage of the project, that is described in this report, the aim was to "*make a proposal for a physical distribution structure for DSM EPP in Europe, in which 'next day deliveries' to all customers in central Europe are possible and to discuss what further should be done to improve the total physical distribution system*".

Scenarios have been introduced, to compare different physical distribution structures. The four scenarios that have been investigated are:

- The actual situation
- Distribution through (common) national warehouses
- Direct distribution
- One central warehouse

Also investigations have been done towards direct distribution only to big customers. This as an alternative on the actual situation.

In all scenarios the possibility of meeting the customer service objectives has been checked with transporters. It appeared that the scenarios with direct distribution and one central warehouse would not satisfy the customer service settings. Therefore a structure with common national warehouses for Erta and Polypenco has been worked out in detail.

The results of the design stage for this structure were, that a structure with:

- four distribution centers,
- combined with the production warehouses,
- within the national organization structures

was the most plausible alternative structure for the actual situation, with 10 warehouses in central Western Europe.

This structure has been compared with the actual situation in performance and costs. In both aspects the proposed structure outperforms the actual situation. Within a structure with national distribution centers, combining Erta and Polypenco distribution centers has proven to be obvious. Also the combination of the distribution centers with the production warehouses seem to be advantageous.

Because the double distribution structure of DSM EPP was one of the most striking remarks, which characterized the physical distribution system of DSM EPP, in this first stage of the project the investigations have been done to the design of a common distribution structure for Erta and Polypenco. In the course of the project however, it became clear that the customer service objectives and the premises that were applied for this study could be a point of discussion.

Although the study shows, that it is obvious that the physical distribution structures of Erta and Polypenco are merged, before being able to make conclusions about the ideal physical distribution structur, further investigations should be done towards the real customer service requirements of different customers for different products. It is also recommended that a sales information system is set up, which makes it possible to keep up customer service performance indicators like desired and performed availability and reliability levels.

Acknowledgements

This report is the result of the work that I have done during the nine months of my graduation project with DSM EPP. I would like to thank all the people who have been a support to me by ending my study in becoming an engineer in Industrial Engineering and Management Science. Some people I would like to give special attention.

Firstly I would like to thank all the members of the project group, especially Peter Verdonckt and Mark Naessens, who I worked with in close co-operation. Secondly a word of gratitude is faced to the attendants of the Eindhoven University of Technology; Corné Dirne and Sander de Leeuw for their supervision and advice during the total project and Mr. Van den Hurk for critically reviewing and correcting the many concepts of this thesis. Last but not least I thank my family for the support they have given me in the course of the total study.

Jean Nijssen
August, 1993

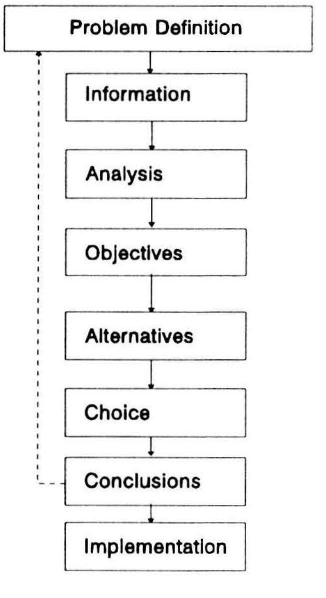
Contents

Introduction

This thesis describes the first stage of a study on the design of the physical distribution of semi-finished products for DSM Engineering Plastic Products in Europe. In this stage the company's customer service objectives are described, the actual physical distribution is analyzed and first investigations are done towards the physical distribution structure. The control and information system are not discussed here. They are part of the next stage of the project.

The approach of this study is as follows. After giving a profile of the company (chapter 1), and a problem definition for the total project (chapter 2), the first step of the study is an informational round. Information is collected to outline the actual situation and to base further investigations on concerning the physical distribution. This step is described in chapter 3.

The second step is the analysis of the information obtained. Here comments are given to the observations in the first step. This is done in chapter 4. Here also the customer service objectives are set to which the company wants to design the physical distribution system. In step 3 (chapter 5) the assignment for this stage of the project is defined. In step 4 (chapter 6), alternatives are introduced to be compared with each other in finding the best possible way to reach the objectives.



In step 5 a choice is made, that represents the proposed way to base further investigations on (chapter 7). This proposed alternative is compared with the actual situation in chapter 8. In the sixth step (chapter 9), conclusions are drawn. Here also the results of the first stage of the project are discussed and recommendations for further investigations are made. We will not go into detail about implementation in this report.

1. Profile

1.1 DSM EPP

DSM Engineering Plastic Products (DSM EPP) is a division of the Dutch multinational DSM. It is the umbrella organization of companies that are specialized in manufacturing and distributing plastic products that are used for engineering applications such as mechanical construction.

Erta was founded in 1933 by Robert Tavernier. In the early years the company produced buttons for clothes. Erta began its first activities in moulding after world-war II. During the years, acquisitions of Cestidur Industries in France and Sheffield Plastics in the U.S.A. took place. New companies like Axxis in Tielt were launched. The Erta group built on a leading position in the market of engineering plastics in Europe and overseas countries. In the late seventies DSM got interested in the company and took over all activities from the Tavernier family. DSM EPP has been established in mid 1990, after DSM got hold of the Polymer Corporation. This was one of the biggest competitors of the Erta group.

The Polymer Corporation has been an independently operating group of engineering plastic producing firms in North-America, Europe and Asia since the early nineteen fifties. Especially strong in North-America, the company's goal was to make fast profits. Owners changed every five to ten years, selling the company again and again with lots of profit. In 1989 the Polymer Corporation became part of DSM. In the division DSM EPP, the Erta and the Polymer group operate together. With its headquarters in Brussels (B), the division actually serves employment to more than 2000 people, from which 800 in Europe. The turnover of DSM EPP in 1992 was about 500 million Dutch guilders.

The division has been split into 3 operational regions: Europe, North-America and the Asia-Pacific region. The subsidiaries of the Polymer Corporation and the former Erta group in Europe form DSM EPP Europe, on which the remainder of this report is focused. It has a decentral structure, with geographically organized business units (profit centers). An organization chart of DSM EPP Europe is given in appendix 1.

1.2 Products

DSM EPP's core business is the production and sales of semi-finished engineering plastic products (called 'shapes'). They are divided into three major product groups. An overview of these product groups, with the materials, the shapes in which they are produced and their applications, is given in table 1.

Table 1 Product groups and their applications

Product Group	Materials	Shapes	Applications
3P	Nylon (PA) Polyacetal (POM) Polyester (PET)	Rods, tubes and plates	Mechanical construction, in many cases these materials replace and outperform metals.
PE	Polyethylene (PE)	Coloured plates	Less demanding mechanical construction and polyboards.
PC	Polycarbonate (PC) VIVAK	Transparent plates	Sound fences, switch boards, protection glass.

Both Erta and Polypenco are in the 3P business. The product ranges and qualities of both companies show some overlap for 3P products, but are not identical. Differences in production methods and (additional) materials, make that both companies have their specific product ranges. Before the merger, PE and PC were only Erta products.

In addition to the three major product groups, semi-finished products of High Performance Materials (HPM) are produced. These are enhanced plastics used in High-Tech mechanical construction. Other products the division produces are precision injection moulded parts, custom casted products and high performance plastic hose. For reasons that will be given later, these products are outside the scope of this project.

The division also owns several machine shops. Here the shapes are transformed into machined parts. Products that are made here are for instance bearings, gear-wheels, pinions and pulleys. Also transparent cut to size plates and polyboards are produced here. Almost all parts are made from shapes produced by DSM EPP Europe.

1.3 Production

The production of shapes in Europe takes place in 5 production plants. 3P products are made at Erta Epec in Tielt (B), Polypenco in Almelo (NL) and Polypenco Ltd. in Welwyn Garden City (UK). PC plates are made at Axxis in Tielt and PE at Cestidur in Balan (F). In table 2 an overview is given of which production plants produce what product groups.

The division produces 3P shapes with two different methods; extrusion and casting. After Polypenco's extrusion capacity in the United Kingdom was relocated to Erta Epec, the extrusion activities for both groups are brought together in Tielt. Casting is done in all three 3P production plants. The overlap in products in the sales programs of Erta and Polypenco is basically extruded 3P.

Table 2 Production plants and the products they produce

Product group / Method	3P Extrusion	3P Casting	PE	PC
Shape	R,T,P	R,T,P	P	P
Erta EPEC, Tielt (B)	●	●		
Axxis, Tielt (B)				●
Cestidur Industries, Balan (F)			●	
Polypenco b.v., Almelo (NL)		●		
Polypenco Ltd., Welwyn Garden City (UK)		●		

R=Rod T=Tube P=Plate

At Erta Epec all extruded products are produced in a cycle of about 6 weeks. For the other production plants the production cycle is about 2 weeks. Because the requested delivery times for catalogued products mostly are shorter than the production lead times, these products are produced to stock. The company also produces non-standard products, which are products from the same materials as the catalogued products, with dimensions that fall outside the standard range. These products are made to customer order only.

With a volume of almost 6 thousand tonnes per year, 3P products represent more than 50% of DSM EPP's total sales of shapes. PC and PE follow with respectively 3 and 2 thousand tonnes. Figure 1 shows the relative production volumes (weight) for the 5 plants.

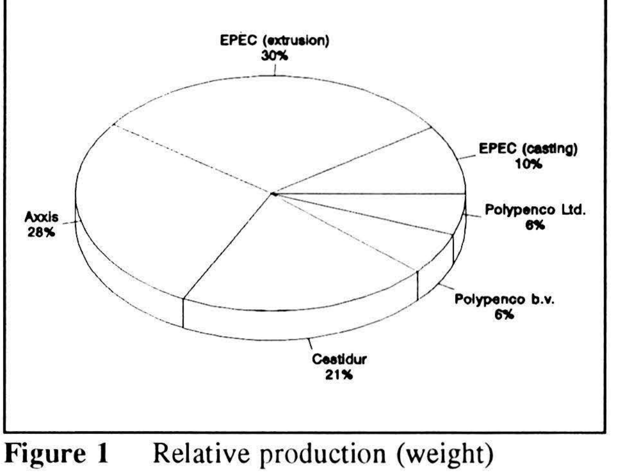


Figure 1 Relative production (weight)

1.4 Marketing & sales

Erta has strong positions in Belgium, France, Germany and the U.K., where it has own sales departments. In several other European countries Erta works with authorized distributors. Polypenco has sales departments in France, the U.K., The Netherlands, Italy, Spain, Belgium and Germany. With market shares of about 33% for 3P products, 12% for PC and 6% for PE, DSM EPP is the market leader in engineering plastic products in Europe.

Erta had an early entry in the European market of engineering plastics. It built on a network of relatively large customers. Its customers mostly operate in 'heavy' industries. Polypenco, who entered the European market later, had to build on a large network of smaller customers. Polypenco has more customers in the fine mechanical industries.

The customers of both Erta and Polypenco can be divided into 3 customer groups (table 3). In distribution theory and practice the term distributor is used only for companies that completely take over the stock keeping function of the produced products for one or more product-market combinations. In this company a distributor is seen as a customer that whether or not it keeps stock, sells the products without machining them. Both Erta and Polypenco do not work with distributors in the proper sense of the word. Although there is made a distinction between distributors and manufacturing customers, in the approach of the customers, the local wholesalers are treated in the same way as own machine shops and others. Only with authorized distributors individual customer service agreements are made.

Table 3 Different customer groups

Customer group	Customers
Distributors	Authorized distributors Local wholesalers
Own machine shops (OMS)	Machine shop DSM EPP
Others	Other customers like machinists and end-users

DSM EPP uses many different brand names. Although some extruded Polypenco products are exactly the same as the Erta products today, in the market the different brand names are said to be appreciated, because end-users and original equipment manufacturers often not only prescribe the material their products have to be made of, but also the brand.

The biggest competition is found in Germany, where companies such as Röchling Sustaplast, TKG and Technoplast are active. The strengths of these companies are high stocks of a limited product range (compared to Erta and Polypenco), and very competitive pricing strategies.

DSM EPP's competitive strategy is based on the assumption that for a customer, often a wholesaler, it is difficult to stock a representative range of products in a market with a lot of different products. If these products can be delivered by DSM EPP in short delivery times e.g. from stock, this can be a competitive advantage for the company. To bind the customer to DSM EPP, the company feels it should deliver small quantities to the customers on a daily basis.

The goals marketing has set for the future are to be outstanding in quality and costs, thereby serving the customer to its wishes. The slogan is: 'Bring the products to the customer whatever the time, the place, the quantity might be'. Appendix 2 shows a fax message that DSM EPP France sent to its customers to make clear the service the company pursues to give them.

1.5 Distribution

In the countries in Europe where Erta and Polypenco have sales departments, they have set up a distribution network to deliver the shapes to the local customers. When DSM EPP established, it held 24 distribution centers (DC's) in Europe. In 1993 the distribution centers with inventories have been reduced to 11. Figure 2 shows where the DC's are located.

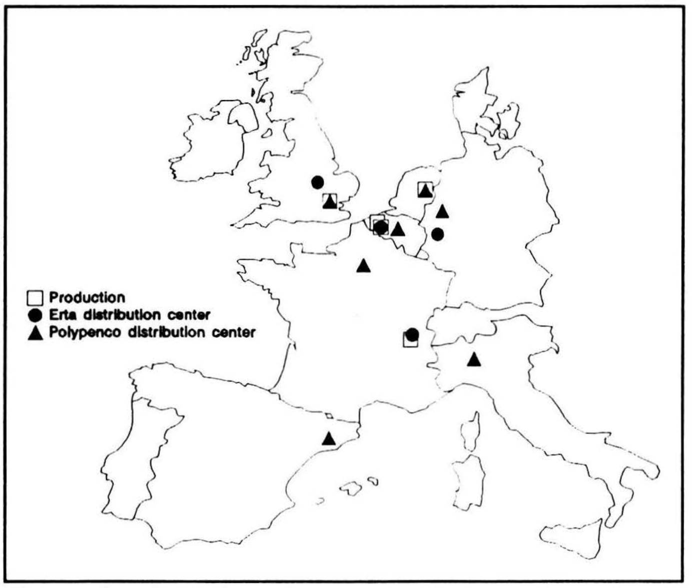


Figure 2 Location of the distribution centers

There is a one to one relationship between warehouses and sales offices. Most DC's are linked to an own machine shop. These are the DC's marked with 'OMS' in the first column of table 4. This table gives an impression of the product ranges of semi-finished products the DC's distribute. Most distribution centers are Erta or Polypenco specialized. After the merger, some Polypenco distribution centers distribute also PE and PC products.

At Polypenco in the United Kingdom and in the Netherlands, the production warehouses are also the DC. The DC's in Italy and Spain have been launched recently to penetrate the local markets. The main activity of the distribution centers in Belgium and Germany is the machining of parts. Now and then they also send unprocessed shapes to their customers.

Table 4 Distribution Centers and their delivery programs of stock shapes

Product group Method		3P Casting	3P Extrusion	PC	PE
Shape		R,T,P	R,T,P	P	P
Erta EPS Belgium, Tielt	OMS	•	•	•	•
Polypenco Belgium, Brussels	OMS	•	•		
Polypenco Netherlands, Almelo	OMS	•	•		
ERTA Germany, Lahnstein		•	•	•	•
Polypenco Germany, Bergisch Gladbach	OMS	•	•		
DSM EPP France,					
Erta EPS, Villeurbanne	OMS	•	•	•	•
Polypenco EPS, Savigny Le Temple	OMS	•	•	•	•
ERTA U.K., Northampton	OMS	•	•	•	•
Polypenco U.K., Welwyn Garden City	OMS	•	•		
DSM EPP Spain, Barcelona	OMS	•	•	•	•
Polypenco Italy, Milan		•	•	•	•

R = Rod T = Tube P = Plate
OMS = Distribution center linked to an own machine shop

The physical distribution is organized as shown in figure 3. After production, standard products are stored in the (5) production warehouses. From the production warehouses the products are shipped to either export customers outside the countries with DC's or to the (11) distribution centers. The DC's deliver the goods to the local customers including the own machine shops.

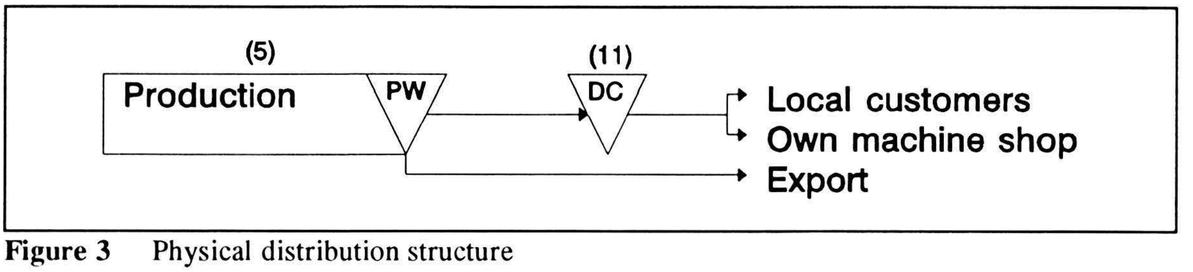


Figure 3 Physical distribution structure

2. Project description

2.1 Motive

In 1987 Coopers & Lybrand Management Consultants (C&L) analyzed the physical distribution of semi-finished products within the Erta group. The main conclusions of that study were that Erta had a product range that was too large, whereby the majority of the products added only a small sales volume. Further they noted high stock levels, low service levels, and a large number of small customers. Recommendations C&L made were to focus on product standards, getting rid of small customers by introducing minimum sales quantities. Also new packaging and handling methods were proposed to reduce costs. An overall distribution management and control system should be installed [1].

From the beginning there was resistance to the C&L concept. Unaccepted propositions were the rejection of slow moving products, because they are seen as 'service items', and the turning away of small customers and minimum order quantities. Also the lack of guidance during implementation lies at the root of this matter. The opposition to the C&L concept has been acknowledged by the group management. The actual insights are that serving the customers in small quantities and having a broad (standard) product range give the company a competitive advantage (see chapter 1). The assumption is that customers are easily driven into the hands of the competitors, that are able to deliver large volumes for low prices, when minimum order quantities are set.

2.2 Problem definition

The Polypenco and Erta companies still operate relatively independent. In production several processes of the two groups already have been combined. In sales and distribution however they still act separately. In the decentralized structure with separate national profit centers for both Erta and Polypenco, the shared vision of the management is that each subsidiary is working at improvements of its own distribution, while not thinking in terms of improvements for DSM EPP as a whole.

Neither of the two companies had an integrated physical distribution control system, nor do they have it now. The management wants to develop an integrated concept for the design of the physical distribution control that enables the company to give effect to its competitive strategy against minimal costs.

A complicating factor for the development of an integrated physical distribution concept is that in the decentral structure, with relatively autonomous subsidiaries for both Erta and Polypenco, overall information of the physical distribution activities is not available.

2.3 The project group

The writer of this report has been asked to help the company in developing structural improvements in physical distribution. However, for this project, full contribution from the subsidiaries is needed. Therefore, a project group has been formed that consists of logistics managers and directors of the 5 production departments of DSM EPP Europe. Herewith all product groups and both Polypenco and Erta participate in the project. The group is supported by the headquarters. The assembly of the project group is found in appendix 3.

Regularly meetings are arranged with the project group. Here the progress of the project and the results of the inquiries are discussed. Also the goals for the total project and for the different stages will be set in these meetings. The project team members regularly inform their ranks and files and get feedback from them.

2.4 Research model

The aim of this project is to design an integrated physical distribution concept for DSM EPP Europe. Figure 4 shows a model with the successive steps that should be taken when designing a physical distribution concept [3].

In the first step of this model, the competitive strategy for the company is determined. This competitive strategy can be recapitulated as 'being a leader in logistic service'. In the second step the customer service objectives are set. Customer service in our case is defined as 'everything that can be done to get the right products at the right time to the place the customer wants to have them'. The customer service objectives are outlined in chapter 5.

The third up to the sixth step concern the design of the physical distribution system. Although these steps, following the figure, do not have to be executed in strict sequence, it is recommended to firstly design the distribution structure, before the control systems, the information systems and the organization around physical distribution. This sequence can be compared with the P-C-I model [5]. In this model the P stands for Processes, the C for Control and the I for Information. The thought behind the P-C-I model is that before information systems can be designed, the control structure has to be attuned to the chosen processes. In our case the process is the structure in which physical distribution takes place.

After a control system has been set up, customer service performance indicators can be made, to control the performance. The customer service performance indicators give measures about for instance availabilities and delivery times that should be compared with the customer service objectives. The process of designing a physical distribution concept is not straightforward. In every step in the development of such a concept a retrospective view should be made to the previous steps.

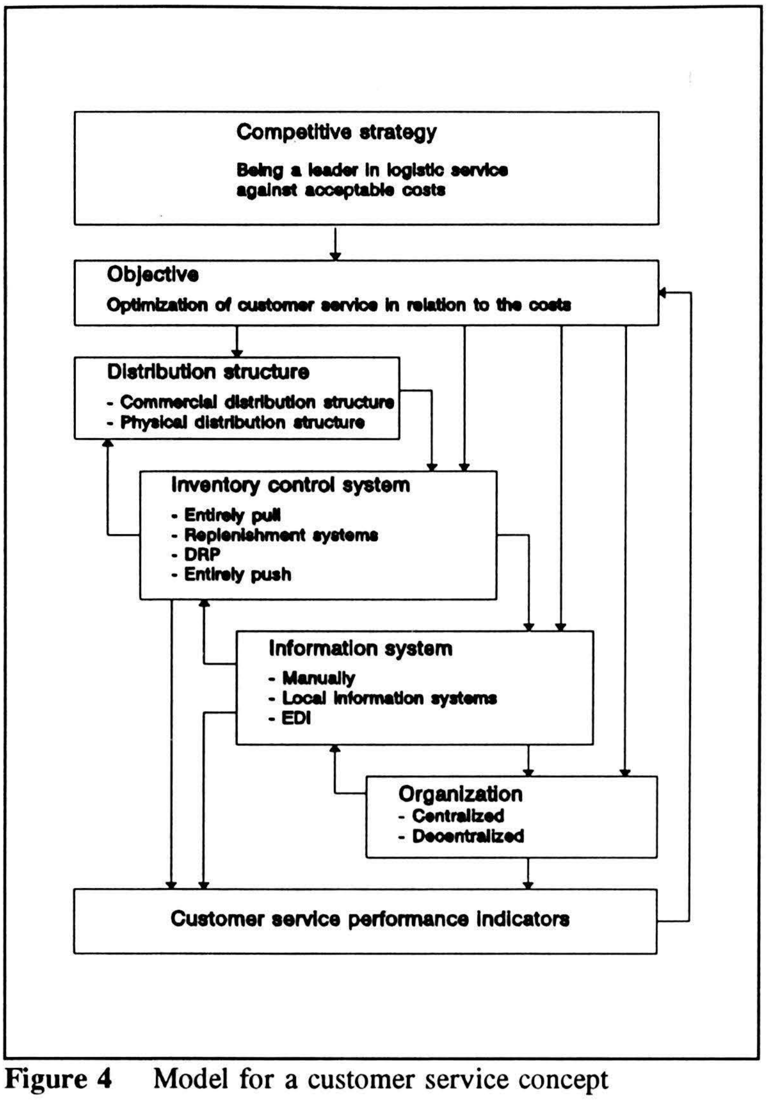


Figure 4 Model for a customer service concept

2.5 Scope of the project

In this project not all of the activities of the division are taken into consideration. We restrict ourselves to the product groups for which the company finds it important that they are delivered from stock. For this stage of the project, also hose and HPM products are left out of the inquiries. They are small, additional activities. The group management found that they are not decisive for the design of a physical distribution concept. Because both these product groups make use of the actual physical distribution structure, we can not totally ignore them. At crucial stages in this project, the consequences of decisions for these products of the inquiries are discussed.

Table 5 shows which products are taken into account. Figure 5 shows the most important flows within DSM EPP Europe.

Table 5 Products that are taken into account

Product group	Commodity of	Investigated	Reason
3P	Erta, Polypenco	Yes	Overlap in products, European distribution
PE	Erta (Cestidur)	Yes	Same distribution channel as 3P
PC	Erta (Axxis)	Yes	Same distribution channel as 3P
HPM	Erta, Polypenco	No	Small, additional activity
Hose	Polypenco	No	Small, additional activity
Custom casting	Polypenco	No	Made to order, delivery from production
Injection moulding	Erta	No	Made to order, delivery from production
Machined parts	Erta, Polypenco	Partly	Seen as customer

The own machine shops are seen as a customer group. Because the four smallest DC's only account for less than 5% of the total sales volume of shapes, we have confined the inquiries to the production warehouses and the larger distribution centers. In this stage of the project, the four mentioned distribution centers will be treated the same as (export) customers. This means we will come back on the function of these DC's later.

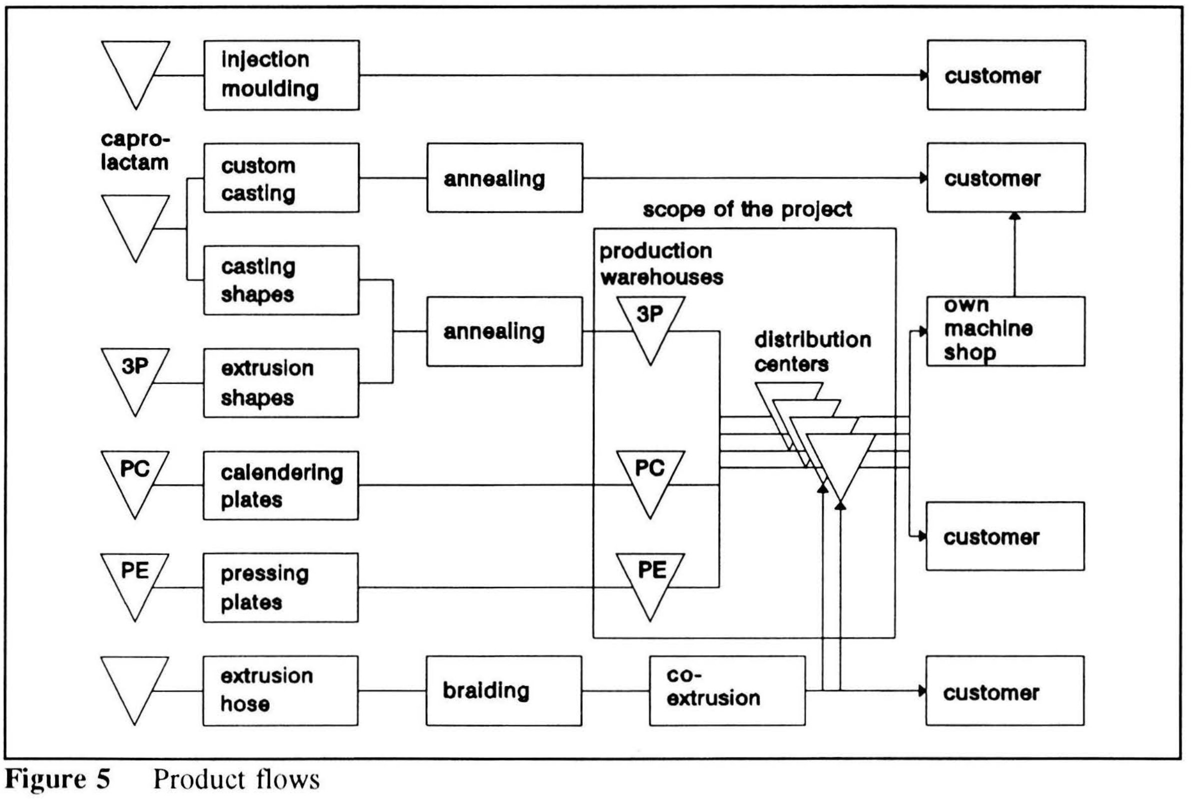


Figure 5 Product flows

2.6 Approach

The approach for this project already has been shown in the introduction. In this chapter the problem definition has been described, and the scope of the project has been given. The next chapter presents detailed information concerning the actual physical distribution. This information, together with the information that already has been presented in the previous chapters, is analyzed in chapter 4. With the help of the information and the analysis, the company's customer service objectives are described. In chapter 5 the assignment for this stage of the project is defined. Here also the approach for the remainder of this thesis is described.

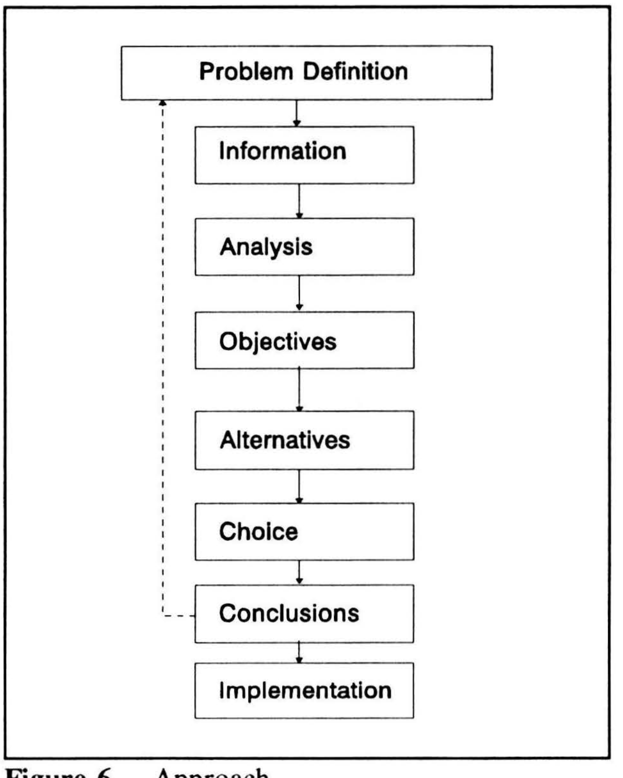


Figure 6 Approach

3. Information

3.1 Introduction

This chapter presents information about the actual physical distribution. What we should know, before designing a physical distribution concept is: who are our customers, where are they located, what are the products they buy and what is their ordering behaviour? Other important information concerns the performance and the costs of the actual physical distribution. This information gives insight in the relation of the physical distribution costs to the total cost price of the products. It also serves as a reference for calculations, later in this project.

To retrieve the desired information about the actual physical distribution, a questionnaire has been made. In this questionnaire (see appendix 4), the customers, the physical distribution performance and the costs are subject of the inquiries.

In obtaining the information, we have made use of the existing European Distribution Information System (EDIS) as much as possible. The system, that is still in development, is introduced to link the information systems of the DC's with the production warehouses. This to create better insight and coordination between sales and production. The system contains data about customers, sales and order sizes. The information in the first part of the questionnaire is retrieved from EDIS by standard queries for all subsidiaries. Only for Polypenco in the United Kingdom, that does not have a connection to EDIS yet, the information is collected manually.

The other information for the most part is collected manually at all subsidiaries. Where necessary, estimations are made for each local situation. Especially some cost factors (as for handling and transportation) are hard to specify in some situations. Multi-functionality of several cost factors and aggregate book keeping lie at the root of this. We are confident that the best possible assumptions and estimations are made in these situations, because there is regular feedback in the project group about these costs.

In this chapter only the information that appears to be important for the rest of the project is summarized. Appendix 5 shows a more detailed overview of the information retrieved.

3.2 Customers

In figure 7 the areas are shaded where most of the customers are located. Together with the individual customers presented in this figure they account for 90% of the total European sales. Most of the distribution centers are also located in the shaded areas. In the detailed local maps in appendix 6 we can see that, especially in the United Kingdom and in France, the Erta and Polypenco customers are not organized around the DC they are delivered from.

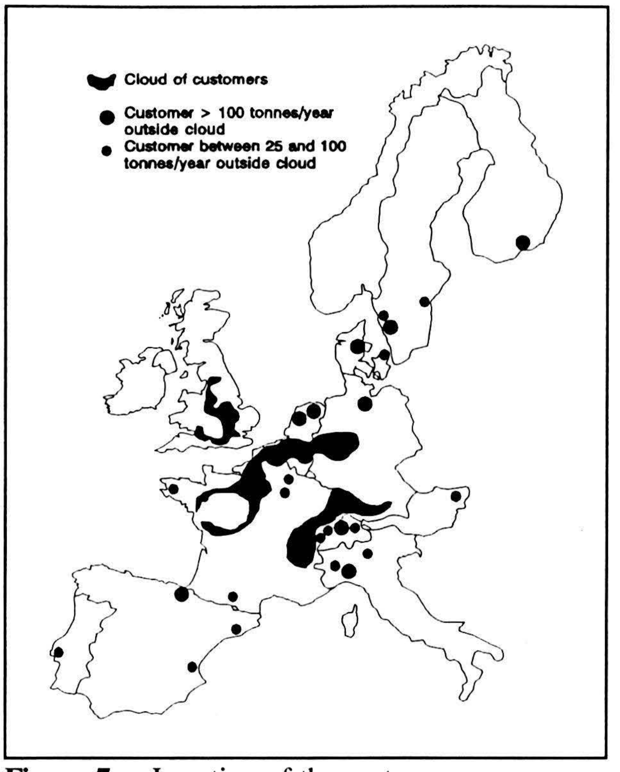


Figure 7 Location of the customers

The total number of customers in 1992 exceeded 4500. Only about 350 customers accounted for 80% of the sales. 'Distributors' accounted for two thirds of the total sales volume. Although the applications of the 3 product groups are different, two thirds of the 40 largest customers of the analyzed distribution centers buy products from more than one product group. Order sizes at the PW's are normally bigger than 500 kilograms per shipment. The distribution centers on average ship less than 100 kilograms per shipment.

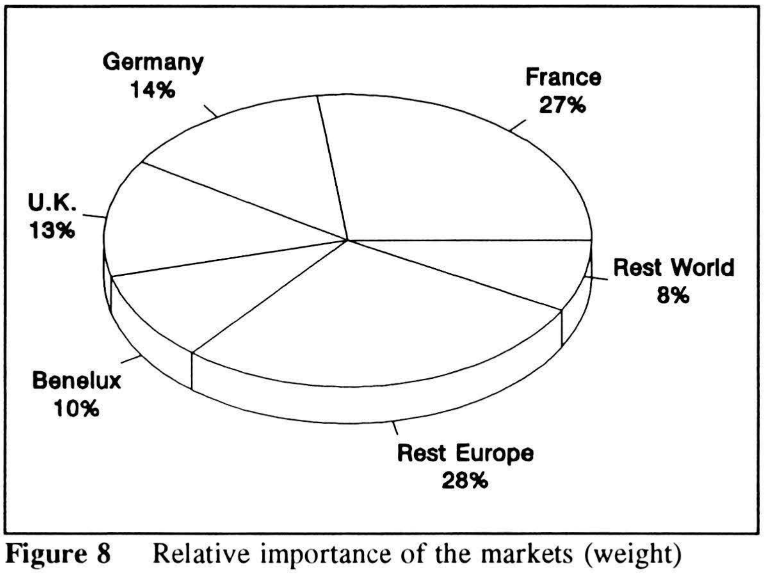


Figure 8 Relative importance of the markets (weight)

More than 90% of the shapes are sold in Europe. With 27% of the total sales, France is the biggest market, followed by Germany, the U.K. and the Benelux. Figure 8 shows the relative importance of the markets of shapes (in weight).

3.3 Warehouses and inventories

Some warehouses have categorized the different products to the sales characteristics into A, B and C-items. This is not done in all warehouses and where it is done, different rules are applied. The stocked shapes in the DC's are not necessarily the same as the standard products of the production warehouses. There are for instance DC-specific 'A' items that are not held to stock in the production warehouses. The total number of standard products is about 3000. The number of items that account for 80% of the sales is estimated at 500.

Typical for the actual situation is that there are islands of goods flow control, which are not integrated. Somewhat surprising is it to see that the production warehouses maintain the same availability conditions to the distribution centers and the authorized distributors, as the DC's maintain to their customers.

The total average stock of shapes in 1992 was 2,400 tonnes. The material cost value of the average stock in 1992 was about 15 million dutch guilders. Part of the costs of keeping stock are the costs of capital (interest on expenses invested in stock), the costs of obsolescence and the costs of insurance of the stock. At a total of 12% (10% interest + 2% obsolescence and insurance) of the production cost value, direct costs of keeping inventory are estimated at Dfl. 1.6 million. The calculations are based on the material cost value, because the material costs in this environment reflect the variable production costs. The fixed (machine) costs are not taken into account, firstly because they are hard to allocate to the products, secondly because these costs will be constant in time and (within limits) are not dependant from the inventory policy.

The costs related to the warehouse buildings, are depreciation or rent and costs of for instance heating, racks and maintenance. Because the costs of buildings are hard to specify for the warehouse on its own, an estimation for the building costs has been made by the individual project team members as by the group management. Total building costs are estimated at 1.3 million Dutch guilders per year for the ten analyzed warehouses. This corresponds with costs per square meter of Dfl. 100 per year, which is thought reasonable by all parties involved.

3.4 Handling, packaging and branding

In the PW the products are picked and packed manually per shipment to a DC or a customer. Because every production warehouse sells both branded and unbranded products, branding is done before consignment. Axxis plates are packed immediately after production in order to protect the vulnerable plates from scratches.

Handling personnel are people in the production warehouse who take products out of the racks, pack them and take care of proper shipment of the goods. The people who put the products from production in the warehouse and packaging people at Axxis are not considered as handling personnel. These activities are carried out by the people in production and are always part of the process. In the distribution centers handling people are the persons at goods receiving, handling in, stock keeping, handling out and packaging.

In 1992 an average of 50 people were involved with handling and packaging in the 10 warehouses analyzed, from which 12 were administrative warehousing personnel. The total expense for handling personnel was Dfl. 2.7 million.

All subsidiaries use different equipment. Most equipment is already depreciated but still works. Through Europe, 29 forklift trucks are used. Besides, all warehouses do have manual, non motorized handling equipment such as carts and hand pallet trucks. The costs of this equipment is negligible, compared to the costs of the forklift trucks. If we only take into account the costs for forklift trucks, and use an average committed operational cost price (included gasoline, maintenance etc.) for a forklift truck of 15,000 guilders per year, equipment costs for handling are estimated at Dfl. 0.4 million per year.

The packaging material used in the production warehouses is suited to pack large amounts of material. In the distribution centers the packages are a lot smaller. Packages here show large variations in size as well as in appearance. Boxes and sacks of different materials, tape and cardboard pipes are used packaging materials. Two thirds of the costs for packaging material were made in the production warehouses. In 1992 the total expenses for packaging material were about 1.6 million Dutch guilders.

3.5 Transportation

A distinction is made between inter-company transport, export and dispatching. Inter-company transport takes place from production to the distribution centers. Export is the transport from production to customers outside the countries with DC's. Most of the export shipments are shipments to authorized distributors. Dispatching covers all transports to the local customers in the countries where the DC's are situated.

Most transports take place by third party transporters. Only between Axxis and Erta EPS in Tielt and for part of the dispatching in Belgium and in the United Kingdom private trucks are used.

To nearly every separate country in Europe goods are shipped (export or inter-company), one specialized transporter per production warehouse is hired. In most cases these transporters are different for each warehouse. For the dispatching of the products from the distribution center to local customers mostly one transporter is contracted.

Table 6 Distinction in transportation

Transportation	From	To
Inter company	Production warehouses	Investigated DC's
Export	Production warehouses	Authorized distributors Other customers outside countries Not investigated DC's
Dispatching	Distribution centers Production warehouses	Local customers

It is difficult to find out what the costs for transportation really are. In many cases it is not clear in all cases which terms of delivery are agreed on. Also the combination of shipments is a complicating factor. The expenses for two thirds of the inter-company shipments (in weight) are calculated at 0.85 million guilders. Extrapolated for the total inter company transportation, the costs are assumed to be about Dfl. 1.3 million.

About three thousand tonnes were shipped directly from production to external customers in Europe. For export shipments, costs of 1 million guilders are estimated. Seven thousand tonnes were shipped via the distribution centers. Transportation expenses to final customers are calculated at about 3.1 million dutch guilders, corresponding with about 70% of the volume shipped to the customers. Total transportation costs for dispatching are estimated at Dfl. 4.5 million, if all transportation would be CPT customer. CPT stands for Carriage Paid To ..., which means that the supplier takes care of all transportation costs until the arrival at the agreed place (according to the *Incoterms 1990* [3]).

The customers are often delivered on a regular scheme. However, mostly they pass through their orders the day before delivery. In most distribution centers the regular shipments are delivered 'next day'. Same day or next morning and over the counter sales rarely occur, except for France and the UK. Express shipment weights are mostly far smaller than normal shipments.

3.6 Secondary operations

Frequently customers require other product lengths or tolerances than standard presented in the catalogue. In this situation shapes are cut to size or grinded. These operations are called secondary operations. It is a service activity, to provide the product to the customer in the quantity he needs it. Secondary operations therefore are seen as a physical distribution activity. In the ten analyzed warehouses 15 people are employed as secondary operators. The costs for secondary operations personnel were 0.8 million guilders in 1992. For secondary operations different saws are used. The costs of them are negligible and therefore not analyzed.

4. Analysis

4.1 Introduction

Before the aims for this stage of the project are defined (chapter 5), in this chapter the obtained information is analyzed. The next paragraph deals with the actual performance. In accordance with P-C-I model, the three following paragraphs deal with respectively the processes, the control system and the information system. In paragraph 4.6 an overview and analysis of the actual physical distribution costs is given. In the last paragraph of this chapter, the customer service objectives are described in the framework of which this project takes place.

4.2 Performance

Both Polypenco and Erta do have a lot of very small customers compared to the average customer size and the 20-80 Pareto rule. Especially Polypenco distribution centers show a large tail of small customers. The question is whether these customers add profit to the company or not.

More than 50% of the shapes goes to customers that buy more than 25 tonnes per year. Authorized distributors are delivered on a regular scheme and that seldom require next day deliveries, setting aside if this would be possible. Local customers however, independent from their size, rely more and more on the service their provider gives them. It is to these customers (that account for 70% of the sales volume) that the company wants to deliver small quantities with high speed. For this project these are the customers in the Benelux, in France, in Germany and in the United Kingdom.

A critical remark is made here. By serving small customers with the same service as the 'key customers', who are often wholesalers, there is a risk of loosing the wholesaler as a customer, by competing him. Another danger is that big customers buy their standard product range with a competitor at low prices and only for 'slow moving' items use the service DSM EPP gives them. Although the service DSM EPP wants to give to its customers can be a competitive advantage, giving too much service can be very expensive and even dangerous.

Detailed figures with regard to the actual external performance are not available. Customer service performance indicators, as far as they are used in the division, are set towards different criteria around the company. Mostly they are indicators for the internal performance, i.e. in what extent production fulfils the demand from the production warehouses. The lack of external performance indicators makes a physical distribution survey very difficult. It is proposed that common definitions for performance indicators like availability and reliability are made. Measures should indicate whether the internal efforts weigh against the external performance.

4.3 Processes

The actual physical distribution structure is the combination of the distribution structures of Erta and Polypenco. The customers of both Erta and Polypenco operate in the same geographical areas. There is commonality in production locations and a large part of the products of the two companies are alike. Despite from this, in some countries in Europe, the division still has a double distribution structure.

If we look at the third step in designing a physical distribution concept (figure 4), i.e. the design of the distribution structure, we expect that the actual distribution structure of DSM EPP is not the ideal structure for DSM EPP Europe as a whole. In physical distribution, nothing seems to stand in the way of a common structure for Erta and Polypenco.

Although the three major product groups have different applications, they have the same market areas and in many cases are delivered to the same customers. Also the product characteristics of these product groups only differ slightly. The value density of all products is almost equal. All products do have non-standard transportation dimensions, that makes their complexity in handling and distribution comparable. For the physical distribution, the three product groups can be treated the same and still be distributed in the same structure as the 3P products.

4.4 Control

There is a local goods flow control on two echelons, which is hardly integrated. No common rules for the classification of items have been set and each warehouse has its own methods for the determination of re-order levels (ROL's) and re-order quantities (ROQ's). The PW's have only slight insight in the real customer demand. One of the commonly distinguished problems is that DC's buffer against stock-outs at production. When, as a result, replenishment times rise and deliveries become less reliable, this buffering accumulates. This phenomenon is generally known as the Forrester effect.

It surprised us to see that the production warehouses maintain the same availability conditions to the distribution centers and the authorized distributors, as the DC's maintain to their customers. The company keeps stock on several places for several different product-market combinations. Stock is held on two levels, where it is not clear in all situations who is responsible for which delivery conditions. This easily leads to excess stock keeping of products, with the danger that the wrong products are stocked at the wrong places. We will come back to this at the end of this report.

Something that is not directly a control issue, but closely relates to it, is the packaging issue. Due to vague agreements and redundant packaging (especially between Epec and Polypenco), the packaging methods and materials are a separate point of discussion. Because in this stage of the project the issues ore of a higher abstraction, we will not go into detail on this issue.

4.5 Information

EDIS has been set up as an information system to create better insight in the inventory positions between production and distribution. However, as indicated in the research model, firstly a control system should be set, before improvements of EDIS can have the desired effects. Because we expect that the physical distribution structure will change, and therewith the control system, we will not analyze EDIS in detail in this phase of the project.

4.6 Costs

Total physical distribution costs in 1992 in Europe are estimated at about 15.2 million Dutch guilders. On average this is more than Dfl. 1.35 per kilogramme sold product. At an average estimated production cost price of 5.5 guilders per produced kilogramme, physical distribution costs add 25% to the total costs of the product. Figure 9 shows the division of physical distribution costs to its different aspects.

In the physical distribution costs 2 important categories are distinctive. The first category are the warehousing costs. These warehousing costs can be divided into inventory, building and handling costs. The second category are the transportation costs. Physical distribution costs outside these categories are the packaging costs and the costs related to secondary operations.

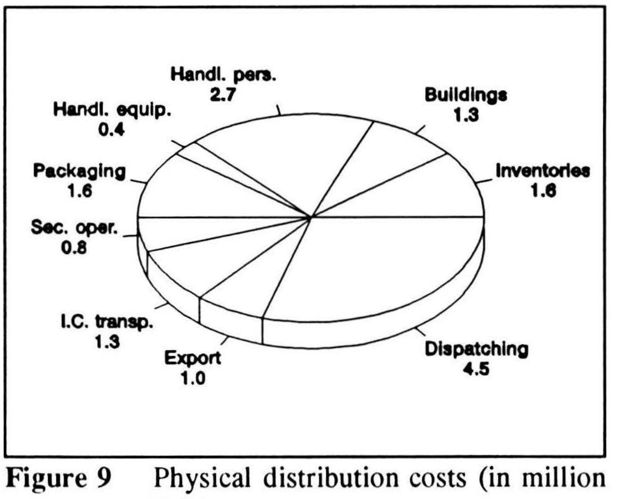


Figure 9 Physical distribution costs (in million Dfl.)

It must be said that the real logistic costs probably are even higher, taken into consideration the complexity of the structure that exists at this moment. Lots of cost factors are hard to determine. One of the main issues of the actual physical distribution is the deficiency of mutual information and coordination.

4.7 Customer service objectives

Customer service has been defined as 'everything that can be done to get the right products at the right time to the place the customer wants to have them'. This definition is of little value when not given concrete form to by operational customer service objectives. Table 7 shows the objectives for the aspects of customer service that have been discussed in the project group.

Table 7 Customer service objectives

Aspects	Objective
Delivery time	Preference for 'next day'
Frequency / order sizes	Daily deliveries
Availability	Actual or better
Reliability	Actual or better

The preferred delivery time is said to be 'next day' for all customers in the areas we are looking at (the Benelux, France, Germany and the United Kingdom). Although a lot of customers are delivered on a regular scheme, the competitive strategy and therewith the customer service objectives are faced towards daily deliveries to all customers in these areas, independent of the size of the customer.

For the actual availability and reliability, we have already made the remark that detailed information about the actual performance is not available. In the design of a physical distribution system, it is very important to know what the effect of the inventories is on the performance to customers.

It is recommended in this stage of the project already, to introduce common performance indicators for availability and reliability to customers. Not having these indicators for this moment, especially for the availability, makes it necessary in this stage of the project, to work with assumptions on the actual and needed level of inventories.

For this stage of the project, the objectives for availability and reliability are said to be 'actual or better'. What the consequences for the lack of information on these objectives are, will become apparent in the remainder of this report. Although it is generally assumed that the inventories at this moment are not based on a certain availability level, in this stage of the project we pretend that they are. In chapter 9 this assumption will be discussed.

5. Assignment

5.1 Introduction

In this chapter the aims for this stage of the project are benchmarked. Also boundaries are given for the scope. Premises are made for factors that are supposed to influence the outcomes of the project, but that not are seen as variables for this project.

5.2 Aim of the thesis

The analysis shows that the actual physical distribution structure, as it has been originated by the combination of Erta and Polypenco, can be discussed. Before going into detail of the control and information aspects of physical distribution, following the P-C-I approach, the design of an integral physical distribution structure is of interest.

With production plants and customers located in different countries, marketing, sales and physical distribution all can have their own optimal structure [3]. The flow of products can be organized totally different from the order and invoice flow. Because of the close contacts of the sales departments with the customers, we leave the commercial distribution structure untouched. Here we only consider the physical distribution structure.

Because of time limits, this thesis can only describe part of the total project. It reflects only the first stage of the total project. The subject of this report will be limited to a design of the physical distribution structure, given the customer service objectives. The aim of this report is:

> *"Make a proposal for a physical distribution structure for DSM EPP Europe, in which 'next day deliveries' to all customers in central Europe are possible. Discuss what further should be done to improve the total physical distribution system.*

5.3 Boundaries

In the next chapter, alternatives are introduced for the physical distribution structure in Europe. The alternatives are distinctive by the nature of several variables. Some factors that influence the physical distribution structure will remain as they are now. In table 8 these premises with the reasons why they are remained unchanged are summarized.

Table 8 Premises for the design of a physical distribution structure

Premises	Reasons
Present product range	Set by marketing department
Location of the production plants	Specialized know-how in plants High moving-expenses of machinery
Production to stock	Requested delivery times are far shorter than production lead times
Areas in which dispatching takes place by DSM EPP	Strategic decision

5.4 Further approach

Having defined the aim for this thesis, in the remainder of this report the process is described in coming to conclusions concerning the assignment. In the next chapter alternatives are introduced for common physical distribution structures. Also in this chapter a first selection is made out of the alternatives. In chapter 7, the alternative structure that best reflects the possibilities for reaching the company's customer service objectives is described in more detail. Here it is explained what settings have been chosen in this alternative and why this is done. In chapter 8 the proposed structure is compared with the actual situation.

In the last chapter (chapter 9), the conclusions are recited. In this chapter also a discussion is inserted about the objectives and the assumptions we have started from. Finally, in that chapter recommendations for further investigations in this project are made.

6. Alternatives

6.1 Introduction

Within the boundaries given in the previous chapter, alternatives for the physical distribution structure of DSM EPP Europe are generated. In this chapter, firstly the important variables in the alternatives are described. These variables are divided into design variables and dependent variables. In paragraph 3 a view is given on the design variables. Here basic physical distribution structures are presented. In paragraph 6.4, four scenarios are introduced in order to find a possible distribution structure for DSM EPP. In paragraph 6.5 a first shift is made between the scenarios. In chapter 7 the most promising scenario is worked out to be compared with the actual situation.

6.2 Variables

In table 9 the cost factors of physical distribution are summarized. All aspects are more or less dependent on the structure in which physical distribution takes place. The most important cost factors as we have seen are warehousing and transportation. The distinctive variables in designing a physical distribution structure are the number and the function of the warehouses, under the assumption that we pretend to know what inventories we should hold for which customers (see previous chapter). Also the location of the warehouses is a design variable. The cost factors that are dependent on these variables are handling and transportation costs.

Table 9 Cost factors of physical distribution and their influence on the structure

Cost factor	Variable	Reason
Inventories	Partly	As far as dependent on number and function of warehouses
Buildings	Yes	Design variable
Handling	Yes	Dependent on number and function of warehouses
Inter-company transportation	Yes	Dependent on number and location of warehouses
Export transportation	Yes	Dependent on location of warehouses
Dispatching	Yes	Dependent on location and number of warehouses
Packaging	No	Independent on design variables
Secondary operations	No	Independent on design variables

Packaging costs (material) are not supposed to be dependent on the physical distribution structure, because in a situation with efficient use of packaging, redundant material should be avoided. We already mentioned that the packaging issue deserves separate attention. Secondary operations are done on customers request. In every structure the amount of secondary operations are the same. Only in efficiency and economies of scale, there can be benefits in secondary operations. Because these benefits are hard to quantify and probably negligible (taken into account the total costs of Dfl. 0.8 million), the secondary operation costs are not seen as a variable for the design of the physical distribution structure.

6.3 Design variables

6.3.1 The number of warehouses

Figure 10 gives a view on the cost relations when determining the number of warehouses. In reducing the number of stocking points there will be a trade-off between warehousing costs and transportation costs. Both the costs of DC's and the costs of keeping inventories go down when decreasing the number of warehouses [3].

In transportation costs there will be lower inter-company transportation costs in a centralized situation. Costs of dispatching however will grow. Transportation costs will show a U-curve when put in a graph against an increasing number of warehouses.

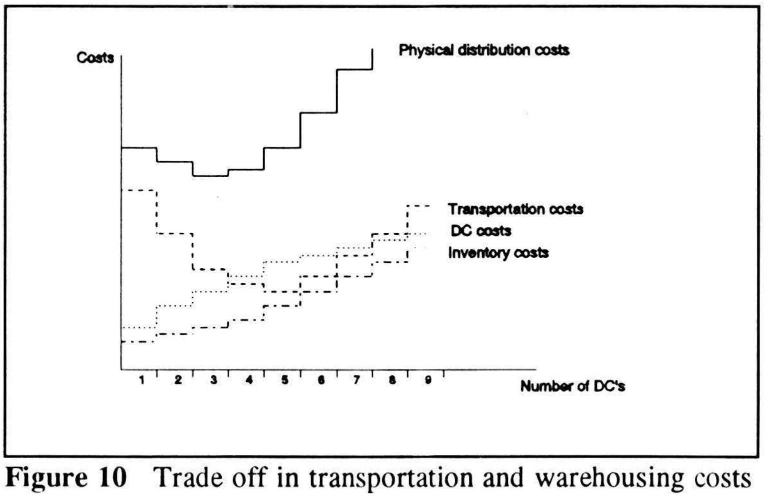


Figure 10 Trade off in transportation and warehousing costs

Somewhere there is an optimum number of warehouses when combining the warehousing costs and the transportation costs. In other words, as long as the total costs of a distribution center including the transportation costs to and from this DC are lower than the costs of direct shipments, the distribution center is economically justified.

6.3.2 The function of the warehouses

The function of the production warehouses is to keep stock of all products that are made in the plant it is connected to, in order to deliver export customers (authorized distributors) and distribution centers from stock. The function of the distribution centers (and authorized distributors) is in first instance to deliver the customers from stock in small quantities with short delivery times.

For the functioning of the physical distribution, several structures are possible, in which the functions of the warehouses and the distance to the customers are the distinctive factor. Figure 11 shows some basic structures for international physical distribution as presented in theory [3]. On the next page we briefly explain the basic structures.

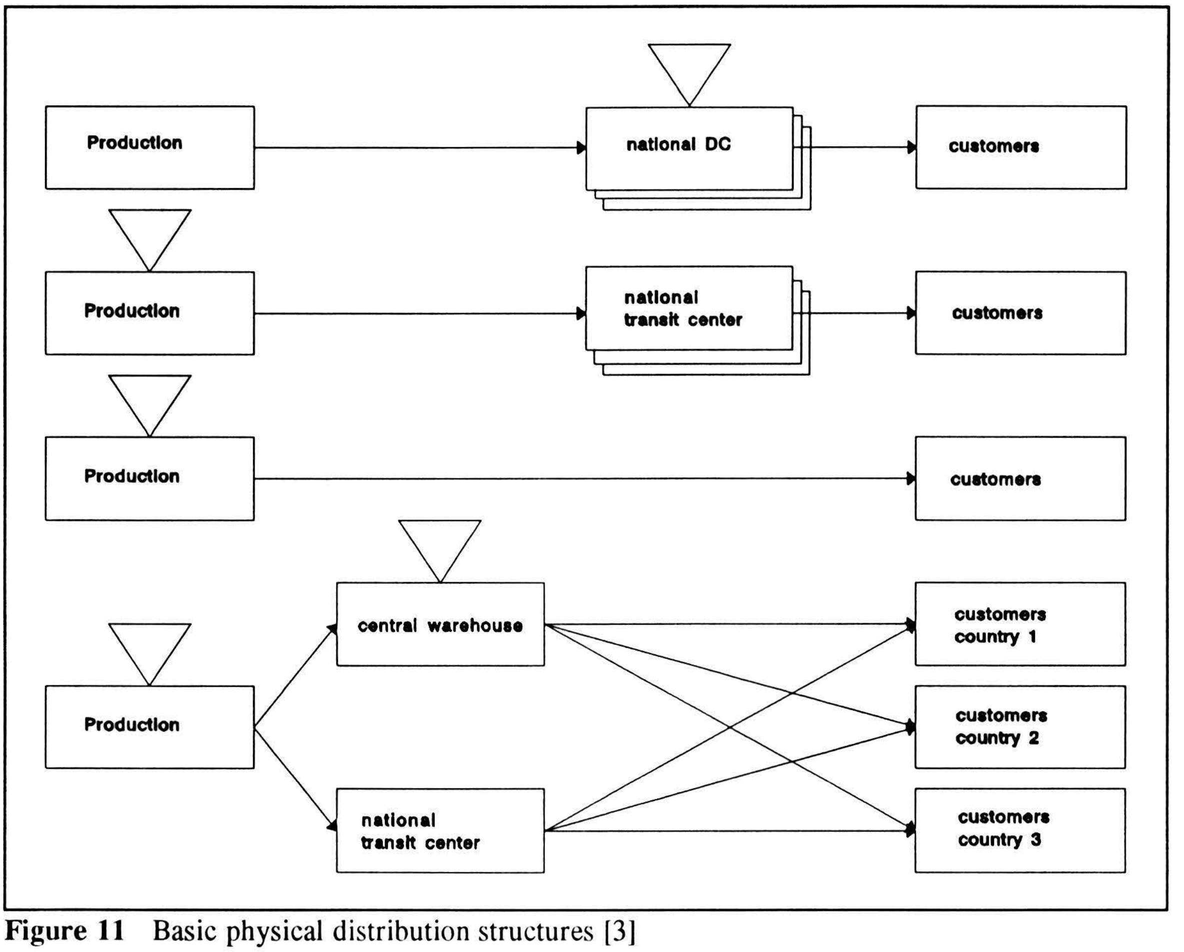


Figure 11 Basic physical distribution structures [3]

National DC's

International transports take place from the different production locations to national distribution centers. The customers are delivered from those DC's. Inventories in essentially are located in the country where the sales take place. Advantages of this basic structure are the relatively cheap international transports and the possibility to deliver the customers from stock with short delivery times. A major disadvantage of this method is the height of the inventories. Safety stock is kept in every country, which normally leads to much higher physical distribution costs than in other basic structures.

Transit centers

In order to force down the costs of keeping inventories, the function of the national DC's is reduced to that of a transit center. In essence the (safety) stock is located at production. To be able to give a decent service level to the customers, replenishment of the transit centers must take place with high frequency. Because there is almost no stock in the transit centers, the vulnerability for deliveries is becoming larger, due to the long supply channels.

Direct distribution

Deliveries to clients take place directly from production. These clients can be end-users as well as wholesalers. The advantages of this structure, compared to the previously described structures, are lower inventory costs and the avoidance of handling in the second echelon. Because shipments mostly take place over long distances, there is a high vulnerability of deliveries.

Central warehouse

An intermediate form of the described structures is the use of a central warehouse, from where customers in different countries are delivered. The central warehouse can function either as a distribution center or as a transit center. The advantages of this method compared to the national DC's is that the (safety) stock can be lower. Compared to direct deliveries the advantages are the possibility of grouped traffic, as well from production to the warehouse (lower frequency) as from the warehouse to the customers (combined product groups). The delivery times will differ for customers in different countries.

The actual situation

Earlier in this project we have found out that within the actual distribution structure of DSM EPP in fact there are two sorts of warehouses, the production warehouses and the distribution centers. In this structure the company works with two echelons of stock keeping units for the same PMC's.

When we compare the actual situation with these basic structures, we see that the division in Europe makes use of a combination of these methods. For different customers in different countries, a different distribution method is applied. Although there is no unified classification of products, there also can be made a distinction to 'slow-moving' and 'fast-moving' products. Table 10 shows which basic structures currently exist for different product-market combinations.

Table 10 Mix of basic structures applied in the actual situation

Basic structure	Customers	Products
National DC's	end-users, machinists and wholesalers in the Benelux, France, Germany and the U.K.	'Fast-moving' products
National transit centers	same as above	'Slow-moving' products
Direct and outlet distribution	Authorized distributors and Export customers	All products
Central warehouse	None	None

6.3.3 The location of the warehouses

When warehouses are located close to the customers, costs for dispatching normally are lower than in a situation where dispatching takes place over longer distances. However, transportation costs are not dependent only on the dispatching, but also on the inbound transports. Inter-company transports highly depend on the distance from production to the warehouses. For export transports the same observation can be made, although the differences here will be less decisive, because the relative differences in transport distance are lower when transporting over longer distances.

The effects of the location of warehouses on inventory costs and handling costs are marginal and therefore not mentioned in our study. The effects of the location on building costs are neglected as far as they concern different costs of buildings in different areas. What should be taken into account in our study are the building costs related to the existing warehouses in the division. Because the division has long term rental contracts for most buildings, the costs for these in another structure can not be neglected.

6.4 Scenarios

In comparing different structures for the physical distribution of shapes for DSM EPP, we make use of four scenarios, which are reflections of the basic structures, in some ways adapted to the specific situation of DSM EPP.

These scenarios are:

- The actual situation
- National warehouses
- All deliveries from production
- One central warehouse

The actual situation
This scenario is introduced to compare the other scenarios with. Because we make use of calculation rules for determining the physical distribution costs in the different scenarios, this scenario serves two purposes. Firstly, comparing the calculations for this scenario with the actual costs given in chapter 3, makes it possible to check the calculation rules. Secondly this scenario serves as a base to compare the other scenarios to.

National warehouses
In this scenario the national warehouses in some cases have different functions, just as in the actual situation. This scenario is described in detail in the next chapter. Here also the calculation rules are described.

All deliveries from production
The third scenario we analyze is a structure with all deliveries from the production warehouses. Some adaptations are made in comparison with the pure basic structure. For 3P products, there are some inter-company flows between the production plants, because it is unlikely to assume that the different casting products to customers for instance in the U.K., are delivered from three warehouses in Europe. Because it is the largest plant, in this situation we assumed that Epec in Tielt is sort of a central transit point between the 3P production warehouses.

One central warehouse in Europe
In this scenario all products from all production plants are stocked at one central place, from which all transportation to customers takes place.

An improvement strongly recommended by the management of some production warehouses, is to deliver large customers on a regular basis directly from production. Because the feeling for direct deliveries only to big customers is so strong, the project group has decided to investigate a scenario, in which only customers that account for more than 25 tonnes per year, that are situated within a distance of 400 kilometres from a PW are delivered from production (scenario 1a). The settings in this scenario have been chosen to have a substantial amount of customers within a radius in which the customer service objectives easily can be met. Scenario 1a is not a basic structure, but an alternative for scenario 1.

6.5 First selection

Because the differences in the costs of each scenario are highly dependent on the inventories that should be held (which also influence the building costs), there is a preference for one-echelon stock keeping. However, in both scenarios where all products are located at only one location within DSM EPP, the objective of 'next day deliveries' is not met for all customers in the countries with the national DC's. Table 11 shows for which part of the customers the objectives are not satisfied according to the information of transporters (see appendix 7).

In this table we have not taken into account the difference between 'slow-moving' and 'fast-moving' products. Because this is not done for both the volume that cannot be delivered next day and the total volume to these customers, we expect that the percentage is representative for the products that are delivered 'next day' nowadays.

Table 11 Percentage of goods (weight) that can not be delivered 'next day' in centralized scenarios

	volume > next day (tonnes)	Total volume (tonnes)	%
Deliveries from production	2110	7060	30
One central warehouse	3880	7060	55

The percentages of goods that cannot be delivered within the requested delivery times are found to be unacceptable in the project group. Although the calculations for the different physical distribution costs have also been calculated for these scenarios (see appendix 7), in the remainder of this report, the two scenarios are not treated in further detail. In a later stage we may come back to the information value of the calculations in these scenarios.

In scenario 1a the influences of direct deliveries to big customers is calculated. The most important trade-off that takes place in this scenario is the trade-off between dispatching and inter-company transports. Because of the transportation distances in dispatching increase in such a scenario, together with an increase in flows (deliveries from different PW's), the costs for dispatching increase. This increase will partly be offset by a decrease in inter-company shipments. The increase in dispatching costs however, is higher than the savings in inter-company transportation, according to the calculations in appendix 7.

The expected advantages in handling are minor. Savings in handling should exceed 120 thousand guilders to offset the increase in transportation costs. Because it is not expected that 2.5 persons in handling can be saved by sending direct shipments to part of the customers, in essence this scenario is rejected. This does not mean that in individual cases, taken into account the customer service objectives, it could be wise to treat some customers in the same way as the authorized distributors.

7. A proposed structure

7.1 Introduction

In the previous chapter we have described the investigated alternative structures. Two of these structures drop out, because they do not meet the customer service objectives. In order to be able to deliver the customers in the countries where the distribution centers are located now, a physical distribution structure with warehouses close to the customers is required. In this chapter we describe a structure that conforms to these requirements. This is the structure of the second scenario we have investigated. In this chapter it is explained how the design variables have given form to. In the next chapter the physical distribution performance and costs of this scenario are compared with the actual situation.

7.2 The number of distribution centers

As we have seen in chapter 6, a trade-off takes place between the costs decrease when combining warehouses, i.e. building costs, inventory cost, handling costs and dispatching costs, and the costs that increase when combining warehouses, i.e. (international) transportation costs. In our case however, combining warehouses in some cases only have advantages.

Because at the moment, in some countries customers throughout the country are delivered by separate Erta and Polypenco distribution centers, combining these warehouses seems obvious. Maintaining two warehouses for the delivery of identical goods to similar customers in the same area is exuberant. Transporting to one common distribution center leads to lower international transportation costs. The average distances for dispatching do not differ largely, taken into account that the common distribution center is positioned just as close to the customers as the separate DC's.

A first reduction in the number of warehouses that therefore is made in this scenario is the combination of distribution centers of Erta and Polypenco in the same country. Taking into account the division's structure with national profit centers, and the objective of 'next day deliveries', four distribution centers are proposed, one in each country (the Benelux, according to its size and the size of its market is seen as one country).

7.3 The location of the distribution centers

There are more than one factor that influence the determination of optimal locations for the warehouses. A first factor of course is the position of the distribution center with respect to the customers. A second important factor is the position of the DC's with respect to production. A third factor that can influence the decision is the actual location of the DC's, because of personal reasons (skilled personnel), or reasons of long term tenancy agreements. For a long term design of the physical distribution structure however, these factors may not weigh too strong in the decision. Also other social, political or economical factors can influence the decision where a warehouse should be located. These factors in this study are not taken into account, because no problems are expected with these factors in the choices that are made.

Looking at the position of the production plants and the position of the customers, we conclude that the production plants, especially in Belgium, France and the United Kingdom all are located within the areas with a high economic activity. Positioning of the distribution centers directly to or near the production plants assures that the distances to both the customers and production is nearly optimal, without having to make complex calculations in order to find optimal locations.

In Germany however, there is no production. The actual location of the DC is located in central Germany, close to the Belgian border. The position of this warehouse may be not optimal, but it is accurate for the design of this scenario.

The location of the four distribution centers in our scenario are chosen in Tielt for the Benelux, in Lyon for France, in Lahnstein for Germany and in Welwyn Garden City for the United Kingdom. The number and location of the warehouses, compared to the actual situation is presented in figure 12. The removal of the warehouse in Almelo is explained in the next paragraph.

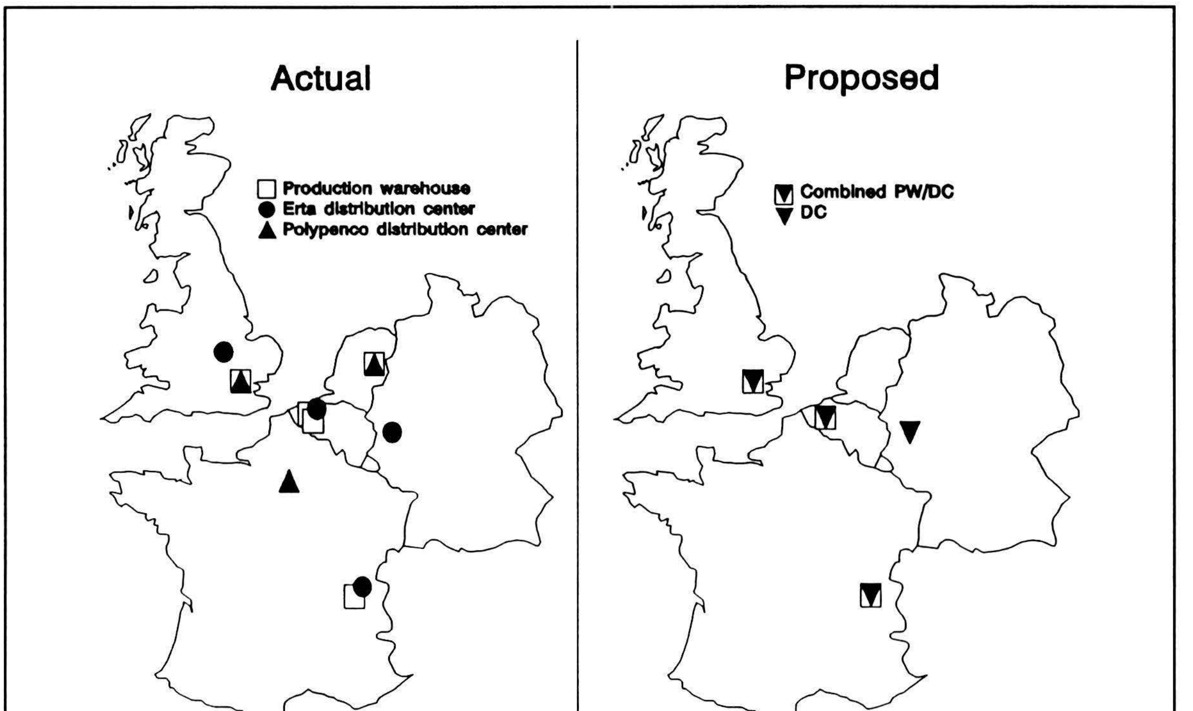


Figure 12 Actual and proposed number and location of warehouses

7.4 The function of the warehouses

In the previous paragraph we concluded that the chosen location of the four distribution centers in this scenario was at or near production. In the actual situation the production warehouses are exactly located there. When, in a new structure, the production warehouses are combined with the national distribution center that lies close to it, the total number of warehouses can further reduce.

Only the production warehouse in Almelo in such case would exist as pure production warehouse. The function of this warehouse then would be restricted to the stock holding unit for products made in Almelo and for the shipment of goods to the distribution centers and export customers. Because of the possibility of combining these shipments with shipments of 3P products from EPEC, it seems better to ship all the goods produced in Almelo to Tielt. The function of the warehouse in Tielt then would be expanded with the function of production warehouse for products made in Almelo. Because most of the products that are made in the U.K. serve the local market, the U.K. warehouse is kept as production warehouse for all products made there.

So, the proposed physical distribution structure contains four warehouses, one in each area, of which 3 fulfil both the function of production warehouse and distribution center. Table 12 shows the function of the different warehouses.

Table 12 Function of the warehouses in the proposed structure

Warehouse	Production warehouse for		Distribution center for
Tielt (B)	3P PC	(Tielt and Almelo) (Axxis)	Benelux
Lyon (F)	PE	(Cestidur)	France
Welwyn (UK)	3P	(Welwyn)	U.K.
Lahnstein (D)			Germany

8. Results

8.1 Introduction

In this chapter, the proposed scenario is compared to the actual situation in performance and costs. Paragraph 8.2 deals with the differences in performance. In paragraph 8.3, the expected savings in physical distribution costs of the proposed scenario, compared with the actual situation are calculated. In paragraph 8.4 a sensitivity analysis is made for the calculations. In paragraph 8.5 the conclusions concerning this structure are given.

8.2 Performance

Combining the distribution centers of Erta and Polypenco in the same countries, as we have seen results in hardly any change in the average delivery times to customers, compared to the actual situation. The average distances from the distribution centers to the customers remain the same in almost all situations. The longer distances for instance from a common warehouse in Lyon, to the Polypenco customers around Paris are offset by the shorter distance to the Polypenco customers around Lyon of which the number is even larger (see appendix 6). Only to the Polypenco customers in the northern part of The Netherlands the distance to the distribution center (that moves from Almelo to Tielt) increase. However, also in this situation next day deliveries are possible. Also for the request of daily deliveries nothing is changed.

8.3 Calculations

8.3.1 Inventories

When the proposed structure is compared with the actual situation, within the same control structure, two factors influence the level of inventories; the combination of distribution centers with production warehouses (from two-echelon to one-echelon) and the combination of Erta and Polypenco distribution centers (only in the second echelon).

At the moment, the desired availability at the first echelon for replenishment of the second echelon is the same as the availability in the second echelon for deliveries to the customers. In such a situation, with inventories of the same products on two levels, the demand at the production warehouses from the DC's is a delayed and combined passing through of the customer orders (see figure 13). The function of a decentral stock then is only to assure a shorter and mostly more reliable delivery time.

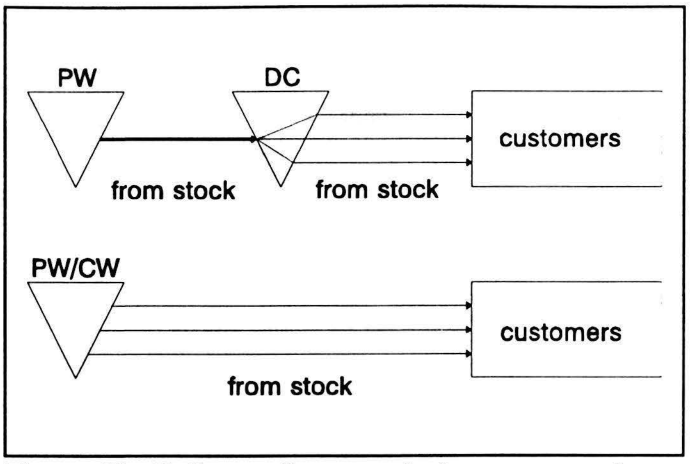


Figure 13 Delivery from stock in a two and one echelon situation

With this equal availability at both echelons, the stock in the production warehouse would be sufficient for direct deliveries to the customers. Even less safety stock is needed. Because customer orders are delivered one by one in a one-echelon situation, the 'lumpy' demand will decrease [4]. This reduction will be neglected.

Originating from the case that stock in the DC's is only kept for delivery-time reasons, by combining the DC's in Belgium and France, the reduction of inventories in the proposed structure is at least the omission of the 3P and PC stock of EPS in Belgium, the extruded 3P stock of Polypenco in Almelo, and the PE stock of both DC's in France. The reduction in this case is estimated at respectively 40, 20 and 60 tonnes, which is a total of 120 tonnes.

The second factor that influences the inventory levels is the combination of Polypenco and Erta distribution centers. One of the most commonly described rules in literature in case of combining warehouses in the same echelon is the 'Square Root Law' (SRL). This law is an approximation of the relationship between safety stock level and the number of consolidated facilities. It measures the change in safety stock when inventory is centralized. Assuming the demands at each stocking facility to be uncorrelated, and the variance of demand to be the same at all facilities, the SRL defines the standard deviation of demand at the centralized facility to be equal to the uniform decentralized standard deviation, multiplied by the square root of the number of consolidated facilities [6].

In our situation, by combining the stock of Erta and Polypenco distribution centers, only for some product groups the stock is consolidated (see table 13). At this moment it is not known which products within these product groups exactly are kept to stock at both Erta and Polypenco in the different DC's. We also have no information about the variance of demand for the individual products. In such a situation it is very difficult to make estimations of the savings that are made by combining these DC's. Although we expect that there are products for which a reduction in safety stock is possible in the proposed structure, by neglecting these savings for this moment, we stay on the save side.

Table 13 Combined products in common distribution centers

Combination of	Products
Polypenco b.v. - Erta EPS	extruded 3P
Polypenco EPS - Erta EPS France	extruded 3P PC PE
Polypenco Ltd. - Erta U.K.	extruded 3P

Table 14 shows the calculated savings caused by the combination of warehouses of two different echelons. Inventory costs are calculated by multiplying the total inventory level by an average material cost price of Dfl. 5.5 per kilogramme product, multiplied by a capital cost factor of 12%.

Table 14 Savings in inventories

Scenario	Inventories as	Inventories (tonnes)	Costs (1000 Dfl)
Actual	Actual	2,410	1,591
Proposed	Actual - 120	2,290	1,511
		SAVINGS	80

8.3.2 Buildings

The number of warehouses in the actual situation is 10. In the proposed structure this number is reduced to 4. In our calculations we will not include costs for redundant warehouses, because in such case we would disregard other opportunities for these places. Vacant warehouse area therefore is not seen as a physical distribution cost factor.

The real total required building space is dependent on the amount of inventories that should be stored, as well in the actual situation as in the proposed structure. According to the information on the actual situation, on average for 0.2 tonnes of products in stock, one square meter warehouse area is needed for all products. A reasonable cost price for a warehouse is said to be 100 Dutch guilders per square meter.

Table 15 shows the total savings calculated with the help of the expected inventory reduction in the previous subparagraph.

Table 15 Savings in buildings

Scenario	Inventories (tonnes)	Warehouse area (m^2)	Costs (1000 Dfl)
Actual	2,410	12,050	1,205
Proposed	2,290	11,450	1,145
		SAVINGS	60

8.3.3 Handling

The required handling personnel is dependent on the amount of goods that are handled in a warehouse. Because of the different volumes and methods of handling, the required number of personnel differs between the distribution centers, the 3P production warehouses and the warehouses for plates. This also is the case for handling equipment.

In the proposed scenarios the functions of some warehouses are combined. This results in a decrease of both handling-out in the production warehouse and handling-in in the distribution center. At the other hand, when in the proposed structure the warehouses are not located directly to production, handling-in activities increase there. Because it is expected that the people who actually place the products in racks (production people), with the same efforts can place them in a truck, for that no extra handling out is required. Table 16 shows the differences in handling activities in tonnes per year in the light of the sales volume in 1992, when in the proposed structure both warehouses in France and in Belgium are not located directly at production.

Table 16 Changes in volumes that are expected to be handled

	By changes of	Handling in (tonnes per year)	Handling out (tonnes per year)	
			PW	DC
Tielt	Erta Epec Axxis EPS Belgium Polypenco Almelo	+ 4,100 (total prod.) + 2,830 (total prod.) - 535 (3P+PC from PW) + 580 (total prod.)	- 535 (EPS)	
Lyon	Cestidur EPS France Polypenco France	+ 2,170 (total prod) - 792 (PE from PW) - 113 (PE from PW)	- 905 (DC's)	
Welwyn	Polypenco U.K. Erta U.K.			
Lahnstein	Erta Germany			

The figures can be explained as follows. Production people place the goods in a truck. As said this activity is done by production people. In the warehouse however, the products are taken out of the truck and placed in racks. In the proposed structure this is a supplementary activity compared to the actual situation, that is necessary for all products that go through the warehouses that are not located at production any more (total Axxis, Epec, Cestidur and Polypenco Almelo production).

The total volume of 3P and PC that is sold in Belgium as also the total PE that is sold in France, is no longer transported from one warehouse to another. For this volume both the handling-out at production and the handling-in in the DC is eliminated. Handling-out for the DC's will remain the same, because the customer orders remain the same. Also for the warehouse in the U.K. and the DC in Germany no major changes in the goods flow are expected.

Because the change in handled volume is especially the change in incoming goods in the warehouse in Belgium, which takes place in large volumes, one extra person is foreseen for the supplementary handling efforts. Because the task of this person is to take care of the incoming goods (pallets) in the Benelux warehouse, there is also reckoned with an extra forklift truck. In Lyon hardly no extra activities take place, so no extra manpower is foreseen here.

The average costs for one person are said to be Dfl. 50,000 per year. Yearly costs for handling equipment Dfl. 15,000 per forklift truck. An increase of handling costs is not expected, though it is reckoned with. Possible extra expenses for handling are determined on Dfl. 65 thousand.

EXTRA EXPENSES Dfl. 65 thousand

8.3.4 Transportation

Transportation costs for every scenario are calculated by an external transporter with a wide network in Europe (Frans Maas). Appendix 7 shows the lists of shipments the calculations are based on. The total volumes are determined with the help of a detailed customer list of 1992. The regions are the places where the transporter has his hubs. In conversations we had with other transporters, these regions represent knots in the networks of more transportation firms. Checks have been made on some calculations by another transporter (Danzas) and compared to actual transports.

In this subparagraph, the influences of the proposed scenario on inter-company and export transports as well as dispatching are explained, to get a better understanding of the results of the calculations. Where necessary, the calculations that are made are discussed.

Inter-company transportation

From the many flows that exist, in the proposed structure the flows will be reduced to four from production at EPEC, Axxis, Polypenco b.v. (Almelo) and Polypenco Ltd. (Welwyn) to the Benelux warehouse; one from Cestidur to Lyon (DC-F) and six flows from the combined warehouses in the Benelux and Lyon to the other distribution centers (see figure 14).

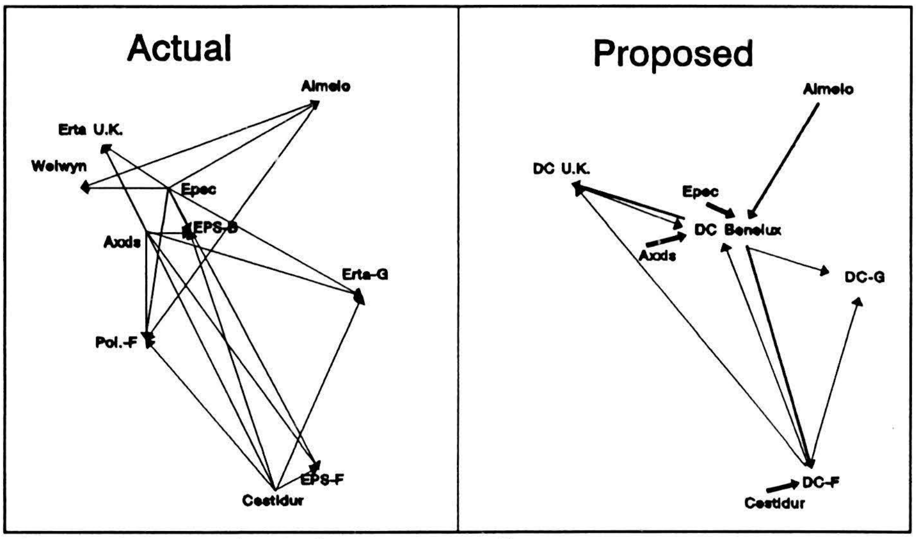


Figure 14 Reduction in inter-company flows

However, more volume is transported inter-company, by sending all products from production to a distant warehouse. In the proposed structure more inter-company shipments are full-trucks than in the actual situation. Transportation of full truck loads per kilogramme costs far less than shared transportation. In the proposed structure the inter-company transportation costs therefore will not increase in the same extend as the volume shipped.

The extra expenses for inter-company transports are presented in table 17. These extra expenses seem low compared to the additional volume. Especially the very small transportation distance (same region) of the volume that is additionally shipped lies at the root of this. The extra expenses again are calculated in the light of the assumption that both the warehouses in France and Belgium are not directly linked to production.

Table 17 Extra expenses in inter-company transportation costs

Scenario	Handled volume	Costs (1000 Dfl.)
Actual	6,325	830
Proposed	15,420	930

EXTRA EXPENSES 100

Export transportation
In export transports, the volume that is shipped to the customers will be the same in both scenarios. However, shipments that nowadays are transported from the different production warehouses to common customers, are combined in the proposed structure.

The savings calculated by the transporter in appendix 7 are enormous (360 thousand Dfl.). This is assigned to the fact that in the actual situation the calculations depart from separately collecting and transporting the goods from EPEC and Axxis. In the actual structure however, these shipments could be combined. The difference in transportation costs of combined EPEC and Axxis shipments then only will be an extra loading stop. Such a stop costs about Dfl. 75.

There are 11 destinations to which important common export shipments of Axxis and EPEC take place, that are all delivered 50 times per year. This would lead to extra costs of 41 thousand guilders in the actual structure compared to the proposed structure. In the calculations this difference was calculated at Dfl. 198 thousand. This figure is retrieved by the enumeration of the export transportation costs to common locations for Axxis and Epec in the first scenario diminished with the common transportation costs for these two in the proposed scenario.

Table 18 Correction for combined Erta-Axxis export transportation costs

	Calculation	Costs (1000 Dfl.)
Calculated	673 - 475 (from appendix 7)	198
Corrected	11 x 50 x 75	41
	DIFFERENCE	157

For other combinations of export shipments in the proposed structure (for instance Almelo-Epec, Almelo Welwyn), combined shipments in the actual situation are not expected to be organized so easily, because the locations of these warehouses are too distant. The calculated savings on these transportation costs are taken into account as they are calculated by the transporter. Total savings in export transportation in the proposed structure are 203 thousand Dutch guilders. These savings may seem high, yet we may not forget that part of the export transports are taken over by inter-company transports in order to create these savings.

Table 19 Savings in export transportation costs

Scenario	Calculation	Costs (1000 Dfl.)
Actual	1,286 - 157 (correction)	1,129
Proposed	926 (see appendix 7)	926
	SAVINGS	203

Dispatching

In dispatching (much less than truck loads), a transporter firstly brings the products to a hub close to the customer. From that hub he distributes the goods to the individual customers (see figure 15). Because the transports from this hub to the customers are equal in every scenario, the transporter only calculated the dispatching costs from the warehouse to the transporters hub.

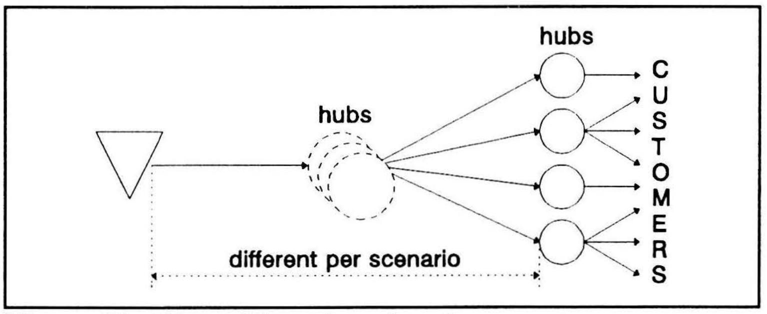


Figure 15 Dispatching takes place in more stages

The effects of combining shipments from different warehouses are the same as described in the previous paragraph. Because in the actual situation it is not reasonable to assume that combination in dispatching is possible, here the differences in costs that are calculated by the transporter are expected to be real.

The actual dispatching costs (chapter 3) are estimated at four and a half million guilders. The calculated dispatching costs to the regional hubs in the actual structure are Dfl. 2.4 million (appendix 7). In addition to the calculated dispatching cost in every scenario it is assumed that Dfl. 2 million is spent on the transportation costs from the hubs to the individual customers.

Table 20 Calculated savings in dispatching costs

Scenario	Calculated costs (1000 Dfl.)	Costs from hub to customer (1000 Dfl.)	Dispatching costs (1000 Dfl.)
Actual	2,450	2,000	4,450
Proposed	2,117	2,000	4,117

SAVINGS 333

8.4 Sensitivity

In the calculations for comparing the proposed structure with the actual situation, we have tried to stay on the save side in determining the expected savings. On some aspects we have not taken into account, opportunities for additional savings in the proposed structure are expected. In table 21 we recite these opportunities.

Table 21 Factors that are expected to influence the savings positively

Cost factor	Opportunities
Inventories	Less 'overhead' Combination of Erta and Polypenco inventories
Buildings	Decrease of inventories (as above)
Handling	Economies of scale Location of the warehouses in Belgium and France (at production)
Inter-company transportation	Location of the warehouses in Belgium and France (at production)

The total savings that are calculated in this study, for the largest part are savings in transportation of small volumes. Transportation costs are expected to increase in the future, due to political (environmental) and economical factors. The proposed scenario, according to the lower transportation costs is expected to be less sensitive for these changes than the actual scenario.

It should be taken into account that the savings calculated with respect to the reduction in inventories, i.e. the savings for inventory costs and for buildings, are based on parameters of which we have little insight. With better information on what products are located at the different warehouses and what purpose they serve, the calculations could have been more accurate and reliable. The savings that have been calculated, show a trend that inventory in the proposed structure is definitely expected to be lower than in the actual situation. However, we should be careful to attach too much value to the absolute figures for the savings that are calculated on these aspects.

8.5 Conclusions

Table 22 shows an overview of the calculated physical distribution costs for both scenarios with for each cost factor the minimum savings that are expected to be realized.

Table 22 Overview of the calculated physical distribution costs

	Scenario	Costs (1000 Dfl.) Actual	Proposed	SAVINGS
Warehousing	inventories	1,590	1,525	80
	buildings	1,205	1,155	60
	handling	3,120	3,185	- 65
Transportation	inter-company	830	930	- 100
	export	1,129	926	203
	dispatching	4,450	4,117	333
TOTAL		12,324	11,838	511

Total savings are expected to be at least Dfl. 511 thousand guilders per year when the distribution structures of Erta and Polypenco are combined as in the proposed structure. The conclusions of this study are that when the company wants to make its customer service objectives operational, only combining the distribution structures of Erta and Polypenco leads to savings of at least 4% of the total physical distribution costs.

9. Conclusions & recommendations

9.1 Introduction

In this chapter firstly an overview is given of the conclusions that are drawn in this stage of the project. In paragraph 8.3 we introduce discussion items for the aspects for which we have taken assumptions in the project until now. At the end recommendations for the remainder of the project will be made.

9.2 Conclusions

In this thesis we have investigated the possibilities for an integral physical distribution structure for DSM EPP. The starting point for the investigations was that the company wants to be a leader in logistic service. For this project this strategy has been translated into objectives like 'daily deliveries' and 'next day' deliveries.

What we have seen in this study so far, is that when these customer service objectives are applied for all customers in central Europe, a distribution structure with totally centralized stock can not fulfil these objectives. Also direct deliveries to big customers in this area from production then do not bring the advantages as expected.

The study shows that a structure with only four warehouses in central Europe outperforms the actual situation as well in performance as in costs. The advantages of combining the physical distribution structures of Erta and Polypenco are demonstrated. For the moment a decentralized structure, with common national distribution centers for both Erta and Polypenco, is found to be an interesting structure to base further investigations on.

9.3 Discussion

In this project, some aspects have been taken for true that are not investigated in detail. One of the most important principles that affect the outcomes of an optimized physical distribution system for DSM EPP Europe is the objective of daily, 'next day' deliveries to all customers. Applying this objective, as we have seen, is an expensive business. Although this can be a goal for the company, it is expected that not all customers need this service. For so far, this study has not dealt with the requirements of different customer groups within the area of inquiry. A study to the extent and characteristics of customers who really need this service could possibly save the company a lot of money in transportation. The outcome of such a study can have influences on the conclusions we have made in an earlier stage, i.e. direct deliveries, or deliveries by a central warehouse.

Another assumption we have made, because we did not discuss the inventory control in this thesis, is that the actual inventories are the base for further investigations. We have seen that the amount of stock has a large influence on the total physical distribution costs. Lower inventory leads to lower inventory costs as well as lower building costs (on the long term). The total physical distribution costs therefore can differ largely from the calculated costs, when the company really knows what products where to locate to serve specific customer groups.

During the continuation of the project improvements on short term can be made, apart from the physical distribution structure. Combining Epec an Axxis shipments and the use of packaging material are two of the issues that have been discussed. As this project is faced towards more structural changes, we will not include this in our further investigations. We leave it as a recommendation for the operational management.

Taken into account the remarks in this paragraph, further investigations should be done, before explicit conclusions on the recommended structure can be made. As the calculations that we have executed in this report for a large part are based on generalizations, more specific information can affect the outcomes of the project. However, the study so far demonstrates the effects of several decisions on multiple factors. On the one hand this thesis gives a starting point to base further investigations on, on the other it contains valuable information on the trade-offs that take place in the design of a physical distribution system.

9.4 Recommendations for further investigations

As already said in the previous paragraph, we still lack important information that is needed for a rational design of an integral physical distribution system. The first recommendation that is made for the progress of this project is, that information should be generated about the actual availability and reliability performance to the customers. Also the desired delivery times should be kept up per customer. The installation of a sales information system can be of great help. In contradiction with declarations earlier in this report, now is the time to set performance indicators, to enable comparisons between the desired and the provided performance. The difference here with the directives in the customer service concept (see paragraph 2.4) is that we do not start from a 'green field' situation.

The proposed approach for further investigations is presented in figure 16. The performance indicators generate input for the first step that is recommended in the continuation of this project; the definition of customer service objectives for different product-market combinations (PMC's). As we have seen, sending goods to all customers in daily, 'next day' deliveries is very expensive. It is expected that this is not necessary for all products to all customers, either. Different customers require different service levels for different products. Together with new information about specific customer groups that can be collected in concerted action with marketing and sales, this should lead to a definition of PMC's, which are distinctive in their customer service requirements.

After customer service requirements have been defined per PMC, information should be retrieved for which PMC's the products should be located near the customers in order to be able to meet the customer service objectives. In this stage, the considerations earlier in this report become important again. The scenarios that we have rejected in this thesis, might be reviewed. With the need of national distribution centers, the proposed structure is a reasonable alternative. An ABC-analysis of products can be a valuable additional input.

Only after these steps have been taken, a sensible integral inventory control system can be designed. From here on the further steps of the customer service concept can be completed. Because we do not know yet what the effect of the investigations above will be, no further specification towards these steps is made here. Anyhow, only then the essential information will be available to base the decisions on.

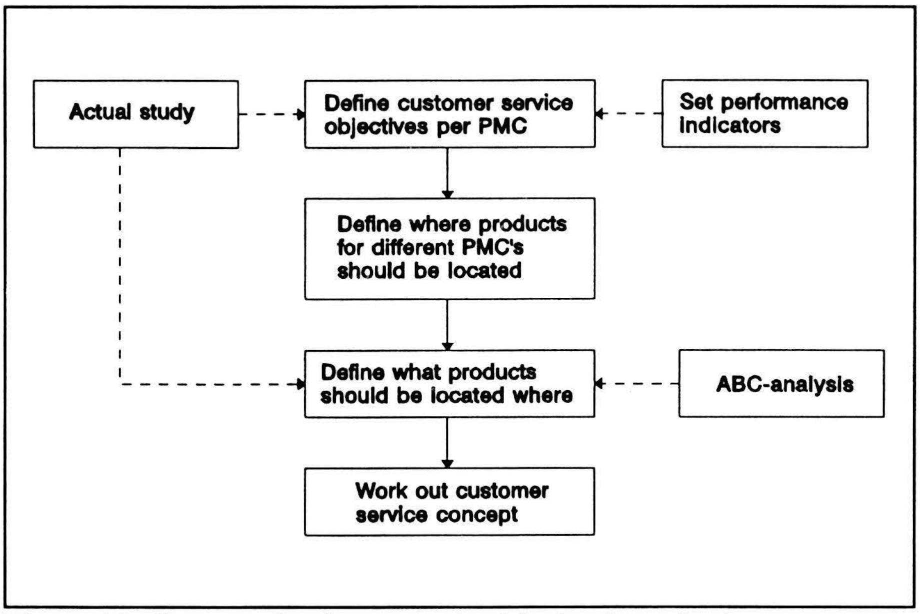


Figure 16 Structure for the approach of further investigations

Definitions and Abbreviations

In the text of this report the following words or abbreviations have been used. Their sense is as given below, unless another explanation is given in the text.

Availability	Percentage of order lines for stock shapes that are available ex-stock.
Axxis	Production plant for Axxis PC and VIVAK and the PW linked to it.
Branding	Putting of a brand name on the products.
Calendering	Production method at Axxis.
Casting	Production method where caprolactam is transformed into nylon.
CW	Central Warehouse. Place where products of all production plants are stored.
Cestidur	Production plant for PE plates and the PW linked to it.
Custom casting	Production method where products are casted to customer specification.
Customers	Own machine shops and external companies that buy shapes.
Customer Service	Everything that can be done to get the right products at the right time to the place the customer wants to have them.
Delivery time	Time between the placement of an order by the customer and the delivery at the customers site.
Dispatching	Deliveries to customers inside the countries where DSM EPP has DC's.
DC	Distribution Center. Place where products are stored, close to the customer (one or a few per country), owned by DSM EPP.
Distributor	Customer that trades DSM EPP's products without machining them.
DSM	Mother company of DSM EPP.

DSM EPP	DSM Engineering Plastic Products.
DSM EPP Europe	The European group of companies belonging to DSM EPP, for which this project has been executed.
EDIS	The European Distribution Information System as it is developed by and used by DSM EPP Europe.
ELS	European Logistics of Shapes. The name of the project described in this report.
Erta (group)	All companies that belonged to the Erta group before the division DSM EPP was formed.
Erta EPEC	Erta Extruded and Cast Engineering Plastics. The biggest production center for 3P products and the PW linked to it.
Erta EPS	Erta Engineering Plastics Services. The distribution centers for Erta products in Belgium and France and their machine shops.
Extrusion	A production method where polymer granulate is transformed into rods, tubes or plates.
HPM	High Performance Materials. Engineering plastics used in very demanding environments. Special products with high prices.
Injection moulding	A production method where products are formed by injecting plastic material with high pressure into a form.
Labelling	Way of branding.
3P	Collective name for Nylon (polyamide, PA), Polyester (polyacetal, POM), Polyethylterephtalate (PET) and Erta Polycarbonate (Erta PC).
Parts	Machined plastic products.
PMC	Product Market Combination. A combination of customers and products with the same demand pattern
PE	Polyethylene. Material from which shapes are produced at Cestidur in France. A separate product group.
PC	Polycarbonate. Material used to produce transparent plates at Axxis. As product group PC also contains VIVAK.

Polypenco (group)	The European production and distribution centers that belonged to the Polymer Corporation.
Pressing	Production method at Cestidur (for PE plates).
PW	Production Warehouse. Warehouse where end-products from production are stored.
OMS	Own Machine Shop. Place in which machining of shapes into finished products takes place, within the division DSM EPP, mostly linked with a DC.
Others	External customers other than distributors.
Reliability	Percentage of order lines for all items that are delivered before the first acknowledged delivery date.
ROQ	Re-Order Quantity. Fixed quantity of products to be ordered.
ROL	Re-Order Level. Inventory level at which re-ordering should take place.
Shapes	Semi-finished products of 3P, PC and PE.
SRL	Square Root Law. Rule for determination of the reduction of inventory, when centralizing the stock.
Stock shapes	Standard shapes that are normally held to stock. All shapes that are marked with a dot in the catalogue.
Traceability	The possibility to have knowledge of the state of the products at all times during transportation.
VIVAK	Transparent sheet produced at Axxis in Tielt.
Warehouse	Place where products are stocked.

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