DYNAMIC CONTROL OF THE PRINTING, POSTPRESS AND DISTRIBUTION OPERATIONS IN NEWSPAPER PUBLISHING

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Abstract: Open database solutions and intelligent control systems in the press, mailroom and distribution areas mean not only new possibilities to automate routine tasks. Information technology may also be used as an efficient tool for global monitoring and control. Modern data management, such as client-server applications and query processing, enable dynamic methods to improve the scheduling and control in the printing plants, i.e. platemaking, printing, inserting, bundling, truck loading and distribution operations.

In a joint project with a distribution company, owned by two of the largest morning newspapers in Sweden, a research group at the Royal Institute of Technology, in Stockholm—Sweden, has been mapping and analysing systems and daily operations from the mailroom to the customer. The processes, their timing and their need for production information have been identified. Special attention was directed at the propagation of delays as well as intersystem monitoring and messaging. Knowledge of the process can be used to create dynamic models of systems and routines.

INTRODUCTION

More than two hundred years ago a business that later became an industry – the newspaper industry – started to grow. The publisher of the 18th century was often a printer that regularly printed a couple of pages with local news. The readers very often bought the products directly from the printing office.

Today, the printed newspaper is just one source of information available on the modern media market. Producing and distributing newspapers is a time critical and resource consuming process. In order to stay competitive and serve readers as well as advertisers, systems based on modern information technology is used.

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The modern newspaper business is dependent on computer-based systems in every production phase – from sales activities and editorial design to printing and postpress operations. The production environment consists of many different subsystems [Stenberg et al 1993]. Many of these subsystems represent a high-technology process, but in most cases intermediate links are missing [Fekete et al 1993]. Modern production environments are based on an open-system philosophy. This means that information exchange is now possible through standardised database solutions, query languages and communication protocols [Eriksson 1992]. A global infrastructure – the first necessary step towards global management – is becoming a reality [Nordqvist et al 1993b].

Efforts are being made to *standardise* the delivery of status information among the subsystems. During the last year an international group of organisations and companies have been working on recommendations for the interchange of newspaper production tracking information – the IFRA Production Tracking Working Group [Enlund et al 1994], [Thoyer 1995].

The next step in the evolution is to develop *global control mechanisms*. This kind of dynamic control has been discussed and partly implemented on a local (prepress) system level during recent years [Alasuvanto et al 1994]. Global systems will act as tools that collect data from the local subsystems, process the data and distribute control information back to the local systems. This will allow scheduling and control from a global perspective. The aim is to become more flexible and to reduce the consumption of resources. The concept has already been presented in terms of a stand-alone simulator [Nordqvist et al 1994].

Scheduling and control from a global perspective requires knowledge about the available resources, the structure of the products and the behaviour of the different processes. A key issue in this research is to create useful models on an adequate and manageable level of granularity. The models will describe the products, processes and resources and how they interact. It is also necessary to create rules for the control of the process. The models and rules will provide a base in systems for dynamic production planning, decision support and control.

This project has focused on the printing, postpress and distribution operations at two of the largest morning newspapers in Sweden. The work was performed in collaboration with a distribution company, jointly owned by the two companies. The emphasis was on investigating and modelling the processes affecting distribution. The project covers activities related to the circulation and the subscribers, the link between press room and mailroom and the co-operation between the mailroom and the distribution organisation. Particular attention was directed to the interaction between the press room, mailroom and distribution organisation during the production run. The resource consumption and sensitivity to disturbances in the distribution operation were identified and analysed.

PRINTING, POSTPRESS AND DISTRIBUTION – THE NORDIC MODEL

There are a number of ways to solve the task of bringing the printed copy from the printing press to the reader. In many countries, most of the copies are sold through retailers and automats. In the north of Europe, most of the morning newspapers are delivered to subscribers early in the morning.

In Sweden approximately 65% of the newspaper income originates from advertising. The circulation and advertising departments at the newspaper companies know their readership and use demographic information to market the newspaper to the advertisers.

However, precise delivery directly to the readers early in the mornings will lead to a number of complications:

- Very tight time-tables to provide the reader with the product before six o'clock.
- Greatly reduced time margins between the processes to ensure products with competitive news.
- Flexible deadlines for the last newspages.
- A labour-intensive delivery operation and at a very inconvenient work time.
- A production that is very sensitive to disturbances due to the resource consuming delivery operation.

Altogether this means that even small disturbances may damage the newspaper's goodwill and financial result. Previous research has shown that even small delays at the editorial department have costly effects on printing and especially distribution [Alasuvanto et al 1994], [Stenberg 1994a], [Stenberg 1994b]. Every delay is transmitted forward to subsequent process phases.

METHODS

During the project a number of different methods have been used. Initially all the activities and flows of material and information were mapped in real production using the *SDA-method* [Fekete et al 1993]. A PC-based program, GraphDoc 3.20, has been used to support the method and output A-graphs.

In order to compare the production and distribution plans with the results, a large number of production and distribution reports were collected and analysed. This investigation covers a period of approximately six months. Nine days, selected from the six-month period, were studied in detail to identify the effects of delays in the production. The production-runs in the two printing plants were compared to the loading, transportation and unloading of every truck. Finally, the number of delayed deliveries was identified and the extra costs caused by the delay calculated. The statistics were collected from a distribution database and then processed in spreadsheet and statistical programs [Stenberg 1994]. For this purpose

different kinds of shrink-wrapped software were used (MicroPhone, Excel, Cricket Graph).

Interviews have been performed with persons responsible for the subscription departments at the newspaper companies, production staff at the printing plants and persons involved in the loading, unloading and distribution.

A questionnaire was sent to approximately 100 persons responsible for the distribution and reporting at 100 distribution centres in the area of Stockholm. Questions were asked about the need for relevant status information and prognoses from the production plants. Seventy percent of the recipients answered the questionnaire.

A GLOBAL PROCESS DESCRIPTION

The following section describes the most significant global parameters that have to be considered. Local activities or parameters without impact on the overall production have been left out.

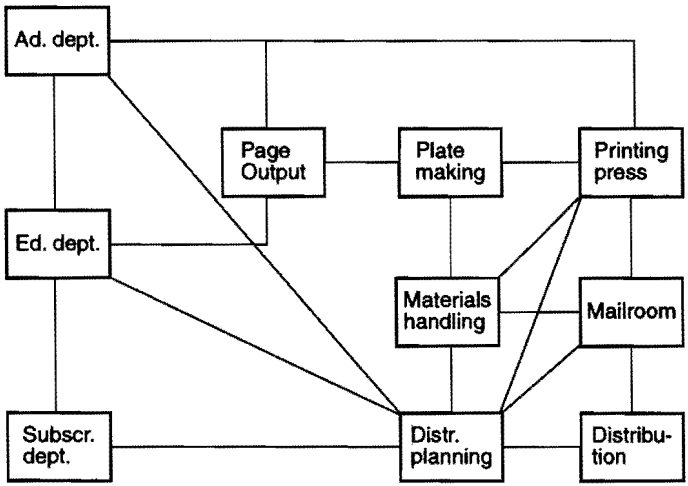

Figure 1: Different subprocesses from a global point of view. Dynamic global parameters that influence the runability in the areas of press, mailroom and distribution are often generated in the marketing and editorial departments.

This paper does not deal with local Production Management Systems in the advertising and editorial departments. Control and management in the area of prepress has been discussed by a number of research groups [Alasuvanto 1994], [Nordqvist et al 1995]. However, to obtain a complete picture of parameters and

activities that influence the control of the printing and postpress operations it is necessary to mention some of the earlier activities.

The description is structured in chronological order which means that it begins with activities connected to the planning phases of the product, production and distribution.

The format planning

The advertising department is responsible for the sales activities and the production of advertising material. The possibilities of booking certain coloured advertising material on certain pages are restricted by the possible press configurations. As the booked ad volume increases, the number of possible press configurations decreases. Some manufacturers of press control systems and advertising systems have linked their equipment to eliminate the risk of impossible ad bookings [Güth 1992], [Diergardt 1994]. The ad-booking process is often completed one or two days before publication. The sales volume of ads sets the total number of pages in the product and thus the press sheet. In Appendix 1 is a proposal for some more detailed definitions of the product and job formats and their relation to the total newspaper design.

The editorial department receives an estimate of the available space a number of days in advance. The ad bookings result in an ad dummy which shows ad positions, the number of pages, the colour configuration and an early decision on the total page and colour volume. This procedure is also known as edition design.

Besides the selling of advertising material printed in the newspaper there are sales activities concerning external inserts in the main product. This means that preprinted material has to be inserted automatically.

The determination of the circulation

The structure of the circulation changes from day to day. The subscription department administrates a database with all the subscribers, their addresses and administrative information. The database is continuously updated as new subscribers are added or the existing ones are moving or cancelling their subscriptions. To manage marketing campaigns the databases often contain information about all the addresses in the distribution area.

Besides the subscriber database it is necessary to have a database containing all the retailers and the number of copies ordered by each one.

The distribution planning

The distribution includes four different steps: the loading, the transportation, the unloading and the carrier operation. In the case-study the distribution company

was responsible for organizing 75 trucks and 1 500 carriers every night. The order in which the trucks are loaded, their routes and the timetable are defined in a distribution plan [Stenberg 1994a].

The *distribution plan* is based on a number of different parameters:

- The location of the subscribers and retailers.
- The printing capacity in terms of press lines, speeds and volumes.
- The capacity in the mailroom regarding inserts, bundling and loading capacity.
- The timetable for the production run in the printing plant.
- The possible weights of the products and sizes of the bundles.
- The drivers capacity to manually load and unload bundles.
- The capacity of the carriers, their districts and routes.
- The latest acceptable delivery time to the customer.

Other restrictions are given by the maximum load on each truck and traffic regulations. The optimization of the distribution plan is a difficult task that has to deal with the interaction between the complex process of manufacturing and the labour intensive operation of distribution [Stenberg 1994a].

The resulting plan contains information about every truck including timetables, routes, drops and approximate load specified in number of copies.

The preparation of circulation and distribution data

Modern mailrooms move towards production of addressed bundles containing an exact number of unique and even addressed copies. The objective of this procedure is automated *sharp zoning*, efficient use of newsprint and on-line addressing of mail distributed copies.

The information sources for these purposes are the circulation and distribution databases. In the daily preparation of the material every single copy of the circulation is converted to addressed bundles, truckloads and addressed mail distributed loads. The distribution methods used depend on the address of the subscriber. Mailing is primarily used in areas with few subscribers.

Data from the circulation and distribution database is also used to generate the loading/unloading lists used by the truck drivers and distribution lists used by the carriers.

The printing process

The printing process consists of two different activities: the preparation, or makeready, and the production. Before the preparation can start it is necessary to determine the *format of the job* [Karttunen 1994]. The press sheet includes several components regarding the number of pages and the colour configuration (see Appendix 1). The number of pages and the volume of colour corresponds to the

webs, press sheet and imposition. In the process of printing press preparation information, i.e. the editorial format choice, is fed into the press control system. The need for newsprint is given by the circulation, the configuration of the printing press and the calculated amount of waste.

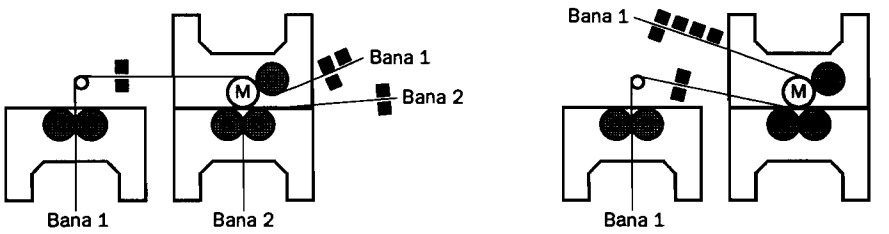

Figure 2: An example of possible solutions of leading webs through the printing units. In the left case the web-lead results in two webs (1+1 and 2+1), and in the right case the result is one web (4+1).

The local process of printing runs must fulfil a number of needs in order to make the overall production successful.

- The print quality must be stable and acceptable.
- The use of material must be efficient.
- The production must follow the timetables.

Particularly the second task requires co-ordination with the mailroom to ensure that the exact number of good copies required in the edition are printed. Other aspects that increase the consumption of newsprint are start-up waste, web breaks and poor print quality.

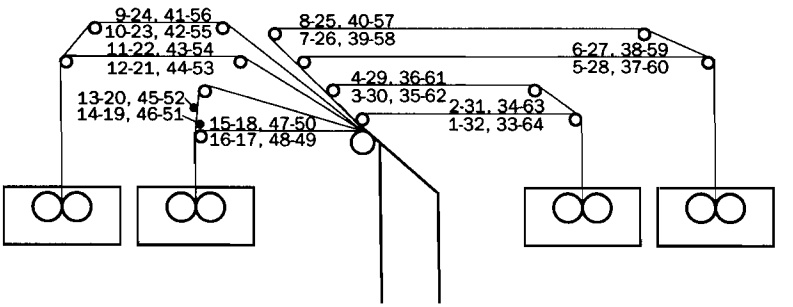

Figure 3: Before the folder all the webs must be collected in the right order. The length of the different webs may vary depending on the configuration of the printing press.

Some products or configurations in the printing press may cause delays caused by:

- Too long a make-ready time or delays in earlier stages.
- Prolonged run start, e.g. the misregister of folder or colours.
- Web breaks and troublesome restarts.
- Quality variations leading to printed waste.
- Products that cannot be printed at the calculated press speed .

The printing process may also be influenced by the production in the mailroom. Complicated mailroom operations may cause reduction of the press speed. Otherwise parts of the printed good copies will end up as mailroom waste due to overflow.

The mailroom process

A modern printing press is capable of delivering approximately 20 copies every second. In the mailroom these copies may be inserted with pre-printed material, addressed, stacked, bundled and transported to a specific truck on a specified position on the loading platform.

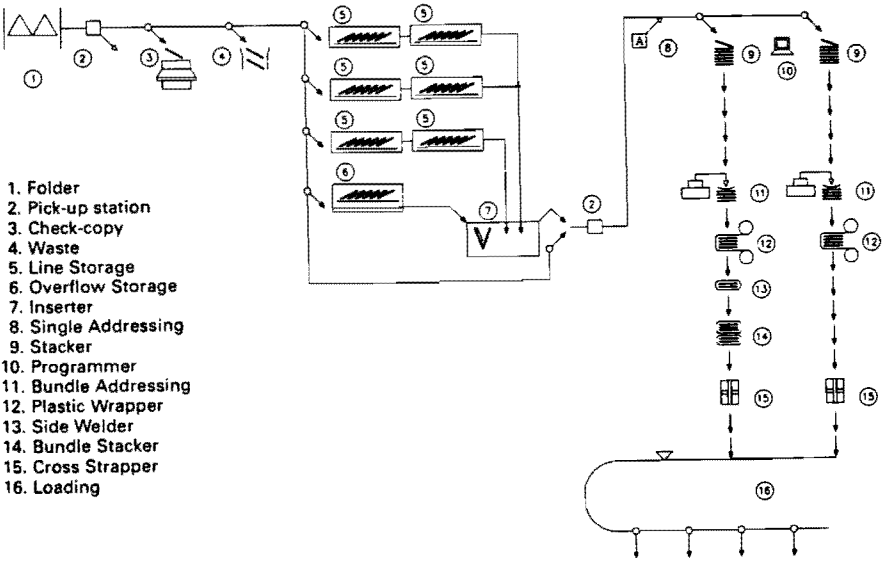

Figure 4: General mailroom system handling copies from one printing press.

The equipment in the mailroom is controlled by a local control system. The architecture of the control system may be centralized or distributed, but the aim of the system is to control all the operations from the folder of the printing press to the truck loading system. This may include buffering, inserting, copy addressing, copy counting, production of bundles, bundle addressing, packaging and finally control of the bundles in the loading system.

These operations must be harmonized with the distribution plan. The trucks have to be loaded in the right order and the truck specific bundles delivered at an optimum pace.

The distribution process

The last phase in the chain is the distribution process. If something goes wrong in the earlier phases the distribution must handle the delay and make the best out of the situation.

The truck drivers are responsible for the loading at the printing plant and the unloading at the distribution centres. The load, in terms of number of copies or bundles, varies every day. Although the more general distribution plan gives the main features; trucks, routes, drops, districts and zones. The number of copies is determined by the orders from the customers and the number of bundles is determined either by the number of pages in the product or by the location of the addressees.

During the loading procedure addressed bundles or standardised bundles are delivered to the trucks. The maximum size of the bundles are stipulated by the equipment in the mailroom or by the weight of the bundles. In the case-study the maximum number of pages in a bundle was approximately 2 200. This corresponds to 20 to 40 copies depending on the number of pages in the product. The load of each truck is up-dated every day and specified in loading lists and in the mailroom control system.

The average truck distributes 6 000 copies on a route but there are big differences from truck to truck. Every route consists of 2 to 4 stops at distribution centres and each centre gets bundles 2 or 3 times a night. Totally this makes more than 230 deliveries every night. From the distribution centres the copies are delivered to the customers by the carriers. The carrying operation starts at 2 am and is finished by 6 am. The number of copies delivered by each carrier is roughly 200 to 400. Every carrier gets up-dated information concerning the present subscribers and retailer [Stenberg 1994a], [Stenberg 1994b].

Under normal conditions the cost of the delivery operation represents 15-20 percent of the total product cost. Due to the labour-intensive operation the costs for the distribution may increase by 20-30 percent in the case of one hours delay. Besides that the newspaper companies will lose income and goodwill.

PRODUCT VARIATIONS

A dynamic process of booking advertising material, inserts and creating the editorial content of the product will attract the two customer categories—the advertisers and the readers. Possibilities to manage late changes without delays will be valued.

The structure of the product will influence every phase of the production and distribution. In the area of printing, mailroom operations and distribution the following parts of the structure are essential and may influence the processes:

- The colour content.
- The imposition, press sheet and sections.
- The number of pages in the main product.
- The occurrence of automated inserting.
- The physical structure of the inserts.
- The occurrence of multiple editions with different content in the main product or different inserts.

The colour content and imposition primarily influence the printing operation. The imposition and the number of pages in the main product influence the printing press configuration and the runability in the printing press. Complicated web leads means large variations in web tension, an increased risk of web breaks and longer make-ready times at press starts and web breaks.

The output product from the mailroom is a bundle—a product consisting of other products in terms of copies. The bundles may all be identical, unique or a mixture of identical and unique, which makes the control and management operation of the mailroom and distribution process unpredictable.

PROCESS AND RESOURCE VARIATIONS

The process runability, defined as the ability to complete the production in the way it was planned, must be known and taken into consideration. Products defined in a product model may influence the process of manufacturing and distributing in a variety of ways.

The variations in the process result in differences in production output and in the use of newsprint. In production runs which include advanced mailroom operations, the output from the mailroom (the number of copies per time unit) depends on the structure of the bundles and on the available resources. The construction of the mailroom, with its parallel chains of linked mechanical equipment controlled by real-time based control systems, makes it sensitive to disturbances. The mailroom productivity is sensitive to the physical structure of the products and the structure of the bundles, i.e. concentrated production of a high percentage of small bundles.

The variations may lead to three different results:

- The production might be delayed.
- The quality of the products might be uneven.
- The cost of the production and distribution might increase.

Especially in the case of increased production costs, the use of newsprint is a key issue. The use of material is an area which belongs to production management (PMS) and has briefly been analysed in an earlier report [Karttunen 1994]. The newsprint *waste* is expensive and consists of many components. PMS data from many subsystems is necessary, in order to create process models of the paper consumption and resource efficiency:

- Paper may be damaged during the transportation, in the storage and in truck handling, i.e. even in the unstripped reel form. Particularly the reel edges are sensitive to hits. Some reels may be not acceptable for mounting in the reel stands at all.
- The reel preparation and endings results in white waste.
- Paper run through the press during the make-ready, run starts, web breaks and restarts produces printed waste.
- Mailroom and inserting operations require waste copies in the starts or in disturbances.
- After addressing and during the bundling disturbances cause most dangerous types of waste—complete and addressed copies and even bundles.

In the beginning of the above listing, the problem is related to the runability of the reels or the paper, while other sources may be identified as sub-phenomena of the processes in question. The term "process waste" may be applied to all stages of the production and distribution.

Handling of white, printed and mailroom waste also causes less prioritized processes called jointly *waste handling*, i.e. from loose paper to waste baling. Production of waste takes as much time as that for the good copies. Waste figures are often collected with less precise definitions and data, and consequently the statistics may be misleading. As pointed out earlier the waste is a key issue in the total productivity and needs precise modelling and data.

Variations in resources have to be managed both at the planning stage and during the production and distribution. The resources may be human resources, materials, equipment and systems used for manufacturing and distribution.

The chain of subprocesses consists of activities which use all of these resources. To manage production planning, the capacity of the available equipment and personnel must be known. The capacity in the production plant is often measured in terms of number of cylinder revolutions per hour in the printing press. But a recent investigation has shown that the printing press is not usually the bottle-neck [Carlerud 1995]. The lack of resources occurs in the mailroom and truck-loading systems. To identify the need for postpress capacity all the available resources in terms of mailroom equipment must be identified on the basis of capacity and availability.

The use of resources in terms of materials also must be prognosticated. The stock of newsprint varies on a day-to-day basis, but the storage levels of the used reel

qualities must be specified, secured and known. The stock levels of other kinds of material such as inks, plates and chemicals must match the consumption prognosis and constantly monitored.

CONCLUSIONS

The process of producing and distributing printed newspapers is a long chain of dependent activities. Decisions taken at the advertising and editorial departments influence the production in the printing press and mailroom. In particular, changes regarding the imposition, number of pages and inserting operations may cause considerable changes in the process runability and resource consumption and thereby cost in the distribution phase.

In order to enable a more flexible structure of the products and a more flexible production, it is necessary to prognosticate the manufacturing and distribution operations. The prognosis may be used as decision support regarding timetables, resource allocation and production plans.

During the production the interactions between the printing process, mailroom operations and truck loading are key functions. A dynamic global control of these separate but concurrent phases will lead to:

- Efficient use of materials.
- Optimized use of resources in the mailroom.
- Optimized production of bundles and loading orders of the trucks to ensure an efficient delivering operation.

In order to implement dynamic control, data must be processed in order to create instantaneous instructions or closed-loop algorithms dealing with disturbances. The optimization may, for instance, be performed in order to minimize the delay cost or to minimize the number of delayed copies.

The dynamic control requires a precise definition of the overall process and monitoring of the status of the available resources. The control must be based on available resources and prognosis concerning:

- The printing operation.
- The mailroom operation.
- The truck loading operation.

Important information from the printing process is the number of good copies that with a certain probability will be delivered to the mailroom during the subsequent 10 to 20 minutes. If the printing process is interrupted by a web-break, a prognosis of the length of the interruption and the loss in output during this period may be used in the mailroom and distribution operations.

As in the printing operation, a prognosis of the capacity in the mailroom can be used in dynamic control. The mailroom capacity is influenced by a variety of parameters: the number of pages in the main product, the inserting, the quality of the inserted products, the individual addressing, the sizes and structure of the bundles, the addressing and packaging of bundles.

Finally the truck loading operation. To be able to optimize the orders of the truck loading, it is necessary to know the timetable and delay cost for every truck. In addition, knowledge of the number of copies in total, and the number of copies loaded, is needed.

Dynamic control may implemented in different ways. One solution is to use a learning system based on accumulated experiences that are continuously updated. The system can perform qualified assumptions on how to use the available flow of copies, bundles and trucks.

To enable dynamic control in the areas of printing, mailroom operations and distribution a great deal of research is still required. We have mapped the processes and found that dynamic control will improve the production. The continuation of this work requires measuring, modelling and development of control mechanisms.

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Appendix 1

Definitions of the product and job formats in the newspaper total design

The total newspaper design can be devided in *page design* and *newspaper design*. The newspaper design must include creative stages, done mainly by the editorial staff, and technical and structural considerations stemming from the press lines available. The so called *press configurations* are the central resource descriptions but we may as well talk about the plant configurations which may include respective configurations and resources of the inserting and mailing lines, loading lines, zones, and the distribution organisation.

In the total newspaper design of the daily editions the page design needs to be completed by the design of the product and job formats. To *define* these we refer to two previously defined concepts, namely the press configuration and the press sheet [Karttunen 1994].

Press configurations are press specific, often catalogued or databased, descriptions of resources, often included in the press control systems. They express and define a spectrum or a hierarchic set of all possible alternative press runs, i.e. number of reel stands, web widths, web leads, colours, colour sequences and folds. From the press configurations we can lead the sections and the total, job specific *press sheet*. The latter is a more complex concept in the multiweb presses than in one-web or sheetfed presses as pointed out [Karttunen 1994]. It is also an interface concept between the pages, imposition, paper consumption and the press [Karttunen 1995]. The press sheet expresses the total page area, i.e. print length x web width over each web in a run. Print length equals the printing cylinder perimeter (in the collect run). If a final copy has been run in two productions and combined by inserting we may also define the press sheet of the final copy.

For the *job format* the press sheet expresses the volume and a link to the total press resources. For the *imposition* the press sheet expresses only the total volume or frame of all pages and sections. The imposition is a combination of the positions of all pages on all webs, made so that the page numbering is correct in the final copy. Sometimes the pages are numbered separately for each section.

In the newspaper design the press configurations may change in the case of units out of order. Such variation is easily expressed in the respective catalogues or databases. The daily editorial (prepress) part of the newspaper design takes the press configuratios as a *resource model* to find the optimal sections (for the departments, ads, and pages), the total volume (depending on the ad volume) and the colour volume. Then the press sheet and the corresponding press configurations are easily found.

In fact, the structure of the whole product is thus decided and its match with the press resources checked. The *job format* is a daily decision and the edition specific choice on the volume (pages and colours), sections, inserts and the rest of the product structure. *Product formats* are a set of alternative product structures led from the press configuration of a given press line. This definition of format has nothing to do with the internal data format of the pages.