Flexible decision support system design
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Chapter 2. LOGISTICS AT CABOFA

2.1. Introduction

The previous chapter discussed two perspectives related to solving planning problems. The first of these concerned the problem of planning formulation. The second perspective addresses solving and supporting methods. This chapter explores the logistics at Cabofa with the aim of analyzing the organizational context.

Logistics is defined here as the process of planning, implementing, and controlling the efficient, cost-effective flow and storage of raw materials, in-process inventoried finished goods and other information related to them, from the point of origin to the point of consumption for conforming to customer requirements. The mission of logistics is to get the right goods or services to the right places at the right times and in the desired conditions, while making the greatest contribution to the firm (Ballou 1992). An overview of logistics at Cabofa is offered to place the production planners’ task into the broader context. It also clarifies a number of restrictions on the organizational level that must be taken into account.

The structure of this chapter is as follows. The first section analyses the production planning and control (PPC). This involves organizing and managing the process of converting raw materials into predesigned finished products (van Wezel 2001). We also describe the bottlenecks that exist in the current design of the production planning and control and propose local measures as a means to remove indicated bottlenecks.

However, this dissertation does not focus on specific bottlenecks and ways to remove them, but on planning and scheduling and way to increase planning support by applying a human problem solving orientated view. The results of this approach are then discussed in an attempt to form a logistic(al) concept. This consists of three stages in which actions are performed. As well as the analysis of production at Cabofa, other production plants were also analyzed. The logistical concept in a corrugated board factory was found to be completely different. This information inspired a proposal to redesign the logistical concept. A similar framework is proposed by Harrison (1994).
However, implementing a new designed logistical concept required additional time, which was not available. Except for this crucial time factor, the company was considering purchasing a default ERP-system, which also may affect the whole design of the logistical concept.

Therefore, the prototyping phase, which is discussed in Chapter 6, uses the current logistical concept. However, the presentation of the new logistical concept may reveal a path whereby improvements in the logistical process can be located. Although many specific planning problems do not depend on the design of the logistical concept, they are nevertheless part of the problem formulation itselfs.

Having sketched the structure of the chapter, we begin by analyzing the production planning and control within Cabofa.

2.2. Production planning and control (PPC)

As mentioned above, production planning and control concerns organizing and managing the process of converting raw materials into predesigned finished products (van Wezel 2001). Van Wezel & van Donk (1996) define production control as a function of management, which plans, directs and controls the materials supply and processing activities of an enterprise. Whereas planning is the process of deciding what to do in the future, directing comprises the operation of issuing orders, and control can be described as the constraining of events to follow plans. PPC covers and overlaps the areas of ‘material management’, ‘operations management’, ‘materials handling’, ‘finished goods and in-process inventory control’ and ‘maintenance management’.

The analysis of PPC starts with the characteristics of Cabofa’s customers. It continues with a description of the primary process, which shows how inputs are transformed into desired outputs. It consists of the following elements:

- The technical system;
- The people at the work floor and the organization;
- The lowest type of logistical control.

The technical system deals with the production machines and how the final product is produced within the factory. The production process consists of a number of consecutive steps carried out on different machines. Both product and machine characteristics are important, both offering restrictions that must be taken into account by factory employees.

Besides production machines, people are needed to operate those machines. From a planning point of view, not much attention is paid to the organization of people working on the factory floor. The primary system is considered as the lowest type of logistical control.

Then, we analyze the logistical control. All stages are analyzed, such as where decisions are performed in order to control the production process. We continue with the organizational setting – how the primary process and logistical control are allocated to the functional departments that exist within Cabofa.

The analysis begins with the distinction of the market segments involved and how they can be controlled.
2.2.1. **Customers of Cabofa**

Characteristics of customers within different market segments often differ. Knowledge about the market segments and the specific characteristics of customers within it may improve the control of the production system. Cabofa serves five different types of market segments. Table 1 shows their market shares.

<table>
<thead>
<tr>
<th>Segment</th>
<th>Market share</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. Bookbindery</td>
<td>50%</td>
</tr>
<tr>
<td>ii. Stationery (manufacturers of document files etc.)</td>
<td>25%</td>
</tr>
<tr>
<td>iii. Puzzles</td>
<td>10%</td>
</tr>
<tr>
<td>iv. Displays and show cards</td>
<td>5%</td>
</tr>
<tr>
<td>v. Diverse</td>
<td>5%</td>
</tr>
</tbody>
</table>

**Source:** Marketing of Cabofa

From a market share perspective, bookbindery and stationery market appear the most crucial. Besides market share, other factors are also important. We shall briefly discuss the trends in the market segments that Cabofa serves. Identifying trends in these markets may give rise to particular actions aimed towards anticipating such changes.

The bookbindery market mainly consists of many small bookbinderies that purchase small quantities. It is difficult to serve this market, because the size of the customer orders and the dimensions of the demanded sheets fluctuate heavily over time. It is therefore difficult to anticipate any changes. Common trends in this market are: restricted volume growth, small order sizes, short due dates, high delivery reliability, high mix variety and no inventories.

Manufacturers in the stationery market mainly produce document files, leaf files and photo albums. The demand is predictable and the variety in sheet dimensions falls within a restricted range. The customers act in a global market, in which only a few players are involved. Recently, many companies in this sector merged, which make them more powerful in the supply chain. Common trends in this market are: no volume growth, relatively constant order sizes, relatively long due dates, high demanded delivery reliability, restricted mix variety, and no inventories.

The size of the puzzle market is stable. The product-specification orders differ, and mainly depend on seasonal effects, such as Christmas and Santa Claus. The main types of products in this sector are the more traditional board games, such as Trivial Pursuit, and jigsaws.

The product requirements are more specific with regard to the cleanness and the liquid percentage of the product. Furthermore, the fibration should be of a high standard, in order that small puzzle pieces fit.
The level of product concentration also increases in this market, which gives the puzzle manufacturers relatively more power in the supply chain. Common trends in this market are: no growth, smaller order sizes, shorter due dates, high demanded delivery reliability, high mix variety, and no inventories.

The displays and show cards market belongs to the offset market. The offset market deals with all professional activities. Here, several types of advertisement messages are printed on a rectangular surface. In order to print these messages four types of products can be used: synthetic material, silkscreen, gray solid board and corrugated board. Figure 5 schematically illustrates the volumes and the costs of the products in the offset market.

![Figure 5: Demand volume in the offset market](image)

From Figure 5 we may conclude that synthetic material is the most expensive product on the offset market, with a corresponding small volume. On the other hand, corrugated board is a cheap product, but holding a large market share.

Most offset activities use corrugated board. It is a cheap product offering reasonably fine quality. Gray solid board is qualitatively better. Silkscreen is cardboard on which white paper is laminated. The most expensive materials in this market use synthetic materials.

If economic growth increases so too does the demand for qualitatively better products. The products of Cabofa are silkscreen, which is a qualitatively high product. This sector shows strong growth. It offers an opportunity for Cabofa, through:

- The substitution effect within the offset sector, to qualitatively better products (e.g. from corrugated board to silkscreen);
- Additional growth.

Most of the displays and show cards are delivered to wholesalers. The wholesaler’s customers normally request a small amount of displays and show cards in unique dimensions. In order to control the inventories at the wholesalers’ warehouse, the wholesaler orders the product in default dimensions and default order quantities. This makes the variation in demand and dimensions of the wholesalers’ customer orders restricted to Cabofa. Thus, Cabofa can use an inventory in these default values.

Common trends in these markets are: an emerging market, smaller order sizes, shorter due dates, restricted mix variety and the use of a product inventory.
By summarizing the trends in the market segments, we derive the following picture. With regard to volume growth, the bookbindery, show card and display markets show some opportunities; the other markets stabilize.

Logistically, it is easier to achieve growth in the show card and display markets, because the mix variety is smaller and the demand is more predictable.

A general trend in all markets is a broad customer base. This seemingly gives more power to the demanding party in the supply chain. Apart from being an apparent threat, it also represents an opportunity for Cabofa – the concentration may lead to a reduction of variety in the demanded product specifications. On the other hand, some smaller companies specialize in a particular niche market. The size of the order quantities of these niche companies is small; however, the variety in product specifications may be high, which may make it unprofitable to accept such types of orders.

The trends described above show the current situation. Cabofa responds to this with a particular strategy. In order to stay independent, the concentration degree on the customers’ side represents a threat. On the other hand, a minimal critical mass is necessary. The response to trends should also depend on the type of market segment.

Another trend common in all market segments is a shift in cutting activities. The customer will outsource his cutting activities, because a centralization of cutting activities at the cardboard manufacturer has several advantages. First, the manufacturer can specialize and has scale advantages. Second, the waste flows from customer back to the cardboard manufacturer disappear, because the cutting losses in the converting process can be used as input in the production process of cardboard as it is located at the same production site.

Thus, the trends offer threats and opportunities. Most important here, is to retain the ability of flexible response to changes in demand. The degree to which the company is flexible also depends on the production process and the available production machines. These aspects shall be dealt with in the following section.

2.2.2. Process description

The process description lists the flow from waste paper to the final product, that being a solid board sheet on a pallet. The production of cardboard sheets takes place in two departments: the mill department and the converting department. The mill department produces large sheets, whereas the converting department cuts these sheets into small sheets. It is not possible to cut small formats directly from the cardboard machine, due to technical reasons. Customers of Cabofa require both large and small sheets.

The production department is located on two production sites and the converting department on one production site. We refer to them as the ‘Sand site’ and the ‘Lake site’. The company possesses four cardboard machines and two paper machines. Each machine has a particular maximum capacity, which depends on the product being produced and the number of setups within a particular week.

If the intake capacity on the cardboard machines is too low to meet demand, Cabofa can contract out to her sister company, Specabo. Specabo has two cardboard machines, which have different properties to those at Cabofa.

Figure 6 shows the production process schematically.
Figure 6: The production process schematically

The production on the cardboard (paper) machine consists of the following successive, integrated steps. The first step of these concerns the transformation of input material (waste paper) into pulp by mixing it with hot water. After filtering, sieving and pressing, the liquid percentage drops to 50%. After the remaining water has evaporated, the inner layer (lining paper) is ready.

The lining paper is rewound onto a reel and stored in the warehouse. However, the lining paper is still too hot to be used as input for the cardboard machine.
immediately. It is only ready for use in the cardboard machine after a period of cooling down has taken place.

If the caliper of the solid board needs to be above a certain value (1.5mm), then the inner layer on the cardboard machine is laminated with lining paper. Most of the lining paper comes from stock and is manufactured by Cabofa itself. Some particular brands of lining paper are purchased from external suppliers, because Cabofa is not able to produce them on their own paper machine. For more details about the relationship between lining paper and inner layer, see Sierksma & Wanders (2000).

The final stage of the cardboard machine involves the product being cut into large formats, which are then stored on pallets. After a quality control on the wrapping line, the product is ready for shipment to the customer, or it is stored in the warehouse waiting additional processing at the converting department. For a detailed description of the production process and the type of machines that can be used, refer to Biermann (1993).

At the converting department, large formats are cut into smaller formats. It uses two types of cutting processes: rotary and die cutting. The converting department contains four rotary-cut machines and one die-cut machine. Besides cutting activities, the converting department is also responsible for other activities, such as relabeling final products and resizing pallet heights, by recombining a collection of pallets with the same product specifications.

The additional operations on the converting department are either rotary or die cutting. Figure 7 shows the relationship between large and small formats. A small format is processed on either the rotary or die cutting machine. Surface specifications are the main difference between the rotary and die cut formats. Rotary cut formats are only either rectangular or square in shape. Die cut formats have either rounded corners or circular hole cuts within the sheet.

![Figure 7: Relationship between large and small format](image)

All rotary cut sheets in a large sheet always have the same dimensions (see Figure 7b). Note there exist two types of cut – horizontal and vertical. Die cut sheets do not require all cuts to have the same dimensions (see Figure 7c).
The dashed rectangle in the large sheet of Figure 7c outlines what is known as a set.

A set consists of a collection of die cut sheets, generally with different sheet dimensions, that are all input for a particular final product. A set often consists of three sheets, for instance the front, back and end view of a book.

From a technical point of view, the ‘set’ may be treated in a similar fashion as a rotary cut format.

We again refer to Figure 7c. It shares the same basic lay out as that of a rotary cut, which also cuts one large sheet into two smaller sheets.

If the capacity on the rotary cut machine is strained by unforeseen demands, exchanging some orders from the rotary cut to the die cut machine could increase the rotary cut capacity. The reverse is not true from the die cut to the rotary cut machine, due to technical restrictions.

Besides cutting activities, the converting department also performs other processing activities, such as rewrapping and relabeling pallets. Relabeling is necessary when the new customer differs from that on the original label. This may happen if the quality of a collection of pallets satisfies the manufacturing requirements with respect to a particular product type, but the collection of pallets was refused by the intended customer. The original customer may have higher requirements of product quality. If another customer then orders a product type with matching caliper and dimensions, the company relabels the pallets and delivers them to the new customer.

Relabeling means that orders that were originally customer-specific go into storage in the warehouse on an inventory. The means that the decoupling point has shifted from the beginning of the production process to the relabeling process. In the literature reviewed, the notion of the decoupling point is a very important one. It identifies the point, in the process, where the production flow changes from general to customer-specific. This meaning has been stratified into engineered-to-order, make-to-order, and make-to-stock (See e.g. Brevé, 1990 and Hoekstra & Romme, 1987).

Engineered-to-order means that the decoupling point is at the start of the development of a new product type. An example may be the ordering of a new customer-tailored production machine. Make-to-order means the decoupling point is just before the production process starts. Make-to-stock means that the decoupling point is on the inventory list of goods stored in the warehouse. In the cardboard industry, the bulk of the produce is make-to-order and only a small part is make-to-stock. For an illustrative description of the entire supply-demand chain, refer to Figure 2.

There are several storage points in the production process. Figure 6 depicts them as triangles. Logistical literature frequently emphasizes a difference between inventory points and waiting queues. In a production waiting-queue, products are waiting because there is no capacity available for further processing. At an inventory point, the product awaits a decision on when to continue processing (See e.g. Hill, 1991; Bertrand et al., 1990 and Boskma, 1988).

The first inventory point (see Figure 6) consists of waste paper. The company purchases old newspapers and uses them as input in the production process. For production planning and control point of view, we shall assume that there shall be enough waste paper available.
The second inventory point consists of lining paper. The lining paper is not manufactured customer-specific. The planner forecasts the lining paper requirements and uses this in order to determine the quantity to be produced on the paper machine.

The next storage points are located after the manufacturing of the large formats. The third storage point, the ready product storage point of large formats, is a mixed one. Most orders are customer-specific, so these orders are just awaiting shipment. A small part thereof may be defined as inventory, namely pallets that are intended for ‘new’ customers and which need to be relabeled; and a small fraction of stock is produced in standardized dimensions and quantities.

The fourth and fifth storage points deal with converting orders. The manufacturing of small-format customer orders uses either a predetermined large format, (unique large format) or straight off the inventories, (large format stock). The unique large-format stock (fourth storage point) is a waiting queue, because the product is already intended for a specific customer. If the due date is so near that the most efficient dimensions of the large format sheet are not available, the order uses a format in stock from the large format stock (fifth storage point). Finally, small formats flow into the ready-product small formats, a waiting queue, which is the sixth storage point. Most orders are customer-specific, except for a small fraction of disapproved orders. This concludes the overview of the production process.

The rest of this section will discuss the product characteristics. The company produces cardboard in several calipers ranging from 0.8 to 4.0mm. If the caliper of the cardboard is above a certain measure (1.5mm), we call the final product laminated cardboard.

Laminated cardboard consists of three layers. The inner layer is produced on the cardboard machine, whereas the other layers are produced on the paper machine, and are called lining paper. In one of the final processing steps on the cardboard machine, lining paper is laminated on the inner layer. If the caliper, however, is thinner than 1.5mm, it is not necessary to use lining paper: only the layer on the cardboard machine is applied. The product is called unlaminated cardboard.

The production department can vary the layer calipers, as long as the total caliper of a cardboard sheet remains equal. If the capacity on the paper machine (cardboard machine) is either too high or too low, then the company may decide to use thinner or thicker lining paper respectively. In Sierksma & Wanders (2000) the laminating process and related aspects are studied in more detail.

Another property requiring monitored control is liquid percentage. The default value is nowadays 8%. The company also offers customers the opportunity to deliver cardboard containing 7% liquid percentage. The liquid percentage influences the cardboard’s application range. As a rule of thumb, 8% liquid percentage customer orders may be manufactured on 7% liquid percentage, but the other way around, 7% liquid percentage customer orders manufactured on 8% liquid percentage, is prohibited.

Besides the choice in caliper, liquid percentage and sheet dimensions, the customer may choose between seven product types. The characteristics of the product types are related to the market segments they serve. The product types that are available are as follows:

(i) ‘Puzzlegreen’, a green cardboard for the puzzle market segment;
(ii) ‘Screen’,  
-and-  
(iii) ‘Print’, are two types of silk screen board directed at the displays and show cards markets;  
(iv) ‘Board’, a gray cardboard to serve the book binderies and stationery market;  
(v) ‘Luxe’, a gray cardboard that is laminated with a smoother lining paper for some particular applications in the book bindery market;  
(vi) ‘Mono’,  
-and-  
(vii) ‘Duo’, are cardboards that are laminated on one, or both, sides with white lining paper.

Most production volume in these seven product types is necessary for the production of ‘board’. From a planning point of view, the production of ‘puzzlegreen’ is the most difficult, because the water control system between the cardboard machine and the paper machine, on a particular production site, is non-independent. If a cardboard machine produces ‘puzzlegreen’, the product on the other machines will also bear a slightly green hue. As a rule of thumb, the paper machine begins with the production of green lining paper. Following the finalization of the run, the cardboard machine should change to a run of ‘puzzlegreen’.

The product types ‘screen’, ‘print’, ‘luxe’, ‘mono’ and ‘duo’ all use external lining paper that cannot be produced on their own paper machines. The delivery times of these lining paper types vary in duration from three till eight weeks. This makes a good estimation of the lining paper needed for these specific product types necessary for efficient stock control management.

Concluding remarks

In this section, we discussed the production process. We showed the stages that the raw materials undergo during the manufacturing process. Two complicating factors here are: the allocation of large and small format orders and the dependency between the paper and cardboard machine if laminated cardboard is in high demand. We also considered the location of the various decoupling points.

Cabofa offers seven product types that cannot be manufactured on all production machines. An allocation of the correct product types (within a particular range of calipers) to the production machines is required.

These complicating factors make control of the production process difficult. In the next section, we analyze the logistical control. From the management perspective, the logistical control should make the complicating factors mentioned less problematic.
2.2.3. Logistical control

Understanding the primary process is important, but understanding the way the process is controlled is even more important. In order to analyze the production process control, we shall describe all separate stages in the process. Figure 8 shows the primary process and the tasks that should control them.

![Figure 8: The primary and control processes](image)

The solid and dashed lines in Figure 8 show the relationships between two boxes and the direction in which the boxes affect each other. We distinguish between processes (rectangles), storage points (triangles), actions (ellipses), tasks (hexagons) and product specifications (rhombuses).

The bold solid arcs represent the stages in the primary process. The thin solid lines represent particular actions, such as ordering a given number of pallets. The
dashed lines show the interdependencies between the tasks that control a particular stage of the production process.

The process starts with the construction of internal orders or the arrival of customer orders (also called external orders). For a complete overview, see Figure 8. Figure 9 illustrates them schematically.

Figure 9: Internal and external order types

External orders are assigned to a customer, whereas internal orders are not. Two categories exist in external orders, namely ‘default’ customer orders and ‘contract’ orders. Normally, a default customer order is completely specified. In particular cases, the customer already reserves a provisional amount of capacity and passes on the specific details upon the time of reservation. This is known as an incomplete order. New customers, or current customers that are considering purchasing a new product type demand an ‘offer with delivery time indication’. Cabofa anticipates that a certain amount of offers will translate into customer orders.

A default customer order can have the following properties:

- On delivery date;
- On call.

Where a customer orders ‘on delivery date’, that customer agrees to receive the order on a particular delivery date. The customer order ‘on call’, allows more flexibility for both customer and the manufacturer. The customer agrees with Cabofa that the cardboard is ready on a particular date. From that date on the orders may be called out, meaning that as and from a specific date the customer may request the cardboard to be delivered to his shipping address.

The contract order is a special type of customer order. It may have either of the following properties:

- An annual contract;
- A consignment.

In a ‘consignment’, a certain fixed amount of cardboard is already in warehouse storage. Should the inventory capacities decrease, Cabofa is responsible for replenishing
them. In a ‘annual contract’, the volume that a customer will demand in a particular year is fixed by prior agreement.

Internal orders are used to replenish existing stocks of standard product types (default stock). Besides holding stock, it is also used to prevent a capacity loss, either because of low order-book level or of cutting losses. In the former, demand in a given week is lower than the capacity available, which allows rescheduling of customer orders from future weeks to the current week. It may be possible that there is still capacity available. Another task here is to create stock for anticipated orders in the near future. These orders are part of the first choice stock. The converting department also retains a specific inventory capacity in order to punctually manufacture rush orders involving converting. They use the large format stock.

In the later case, cutting losses, the available set of orders at hand leads to unacceptably high cutting losses. The creation of artificial order sets this cutting loss off against a (more sustainable) inventory cost, because the order has no customer yet. Thus, the extra cuts are therefore always of the same calipers as the order proper, with dimensions that the production planner expects a customer may request in the near future (Wanders et al. to appear).

From the order types discussed, most prominent are the ‘default’ customer orders on delivery date. Orders on call may provide some slack to the planning department, but lead to higher store costs. Contract orders represent a small amount of the entire set of orders. Internal orders are used to save capacity. Only orders from the product types ‘print’ and ‘screen’ are controlled independent of customer demand.

Inbound orders are checked for product specifications, capacity load and date due. Each sales agent that serves a limited number of customers has a particular capacity to sell in a given week. If the new order falls within the available capacity of the sales agent in a particular week and other parameters are also correct, the order will be considered commercially acceptable. Thus, orders flow directly into a bucket system, which assesses whether the capacity is available. If everything is okay, the order will be contractually accepted (customer order acceptance).

Once the order is commercially accepted, it passes to the ‘rough planning of the cardboard machine’ or to the ‘rough planning of the converting machines’. Both rotary and the die cut machines have distinct rough planning schedules. If a customer places a small format order, it is directed to the rough planning office of the converting department, all other orders are forwarded to the rough planning office for the cardboard machine.

Noteworthy here is that, in Figure 8, a directed arc links the rough planning of the converting machines to the rough planning of the cardboard machine. This is because the small format requires a specific large format, which normally should be manufactured on the cardboard machine. Some capacity on the cardboard machine shall be reserved to produce the large formats that are afterward used as input in cutting the requested small formats. If the converting planner accepts the customer order in his rough planning, and if the cardboard machine produces the large format, then the specified large format and its amount, are set automatically in the cardboard machine’s rough planning list.

From the cardboard machine’s rough planning an estimation of the lining paper required is drawn up on a weekly basis. It controls the ‘fine planning’ of the paper ma-
chine. If the lining paper needed is higher than that available, some lining paper should be purchased through external suppliers. This prompts the following task, purchasing. In the purchasing task the following decisions about ordering products have to be made:

- Ordering waste paper;
- Ordering lining paper at external suppliers;
- Ordering pallets.

From the above decisions, only the second and third one will be considered here, since we assume that the availability of waste paper shall not pose problems in the near future. Although the waste paper inventory capacity varies with time, the waste paper inventory control is primarily based on fluctuating prices of the waste paper market.

On an annual basis, Cabofa makes an estimate of what it will retail over the coming commercial year (yearly production budget). It provides guidelines of the goals each department in Cabofa should obtain. The capacity is already divided on a weekly basis, taking the service needs of the machines into account. In this way, it prescribes the targets at a rough planning level for the cardboard, paper and converting machines.

After finalizing the rough planning on the cardboard machine, the next stage is ‘fine planning’. This stage involves orders being selected on the basis of their calipers, liquid percentages, product types and the dates they are due. A collection of orders in a particular production plan is defined as a ‘run’, when all orders hold the same characteristics. Each run should be planned such that the trim loss is minimal. A second sub task in this stage is the setting out the order of each run. The most efficient solution here is to alternate gradually from a thick to a thin caliper and vice versa. Disturbances of this ideal pattern occur because of strict due dates and low stock levels among some other reasons. If a rush order arrives in a caliper, which cannot be manufactured in the short run, and the order must be manufactured, it disturbs this ‘ideal’ pattern.

The ‘fine planning’ of the paper machine often depends on the progress of the cardboard machine fine planning. The stock level of lining paper determines whether both types of planning are dependent on one another. If the level of lining paper is low, the due dates of the customer orders determine the weight of the lining papers that are produced.

The ‘fine planning’ of the converting machines is very different from that of the cardboard and paper machines. In this stage, only the orders in which the small format orders are processed remain important. An important characteristic on the rotary cut machine is the number of knives necessary to cut the small format sheets from the large format sheet.

‘Inventory control’ is primarily concerned with assessing storage level. The converting department normally uses either predetermined large formats or formats already in stock. In particular cases, the converting department uses large formats from on-call orders, when Cabofa expects that these orders shall not be called out soon. Customer orders are either on call or on delivery date. If they are on delivery date, the date is fixed, otherwise Cabofa agrees a certain date upon which the product is ready for delivery and the customer can call it out to deliver.
Finally, transport of pallets containing cardboard sheets to the customer also requires planning. This is more integrated into the whole process than Figure 8 suggests. We do not pay attention to it, because it produces few restrictions regarding pallet weights and heights that require regulation by the production planner in order to load and transport the corresponding orders efficiently.

Now we have sketched the logistical control at Cabofa. Many types of planning and scheduling exist that interrelate with one another – changes in the one type of planning affect the other type of planning.

One main principle in the logistical control at Cabofa is the differentiation of rough and a fine planning. Rough planning is necessary to control the available capacity of the production machines, whereas fine planning provides the exact assignment parameters in order to manufacture as efficiently as possible.

The logistical control and the process description are analyzed above. The next stage is to relate this information to the organizational settings, in order to illustrate the responsibilities of each functional department within Cabofa. These aspects shall be discussed in the next section, which focuses on the organizational setting.

### 2.2.4. The organizational setting

In the previous sections, we discussed the market segments served, the primary process and the related tasks that control that process. In this section, we look into the way the logistical control is divided over the various departments within Cabofa.

We distinguish between the logistics, commercial, business economics and administration, information communication technology and the production department. We now take a closer look at each of these departments.

The division of tasking is set in a functional approach. Each department is responsible for a particular number of tasks. In this section, we discuss the responsibilities of each department and relate them to the primary process and the logistical control. We start the description with an analysis of the responsibilities of the logistics department.

**Logistics department**

The logistics department consists of three divisions that require controlling, namely the departments of mill planning, converting and transportation.

The mill-planning department draws up new production plans and controls both the cardboard and paper machines. The mill planning department is responsible for:

- Making a ‘good’ production plan for both the cardboard machines and the paper machines;
- The administration of the production registration;
- The inventory control of the ‘print’ and ‘screen’ stocks;
- The inventory control of first choice stocks;
- The coordination of external production;
- The production data that is necessary for the yearly production budget.

Cabofa has two production sites. Each of these sites possesses two cardboard machines and one paper machine. The production planning and scheduling of these ma-
chines is performed through a decentralized approach, i.e. the production planners are only responsible for the machines on their site. In total, there are three production planners, two at the Sand site and one at the Lake site. The production planners control both fine and rough planning in their mill.

Some additional production capacity is available at Specabo. As mentioned above, Specabo is a sister company, which can manufacture cardboard sheets for Cabofa on demand. The production planners see to the coordination of customer orders that are outsourced to Specabo. They only consider orders that can be produced on the Specabo cardboard machines with an acceptable trim loss. Setup costs on the production machine give rise to a specific capacity that is then outsourced. The outsourced level is allocated at the management level.

The planning department manages the inventory capacity of ‘print’, ‘screen’ and ‘first-choice’ stocks. The ‘print’ and ‘screen’ stocks are non-order specific inventories, which continuously deliver to wholesalers in the show cards and display market. Most customer orders in this sector have standardized dimensions. The first-choice stock consists of both: (a) pallets that satisfy the company requirements, but were disapproved for delivery to the intended customer; and (b) pallets that have been manufactured as an internal order. Internal orders are sometimes necessary in order to reduce trim-loss on the cardboard machine. The production planner anticipates that some customers may order the product in these specifications.

Cabofa’s policy is to use first choice stock first, if a customer demands cardboard sheets that are already available in stock. If it is not available, it permits manufacture of the customer’s order on the production machine.

The second discipline controlled is the converting department. It is responsible for:
  - Planning and scheduling the die cut and rotary cut machines;
  - Production of the small format sheets on the production machines;
  - Coordination of external production with respect to small sheet orders;
  - Other sundry activities, such as relabeling of first choice stocks for a new customer, etc.

Although this department is controlled as one division, it is common to make a distinction between planning and production activities. The focus in the description is on the planning, but at this department, making this distinction is not a strong practice.

The converting department accepts customer orders that require a converting processing step. A converting processing step is necessary where the product does not have the desired characteristics after manufacturing on the cardboard machine, whereupon other processing steps are necessary. It is common to define these processing steps as ‘converting’. After being accepted at the converting department, the order flows automatically into the cardboard machine’s rough planning schedule, if the corresponding large format should be produced first.

Only the die cut machine and rotary cut machines are planned. The other activities do not occur that much and, therefore, are not planned frequently. One person performs the planning and scheduling and another is responsible for the administration at the converting department.

There are two types of activities on the factory floor: loading and unloading pallets and the production control of the converting machines. One person operates a forklift truck and transports pallets with large and small sheets to and from the ware-
house. One person controls each production machine and one person performs loading activities.

The transportation department is responsible for the transportation of the customer’s orders to the customer. As the company is globally orientated, it uses both lorries and ferries for transportation. Many detailed aspects of the transportation planning are important. However, we shall not address all of these issues here.

On call orders represent an important aspect of planning in the transportation department. It is uncertain as to when those orders shall be called off and thus the capacity needed for a specific day of the week varies. Most orders are loaded on Monday, Tuesday or Friday.

Both production sites have a forwarding department, whereby customer’s orders are loaded into the trucks that transport the order to the customer. The transportation planner controls this aspect of planning. Customer orders for delivery in Asia, the Pacific Islands and North America are transported by shipping.

**Commercial Department**

The Commercial department consists of the ‘sales division’ and the ‘marketing division’. The sales division is responsible for:

- Maintenance of customer relations;
- Approaching new potential customers;
- Constructing offers for customers;
- Setting the commercial budget.

The first of these tasks is quite clear. In order to have satisfied customers, you need to maintain constant contact with them. Apart from maintaining existing contacts, finding new customers is equally important, together with making of new offers.

One of the activities that has some planning and scheduling elements is the commercial budget. This is a kind of bucket system, whereby each region manager has a fixed sale capacity for a given week. If the demand in his department is higher than the available capacity, he cannot satisfy all customers requested due dates, and the offered due dates will be set one or more weeks later. This system makes it possible for region manager A to have capacity for week $x$, while region manager B cannot deliver before week $x + 5$.

Cabofa is an internationally orientated company with offices in a number of countries. These ‘Own Sales Organizations’ (OSOs) are responsible for the sale of cardboard products in those countries. Some OSOs also possess cutting capacity, in order to react flexibly to the local market demand for small sheets. Normally, these capacities are reserved for orders from the local market.

Organizationally, these OSOs fall into the sales department. If the converting department needs additional cutting capacity, it is possible to provide it at an OSO with a rotary-cut machine, but normally the OSO only cuts small format orders for sale on the local market.

The marketing division develops new products and continuously carries out research on market characteristics.
Business economics and administration department (BEAD)
The BEAD is responsible for control of financial flows. It checks the credit status of perspective customers. This check of credit status may reveal that a customer neglected to pay for an order, which may result in stay of order. This means that the forwarding department is not allowed to load this customer order. These decisions influence the efficiency of loading the trucks and at the inventory level in the warehouses.

Information and communication technology department (ICT)
The importance of the ICT-department is increasing. Nowadays, it coordinates the selection and development processes through a default ERP-system, which will replace the old logistical information system.

The selection route is based on project planning. A more structured task is maintaining the current information and communication systems and developing it such that employees are able to do their job carefully.

Production department
The production department is located on two sites. Each site has its production manager, who is responsible for that production department. The production department’s main activities are manufacturing cardboard and lining paper. This production phase is performed in a five-shift system.

Concluding remarks
The logistics department may be likened to a spider in a web of management relations within Cabofa.

The functional, commercial and production departments are the most important partners of the employees within the Logistics department, because these departments are direct neighbors in the supply chain.

The other departments, ICT and BEAD, support particular tasks in the whole process, namely the information facility and credit management. From a planning point of view, this makes the necessity to communicate with these departments less important than that of the departments mentioned above.

2.3. Analysis of the production planning and control
The current design of the production planning and control is the result of many changes over the years. The stages in the production process are more or less fixed. The production machines are rigid and inflexible. Some bottlenecks can be identified within the current production planning and control. We have uncovered several bottlenecks during the logistical analysis. In this section, we shall first describe the bottlenecks revealed and later we shall look at preventative measures aimed at removing the impact of these bottlenecks on the production planning and control.
2.3.1. Bottlenecks

Customers
The company’s customers can be divided into five market segments. One bottleneck with regard to the customers is the:

- Predictability of the trends and customer characteristics of the orders in the market segments.

Within a market segment, conflicting developments arise, which disturb the overall view on those developments. We wonder whether the market segment level is the correct level at which to analyze the market trends, on which the logistical decisions concerning inventory capacities are based.

Process description
An important bottleneck in the primary process lies in the:

- Available capacity at the converting department;
- Implications of the two-stage system, given the rigid and inflexible nature of the production machines.

The available capacity on the converting department is too low in relation to customer demand. The company expects that the shift from large to small sheet orders will continue to rise. The due dates for small sheet orders are shorter than those of large sheet orders. If the distribution of large and small sheets switches in favor of smaller sheets, this may have several consequences for logistics.

The two stage system also offers problems, because small sheet orders generally have a shorter due date. If the orders cannot be manufactured in a preplanned production run, an additional setup may be necessary with an inserted run that consists the small sheet order. The additional setup reduces the available capacity of the cardboard machines.

Logistical control
The logistical control concerns ways in which the production process is controlled by various tasks. So far, we have revealed the following bottlenecks:

- Order acceptance. The implementation of order acceptance in the logistical process at Cabofa is not very clear. Both the sales and mill planning departments perform rough planning tasks; the sales department is responsible for the bucket system and the mill planning department for order acceptance. The bucket system controls the available capacity over the following weeks. Order acceptance uses the orders that output the bucket system.
- Fine planning cardboard and paper machines. Fine planning on both these machines are highly interrelated. Actions in one type of fine planning affect the other. Normally, the paper machine planning is derived from the fine planning at the cardboard machine. If the lining paper of particular grades on inventory is too low, the paper machine planning controls the fine planning at the cardboard machine.

The cardboard and paper machine planning are related to each other, because the cardboard machine needs lining paper in order to manufacture laminated cardboard. If the company wishes to decouple the cardboard and paper machine, it requires a larger
inventory of the most popular grades. In some periods, this can only occur with externally supplied lining paper, when lining paper requirements exceed the available capacity on the paper machines.

**Organizational setting**

In the organizational setting, we discuss the way logistics control is embedded into the organizational structure. The bottlenecks at this stage are:

- **Unspecified orders.** The company has decided to abolish the possibility of unspecified orders for the majority of their customers. However, customers demand a certain level of flexibility. Thus, they place an order without a detailed specification. The capacity they need is reserved. Eventually, they decide which specific product they require. Unspecified orders complicate the planning process, because the production planners do not know which grade is intended for processing and, furthermore, if those are large and/or small sheet dimensions. Thus, this causes inflexibility and diminishes exchange opportunities in the planning and scheduling phase. A grade shows the quality and caliper of the requested product.

- **Delivery from stock or delivery on customer order?** Presently, a new customer order flows directly to the mill planning, in order to be produced on the cardboard machine. This occurs even when the product is available in stock in the demanded grade and size. A new concept might take into account existing stocks, before the order is scheduled and produced on the cardboard machine.

- **Locating pallets in the warehouse.** One of major problems in the forwarding department is that sometimes a particular customer’s pallets cannot be located in the warehouse. The warehouse has a free layout. If a particular order is manufactured piece by piece at the cardboard machine, and shifts change in between, it can happen that not all pallets are collected at one location.

**Concluding remarks**

In this section, we uncover several bottlenecks that exist in the production planning and control. In the next section, we propose several measures to remove the bottlenecks revealed. These measures have been derived from logistics literature (see e.g. Slack et al, 1995).

### 2.3.2. Removing the bottlenecks

**Customers**

One of our proposals aimed at improving the predictability of order trends was to introduce product-market-combinations (PMCs). PMCs offer better control possibilities of the various flows within a specific market segment.

At the PMC-level, the company specifies which PMCs are delivered from stock by default, and which PMCs are allowed to be produced on the cardboard machine. If these PMCs are marketed directly to Cabofa’s customers, the customers can rely on these announcements.
For example, in the bookbindery market, a distinction in the types of books could be identified, and each flow could be controlled differently.

As some PMCs are delivered from stock, the production planner is allowed more slack when drawing up an optimal production plan. The additional flexibility also improves the delivery performance.

Another advantage is the reduction in the need to place an unspecified customer order, one of the bottlenecks identified at the organizational setting level. This also reduces planning uncertainty.

With the approach of introducing PMCs onto the market, the total inventory capacity may be increased, but only in relevant PMCs that require more flexibility and better delivery performance.

**Process description**

The main bottleneck in the primary process was the lack of capacity on the converting machines. In order to increase capacity, the company purchases new converting machines.

Introducing a large format inventory in a selected number of grades and sizes may reduce this second bottleneck, related to the two-stage system. The large format inventory already exists, but a higher inventory capacity in the large format stock results in more decoupling of control on the cardboard and converting machines. It is easier to construct an efficient flow or set orders for each production machine individually.

In order to increase capacity, several new converting machines should be purchased. However, one problem with regard to the small format rush order remains.

**Logistical control**

The revealed bottlenecks at the logistical control were related to the order acceptance process and the fine planning on the cardboard and paper machines.

With respect to order acceptance, the process might be improved where both types of planning (converting and mill planning) at the rough planning level integrated with one another. The means that orders are checked against available capacity in the requested production weeks and, after this stage, the system automatically allocates the order to the consecutive production machines. The system also recommends alternative routes through which the order can also be finished. So, if a machine breaks down, a substitute process can be readily implemented. A similar system works in a corrugated mill factory. Take note, however, that this layout can only be successful if one department remains responsible for the rough planning. Otherwise, conflicting objectives make a balanced judgment difficult.

The second bottleneck at the fine planning level may be reduced by decoupling the planning of the cardboard and paper machines. This means that the inventory of lining paper is at a sufficient level. To obtain this level, the management must consider purchasing external lining paper against additional costs. The decoupling makes the planning process easier, and decreases the number of setups on the production machines, which may result in higher available capacity.
Organizational setting

The bottlenecks at organizational level deal with unspecified orders and the decision of whether to deliver from stock or on customer order.

Unspecified orders disturb the planning and scheduling processes. The motive of the customer is to have a specific capacity reserved, in order to have the demanded product on time, no matter what the product specifications. If this uncertainty could be removed, then the need to place an unspecified order shall be reduced. The introduction of the product market combination (PMC) may be of assistance here.

The decision to deliver from stock, or produce on customer order, deals with the habits of the factory employees. Nowadays, each new order entry is manufactured on the production machines. It is more profitable to deliver from stock, which makes it possible to manufacture another order, thus increasing capacity. However, the inventory capacity in the warehouse will be reduced.

Concluding remarks

In this section, we proposed several measures of removing bottlenecks that were revealed in the production planning and control. The most important of these is the introduction of product-market combinations, which: makes market trends more predictable; creates additional slack on the production machines; increases available capacity; and reduces the need to place unspecified orders.

Other measures may also reduce the impact of this bottleneck, but only have a local effect.

2.4. Logistical concept

Solving all bottlenecks in the production process structurally may require redesigning the entire logistical concept. A logistical concept shows how the organization should function from a logistical point of view (see e.g. Verstegen, 1989 and De Vries, 1999). A new logistical concept may streamline the stages to be performed before a product for a particular customer is ready. In this section, we shall first examine the current system and continue with our proposals on improving performance. Some details shown in the figures in this section shall be discussed further in Chapter 4.

2.4.1. Current system

The current logistical concept consists of three phases, in which the employees at Cabofa make the decisions. The phases describe distinct aggregate levels, on which the variables in planning are based.

Figure 10 shows the system as it currently stands.
The current system consists of three phases. In the first of these phases, the orders are checked against the available capacity on the production machines for the required delivery date. The second phase deals with the parameter check: is the order allocated to the correct machine and are the specifications viable? Finally, the third phase assigns the orders to the production machines in a structured way.

The main problem with the current design is that employee’s responsibilities are insufficiently defined. Officially, these responsibilities are set out very clearly, but in practice the boundaries where the task of the one employee ends and that of another starts is rather vague. Many employees are involved in the decision process. This makes good coordination essential. As an example, the bucket system controls the capacity at the aggregate level. The same type of action is performed during the rough planning, but with a different view on the problem. The main objective of the bucket system is to divide the total available capacity over the commercial regions, whereas, in the rough planning, the main objective is to control the workload of the production machines. Finally, the converting planning directly influences the mill planning on the cardboard machines.

Figure 10: Current logistical concept
2.4.2. Redesign

Redesigning the logistical concept should streamline the decision process within Cabofa. We should continue to use three phases, because the problem formulated make distinct aggregate levels necessary. Firstly, the orders are assigned to machines with respect to capacity, and then the detailed planning is made, continued by the real assignment. We proposed redesigning this as shown in Figure 11. The decomposition in stages is designed more logically, merging the bucket system and the rough planning in the first stage. The fine planning stage disappears; the preprocessing activities are located in the second stage. Finally, the definite assignment considers all arguments integrally.

Figure 11: Redesigned logistical concept

Redesigning in this way streamlines the flow of information within the factory. In the first stage, the bucket system and the rough planning are merged. The responsibility for this module stays at one department. Experiences with this control model can be found in a corrugated board mill within the Netherlands.

Phase 2 consists of separate modules that dynamically allocate the orders to the most efficient machine. Finally, phase 3 performs the detailed planning of orders on the production machines. In each stage, one particular employee holds responsibil-
ity, whereas other persons control the various modules within that stage. This reduces the need of continuous coordination and streamlines the information flow significantly.

However, typical planning problems still exist within the separate modules. These problems require a thorough analysis of the planning problems and the ways in which they can be solved. In our opinion, the production planner plays an important role in the whole process and, as a starting point, we use the current practice of solving the planning problems.

2.5. Concluding remarks
In this section, we analyzed the logistics at Cabofa. We showed that it involves a rather complex process. We began with an analysis of the production planning and control. Within this area, we explored trends in the market segments, described the primary process, analyzed the logistical control and organizational settings.

The trends in the market segments show that opportunities for growth are somewhat limited. Trends toward globalization represent both threats and opportunities on the demand side, which result in larger volumes requested by customers. The threat is a reduction of Cabofa’s market position in the supply chain. The opportunity lies in a rationalization of the diversity in sheet dimensions.

The primary process describes the flow from waste paper to cardboard sheet. The production process consists of two stages. The machines are rigid and inflexible.

The logistical control is concerned with how the primary process is controlled by particular tasks. Within Cabofa, five functional departments perform these particular tasks. The sales department and the production department are the most important partners for the employees within the Logistics department.

Several bottlenecks were revealed within production planning and control. A prominent measure to reduce the impact of these bottlenecks may be the introduction of a product-market combination.

In this way, the total inventory capacity may be increased, but only in relevant PMCs that demand more flexibility and better delivery performances. In the end, the production planners are provided with slack, which results in more options of improving the quality of the constructed production plans.

The measures to remove these bottlenecks only constitute redesigning at a local level. The best way to remove bottlenecks is to redesign the logistical concept. We developed a redesigned logistical concept.

Although the new concept may reduce the information flow and coordination within the various processes, some typical planning and scheduling problems remain. In order to remove these types of problems, a thorough knowledge of the planning and scheduling domain is indispensable.

The next chapters analyze the planning tasks and domain. By means of obtaining verbal reports, we performed a task analysis in order to understand the strategies a production planner implements when executing his tasks. In Chapter 3, the applied methodology is discussed.