MASTER

Re-configuration EMI Warehouse Uden

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RE-CONFIGURATION
EMI WAREHOUSE
UDEN

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ABSTRACT

This report is concerned with re-structuring the warehouse of EMI Uden. The increased demand on warehouse activities causes the need for actions. By means of improved warehouse information and reviewed procedures, equipment and lay-out, improved performance-control is accomplished.

PREFACE

Dear reader,

Imagine, it is november 1990. After four tough years of studying, I walk in at EMI Compact disc in Uden. The final part of the study, Industrial Engineering at the Eindhoven University of technology has started. I am expected to apply all the theories, I gathered for years in a practical situation.
I am curious, innocent and unexperienced, but prepared and willing to work. At this moment, I think of the Dutch marines who leave this day to the Gulf.

Nine months later, it is August 1991. Kuwait is already free for months, and finally, I am finishing my job. I look back and see a period full of challenge, unexpected situations, motivating people, fascinating trips and a very interesting project.

For all the possibilities, first of all, I would like to thank EMI Uden, my supervisors Mr. von Imhoff and Mr. Solleveld, who were the main stimulants in doing the job, and all the people who supported me, and I worked so closely and enjoyably with, during the last nine months.

My special thanks, I send as well to Mr. Tilanus and Mr. Van der Ven of the University, who kept my feet on the floor and where an important support for the theoretical back-ground.

And not to forget of course, my parents for being interested and helpful all these years, and my house-mates for our home, the friends of my dispute Quare, Michel and Paulien, and all friends I did not mention yet.

I hope this report is worthwhile and interesting to read for you, and can be a reflection of all the experiences I gathered during this period.

Theo van Aalst.

CONTENTS

SUMMARY

EMI Compact Disc (Holland) takes care of shipping CD's out of the factory to (EMI) distribution centra on the continent of Europe, and is responsible for direct deliveries of all kinds of sound carriers to customers in the BENELUX.

Future developments in economical/political, technical and music market related areas are expected to have a significant influence on the activities in the warehouse. Volumes are forecasted to increase by 30%, while volumes per order are decreasing by 10%. To be able to match the objectives on customer service, the warehouse is planned to be re-constructed.

This study focuses on the requirements set to the warehousing function by a changing environment.

First, in this survey, is to define the warehouse function. The Uden Warehouse finds its function in decoupling production from customer demand, thus enabling the factory to produce in economical ways and serving the customers with short delivery times. The essence of the warehousing function is formed by holding stock.

The stock clearly separates the activities, part of which is stock-driven (the stock maintenance function), part of which is customer order driven (the delivery function).
The effectiveness of these sub-functions is measured by fulfilment (what is available on stock) and service level (what part of the availability is delivered in what time).
These measurements basically determine the customer service.
To improve customer service, it is crucial to distinguish what processes are assigned to the sub-functions. For this reason transaction groups are defined. A transaction group is a combination of serial activities, separated by structural stocks or waiting queues, which clearly can be assigned to the specific warehouse functions. A group is started by generation of an order and stopped by confirming this order.

As can be concluded from this, two major flows drive the warehouse processes: information and product.
According to these flows the original warehouse situation is described per transaction group. The qualitative description provides an insight into the warehouse handling procedures, the warehouse flows and the lay-out.

By obtaining this overview, problem areas are distinguished. The original situation can be characterized by the occurrence of several irrational stocks and waiting queues, undefined and complex procedures and a relatively high number of handling stages.

In order to set priorities among the actions that are required to solve the problem areas, detailed measurements of warehouse processes are required.
In the original situation hardly any information is available that measures the activities on short term base.

To be able to evaluate warehouse processes and to control them, an information system is of highest importance. It has to measure the output of a process, the throughput times and the efforts taken to realize it (input). The relation of output and input is measured by the productivity ratio.
A daily report is created, measuring warehouse transaction groups on these variables. It provides management the information to judge the activities and to decide whether and where actions have to be taken.

The information gathered by this set up, provides the base for distinction of bottle-necks.
The transaction groups assigned to the two customer service elements are analyzed in detail, establishing throughput times.
By this exercise, the booking-in activities and the order fulfilment in the single unit picking area, showed to be the main bottle-necks in warehouse performance.
In the transaction groups not negatively affecting the customer service at the moment, significant productivity improvements can be gained by improving procedures, lay-out or equipment.

According to these three elements, the alternatives selected to improve the performance, are described.

The warehouse procedures are reviewed per transaction group:
- the equipment available is delineated;
- the applications for Uden warehouse determined;,
- the techniques are selected.

For re-structuring of the warehouse, the emphasis is put on the resolution of the bottlenecks.

For this, the proposed investments are:

- A new barcode driven conveyor belt;
- Flow-racks in the picking area;
- Automated weighing and checking at final station;
- Automated box closer at the end of the picking process;
- Barcode equipment for checking, registration and confirmation in the booking in area.

The proposed investments have been authorized by higher management, and will be implemented shortly.

The new procedures and equipment resulted in a new design for the warehouse, ensuring a smooth throughput of purchase-, and customer orders through the warehouse.

1. THORN EMI COMPANY DESCRIPTION

1.1. Thorn EMI Limited

In 1931 EMI, Electric and Musical Industries, was founded out of two music companies. The fusion with Thorn Electrical Industries in 1979 was the beginning of Thorn EMI Limited.
THORN EMI is an international company, operating in 43 countries all over the world, employing about 60.000 people.

It is divided into 5 product groups: Music, Rental and Retail, Technology, Lighting, Kenwood.
Together they realize a turnover of 3.7 billion English pounds. (31-12-1990). Half of the activities take place in the United Kingdom, where the main board is located.
For the organisation chart of Thorn EMI is referred to appendix I.

1.2. EMI Music

EMI Music is concerned with selling, producing and distributing divers kinds of sound carriers. In its catalogue famous artists as the Beatles, Pink Floyd, Tina Turner, Queen, Marillion and Cliff Richard can be found. Next to various pop-artists EMI is well known for its extensive classical catalogue.

EMI Music is subdivided in two parts:
1. EMI operations (production and distribution)
2. EMI marketing
Both operate worldwide, and have companies in several countries.
The Music activities resulted in a turn over of 1 billion English pounds in 1990.
In Europe, marketing is represented in almost every country.
Operations has plants in the UK (vinyl, cassette and cd), Holland (cd), Germany (vinyl) and France (cassette). The distribution centra are regionally centralized.

1.3. EMI Music in the BENELUX

EMI Benelux started with the foundation of the record company BOVEMA in 1946. In 1967 the company became part of EMI. After the move over of the vinyl production to Germany and the Music Cassettes to France, EMI started the CD factory in Uden in 1990. Nowadays, EMI has three companies in the BENELUX region:
1. Marketing company BOVEMA in Heemstede;
2. Marketing company EMI Belgium in Bruxelles;
3. Operations in Uden (CD-factory and Distribution).

The marketing companies are responsible for the sales in the Benelux. The CD-factory produces CD's mainly for the EMI companies on the European continent. Finally, Distribution is responsible for distribution of products to customers in the BENELUX and for shipments of final products out off the CD factory.
Appendix I shows the organisational set up at EMI Operations Uden.

1.4. The Uden Distribution centre

1.4.1. The Organisation

The EMI Compact Disc Distribution Centre Uden is responsible for storing, handling and shipping the products of the Marketing companies and the CD-factory.
Since stock control responsibility is moved over to the marketing company (01-04-1991), Distribution can be subdivided into four areas:

1. Customer Service, dealing with all kinds of customer requests, to ensure they are served at the best possible level;
2. Goods in and Bulk, dealing with booking in ordered product, replenishment of stock and picking of bulk quantities;
3. Picking, dealing with the fulfilment of customer orders ordering small quantities;
4. Shipping, dealing with despatch preparation of shipments to customers in the BENELUX and of CD-factory shipments.

Twenty-five people are employed in the distribution centre. Eighteen of them are assigned to physical handling activities in goods inwards, bulk, picking and shipping (the direct labour force). Seven of them are concerned with indirect activities; supervision (2), customer service (2) and administration (3).

1.4.2. The Product

The Distribution Centre delivers service, defined as distributing products of a customer-order in certain quantities, within a certain time frame at a place. This involves three dimensions; physical, musical and time related.

The physical dimensions are the different kinds of carriers:

- Vinyl (7" 12" and Albums)
- Music Cassette (Albums, Singles)
- Compact Disc (3" 5" and Albums)
- Video

The music related dimensions (the kind of music, that is ordered) refer to the catalogue:

- title
- popular or classical
- new release (release date less than three months ago) or back catalogue (older than three months)

The time related dimensions are measured from 'cut-off time' (in EMI case 12.00 a.m.). This is the moment, that order-delivery lead times start.

For the definition of EMI terms, used in this report, is referred to appendix II.

2. THE PROBLEM DEFINITION

2.1. Justification

Changes in market-demand have resulted in increased workload for the DC. Product-mix changed considerably, volumes to be shipped increased over the last years over 50% and market-demand led to stronger chart orientated marketing activity.
Future developments in the European market will, according to the European strategy, even strengthen these increased requirements and lead to new ones.

In spite of the changes, the current way of handling product has not been improved considerably over the last 5-8 years. Staff has been cut without further investments in automation and in new operations and procedures.

2.2. Objectives

Management defined the following objectives to improve the performance of the DC:

1. to improve the customer service fulfilment rate from currently 90% up to 95% in three years;
2. to improve the 24 hours service level from 88% to 92% in three years time;
3. to cope with forecasted increasing volumes (about 6-8% over next plan years) with the existing levels of full time equivalents (17.5 FTE's) and only allowing overtime and temporary labour force (Temps) for peak periods;
4. to create the conditions that make it possible to play a key role in the European strategy as a Central facility for slow moving and other business related products without unreasonable increase of FTE's and investment.

2.3. Project BB12, Uden Re-configuration

To cope with the objectives regarding fulfilment, service level, volumes and the European strategy, management is convinced that the Uden DC has to be reconstructed.
The re-configuration will primarily affect:
a. the computer hardware;
b. the handling operations and the product flow in the warehouse;
c. the equipment of the warehouse.
The project group BB12 was formed for the re-configuration of the Uden warehouse.

2.4. Problem definition

At the initial stage of the project, project group BB12 is confronted with the problem, that no quantitative basis is available for founding the Re-configuration project.
Management is not able to influence the performance. First, because no information is available, that indicates the need for actions and second, management has hardly any insight in the effects of actions on the performance.
This study is carried out to base the Re-configuration project. It focuses (1) on the set up of an information system that enables management to determine problem areas and (2) on solutions of bottlenecks.

The aim is to come to:
1. more efficient handling activities;
2. more effective control on product- and information-flow,
thus being able to achieve the objectives set by higher management.

This is foreseen to result in:
- management information system to control warehouse activities;
- new warehouse lay-out;
- new equipment to be installed;
- defined and written down procedures;
- project framework how to implement suggestions.

2.5. Problem approach

The study is worked out in an investigation dealing with:

1. Getting a better overview on current situation.
   A description in detail of the activities in the warehouse has to be made. This means making a flow chart of product-, and information flow, establishing the size of these flows under different headings.

2. Measuring the performance.
   The objectives set by the distribution management do provide 3 measurable indicators for the performance of the distribution centre. The current performance on these indicators has to be reviewed and new standards for individual activities in the warehouse have to be found and measured.

3. Statistical analysis of the current situation.
   Problem areas and bottlenecks have to be distinguished, based on the information provided by previous steps.

4. Generating alternatives.
   Among the problem areas established, priorities have to be set and improvement actions mapped out.

5. Statistical simulation and analytical reflection.
   Building a model and run alternatives through models.

6. Proposal of improvements.
   The results of step 5 together with financial analysis will set priorities in the generated alternatives and support the decision-making process.

Because no information is available, much attention will be necessary to define and obtain the required information.
In the end, it will result in a framework for implementation of project BB12: UDEN RE-CONFIGURATION. It will end at the moment that the conditions are created. The commissioning phase, implementation and training, are not seen as part of this study.

3. FUNCTION OF THE WAREHOUSE IN THE LOGISTICS CHAIN

The warehouse is a part of a the logistics chain. This chapter describes the function of the warehouse in this chain and the logistics situation at EMI.

3.1. The logistic chain

All processes of the logistics chain are concerned with one goal: to ensure that the right product is available at the right moments on the right places, in right quantities at lowest possible costs. This is defined as the integral product flow control.

In the logistics chain, two sub-systems can be distinguished:
- Materials management; the activities committed to control the productflow from raw material acquisition for manufacturing to final product storage;
- Physical distribution; the activities committed to control the productflow from final product storage to customer delivery.

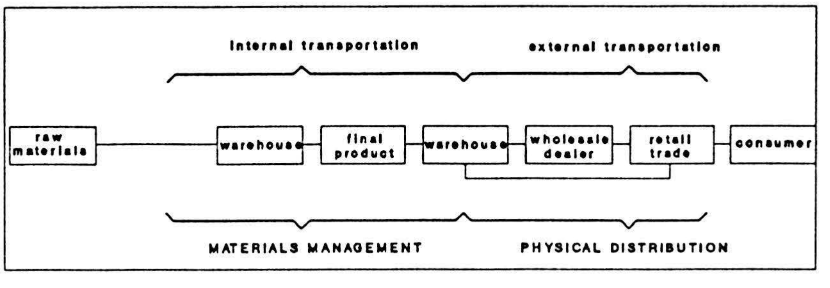


Figure 3.1 Materials management and physical distribution

The elements of both the logistic systems are:
1. acquisition of system input (raw material/final product);
2. planning and control of productflow;
3. warehouse functions;
4. stock control;
5. internal transport;
6. external transport.

In what way they are organized, depends on the position of the customer order decoupling point. This point separates planning based activities from customer order generated activities.
The impact of actual customer orders on the logistics activities, determines the logistics set up.

3.2. The logistic chain at EMI Uden

Within EMI, wholesalers and retailers are regarded as being the customers. They place orders with the local distribution centres. In Europe 14 local distribution centres serve regional markets. The local distribution centres fulfil customer orders from stock.
The stock levels are determined by expected demand (market forecast). Anticipating on this forecast, the distribution centres place orders with the EMI factories.

The factories consider the distribution centres as their customers. The actual demand of the distribution centres, throughput times and the delivery times determine the acquisition of raw material.

In conclusion, the logistic sub systems, materials management and physical distribution, are clearly separated, having their own decoupling point. For materials management it is located at the supplier, for physical distribution at the local distribution centres. Figure 3.2. shows the logistics set up for this situation.

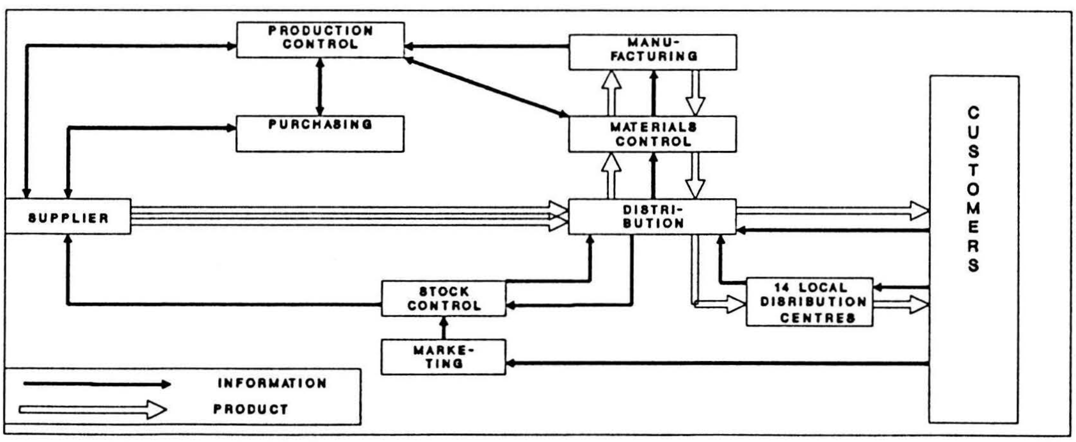


Figure 3.2. The logistics set up for EMI-Uden

3.3. The warehouse function

The position of the Distribution warehouse in the logistics chain can now clearly be defined. The warehouse allows production to be uncoupled from distribution by holding stock.
Thus serving customers by short delivery times and permitting manufacturing to produce in efficient ways.
The position of the customer order decoupling point separates the activities of warehousing in stock driven (based on expected demand) and customer order driven activities; the warehouse sub-functions.

The two sub-functions of the warehouse are realized by transaction groups. A transaction group is a combination of interdependent activities that are separated by structural stocks or waiting queues in the product flow.
In principal, the activities of a transaction group start with the generation or activation of an order and end with the confirmation of an order.

In Uden Warehouse following transaction groups can be defined:

1. Goods In;
2. Inward processing;
3. Bulk processing;
4. Returns;
5. Add Value activities;
6. Pickheader production;
7. Order Fulfilment;
8. Final station;
9. Despatch;
10. Shipping.

The activities that specify the transaction groups, are described in chapter 4. Organisationally the transaction groups are designated to four areas:

1. receipts, the goods-in area;
2. stock maintenance, the bulk area;
3. order picking, the picking area;
4. despatch, the shipping area.

3.4. Future developments in the EMI logistics chain

Developments in all logistics related areas will have a significant impact on the business profile.
The music market is expected to keep on growing. For EMI-Benelux, volumes (in sets) are forecasted to increase by 30%, but quantities per order-line are expected to decrease by 10%.
Meanwhile the product mix is changing considerably. Vinyl is disappearing, the share of CD is rising, and new techniques, like DCC, are being developed.

As far as logistics is concerned, EMI plans to re-act by regionalization of the existing European distribution structure, establishing several categories of service centres:
- two International Distribution Centres (IDC), responsible for re-ordering of the smaller ones and direct and cross border delivery to retailers;
- about five National Distribution Centres (NDC), responsible for service to large country markets;
- smaller local shipping points (LSP) closely to specific areas.

This reorganization will primarily have effect on the stock situation. Classical stock is already centralized in Germany, Pop is likely to be in Uden.

These changes will affect warehouse business by:
- stronger picking orientation, (currently 45% of all sets shipped up to 55% in future);
- increased workload on customer driven activities by increase of orders (44%);
- increased customer requirements (service level, fulfilment);
- differentiated requirements (chart product, fast and slow movers);
- increased stock and workload of all activities by increase of volumes.

For literature used in this chapter is referred to page 56:
[1], [8], [12]

4. DESCRIPTION ORIGINAL SITUATION

To control distribution operations, it is essential to understand the original situation. Only by knowing the business profile, problem areas can be established, alternatives can be looked for, and solutions can be selected.
Within the warehouse two major flows are distinguished:
1. the product flow;
2. the information flow.

The different stages of the flows are determined by the transaction groups. According to these groups, the flows are categorized and described.

4.1. The transaction groups

In Uden Warehouse, following transaction groups are defined:

1. goods in;
2. inward processing;
3. bulk processing;
4. returns;
5. add value activities;
6. pickheader production;
7. order fulfilment;
8. final station;
9. despatch preparation;
10. shipping.

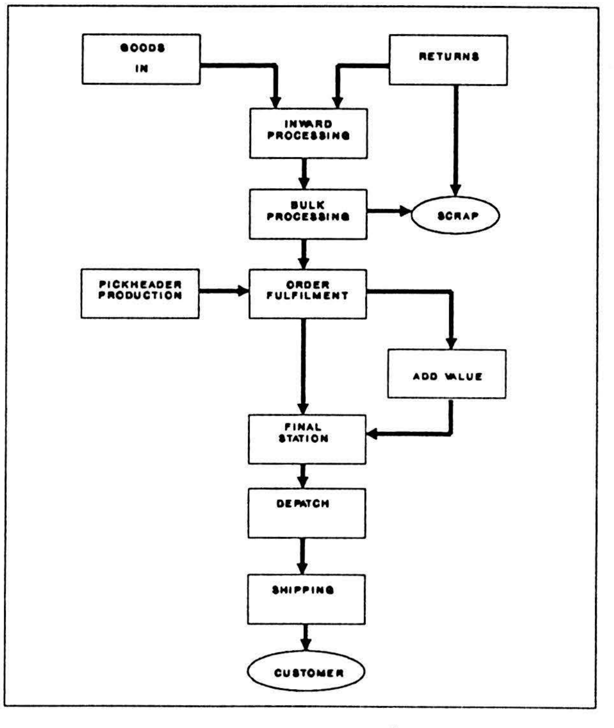


Figure 4.1. The transaction groups

The activities, the transaction groups include, are worked out in next sections.

4.1.1. Goods in

Goods in is concerned with the preparation of goods received for final storage in the warehouse.
The stock control department places orders with the EMI-companies or third party suppliers. As a shipment arrives, the truck gets unloaded and the shipment is checked (arrival checking). This is registered on the arrival note. Checked goods are stored in the entrance warehouse, awaiting entry checking.
From here, goods are moved to the checking area. The shipment gets unpacked, and is sorted and checked on quantities per line (entry checking). This is registered on a checking note.
To add a supplier number, the checking notes are sent to Stock Control. They return the notes to the checking area, where the shipment data are manually entered into the computer system. The computer decides where to store the goods, and generates a storage order. The storage order is printed out on a storage note. This activity indicates the end of the Goods in process.

4.1.2. Inward processing

This transaction group includes the activities of physical storage of products in pre-described locations.
Goods received can be located into four different stocks, depending on the number of sets per line delivered:
- pallet stock for number of sets per line >1500;
- bulk stock for number of sets per line <1500 and >100;
- reserve stock for number of sets per line <100 and >box volumes;
- picking stock for number of sets per line < box volumes.

Each location is defined by a lane, a column, a row, and a shelf. Start of the inward processing activities is picking up the storage note at data entry. The operator moves the lines and quantities indicated to the location indicated, until a storage order is completed. Completed storage orders are confirmed in the system at data entering. Only then, product is available for sale. The confirmation indicates the end of Inward processing.

4.1.3. Bulk processing

The Bulk processing activities take care of the movements between the stocks mentioned above. Physical movements to consider are:

1. Automatic replenishments,
   movements from pallet and bulk to the reserve stock and picking, automatically generated by the system;
2. Internal movements,
   movements between stocks for re-ordering purposes or for replenishment functions in case Automatic replenishment is not carried out. This movement requires manual generation;
3. Returns restoring,
   movements to restore returned product in the warehouse;
4. Scrapping,
   movements to re-move product from stock for being destroyed;
5. Production movements,
   movements from Distribution to the CD-factory and back again e.g. to add new booklets or to sticker jewel boxes.

A movement order is generated either automatically or manually and is printed out on a movement note. The operator moves to the location indicated, takes out the required quantity of product and moves it to the new location. This procedure is repeated until all lines of the order are relocated. The order is completed at the moment it is confirmed into the system.

4.1.4. Returns processing

The activities of returns handling are directed to the acceptance and validation of products returned by customers.
Customers can send in a request for returns. Customer Service and Marketing decide wether the request will be honoured, if so, a returns order is generated and sent back to the customer.
Physical activities start as the returned product actually arrives at the entrance warehouse. The returns are checked (returns arrival checking), and stored in the entrance warehouse.

From here, product is moved to the returns area to be checked on quantities per line and returning reason (against returns order). Returns can either be restored in the warehouse (eventually after repacking), or can be destroyed. For these purposes a returns restoring order respectively a returns scrapping order is generated. The procedures of these orders are common to normal storage and scrapping orders. Returns awaiting restoring or scrapping are stored in the returns warehouse.

4.1.5. Add Value Activity

This transaction group is involved with the enhancement of value to a product by physical activities like stickering, blistering, repacking etc. The activities are started by the generation of an internal movement order (bring product to boxless) on request of marketing. In the boxless area, the re-conditioning is carried out, and the data in the system are updated. The product is re-stored in the original location and available for sale. Confirmation of last action indicates the end of this transaction group.

4.1.6. Pickheader Production

Pickheader production is defined as all the activities concerned with the transformation of customer orders into picking headers. The marketing companies (Heemstede and Bruxelles) receive the customer orders. After a solvency check, orders are transmitted and available for distribution. The distribution activities start with calling-in and allocating the available orders.
If product ordered is available on stock, it is assigned to a specific customer order-line. Lines ordering less than box quantities are served from the Picking area, lines ordering quantities in box volumes are picked from the Bulk Area. For this reason one order can be split up in several headers.
If product required is not available, orders can either (partly) be taken into backorder or deleted after customer consult. Orders can purposely be taken into backorder on customer request.

An allocated order is printed out as a picking header. A picking-header for the picking area is put into a type of box, indicated on the note, and the box into a carrier on the conveyor belt.
This is the end of the Pickheader production.

4.1.7. Order fulfilment

The picking headers show the lines and volumes to be picked and the location of the lines. The boxes are moved via the conveyor to each station, where the box should switch off, if product is required. If no line of a station is required, the carrier is moved to the next station. If lines are required, the picker moves to the location indicated, picks out the product and packs it into the box. If all lines of a station are fulfilled, the box is moved on to next station. If all stations required are visited, the fulfilment is completed.

Bulk orders provide the same information. The Bulk operator pick up the order at data entering, moves to the location indicated, picks the required lines and volumes and moves the fulfilled orders directly to final station.

4.1.8. Final station

Final station is the group of activities that checks the order fulfilment and prepares the invoices and packing lists.
Final checking holds registration of weight, number of sets, order number and customer. After checking, invoices and packing notes can be printed. The activities are started by the arrival of fulfilled orders and ended by printing-out the notes.

4.1.9. Despatch Preparation

The despatch transaction group is concerned with the preparation of fulfilled and checked orders for final delivery.
The invoices are fed into the box, the box gets taped and the packing note is added. Then, boxes are sorted on destination. Orders are collected on pallets and roll cages. Completed pallets and cages are moved to the shipping area, get shrinkwrapped and are stored.

The second flow of goods to be shipped consists CD's out of the CD-factory. Shipments are checked on export documents, number of sets, lines, boxes and pallets. This is registered and transferred to the CD-factory. The shipments are shrinkwrapped and sorted on their destination (countries) and stored in the warehouse.

4.1.10. Shipping

Shipping is concerned with the actual delivery of the orders to the customers.
At 18.00 p.m., the contracted expeditor picks up the prepared shipments. They are checked on number of sets, boxes, pallets and destination. This is entered into the computer, after which shipment notes can be printed out.
From here the contracted freight delivery system takes over the activities. This transaction group ends with the actual delivery. Shipments of the CD-factory are shipped several times a week, depending on destination. If shipping is required, an external expeditor is phoned and shipments are transported.

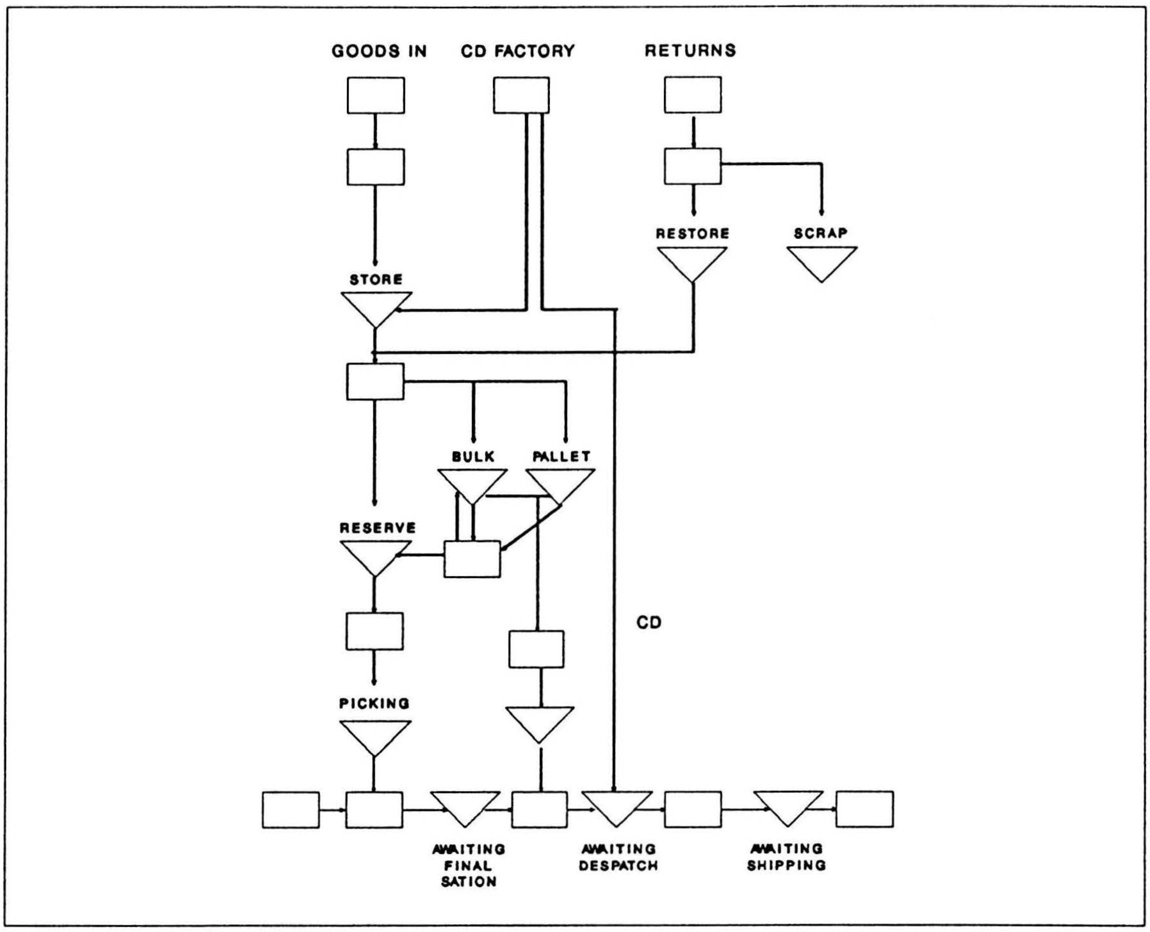
4.2. The product flow

The stages of the product flow are defined by the transaction groups.
In general, stock driven transaction groups are separated by stocks, the customer order driven action groups by waiting queues.
Table 4.1. shows the stages of product within the warehouse.

TRANSACTION GROUPS	INPUT STOCK/QUEUE	OUTPUT STOCK/QUEUE
Goods in:	Goods arrived	Goods to be stored
Inward processing:	Goods to be stored	Pallet/Bulk Reserve stock
Bulk processing:	Pallet/Bulk Reserve stock	Bulk/Reserve Picking stock
Returns:	Returned goods	Returns Restore or Scrap stock
Add value:	Pallet/Bulk/ Reserve/Picking	Boxless (re-conditioning stock)
Pickheader prod:	Pallet/Bulk/Picking stock	Allocated P/B/Pi stock
Order fulfilment:	Allocated P/B/Pi stock	Goods awaiting Final Station
Final station:	Goods awaiting Final Station	Goods awaiting Despatch
Despatch:	Goods awaiting Despatch	Goods awaiting Shipping
Shipping:	Goods awaiting Shipping	Goods delivered to Customer

Table 4.1. The stages of the product flow

In Figure 4.2. the productflow is globally described. Following the description, it is clear that even more structural stocks, waiting queues and handling stages occur than indicated.



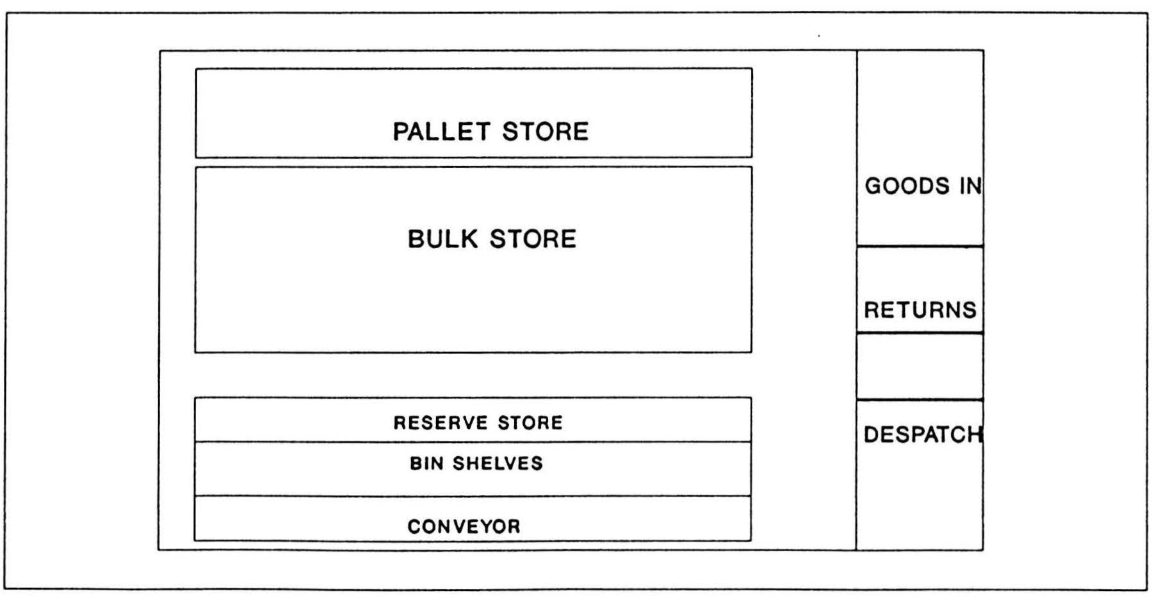


Figure 4.2. Global overview of the original productflow and lay-out
(Page 52 shows the improved product flow and lay-out)

4.3. The information flow

The stages of the information flow are defined by the transaction groups as well. Theoretically a transaction group is started by generation or activation of an order and stopped by the confirmation of an order. In practice however, the information flow is not directly assigned to the action groups. Table 4.2. summarizes the informational support of the transaction groups.

TRANSACTION GROUPS	START/ INPUT	END/ OUTPUT
Goods In:	Purchase order *shipping note *status P-order	Storage order * shipping note * arrival note * checking note * storage note Confirmed P-order Status S-order
Inward processing:	Status S-order	* storage note Confirmed S-order
Bulk processing:	Request for movement Movement order * movement note	Confirmed M-order * movement note
Returns:	Request for return Returns order * consignment note	Storage order Scrap order * storage note * scrap note * credit note
Pickheader prod:	Customer order	Order-header Back order * picking header
Fulfilment:	* picking header	* picking header
Final station:	* pickheader	Confirmed P-order * pickheader * invoice * packing note
Despatch:	* invoice * packing note	* invoice * packing note
Shipping:	* invoice * packing note	Shipping order * shipping note

Table 4.2. The stages of the information flow (*=physical notes)

5. IMPROVE CONTROL ON WAREHOUSE ACTIVITIES

To obtain control on warehouse processes, it is essential to be able to measure the processes by retrieving the right information at the right times. The original situation does not provide information on a regular base. This chapter will focus on the set up of an information system for physical distribution.

5.1. Logistics control

The base of a logistics control system is the position of the decoupling point in the chain. By defining this position the control system is determined.
Three major logistics control systems can be distinguished:

1. stock driven, final product is produced on stock and deliveries take place on customer order;
2. program driven, final product is produced on production plan, based on sales forecast. Deliveries take place on actual customer order;
3. order driven, production and delivery are generated by actual customer order.

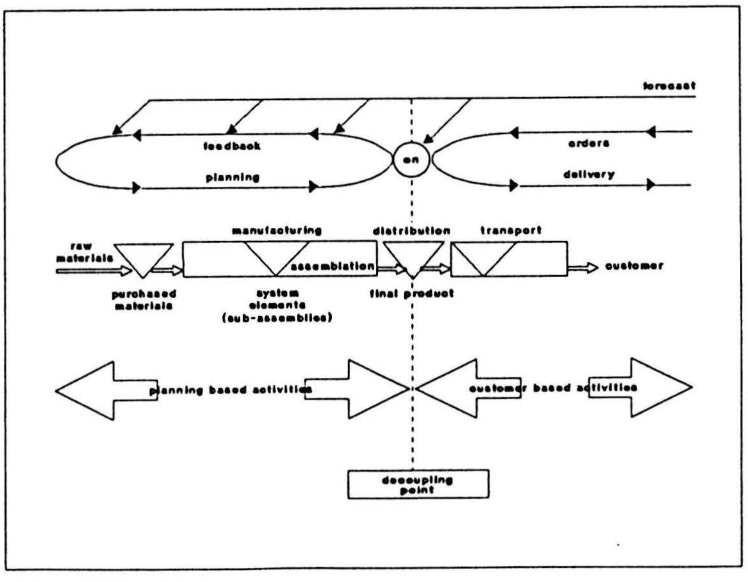


Figure 5.1. The logistic control system for a stock driven system

At EMI Uden, the processes are stock driven. This implies that part of the activities is planning based, and part is based on actual customer order. In overview a system as shown in Figure 5.1. will be likely to drive the overall logistics chain.

5.2. The physical distribution control system

Within this overall logistic control system, the warehouse control system is developed. At EMI, Marketing provides a monthly forecast on sales. Based on this forecast, the overall capacity requirements can be planned (how many FTE's are needed). Actual customer orders determine the daily assignment of the operators to the warehouse activities.
The warehouse control system has to assure, that the assigned FTE's achieve the expected handling activities. This requires measurements of the input (manhours needed), the output (physical units handled) and the handling time. The measurements are compared with norms set to them. If there are discrepancies, management (the regulator) can decide to intervene the situation. Figure 5.2. shows this process of regulation.

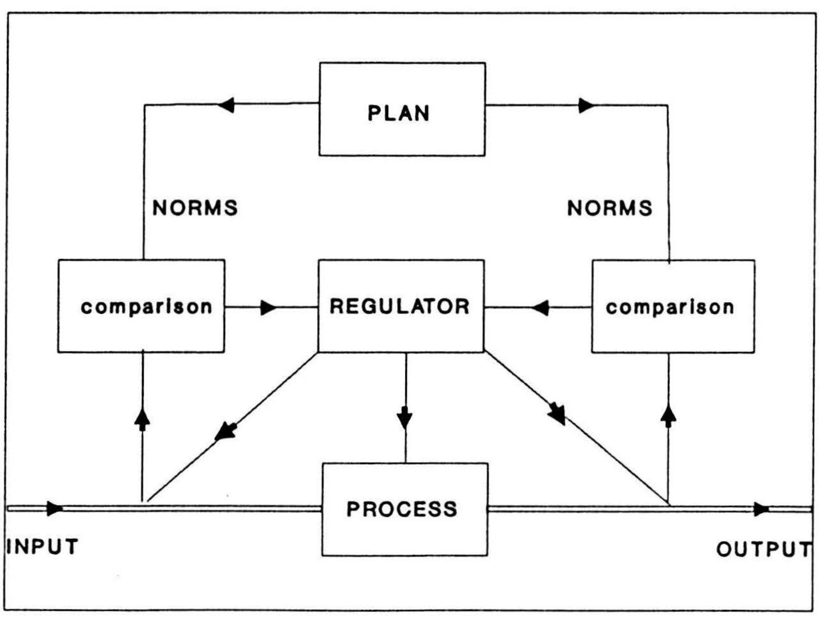


Figure 5.2. The regulation process

5.3. Developing a warehouse control system

The development of a regulation process within the warehouse, is a continuous operation of measuring, analyzing, (re)defining norms and intervening of the situation. This operation is described in the control circle, developed by the NEVEM working group [10].

The circle includes the following steps:

1. define goals;
2. define objectives;
3. define activities;
4. define units of measurement;
5. define performance indicators;
6. define norms;
7. gather information;
8. define steering instruments;
9. intervene situation.

In the first instance, we focus on feed-back control (measuring the output). Process monitoring (observing the process) and feed forward (measuring the input) will complete the control system.

5.4. The control circle at EMI

According to the steps of the control circle, the set up for EMI Uden will be described.

Step 1: Define goals.
The goal of the system is to enable management to influence warehouse performance on a daily base. This short period implies, that information is gathered on operational level.

Step 2: Define objectives.
The decoupling point separates the warehouse function in stock driven and customer order driven activities, as defined at the logistics control system. For both sub-functions, objectives have to be determined.

The following objectives are considered:

a. Fulfilment (stock driven),
defined as the lines and sets delivered from stock in percentage of ordered. These figures are measured for the overall catalogue, new releases and back catalogue. The objective is, to fulfil back catalogue by 90% and new release by 95% of sets and lines ordered (overall 93%).

b. Service level of sets and lines (order driven),
defined as the percentage of sets and lines available in stock, that is shipped within 24 hours (service 1), within 48 hours (service 2), or in more than 48 hours (service 3). Objective is to ship 100% of sets and lines in stock within 24 hours.

c. Service level of orders (order driven),
defined as the percentage of orders that is shipped within 24 hours. Measuring point is the cut off time (12.00 a.m.). Orders entered before 12.00 a.m. are delivered within 24 hours if they are delivered next day before 12.00 a.m.
The objective is to deliver 95% of the orders within 24 hours.

d. Volumes shipped (order driven)
This factor is not as influenceable as the others, but as warehouse revenue is based on this (4.75% of dealer price), performance on this objective should be measured as well.
The objective is to ship forecasted volumes.

Step 3: Define activities.
To ensure people are able to influence the processes they are judged on, measurements should be in line with organisational set up. Three levels of measurements are chosen; overall warehouse performance, area performance and transaction groups. Table 5.1. shows the levels on which the performance is measured, and the relations in between.

Warehouse	Area	Transaction group
Overall	Goods in Bulk Picking Shipping	Goods in Inward processing, Bulk processing, Add value, Returns and Bulk order fulfilment pickheader production, Picking order fulfilment Final station, Despatch, Shipping

Table 5.1. Three levels for measuring activities (warehouse, area and transaction group)

Step 4: Define Units of measurement

On operational level, detailed measurements are required on short term base. The Nevem working group advises to combine financial and physical dimensions. However, financial indicators are of no use, as:

- they are not influenceable on short term;
- handling cost are not depending on the value of product;
- price fluctuations trouble the insight in the processes.

In conclusion, on operational level, measurements should be calculated on physical base.
The output is determined by sets, lines, boxes and orders, the input by the number of manhours used and the process by throughput time in minutes.

Step 5. Define Performance indicators

The performance indicators calculate the ratios of input and output, actual and expected (norm). Depending on which combination is considered, five performance indicators can be distinguished (see Table 5.2.).

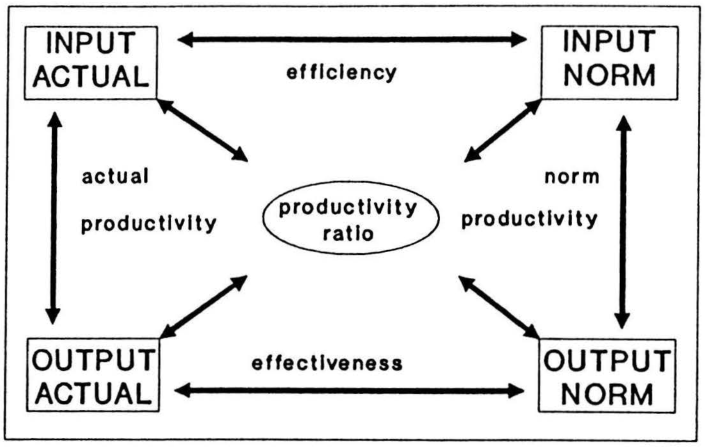


Figure 5.2. Survey of performance indicators

In this stage we concentrate on the output related indicators. In a feed back situation it is of no use to measure input actual against input norm, as this does not provide useful information. (A fall in efficiency only can be judged about, if the output is considered).

To be measured are the effectiveness (output actual/ output norm) and the productivity ratio (actual productivity/norm productivity). The normal productivity is 52 lines per hour and 268 sets.

The relation of throughput times and output is worthwhile to be considered as well, but is not foreseen to be available on regular base. Indication have to be obtained by statistic sampling.

By developing weighing factors to each performance indicator, the contribution of each activity and area can be calculated.

Step 6: Define norms
Norms can either express the expected performance or the desired performance (motivating norms). For EMI individual activities and areas are measured against motivating norms, overall warehouse against budgeted and forecasted performance. The motivating norms are developed by historical analysis, management experience and process analysis. Periodically these norms have to be redefined and recalculated.

Step 7, 8 and 9: Gather information, define steering instruments and intervene the situation

Together, these steps form the operational use of the system and have to be carried out daily. Management has to ensure the right information is transferred, analyze the information and define actions to improve performance. The control system provides the information whether and where to intervene the situation.

As a numerical illustrative, the daily productivity and the moving monthly average productivity is shown. If daily productivity falls below 40 lines per hour, actions should be taken. The sheet calculations indicate in what area (appendix IV).

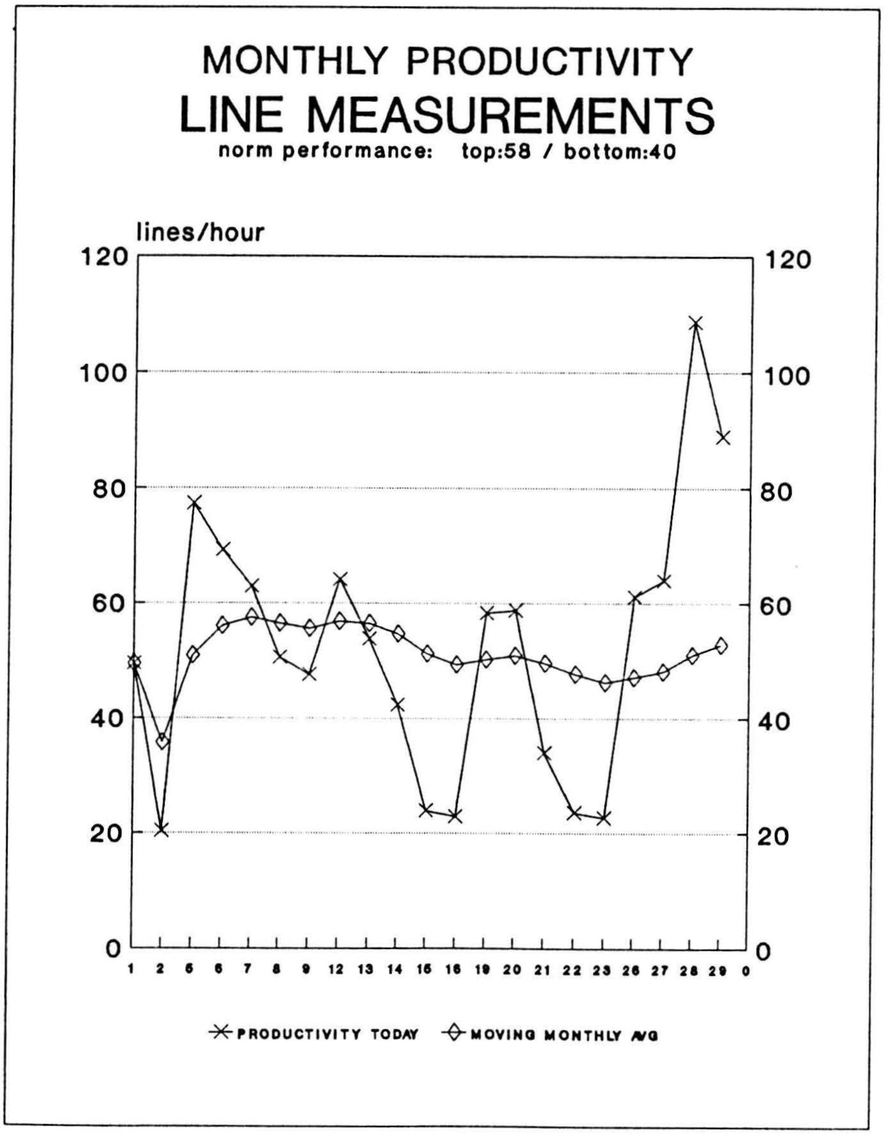


Figure 5.3. Monthly productivity measurements

Appendix III shows the warehouse performance sheet created for the Uden Warehouse, Appendix IV the productivity sheet and the productivity measurements per area for July 1991.

This set up for warehouse information has been used for developing the Uden Re-configuration project, which will be described in the next chapters.

For literature used in this chapter is referred to page 56:
[1], [2], [5], [7], [8], [9], [10], [13], [14]

6. ANALYZE ORIGINAL SITUATION

A distribution control system, as defined in the previous chapter, enables us to evaluate the distribution profile by describing it in quantitative terms. In this chapter, the procedure of determining bottlenecks in the product flow is worked out.

6.1. The objectives

The objectives set to overall performance measurements, define the necessity of improvements. In this stage it is important to clarify the contribution of the transaction groups to the objectives.

The assignment of transaction groups to objectives, is determined by the logistics control system that drives the transaction groups. The transaction groups, that affect fulfilment are stock driven, the transaction groups affecting service level and volumes shipped are customer order driven. Add value influences the volumes shipped by the increased value. Finally, the productivity is affected by all transaction groups. Table 6.1 indicates whether a relation between transaction groups and the objectives exists.

TRANSACTION GROUPS	Fulfilment	Service Level	Productivity	Volumes Shipped
Goods in	X		X	
Inw proc.	X		X	
Bulk proc.	X	x	X	
Add value	X		X	X
Pickh. prod.		X	X	X
Order fulfilm		X	X	X
Final station		X	X	X
Despatch		X	X	X
Shipping		X	X	X
Returns	X		X	

Table 6.1. Relations between transaction groups and the overall objectives (X=relation exists)

6.2. Improvements of fulfilment

Five transaction groups have influence on the fulfilment. As the add value activity just takes place incidentally (less than ten times a month), it will have no influence on fulfilment and is not considered. By statistic sampling, the throughput times are determined. The information system provides insight in average volumes processed per day. Table 6.2. shows the figures, the calculations of this chapter are based on. In Appendix V, the details are worked out.

TRANSACTION GROUPS	PROCESSING PER DAY sets	lines	orders	THROUGHPUT TIME/ORDER
GOODS IN	35000	88	23	4.46 hours
INWARD PROC.	35000	114	23	3.12 hours
BULK PROC.	5200	43	31	0.05 hours
RETURNS	875	120	52	not measured

Table 6.2. Statistics of the fulfilment related transaction groups

To determine the impact of volumes processed on the fulfilment, (availability of product), they have to be compared with volumes available on stock, currently 7500 lines and 0.98 million sets. Then, we see that goods-in and inwards processing (together the booking-in process), will have minor effects (3.5%), and returns and bulk processing will almost have no effect on fulfilment (0%).

However, in specific situations, as release of new product, the fulfilment is strongly related to the booking-in throughput times. The agreement with marketing is, that goods are available for sale, two hours after arrival in Uden. The actual throughput time of 7.5 hours for the booking-in process is far above this norm. For this reason, actions in goods-in and inward processing are required and have highest priorities.

The effects of bulk processing on fulfilment is determined by the time that product is not available for sale, due to processing. Looking at the actual throughput time and volumes learns that bulk processing will not generate any problems.

6.3. Improvements of service level

The performance on service level is measured as the percentage of orders that is delivered within 24 hours. The objective is set to 95% and the actual performance is 96%. Although actual performance is in line with the agreement, future developments require increased capacity.

For the analysis of the customer order driven processes, the bulk and single unit (=picking) area are separated, as throughput times in these areas are determined by different procedures. Table 6.3 displays the average volumes processed per day per store-type.

	TOTAL	BULK		PICKING	
sets	35000	19250	55%	15750	45%
lines	6881	250	3%	6631	97%
headers	518	100	20%	418	80%

Table 6.3. Volumes picked per day per store-type

The throughput time of orders is determined by the order driven transaction groups; pickheader production, picking, final station and despatch preparation.

6.3.1. Pickheader production

Pickheader production is combined for both store types. On average it takes 5 minutes per order, in peak times however, allocation time rises up to 4 hours.
In normal business, pickheader production will not be a problem achieving a throughput of 1.60 orders per minute. In peak periods however, this stage causes enormous time delays due to limited capacity of the computer system.

6.3.2. Picking process

Throughput time per order in the picking process is determined by picking time and waiting time.

Picking time per order comprises four elements:

1. fixed time (reading notes, checking product);
2. travel time (expected moving time);
3. pick time (reaching and extracting);
4. down time (factor for the inefficiency of the system).

The overall picking times have been determined by observing the picking of 600 orders (see Appendix VI and VII) and by the EVO standards of order picking (Appendix VIII).
In formula, picking-time per order (T) is calculated as:

$$T= (ft+r*g*pt+r*b/v)*(1+dt)$$

ft= fixed time per order,
g = number of reaches per line,
pt= pick time per reach,
r = number of lines per order,
b = moving distance per line,
v = moving speed (walking 1 m/s, driving 1.2 m/s),
dt= down time factor (maximum 10% for inefficiency in depth, height and organisation (maximum 1.1*1.1*1.1))

The waiting time per order depends on the utilisation ratio (U) and handling time (=the picking-time). Based on the principals of the waiting queue theory, waiting time (W) is calculated as:

$$W= (U/2(1-U))* T$$

U = Utilisation ratio = processing time / time available,
T= Picking-time

The processing times per order for the bulk and the picking area can now be calculated. Table 6.4 shows the figures to be used.

VARIABLES	PICKING (*)	BULK
fixed time reaches/line pick time lines/header distance/header moving speed down time down time factor	14.60 sec 1 2.00 sec 2.65 31 mtr 1.0 m/s 5.3 sec 1.1	25.0 sec 3 5.0 sec 2.5 149 mtr 1.2 m/s 39.4 sec 1.2
PICKING TIME	56.2 sec	226 sec
Utilisation ratio	87 %	42 %
WAITING TIME	188 sec	82 sec

(*) per station

Table 6.4. Throughput times for the Bulk and Picking area

The throughput time in the picking area is about 4 minutes per station, or 24 minutes for the 6 stations.
The throughput ratio is (U*3600/T=) 56 headers per hour.
Simulation (Simulation model developed by Sirrus, EMI-UK) shows an expected throughput of 55 orders. The simulated throughput ratio is considered.

For the bulk area processing time is 3.8 minutes. Waiting time is difficult to calculate as operators in the bulk area combine several activities. Utilisation ratio is rather theoretical. But it may be clear, Bulk picking will not generate problems.

6.3.3. Final station

The average volumes processed per day is the combination of Bulk and Picking fulfilment; 35000 sets, 6881 lines and 518 headers.
The throughput time of final station is approximately 60 sec. per header. This implies a throughput of 1.00 order per minute.

6.3.4. Despatch

The actual throughput time in despatch preparation is on average 36 sec. per order. Theoretically a person will be able to insert invoices, close the box and sticker the address at a rate of nearly 1.66 per minute. No one however, can be asked to carry out this monotone task, at this ratio, on a permanent base. For reasons of work conditions, it would be advisable to replace this task by automation.

6.3.5. Bottleneck overview

In conclusion, the bottlenecks in the transaction groups are found in the picking environment. Future requirements, like an increase of orders through the picking environment by 44% as is expected, will strengthen these problems. Figure 6.2. shows the current average throughput, the capacity and the future required throughput. This bottleneck overview provides an indication of priorities in the established problem areas.

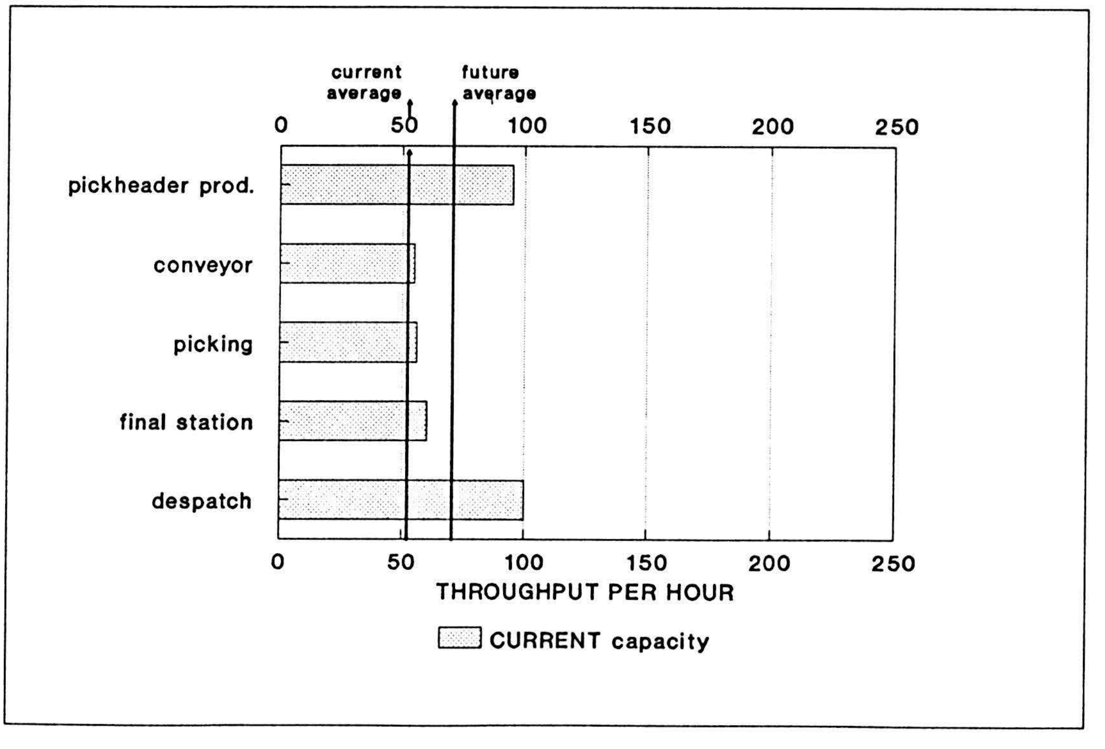


Figure 6.2. Bottle-neck overview Single unit picking area

6.4. Improvements of productivity

Actions that improve the processing time in any transaction group, will effect an increase in productivity. (See table 6.1)
The overall average productivity (calculated as volumes shipped/manhours used) is planned to be improved from currently 223 sets/hour and 43 lines/hour, up to 268 sets/hour and 52 lines/hour.

6.5. Overview of problem areas

The description of the original situation in chapter four, revealed several overall physical handling problems, that have not been mentioned yet. Table 6.6. summarizes these problem areas.

1. COMPUTER HARDWARE AND SOFTWARE PROBLEMS
   - capacity limited
   - long allocation time customer orders

2. HANDLING PROCEDURES
   - Confusing, not defined
   - Time consuming:
     * replenishment 10.5 hrs per order,
     * booking in 7.5 hrs per order
   - No structural changes since 15 years
   - No informational support/control
   - Paperwork creating

3. MECHANICS AND EQUIPMENT
   - Conveyor belt
     manual pushing parcels, model over-aged (serial stations)
   - Space inefficient trucks
   - Limited and inflexible storage capacity pigeon holes
   - Manual or no checking and registration

4. LAY-OUT AND PRODUCT FLOW
   - Physical separation of transaction group activities
   - Occurrence of 12 structural stocks/waiting queues
     double handling and registration activities
   - Cross traffic
   - No differentiation for slow and fast movers

Table 6.6. Overview problem areas

For literature used in this chapter is referred to page 56:
[3], [6], [16], [17], [18]

7. IMPROVE EFFICIENCY OF WAREHOUSE ACTIVITIES

The efficiency of warehouse processes is determined by the procedures, the equipment in use, and the lay out of the warehouse. Bergen Brunswig Cooperation [8] developed a seven-step approach of improving the warehouse efficiency, shown in Table 7.1.

1.	Obtain a five years projection of volume growth
2.	Analyze business profile
3.	Analyze materials handling equipment
4.	Establish relations and space requirements
5.	Improve procedures and select techniques
6.	Draw several alternative lay-outs
7.	Select the best lay-out

Table 7.1. The seven-steps approach for improving warehouse lay-out

The first four steps have been described in previous chapters. The space requirements will be taken into account as constraints for selection of techniques and design of the lay-out. This chapter focuses on the last three steps.

7.1. Procedural changes

This section provides an overview of the procedural improvements proposed to improve warehouse performance.

Goods in: The main problem of too many handling stages is solved by combining arrival and entry checking in one area and allowing data entry to add the supplier number. As 85% of orders delivered is correct, statistics based checking can reduce throughput significantly.

Inward processing: The inefficiency is caused by the number of locations, one line is stored in (delivered daily 88 lines, stored 114, (see Table 6.2.)). By reducing the number of stocks, double handling is minimized and sorting and storing time is reduced.
In the original situation the reserve stock is abolished, and the bulk stock is planned to be combined with the pallet stock.

Bulk processing: The proposed reduction of stocks will also decrease the number of inter-stock movements. Further reduction of movements can be achieved by increased storage capacity (in lines and in sets) in the picking area, thus decreasing the number of replenishment moves.
The bulk-operators will have more time available to carry out the replenishment function in advance (triggered by the computer), instead of replenishment when picking is physically running out of stock (as currently is done).

Pickheader production: The time required to allocate orders will be improved by cleaning up of the data-base. The reduction of number of stock will improve allocation time, as product is stored in maximum two locations (currently four).

Order fulfilment: The picking procedure can be improved by the new techniques (see next chapters), enabling pickers to walk, pick and pack simultaneously, thus reducing walking, checking and packing time.
Additional reduction of picking time can be achieved by the introduction of location picking only, instead of picking on suffix number (searching for the location indicated, not for the product-number). This will decrease searching and checking time and the error rate. Confirmation of an individual pick will enlarge the control on the activity.
Finally, the separation of the picking and replenishing activities, enables pickers to concentrate on the fulfilment of orders.
In the bulk area, order fulfilment is facilitated by the reduction of stocks (one line is stored in one location).

Final station: The techniques available for final station minimize the need for manual intervention. Statistics based checking has to verify techniques correctness. Then, operators are only required to check orders that are selected, (special customers, statistic check), or rejected by the automatic weigher.

For returns, despatch and shipping, no procedural improvements have been proposed yet.

7.2. The warehouse automation techniques

This section provides an overview of the techniques, that are selected to improve warehouse performance.
First, the techniques that are available for warehouse automation are mapped. Appendix IX presents the alternatives per transaction-group. The techniques marked, are likely to be applicable for the Uden warehouse.

From the analysis of the original situation, we determined the picking area being the main bottleneck. To improve service and productivity performance, it is planned to replace the old conveyor, to install flow-racks and to automate final station.
To improve fulfilment, barcode equipment will be introduced.
The selection of these techniques is described next.

7.2.1. Replacement of the conveyor belt

For the function of the conveyor belt, which is transport, highly sophisticated applications, (AGVS, ASRS, robots) are available. For the Uden business profile they are not likely to be profitable. The alternatives that remain are preservation of the old conveyor, replacement of the old conveyor and introducing picking cars.

The main advantage of keeping the old conveyor is, that (almost) no investments have to be made. However, the maintenance cost are expected to rise considerably, while the risk of a total breakdown remains. Besides that, any other improvement in the picking area will hardly result in a better performance, for the conveyor will limit order throughput and productivity improvements.
Although the picking cars do not require major investments as well, the productivity is calculated to decrease by 30%.

For these reasons, the conveyor is planned to be replaced.
The new conveyor can handle increased throughput, for it allows access from both sides and it includes a loop that permits orders to bypass a station that is occupied or not needed. The new conveyor will be barcode driven to minimize manual intervention.

7.2.2. Implementation of flow racks

The way to select picking related storage techniques, is very much business profile related. It depends on a complex set of variables, that can not be separated from the conveyor and the lay-out.
In Table 7.2. most important variables are indicated.

1.	average number of orders per period
2.	number of lines, average and variance
3.	delivery unit (per set/box)
4.	packaging of the products
5.	volume of products
6.	product weight (heavy product first in box)
7.	conditions of products
8.	time required to pick

Table 7.2. Variables influencing the picking process

Basically three different order picking methods are distinguished:
a. automated picking;
b. location to picker;
c. picker to location.

a. The automated picking method
In the single unit picking situation automated storage and retrieval systems (ASRS) are being developed. Computer controlled a-frame racks, in combination with conveyors can achieve high level productivity rates. The investments in fully automated systems are considerable, limiting application to large businesses or dangerous environments. For music carriers, ASRS are not yet applicable.

b. The location to picker method
This system of picking is suitable in cases where few picks have to be made per location from a large catalogue, thus reducing long walking distances by the rotation speed of the system.
The main representative in this category is the carousel.
This system however, requires large investments. It involves that the overall number of picks from the carousel catalogue has to be extensive for the system to be profitable.
In Uden warehouse the picking time per line has to be improved by nearly 50%. In reality this is not achievable.

c. The Picker to location method

In cases of low level business profile this method is most common. The three major routines are:

1. picker picks one entire order in one run;
2. picker picks more orders simultaneously per run;
3. picker picks just a part of an order.

In Uden warehouse routine three is chosen for it reduces walking distances (compared to routine 1.) and minimizes error risk and checking time (compared to 2.). The new conveyor allows to introduce the walk-and-pick method, by which the picker moves the outer box with him over the conveyor belt, and picks simultaneously. This reduces walking time as pickers are not returning to a static outer box after a pick.

The selection of storage is also business profile related. Table 7.3. shows what system is likely to be applicable in what situation.

Number of picks/line	Picking unit Pallet	Box	Unit
High	Pallets in Bulk	Flow Racks Pallet picking	Flow Racks
Medium	Pallet shelves Bulk	Flow Racks Shelves	Flow Racks Shelves
Low	Pallet shelves Bulk	Shelves Carousel	Carousel Flow Racks Shelves

Table 7.1. Storage systems and their applications

In the picking area of Uden Warehouse, the flow racks and the low level bin shelves are likely to be applicable.

The alternatives to be considered are the situations with Flow-racking, the bin shelves and the bin shelves in an adjusted lay out. The costs of each alternative are determined by the walking time, the replenishment activities and the depreciation. Next graph shows the relation between cost and expected occurrence. (Calculations are worked out in Appendix X and XI).

On the X-axis the number of lines that have to be picked on a day are indicated, on the Y1-axis the cost per line per alternative and on the Y2-axis the probability that the indicated number of lines occurs.

This graph enables us to select the most appropriate technique at different business profiles. With current business profile (average 6631 line picks per day), flow racks are calculated to be most profitable. The expected increase in lines reinforces this conclusion.

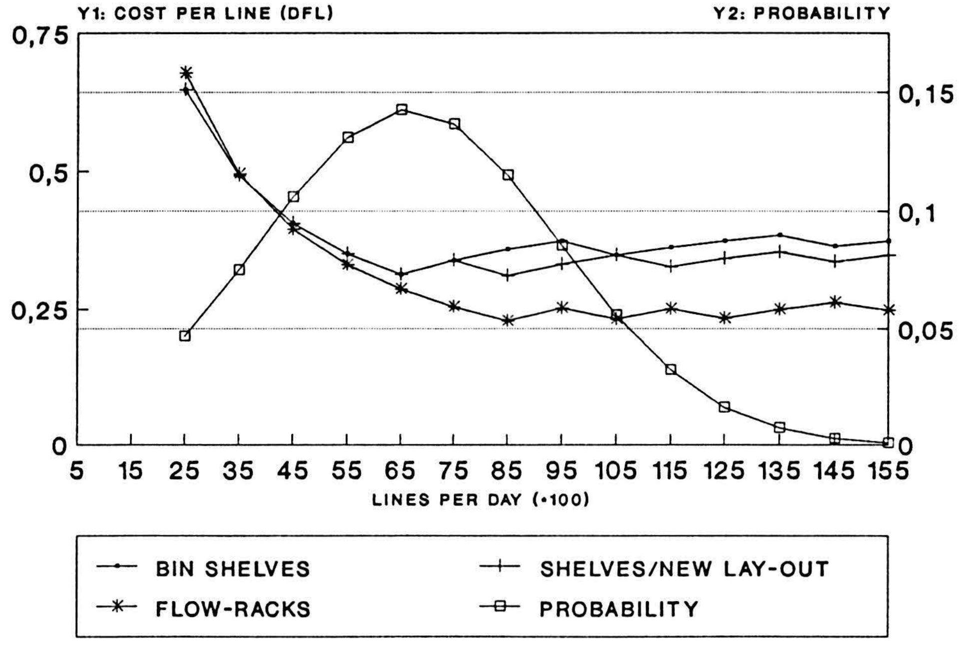


Figure 7.1. Cost per line related to business profile per day and the profile probability

7.2.3. Automation of final station

The automation of final station completes a smooth order throughput ratio for the overall order driven process. Proposed applications are an automated weighing facility and a box-closing/tape machine. The fulfilled order boxes arrive at final station and get weighed. The actual established weight is compared with the expected weight. If they are equal (within certain tolerances) the box is moved on to the taper; If weight is not correct the box is sent to a reject conveyor roller to be checked. In this way manual intervention is minimized (reduction 1.5 FTE) and smooth order-throughput is accomplished.

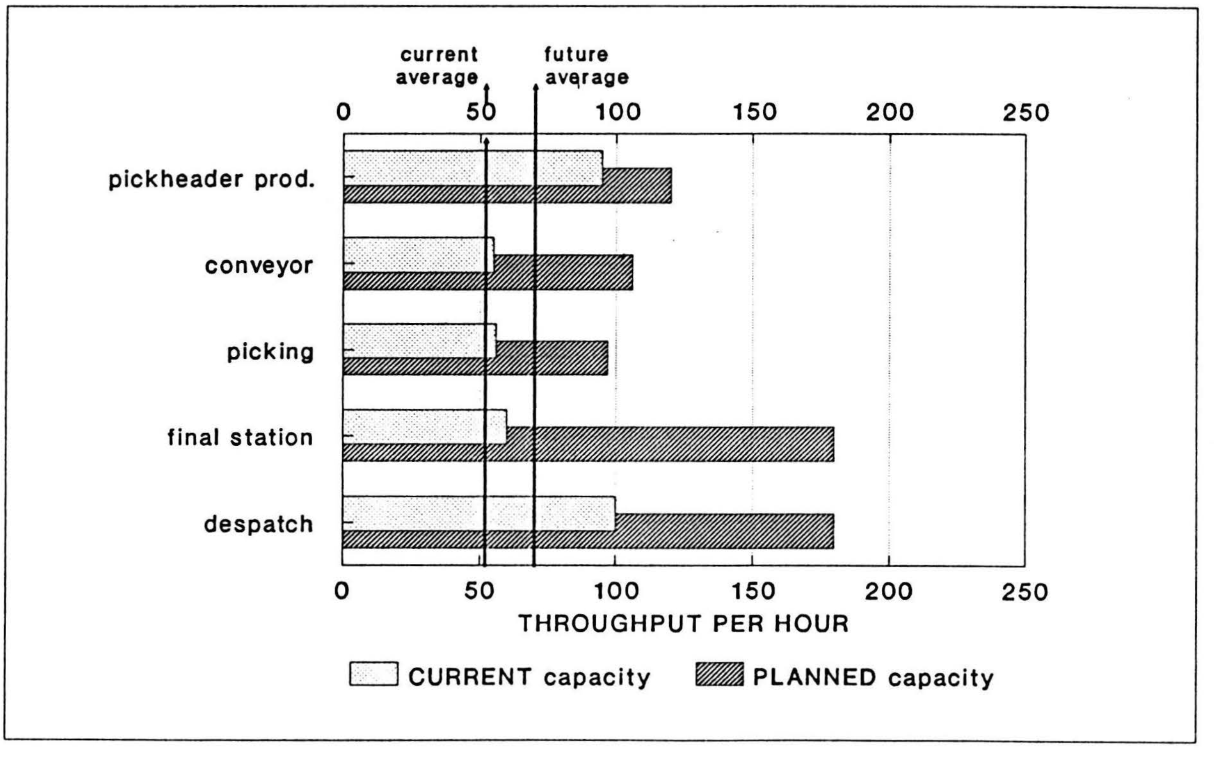


Figure 7.2. The bottleneck solution in the picking area

7.2.4. Installation of barcode facility

The barcode control of movements within the warehouse will not only improve productivity ratios, but will also have a significant influence on warehouse control.
The applications can be found in almost all transaction groups. In first instance, only the goods in area is considered. It will reduce booking-in time, as shipments data have to be entered only once (reducing paperwork), information is transferred quickly and error rate is minimized. Besides of that, control on activities can be improved.

7.2.5. Future plans

The proposal focuses on the re-solution of the most important bottlenecks, thus ensuring that order fulfilment (mainly in the picking area) will be able to match the service-level norms and the booking-in activities will match the marketing agreed processing times. The transaction groups, that are not negatively influencing the throughput ratios at the moment, will be looked after in later phase of the project. At this stage following techniques and lay-out improvements are planned to be implemented:

- Box erecting machine and sheet feeder;
- Pallet racking for total bulk area;
- Barcode facilities for all warehouse movements;
- Palletiser for sortation in shipping area;
- AGV for direct factory shipments;
- EDI contact with supplier, expeditor and customers;
- Automated replenishment orders generation;
- Combined shipping/entry area and re-shuffling loading docks lay-out.

After these improvements will have been implemented, capacities in the various transaction groups will be sufficient to cope with future growth.

7.3. The cost calculations of the proposal

The alternatives and the main advantages of the proposed investments are described in last section. Table 7.2. compares the cost of the alternatives available.

1. Replacement of conveyor
Cost comparison (1000 * pounds):

	Today Dfl.	Replacement
Maintenance	26	-
Depreciation	-	35
Related expenses	-	22
Temp. Labour	67	-
	93	57

2. Implementation of flow-racks
Cost comparison (1000 * pounds)

	TODAY	OLD RACKS	PART SOL.	ADJ. RACKS	FLOW RACKS
Depreciation	-	-	9	-	18
Related exp.			6		6
Labour	12	12	12	5	-
Replenishm.	22	34	14	34	-
	34	46	41	39	24

3. Automation of final station
Cost comparison (1000 * pounds)

	Today	Automation	Manual
Depreciation:	-	6	-
Related exp.:	-	1	-
Labour:	44	11	54
	44	18	54

4. Instal barcode facility
Cost comparison (1000 * pounds):

	Today	Barcode
Depreciation:	-	3
Related exp.:	-	3
Labour:	11	-
	11	6

Table 7.2. Cost comparison of alternatives

7.4. The planned lay-out and product flow

The proposals will result in a lay-out that minimizes travelling distances and limits cross traffic to specific areas. The proposed layout and productflow are shown in Figure 7.3.

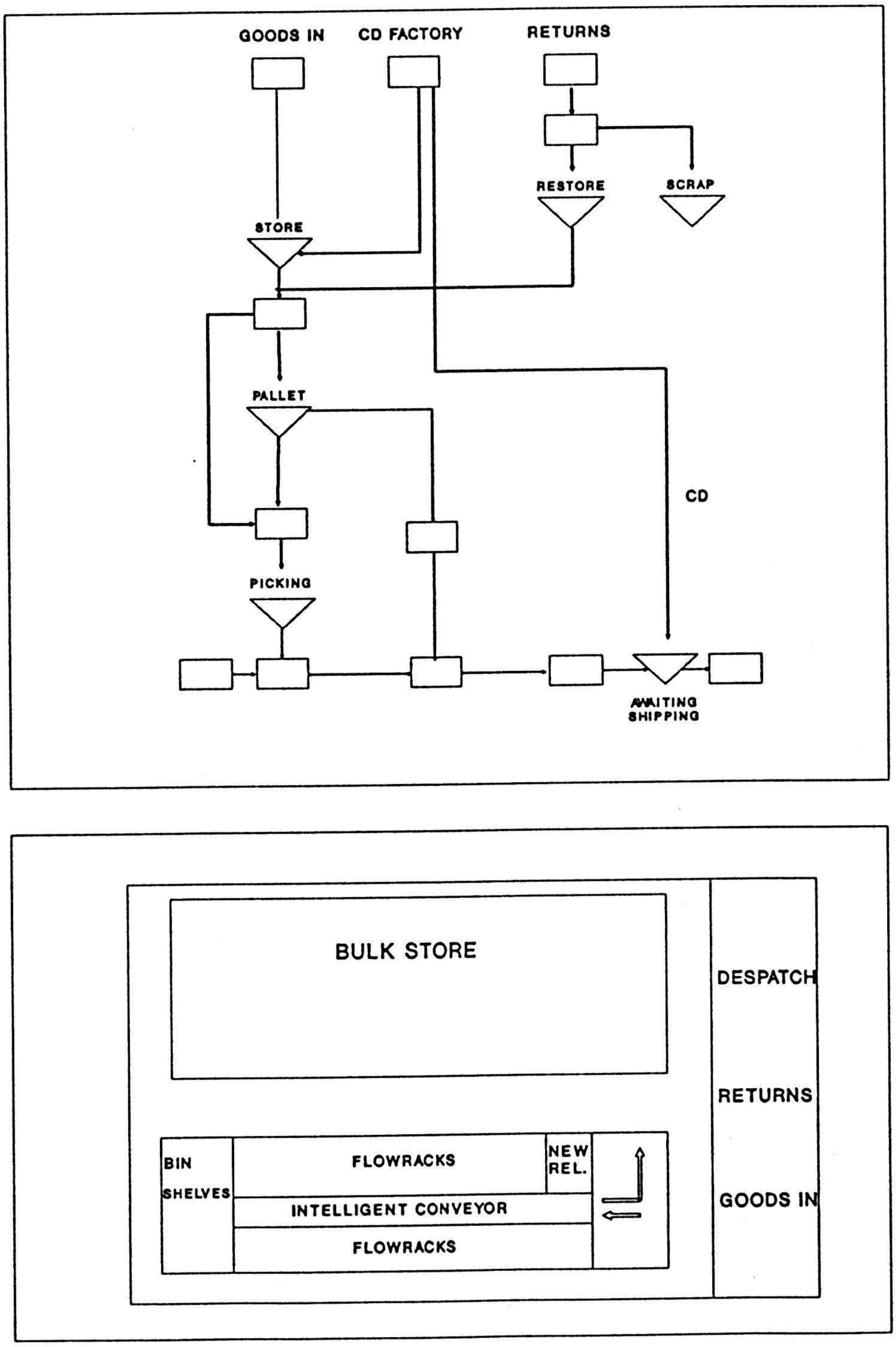


Figure 7.3. The proposed productflow (above) and lay-out (below)

The new product flow shows, in comparison with the original one in Figure 4.2., that the number of handling stages is reduced.
In goods-in we combined the two data entering stages and the arrival and entry check. In the end it is even planned to combine all the booking-in activities in one transaction group, instead of two currently.
At final station, the automated equipment allows the integration of final checking and despatch preparation (box closing).
By combining theses handling stages, the number of waiting queues and physical movements between the stages (work in process) will be reduced as well.

Furthermore the number of structural stocks is reduced. The Pallet, Bulk and Reserve stock are replaced by pallet racks only. This will result in a decrease of movements between stocks (replenishments, re-ordering) and an increased throughput by reducing sorting and searching.

Finally the automation in the picking area will assure that the output ratios of the processes match, thus reducing waiting queues between the order driven processes.

With respect to the lay-out, it is noticed, that despatch and the goods in area are combined in one area. This minimizes moving distances and limits cross traffic to a restricted area.
In the picking area, a special fast movers area is created to assures that fast movers are received, stored, picked and shipped in most efficient way (least moving distances).

For literature used in this chapter is referred to page 56:
[1], [4], [6], [8], [11], [13], [15], [16], [17]

8. CONCLUSIONS AND RECOMMENDATIONS

Although currently, rising business volumes are handled, while high levels of service are achieved, future developments require actions in managing the distribution activities.

The performance levels show strongly fluctuating patterns per area, and per day of the week. This indicates, that management is not able to control the warehouse processes. This main cause of this is the a lack of information:

- Actions to improve performance are based on monthly overall figures only, resulting in delayed impact of actions;
- The influence of actions on performance is speculative, as the relation between activities and performance is hardly known.

By this, the need for an information system is justified.

The first part of the study focuses on the information system. The proposed information system provides the information where, when and why to intervene in an area. Regular forecasting can complete the process of control by enabling management to plan activities and resources required.

The other part of the study focuses on equipment, procedures and lay-out. Main conclusions:

- The current equipment is over-aged and old fashioned, new techniques can improve productivity significantly;
- Procedures are confusing, not clearly defined and time consuming, due to habitual developments and insufficient support with information and techniques;
- The lay-out and product-flow are characterized by the occurrence of many structural waiting queues and stocks, double handling stages and cross traffic.

The process of setting priorities among problem areas indicated:

a. the need for improvements in the goods inwards area and the single unit picking area (bottlenecks);
b. the possibility to improve productivity ratios in all the other transaction groups.

The overall Re-configuration Plan enables distribution to match the future requirements.

The recommendations regarding the information system and the technical facilities required have been integrated in the report and will not be repeated here.
There remains on additional recommendation to be made regarding the organisational set up.

In the current situation operators are quite strictly bound to the area they belong to. In this situation the implementation of flexible work-force is unlikely to be successful.

In my opinion operators should be assigned to functions they serve, rather than to organisational areas. By knowing the expected workload of functions within a certain period, the capacity in manpower can be allocated. Thus it is possible to equalize the workload for all transaction groups.

Overall, the warehouse activities should be directed to the question "What do we have to do and how can we achieve it", rather then to "What are we doing and what is the result of it".
This report tries to make a contribution to this change-over.

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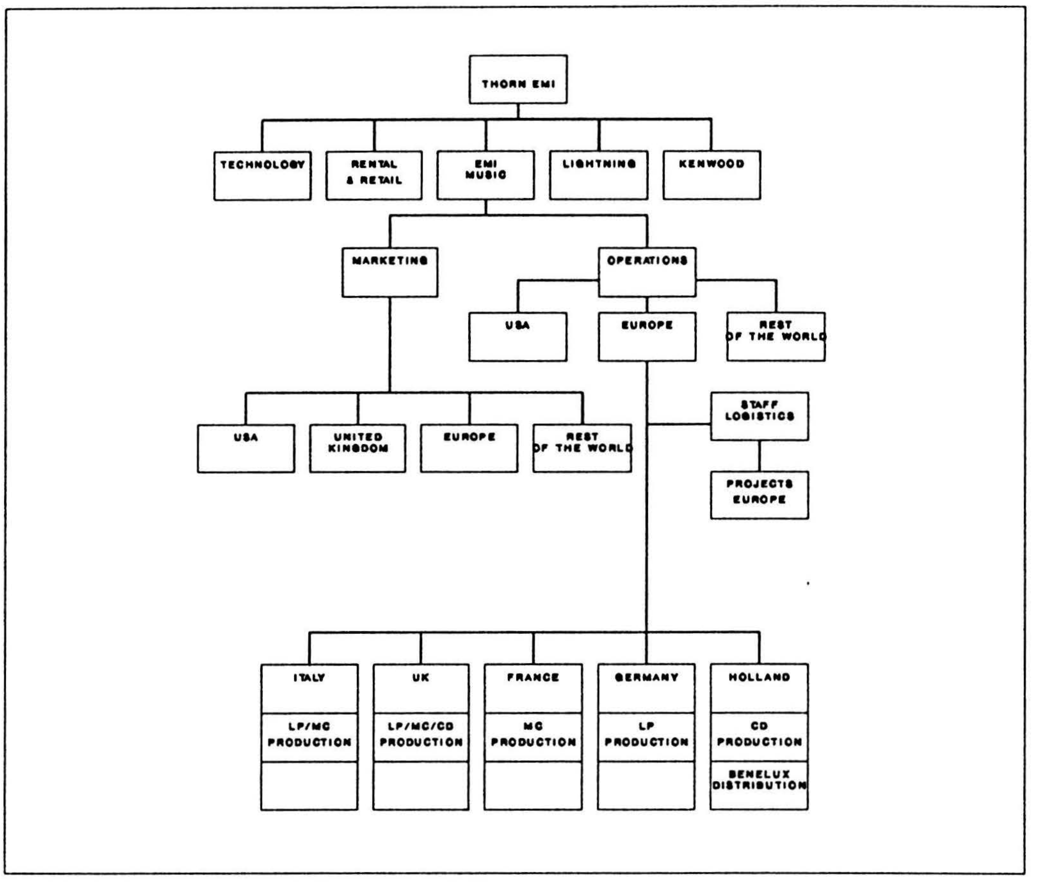
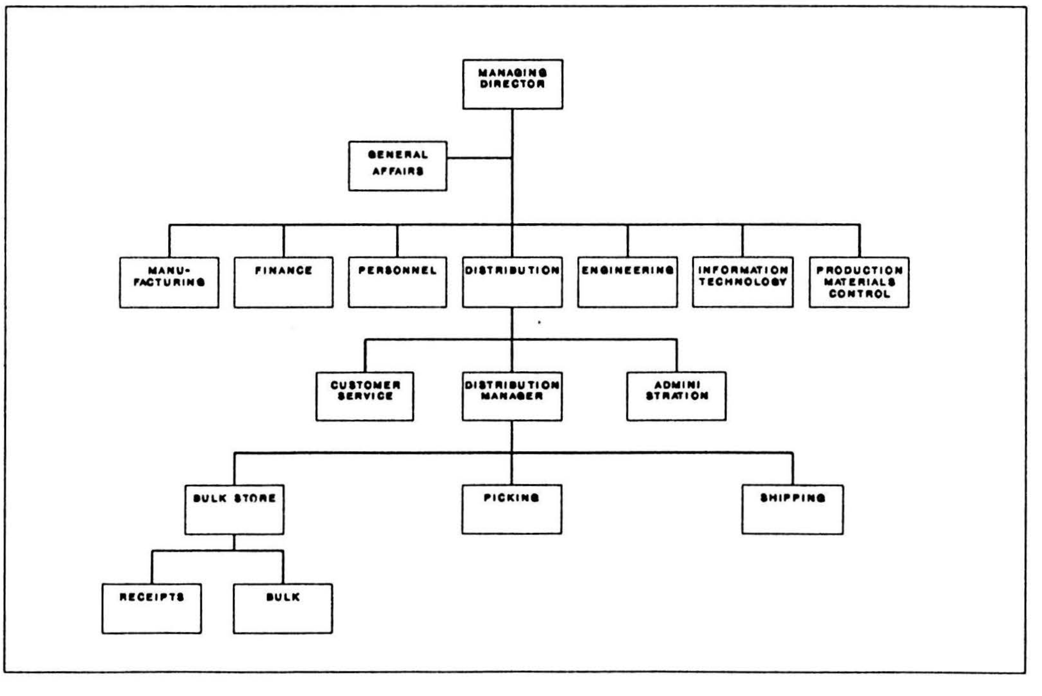
APPENDIX I ORGANISATION DIAGRAMS





APPENDIX II GLOSSARY OF TERMS

Add value:	Activity of re-conditioning product
Back catalogue:	Product been on catalogue longer than 90 days
Back order:	Previous order carried forward
Booking in:	Activities between arrival of final product and final storage
Box:	Finished product storage
Box outer-/order-:	Product packaging medium
Bulk:	Storage of product in boxes
Carrier:	Music medium (LP-CD-MC-Video etc.)
Catalogue number:	A title on a certain kind of carrier
Cut off time:	The moment that order delivery lead times start (12.00 a.m.)
DC:	Distribution Centre
DP:	Decoupling point
Fulfilment:	Capability to deliver from stock
Header:	Customer order split up for picking in specific warehouse area
IDC:	International Distribution Centre
IT:	Information technology
Item:	Single article/unit
Line:	Product/catalogue item or number
Line (order):	Line on an order for a particular catalogue number
Location:	Position in storage identified by unique reference number
New Release:	Product on catalogueless than 90 days
Replenishment:	Movement of stock from Bulk to single unit picking area
Set:	Item on catalogue (handling unit)
Unit:	Single article/item (double CD = 2 units/ 1 set)

APPENDIX III PERFORMANCE SHEET

DAILY REPORT ON WAREHOUSE PERFORMANCE
REPORT DATE:

EXTERNAL RELATED ACTIVITIES			
GOODS IN	ORDERS	LINES	SETS
ORDERED DELIVERED STORED			
ORDER DELIVERY	ORDERS	LINES	SETS
ORDERED SHIPPED - normal order - back order TOTAL MONTH CD-FACTORY			

PERFORMANCE INDICATORS

FULFILMENT OF ORDERS:
ORDERED :
DELIVERED 24HRS :
SERVICE LEVEL :

FULFILMENT OF LINES AND SETS:

	NEW RELEASE lines	NEW RELEASE sets	BACK CATALOG. lines	BACK CATALOG. sets	TOTAL lines	TOTAL sets
ORDERED						
IN STOCK						
NEXT DAY						
>NEXT DAY						

PRODUCTIVITY:

PROCESSING
-standard
-percent

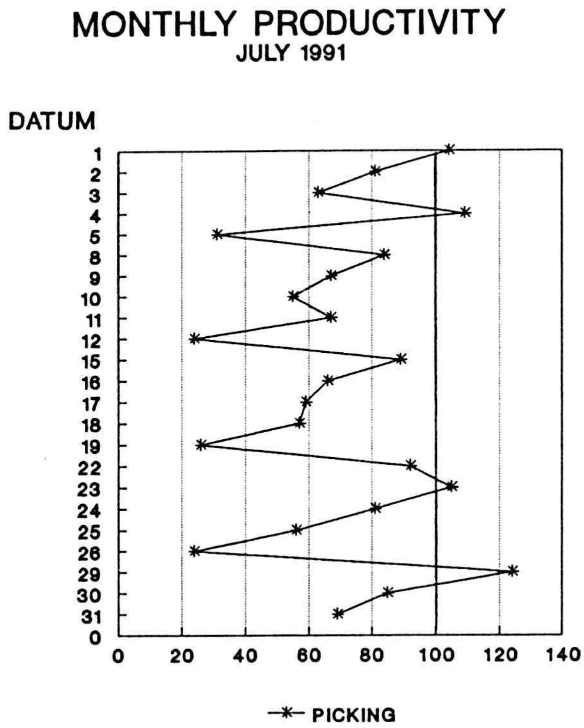
HOURS USED
-standard
-percent

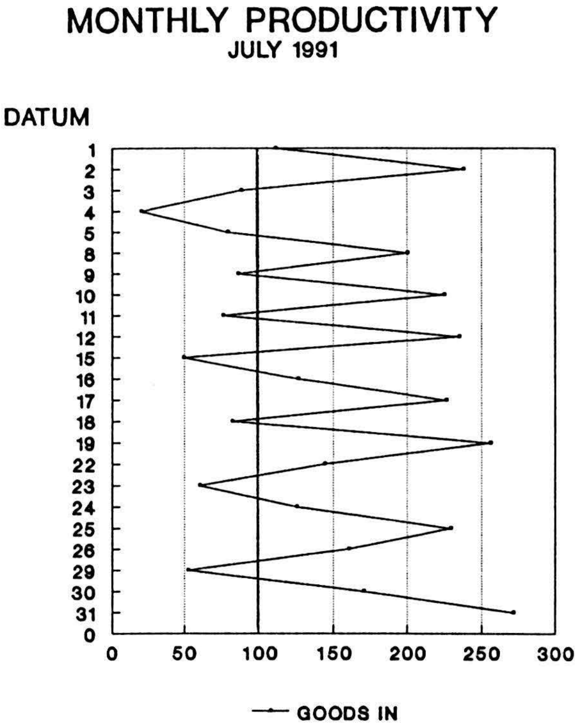
PRODUCTIVITY
-standard
-percent

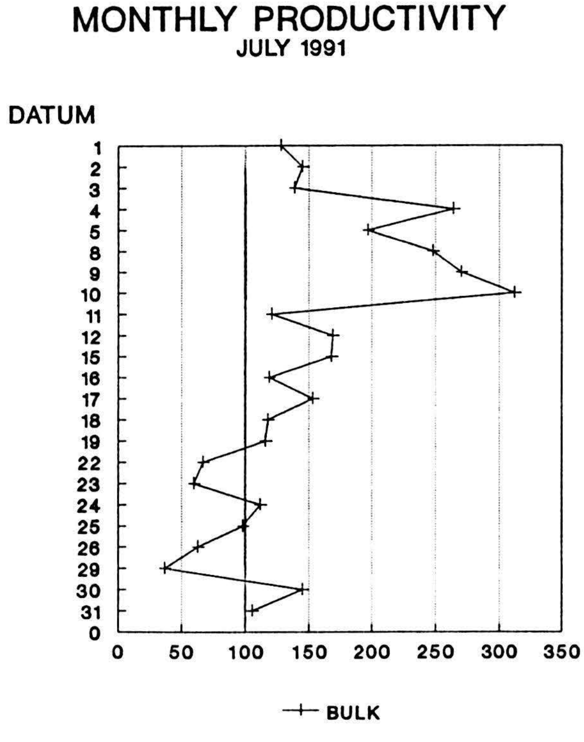
APPENDIX IV PRODUCTIVITY SHEET AND MEASUREMENTS

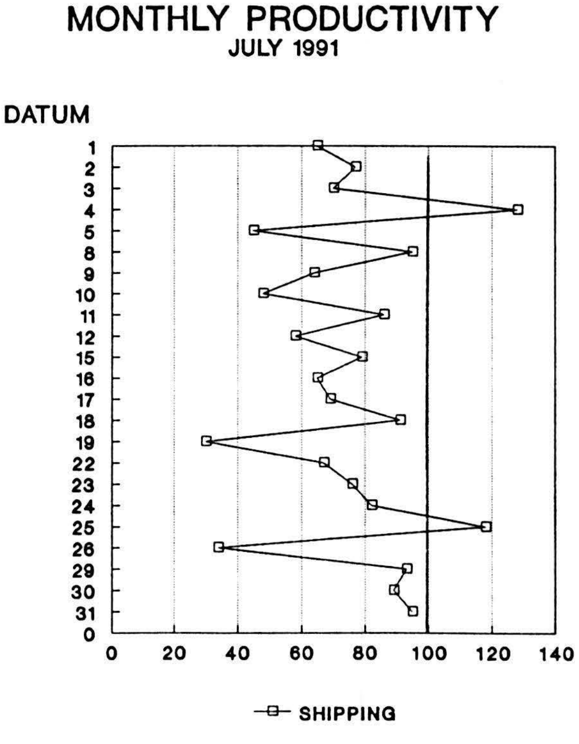
DAILY REPORT ON PRODUCTIVITY
REPORT DATE:

GOODS IN:	PROCESSING -standard -percent PER HOUR -standard -percent	order boxes lines sets
BULK AREA:	STORAGE -standard -percent REPLENISH -standard -percent PICKING -standard -percent PER HOUR -standard -percent	order boxes lines sets
PICKING:	PROCESSING -standard -percent PER HOUR -standard -percent	order boxes lines sets
SHIPPING:	PROCESSING -standard -percent PER HOUR -standard -percent	order boxes lines sets


MONTHLY PRODUCTIVITY
JULY 1991
DATUM
1 2 3 4 5 8 9 10 11 12 15 16 17 18 19 22 23 24 25 26 29 30 31 0
0 20 40 60 80 100 120 140
PICKING


MONTHLY PRODUCTIVITY
JULY 1991
DATUM
1 2 3 4 5 8 9 10 11 12 15 16 17 18 19 22 23 24 25 26 29 30 31 0
0 50 100 150 200 250 300
GOODS IN


MONTHLY PRODUCTIVITY
JULY 1991
DATUM
1 2 3 4 5 8 9 10 11 12 15 16 17 18 19 22 23 24 25 26 29 30 31 0
0 50 100 150 200 250 300 350
BULK


MONTHLY PRODUCTIVITY
JULY 1991
DATUM
1 2 3 4 5 8 9 10 11 12 15 16 17 18 19 22 23 24 25 26 29 30 31 0
0 20 40 60 80 100 120 140
SHIPPING

APPENDIX V IMPROVEMENTS OF FULFILMENT

mean value (μ) = $(\Sigma x)/n$
variance (s) = $(\Sigma(x^2)-(\Sigma x)/n)/(n-1)$
95% confidence interval = μ +/- $1.960*s/n$

Goods in:

Sample: 192 orders out of 840 available two months
Sample mean: 4.46 hours
Sample variance: 10.98
95% Confidence: $3.99 < x < 4.93$

Inward processing:

Sample: 192 orders out of 840 available two months
Sample mean: 3.12 hours
Sample variance: 20.07
95% Confidence: $2.49 < x < 3.75$

Bulk processing:

Sample: 364 orders out of 1261 orders available in two months

Automatically generated orders
Sample mean: 10.5 hours
Sample variance: 18.48

Manually generated:
Sample mean: 0.05 hours
Sample variance: 0.00427 hours

For this large samples, 95% confidence interval for estimating mean value, the interval is approximately average +/- 1%.

Conclusion: not only average throughput times are considerably above expectation, the variance is that high, that average throughput ratios hardly provide any information.
Long and unplanned throughput times with high variance clearly indicate that processes are uncontrolled

APPENDIX VI IMPROVEMENTS OF SERVICE

Pickheader production:

Sample:	measuring 5 days week 3 jan. 1991
Sample Mean:	108 headers per hour
Sample variance:	54

Confidence interval is not useful as standard deviation mainly is determined by the flexibility in capacity available. As qualitative considerations confirms the mean value, this is considered the capacity of this transaction group.

SINGLE UNIT PICKING AREA:
The Picking process:

The picking process is determined by
1. the number of headers to be fulfilled,
2. the number of picks to be made (lines ordered),
3. the number of stations (fixed 6),
4. the walking distances per station (determined by catalogue size)
5. fixed time per order
6. fixed time per line pick
7. moving speed

Sample: april 1990 - april 1991
248 days
Time measurements: observing 600 orders december 1990
As the measurement procedure was manually carried out, calculations are restricted to measured averages.

1. average headers 418
   standard deviation 195

2. average lines 6631
   standard deviation 2780

   lines per header relatively constant $\sigma 1/\mu 1 \approx \sigma 2/\mu 2$
   average lines per header 15.86

3. average lines per station 2.65

4. walking distances
   a. Picker has to walk into the station in x direction
   b. Picker has to walk into the lanes in y direction

   Assumption product is homogeneous distributed in x-, as well as y-direction.

a. the x-direction
expected walking distances (E(wd)) in x-direction = 2*W*R/R+1
W= width of station in x direction
R= expected number of picks (2.65)
Case Uden : B = 8.60 (6*0.6m shelves and 5*1.0m lane)
R = 2.64
(Ewd-x) = 2*8.60*2.65/3.65 = 12.48

b. the y-direction
expected walking distances is 2*R*½D
D = Depth of the lane
Case Uden: D = 7
R = 2.65
E(wd-y) =18.55

Expected travelling time: 31 sec

5. Fixed time per order.
This holds the time required for checking, packing etc. EVO advises for small orders a standard of 10 sec.
In the actual situation, a fixed time of 5.5 sec per line is measured, 2 sec for checking per line, 2 sec for packing, 1.5 for searching, thus a fixed time per order of 14.6 sec

6. Fixed time per line
In our situation it requires about 1 second to reach and 1 second to extract the product from the shelves. This is calculated as the fixed time per line. For an entire order it requires 5.3 sec for retrieval.

7. Down time
In the actual measurements, we caculated a total searching time of 3.5 sec per line, minus the 1.5 second we consider as being normal, remains 2 sec per line being inefficiency. This involves for one order 5.3 sec
Overall this is 10% of the total picking time. This calculated inefficiency factor is in line with the standards provided by EVO.

The total expected average picking time now can be calculated:

Fixed time:	14.6 sec	
Travelling time:	31.0 sec	
Pick time:	5.3 sec	
Down time	5.3 sec	
	56.2 sec	per order

THE BULK PICKING PROCESS

Basically the procedure is the same as in the picking area. Detailed measurements on time and motion studies are not carried out. Expected picking times are determined by the EVO picking standard sheet.
Three graphs determine the expected picking time:

1. Number of reaches per order line:
   assumption: 25 sets per box
   77 sets per line
   expected number of reaches: 3

2. Number of lines per order:
   250/100=2.5

3. Average moving distances:

x-direction:	2*2.5/3.5*40	= 57.00 metre
y-direction:	2*37/2*2.5	= 92.50 metre
total expected		=149.50 metre

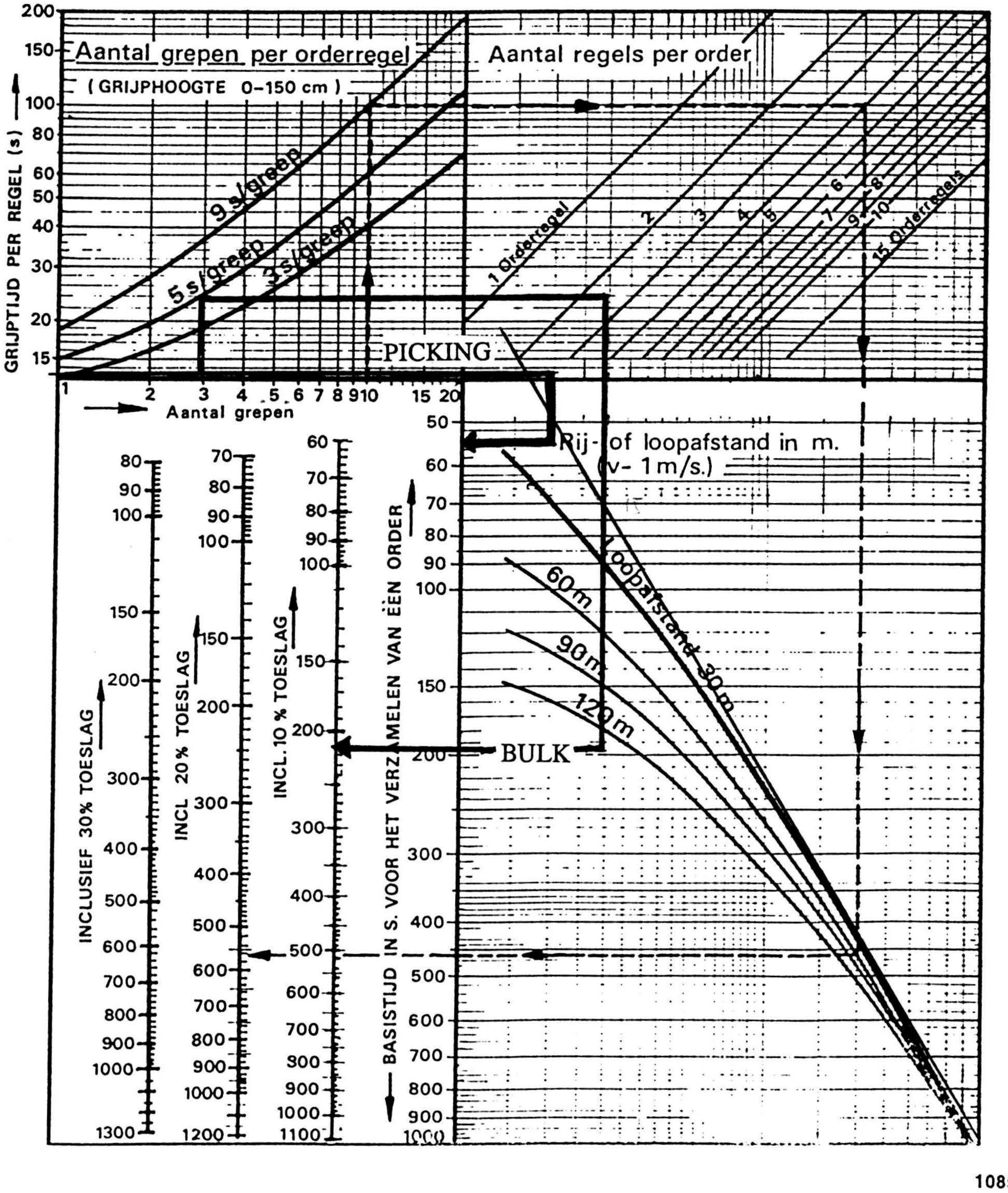
In the EVO sheet, average moving speed is 1 m/s. We assume a moving speed of 1.2 m/s. For the use of the sheet, we determine average distance: 149.5/1.2 = 125 meter

Final station:
Idications of throughput times used:

- printing 2 sheets:	30 sec
- checking/registration	25 sec
- down time 1.1	5 sec
total expected:	60 sec

EVO	**Cyclustijden voor het orderverzamelen**	**Standaardblad** © EVO

Voorbeeld: Een order bestaat uit: 4 orderregels van elk 10 volumineuze artikelen, terwijl de totale loop- of rijafstand 60 meter bedraagt. Verzameld wordt uit open vakstellingen, hoogte 180 cm, diep 60 cm. Uit de ingetekende lijn in het nomogram blijkt hiervoor een basistijd van 460 s. nodig te zijn. Voor ongunstige stellinghoogte en diepte wordt een toeslag van 20% berekend zodat de totale verzameltijd van deze order bijna 560 s. = ca 10 min. bedraagt.



APPENDIX VIII GOODNESS OF FIT, EMI BUSINESS PROFILE

The concept underlying the goodness of fit test, is the comparison between expected counts and observed counts in for an interval. If the observed counts approach the expected, the hypthesis, that they follow the same distribution, can not be rejected.

Statistical:

Data: The data appear as counts in a contigency table with cells combined into intervals.

Null Hypothesis:
The propability for observations to fall into an interval is defined by the normal distribution.

Test statistic:
$T=\Sigma(Oi-Ei)^2/Ei$ for i=1...k (k=number of intervals)

Decision rule:
Reject the nul Hypothesis at the α-level of significance if T exceeds the $1-\alpha$ quantile from the chi-square distribution with k-1 degrees of freedom. The critical values are found in statistical tables.

Definition of intervals: $k > \sqrt{n} \rightarrow k > \sqrt{248} = k > 16$

Testing the hypothesis:

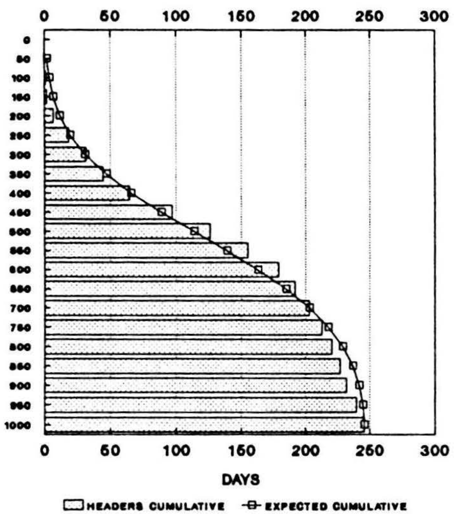
1. The headers are normal distributed with
$\mu=520$ and s=195
k=20
T-critical (α=5%, df=k-2) = 28.87
T actual = 17.04
The nul-hypothesis is not rejected

2. The lines are normal distributed with
$\mu=6631$ and s=2821
k=20
T-critical 28.87
T actual = 10.99
The nul-hypothesis can soundly not be rejected

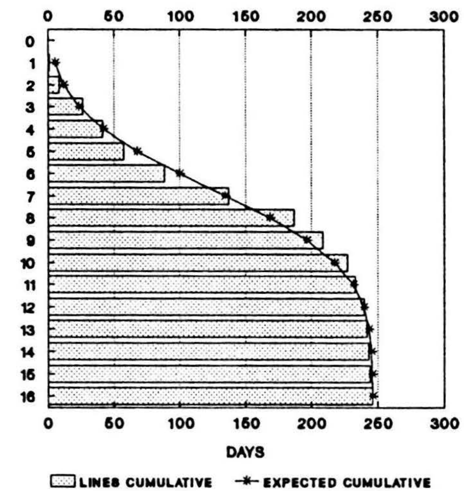
3. Sets shipped are normal distributed with
$\mu=33968$
s=16237
k=18
T-critical 23.54
T actual = 13.832
The nul-hypothesis is not rejected

In conclusion the daily load of the order driven transaction groups is determined by normal distributed demand in headers and lines as well as sets.

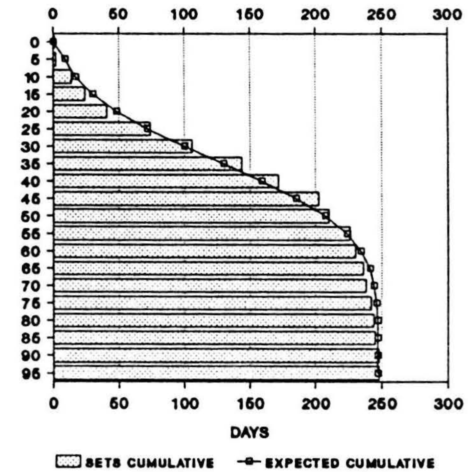
MODELLING HEADERS LINES AND SETS SHIPPED 1990-1991



HEADERS CUMULATIVE
VERSUS EXPECTED



LINES CUMULATIVE (•100)
VERSUS EXPECTED



SETS CUMULATIVE (•1000)
VERSUS EXPECTED

APPENDIX IX OVERVIEW WAREHOUSE TECHNIQUES

TRANSACTION GROUP	ACTIVITY	TECHNOLOGY
Goods in:	Movements	Hand Pallet trucks +
		Counterbalance trucks +
		Reach trucks
		Truck attachments
		Conveyor
		Automated Guided Vehicle (AGV)
	Checking	Radio data terminals
		Data capture terminals
	Sorting	Automated sorting conveyor
	Orders in	EDI
Inward processing:	Movements	See movements Goods In
	Storing	Picker truck +
		Turret truck
		Fix path pickers
		Automated storage/retrieval (ASR)
	Checking	Radio Data Terminals
Bulk processing:	Movements	See Goods in
	Storing	See Inward processing
	Storage	Flexible location
		- pallets +
		- trucks
		- roll-cages
		- paternosters/carousels
		Fixed location
		- Pallet-racking +
		- Flow-racking
		- A-frame racking
		- Bins
		- High-bay shelves +
	Picking	See storing
Pickheader production:		
	Order entry	Electronic data interchange
	Box erecting	Automated box constructor
		Sheet feeder
		Marker/Labeller
Order fulfilment	Bulk area	See Bulk processing
	Picking area	Picker to location
		- Bins
		- Low level shelving +
		- Pallets
		- Flow-racks
		- A-frame
		Location to Picker
		- Carousels
		Automated
		- ASR
Final station:	Checking	Automated Weighing

Despatch:	Packing	Sheet feeder
		Wrapper
		Automated box fixation
	Closing	Box closer
		Strapper
	Sorting	Palletiser
		(Mobile) conveyor
		AGV
Shipping:	Movements	See Goods In
	Orders out	EDI
Returns:	Checking	Data capture terminals
	Sorting	Automatic sortation
	Storing	See Inward processing
	Scrapping	Grinders/shredders

APPENDIX X CALCULATIONS OF FLOW-RACKS IMPROVEMENT

LABOUR COSTS		OLD/OLD		OLD/NEW		NEW/NEW		OLD/OLD	OLD/NEW	NEW/NE
LINES		FTE	cost	FTE	cost	FTE	cost	COST PER LINE		
500		5	1356	5	1356	5	1356	2.7125	2.7125	2.7125
1500		5	1356	5	1356	5	1356	0.9041666	0.9041666	0.9041666
2500		5	1356	5	1356	5	1356	0.5425	0.5425	0.5425
3500		5	1356	5	1356	5	1356	0.3875	0.3875	0.3875
4500		5	1356	5	1356	5	1356	0.3013888	0.3013888	0.3013888
5500		5	1356	5	1356	5	1356	0.2465909	0.2465909	0.2465909
6500		5	1356	5	1356	5	1356	0.2086538	0.2086538	0.2086538
7500		6	1759	6	1759	5	1356	0.2345666	0.2345666	0.1808333
8500		7	2162	6	1759	5	1356	0.2543823	0.2069705	0.1595588
9500		8	2565	7	2162	6	1759	0.2700263	0.2276052	0.1851842
10500		8	2565	8	2565	6	1759	0.2443095	0.2443095	0.1675476
11500		9	2968	8	2565	7	2162	0.2581086	0.2230652	0.1880217
12500		10	3371	9	2968	7	2162	0.2697	0.23746	0.17298
13500		11	3774	10	3371	8	2565	0.2795740	0.2497222	0.1900185
14500		11	3774	10	3371	9	2968	0.2602931	0.2325	0.2047068
15500		12	4177	11	3774	9	2968	0.2695	0.2435	0.1915

DEPRECIATION COSTS		OLD/OLD	OLD/NEW	NEW/NEW	OLD/OLD	OLD/NEW	NEW/NE
LINES					COST PER LINE		
500				233.33			0.46666
1500				233.33			0.1555533
2500				233.33			0.093332
3500				233.33			0.0666657
4500				233.33			0.0518511
5500				233.33			0.0424236
6500				233.33			0.0358969
7500				233.33			0.0311106
8500				233.33			0.0274505
9500				233.33			0.0245610
10500				233.33			0.0222219
11500				233.33			0.0202895
12500				233.33			0.0186664
13500				233.33			0.0172837
14500				233.33			0.0160917
15500				233.33			0.0150535

RELENISH COSTS		OLD/OLD		OLD/NEW		NEW/NEW		OLD/OLD	OLD/NEW	NEW/NE
LINES		#	cost	#	cost	#	cost	COST PER LINE		
500		30	53	30	53	12	21	0.1050	0.1050	0.0420
1500		90	158	90	158	36	63	0.1050	0.1050	0.0420
2500		150	263	150	263	60	105	0.1050	0.1050	0.0420
3500		210	368	210	368	84	147	0.1050	0.1050	0.0420
4500		270	473	270	473	108	189	0.1050	0.1050	0.0420
5500		330	578	330	578	132	231	0.1050	0.1050	0.0420
6500		390	683	390	683	156	273	0.1050	0.1050	0.0420
7500		450	788	450	788	180	315	0.1050	0.1050	0.0420
8500		510	893	510	893	204	357	0.1050	0.1050	0.0420
9500		570	998	570	998	228	399	0.1050	0.1050	0.0420
10500		630	1103	630	1103	252	441	0.1050	0.1050	0.0420
11500		690	1208	690	1208	276	483	0.1050	0.1050	0.0420
12500		750	1313	750	1313	300	525	0.1050	0.1050	0.0420
13500		810	1418	810	1418	324	567	0.1050	0.1050	0.0420
14500		870	1523	870	1523	348	609	0.1050	0.1050	0.0420
15500		930	1628	930	1628	372	651	0.1050	0.1050	0.0420

INRICHTING VAN HET ORDERPICK-PROCES VOOR SINGLE UNITS

GEÏLLUSTREERD AAN DE HAND VAN HET PICK-PROCES
BIJ EMI COMPACT DISC (HOLLAND) IN UDEN

Student: Th.B.M. van Aalst
Id. nr.: 244722

DE INRICHTING VAN HET ORDERPICK PROCES, TOEGESPITST OP PICKING VAN SINGLE UNITS

1. Inleiding

In veel bedrijven onstaat een toenemende aandacht voor alle elementen van de logistieke keten. Marktontwikkelingen hebben geleid tot de noodzaak van korte, betrouwbare levertijden en een hoge kwaliteit van het geleverde product. De concurrentie dwingt om dit te realiseren tegen zo laag mogelijke kosten.
Voor de magazijnfunctie, als deel van de logistieke keten, heeft dit geresulteerd in het vereiste, dat de doorlooptijd van processen moet worden verkort en de nauwkeurigheid vergroot met een beperkte inzet van middelen.

De magazijnfunctie is in veel bedrijven nog steeds een arbeidsintensief proces. Kleine productiviteits-verbeteringen kunnen daarom leiden tot aanzienlijke tijd-, en kosten-reducties. Dit artikel behandelt de berekening en de verbetering van productiviteit in één van de magazijnprocessen: de orderpicking. Het doel van dit artikel is het verschaffen van inzicht in het orderpick proces, aan de hand van een procedure voor de selectie van technieken die de productiviteit kunnen verbeteren.

2. Het belang van orderpicking

Waarom speelt de orderpick-activiteit binnen de magazijnfunctie zo'n belangrijke rol?

In de eerste plaats is het picking proces de meest arbeids-intensieve en (dus) duurste van alle activiteiten in het magazijn. De bijdrage van deze activiteit aan de totale directe magazijn kosten kan oplopen tot zo'n 65%.

In de tweede plaats neemt de relatieve omvang van de activiteit toe door het veranderende orderpatroon. Klanten bestellen vaker, maar in kleinere hoeveelheden. Bij een gelijkblijvende vraag effectueert dit een groter aantal orders. Bij een groeiende markt neemt de belasting van het orderpickproces alleen nog maar toe.

In de derde plaats is orderpicking in belangrijke mate bepalend voor het serviceniveau dat een magazijn de afnemers levert;

1. De levertijd van klantenorders wordt binnen de magazijnfunctie voornamelijk beinvloed door de doorlooptijd van het pickproces,
2. De kwaliteit (uitlevering van juiste aantallen in de juiste condities) wordt mede bepaald door de nauwkeurigheid waarmee het proces uitgevoerd wordt.

Gezien het toenemende belang dat gehecht wordt aan beheersing van levertijd en kwaliteit, kan orderpicking beschouwd worden als één van de sleutelactiviteiten binnen de magazijnfunctie.

Tot slot geeft de opkomst van nieuwe orderpick-technieken de mogelijkheid om tot aanzienlijke productiviteits-verbeteringen te komen met beperkte inzet van middelen.

3. Orderpicking in theorie, geïllustreerd aan de hand van de situatie bij EMI Compact Disc

De orderpick-activiteit wordt gedefinieerd als het verzamelen van producten of materialen uit voorraad voor klanten-orders.

De belangrijkste elementen van de activiteit zijn:

a. uitnemen, (pick time);
b. lezen, controleren en pakken, (fixed time);
c. zoeken, sorteren, (down time);
d. lopen/rijen, (travelling time).

In deze fase is het van belang onderscheid te maken in (1) picking vanuit de bulk voorraad en (2) picking vanuit de zogenaamde forward picking area. In het eerste geval worden veelal grote hoeveelheden in doos-, of pallet aantallen gepickt, in het tweede geval gaat het om individuele items of kleine doosjes. We concentreren ons op de forward picking.

De selectie methode van de meeste geschikte orderpick-wijze en -techniek wordt beschreven in onderstaande stappen.

3.1. Inventariseer alternatieve orderpick methoden

Drie belangrijke orderpick methoden kunnen worden onderscheiden:
1. geautomatiseerde-picking methode;
2. locatie-naar-picker methode;
3. picker-naar-locatie methode.

1. Geautomatiseerde-orderpicking metode
   In de forward picking area zijn de toepassingen nog beperkt tot een aantal situaties (hoge volumes, gevaarlijke stoffen). Hoewel automatische picking systemen een productiviteit kunnen realiseren van zo'n zes picks per seconde (20.000 per uur), zijn de investerings kosten in veel gevallen te hoog om effectieve kosten besparingen te genereren.

2. Locatie-naar-picker methode
   Deze systemen vinden hun toepassingen in situaties waar lange loopafstanden overbrugd moeten worden. De tijd hiervoor nodig wordt vervangen door de rotatie snelheid van een locatie. Wanneer weinig locatie bezoeken (picks) plaats vinden bij een uitgebreid assortiment (slow movers bijvoorbeeld) zijn toepassingen zeer geschikt. Maar ook hier moeten productiviteits verbeteringen (zo'n 25% in vergelijking met lopen) afgewogen worden tegen de investeringen.

3. Picker-naar-locatie methode

In situaties waar een laag aantal locatie bezoeken (picks) plaats vindt, is deze methode het meest gebruikelijk. Ook binnen deze methode kunnen we gebruik maken van automatische hulpmiddelen (breng picker naar locatie), maar productiviteits verbeteringen wegen vaak niet op tegen de hoge investering. De drie meest gebruikte procedures zijn:

a. De picker behandelt één gehele order in een keer;
b. De picker behandelt meerdere orders tegelijk;
c. De picker behandelt een gedeelte van een order.

Aan de hand van de laatste situatie wordt de inrichting gevolgd, voor andere orderpick-situaties is de procedure analoog.

3.2. Inventariseer picking technieken

De orderpick methoden bepalen voor een deel welke (geautomatiseerde) technieken toepasbaar zijn. De toepasbaarheid van technieken is verder afhankelijk van de omvang van de operatie, de aard en omzet snelheid van producten.
Tabel 1. geeft een voorbeeld van technieken die toepasbaar zijn in een magazijn voor kleine enkelvoudige producten met een relatief laag aantal picks (omvang operatie is klein).

Tabel 1. Inventarisatie van toepasbare technieken

	Eenheid waarin gepickt wordt	
Aantal line picks	Doos	Enkel stuks
Hoog	Flowracks Pallets	Flowracks
Gemiddeld	Flowracks Bin shelves	Flowracks Bin shelves
Laag	Bin shelves Carousels	Flowracks Carousels Binshelves

Zijn de toepasbare methoden en technieken geïnventariseerd dan kunnen de productiviteits-ratio's ervan berekend worden.

3.3. Bereken productiviteit van toepasbare alternatieven

De productiviteit van een systeem wordt veelal bepaald aan de hand van historishe analyses. Dit geeft een overzicht van de gerealiseerde picking productiviteit. Voor een rationele afweging tussen alternatieve pick-procedures biedt de orderpick capaciteit van systemen een betere basis.

De capaciteit wordt berekend aan de hand van de elementen van het pick proces. We beschouwen de variant waarbij de forward picking bestaat uit meerdere serieel geschakelde zones (de stations), die allen een deel van de order picken.

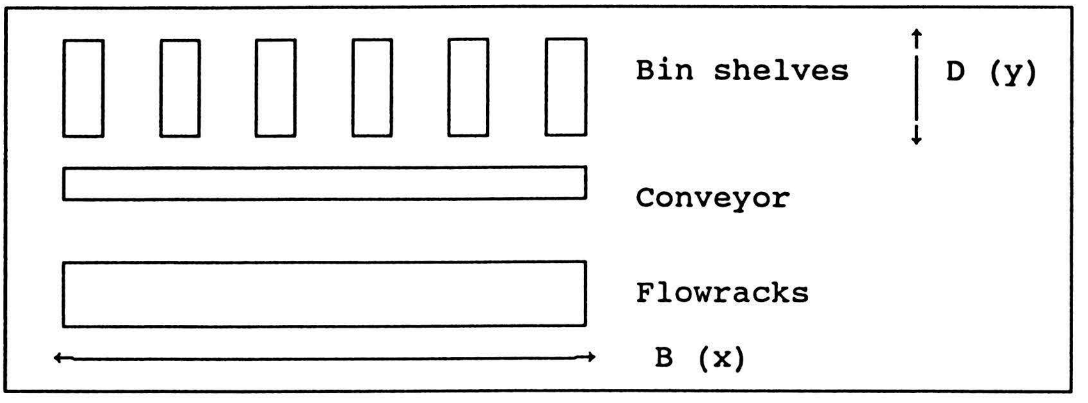
a. Het uitnemen (**pick-time**) wordt bepaald door het aantal lines dat gepickt wordt en het aantal keer per line dat gereikt moet worden. Door proces observaties (time-and-motion studies) wordt de reiktijd berekend. Als indicatie voor reiktijden kunnen de volgende cijfers dienen:

Kleine artikelen	1-3 seconden;
Normale dozen (6kg)	3-5 seconden;
Volumineuze artikelen	5-9 seconden.

b. Het lezen, controleren en pakken (**fixed-time**) kan gerelateerd worden aan het aantal lines dat gepickt wordt of aan een gemiddelde order. Bepaling van de fixed time per order is het gemakkelijkst, omdat de activiteiten per order en niet per line uitgevoerd worden. Via het gemiddelde aantal lines per order is de fixed time per line te bepalen (circa 10 sec.).

c. De zoek en sorteer tijd (**down-time**) is afhankelijk van de organisatie graad van de forward picking. Het is van directe invloed op alle elementen. Een factor voor de inefficiëntie van het systeem geeft deze relatie weer.
Drie factoren worden onderscheiden: inefficiëntie van mensen, inefficiëntie van opslagwijze (hoogte en diepte) en inefficiëntie van opslagsysteem (op nummer/locatie, consequentie etc.). Voor alle drie factoren nemen we een toeslag van maximaal 10% (dus maximaal 1,1*1,1*1,1).

d. De looptijd (**travelling-time**) is direct gerelateerd aan het aantal line picks dat wordt gemaakt. Deze wordt bepaald door de loopafstand en de loopsnelheid (circa 1,2 m/s). Twee algemene situaties die als voorbeeld kunnen dienen, zijn hieronder uitgewerkt.



Voorbeeld A: Een picker loopt vanaf het begin van de conveyor de binshelves in, en pickt alle lines in een keer. De te verwachten loop afstand is dan (zie figuur voor symbolen):
In y-richting: Het aantal lines (R)* (½D (in) + ½D (uit))= R*D
In x-richting: R/(R+1)*(B (heen) + B (terug)= 2*B*R/(R+1)
Totaal te verwachten loopafstand is dan R*((2B/(R+1))+D)

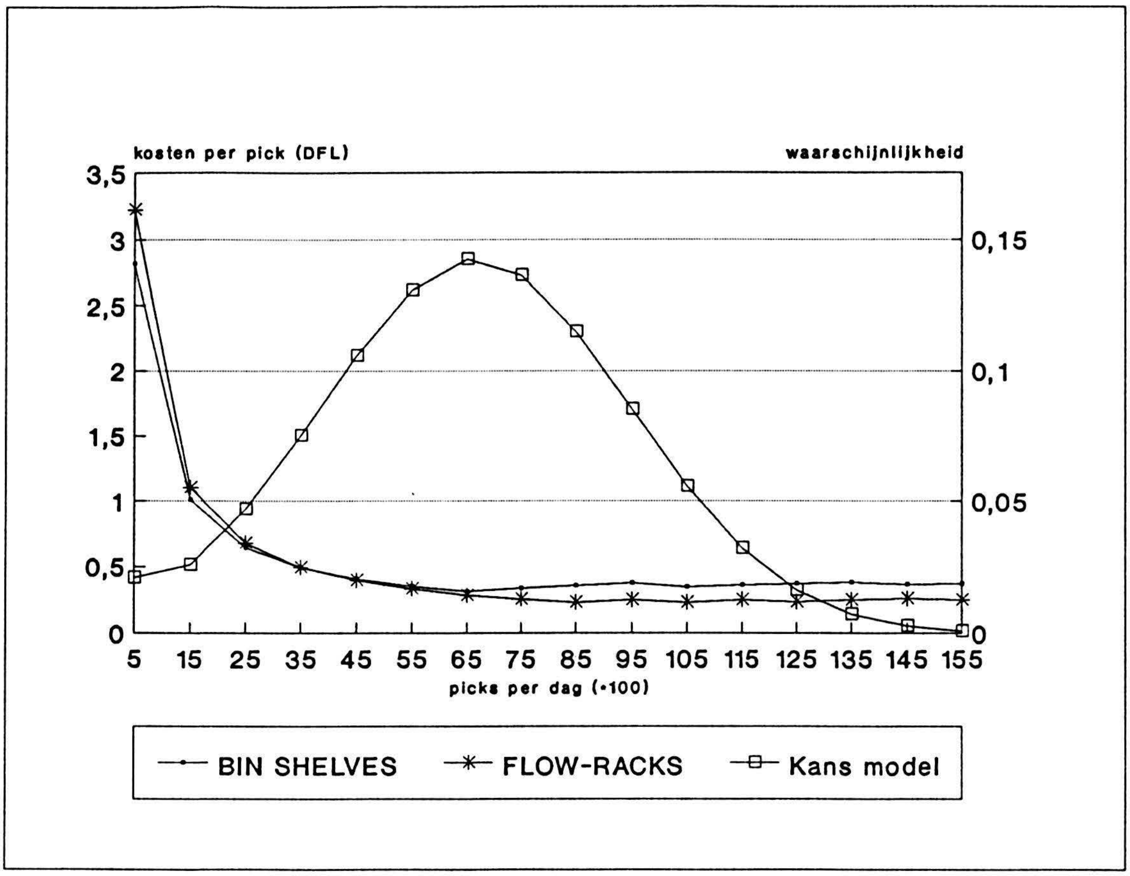
Voorbeeld B: Een Picker loopt langs de flowracks, pickt de lines en loopt terug naar het startpunt. De te verwachten loop afstand is:
In y-richting 0, en in x-richting wederom 2B*R/(R+1)

3.4. Vergelijk de toepasbare alternatieven en maak een keuze

De selectie van één van de toepasbare alternatieven geschiedt op basis van een afweging tussen operationele kosten voordelen en investeringen die moeten worden gemaakt.

De investeringskosten (afschrijvingen) worden berekend per periode. De operationele kosten zijn voornamelijk afhankelijk van de omvang van de operatie (aantal line-picks of orders) in die periode (een situatie).

Om beide kosten te vergelijken worden de kosten berekend <u>per linepick per situatie per periode</u>. De verwachte kosten worden gevonden door de kosten van een situatie te relateren aan de kans dat deze situatie zich voordoet.
Onderstaand grafiek geeft een beeld van de kosten verschillen voor de genoemde voorbeelden A en B. Het geeft de situatie weer bij EMI Compact Disc, een bedrijf met een relatief laag aantal picks per periode (gemiddeld 6800). Omdat de omvang van de orderpick-activiteit sterk fluctueert per dag, wordt deze tijdspanne als de te beschouwen periode genomen.



Figuur 1. Kosten vergelijking van orderpick-technieken
Cijfers van situatie bij EMI Compact Disc (Holland)

Met deze methode is het mogelijk kosten te vergelijken voor verschillende situaties. Het enige wat verandert is het kansmodel dat de omvang van een operatie in een periode beschrijft. Dit geeft de mogelijkheid om verschillende scenario's (optimistisch, gemiddeld en pessimistisch) betrekkelijk eenvoudig te beschouwen en door te rekenen.

4. SAMENVATTING

Het orderpick-proces speelt een belangrijke rol binnen de magazijnfunctie. De veranderende klantenvraag, kleinere orders en een hoger serviceniveau, hebben geleid tot een toename van het belang van het orderpick-proces.

Het arbeidsintensieve karakter van het proces en ontwikkelingen in picking-technieken maken het mogelijk om aanzienlijke productiviteits-verbeteringen te realiseren.
Dit kan echter alleen bewerkstelligd worden op basis van een gedetailleerd inzicht in de elementen die de productiviteit bepalen. Juist dit inzicht ontbreekt veelal.

Dit artikel beschrijft een stapsgewijze methode om het orderpick-proces te analyseren en alternatieven voor productiviteits-verbeteringen te selecteren. De beschrijving is toegespitst op het picken van single units en is geïllustreerd aan de hand van de situatie bij EMI Compact Disc Holland. (klein hoogwaardig product, lage volumes)
De methode behelst (1) het inventariseren van pick-methodes en (2) technieken, (3) de berekening van de productiviteit voor de mogelijke pick-situaties en (4) de vergelijking van en keuze uit deze mogelijkheden.

De keuze van de pick-methodes wordt bepaald door het aantal picks per dag in vergelijking met de te maken investeringen. Het blijkt dat de geautomatiseerde picking methodes beperkt blijven tot bedrijven met een hoog aantal picks per dag of gevaarlijke situaties.
De keuze tussen de pick-technieken wordt bepaald door de eenheid waarin gepickt wordt (doos of enkel stuks) en de omslagsnelheid van producten (snel-lopers, medium-, en langzaam-lopers). Voor producten met een lage omslagsnelheid zijn bin-shelves of flowracks het meest geschikt.
De productiviteit kan vervolgens worden berekend op basis van de elementen van het pick-proces: Pick time, fixed time, down time en travelling time. Het artikel geeft een richttijd of een berekeningswijze voor deze elementen.

Aan de hand van de voorgaande stappen kunnen de alternatieven vergeleken worden en een keuze gemaakt worden. Daartoe is als vergelijkingsbasis "de kosten per pick per dag per alternatief" gedefinieerd.
Het verloop van deze kosten in combinatie met de kans dat een bepaalde situatie zich voordoet biedt de mogelijkheid alternatieven in één grafiek weer te geven en te vergelijken. Het effect van toekomstige ontwikkelingen is relatief eenvoudig te bezien.

Voor EMI Compact Disc betekent dit dat de combinatie van flowracks met de picker-naar-locatie-methode de meest geschikte toepassing is voor picking van single units.

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VERKLARENDE WOORDENLIJST

Binshelves	:	Opslag medium, kasten of rekken verdeeld in kleinere vakken
Conveyor	:	Transportband
Flowracks	:	Opslag medium waarbinnen producten kunnen bewegen, doorrol stelling
Forward picking	:	Een deel van de magazijn voorraad, waar producten in kleine verpakkings eenheden (vaak individuele items) uitgenomen worden
Line	:	Een artikel uit het assortiment
Line pick	:	Zie pick
Order-line	:	Eeen artikel uit het assortiment besteld door een klant
Order-picking	:	Het verzamelen van producten uit voorraad voor klantenorders
Pick	:	Het verzamelen van producten voor één order-line, ook wel: locatie bezoeken
Zone	:	Een deel van de forward picking gericht op een gedeelte van het assortiment