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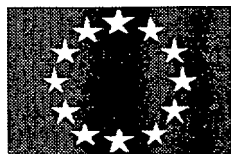
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# **PRINTPLAN**

## **A Shop Floor Planning and Control System for the Printing Industry**

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# 1 Abstract

Due to their size and the skills of their employees, most printing companies today lack a well-understood production planning and control process. The PRINTPLAN project aimed to improve this situation by introduction of a shop floor control system combined with the creation of appropriate organizational structures in the printing companies who took part in the project. This paper introduces the initial situation in a typical printing company and the project definition resulting therefrom. Then, the organizational and technical results of the project are presented, focusing on the C++ class system developed for production planning and short-term scheduling. It is concluded that a big step has been done towards an orderly production planning process by developing an industry-specific shop floor control system.

## 2 Introduction

The printing industry mainly consists of small and smallest enterprises with companies of more than 200 employees being the big players. Conducting a research project on production planning and control in this industry branch initially confronts the researcher with a very special situation.

Let's have a look at a typical printing company with 50 to 100 employees. Each of them is a master in his or her respective profession, as a printer, bookbinder, or reprography expert. The production process is based on the most advanced technology - without hesitating even small companies will spend a million ECU for a high-quality printing press. Every year several thousand orders are processed, up to 200 or 300 orders in parallel. These orders are of a great diversity: one may be a four page flyer in a drawing of several hundreds of thousands, the next one a high-quality auction catalogue, and finally there are 200 business cards for Mr Jones. However, if Mr Jones happens to be the CEO of the biggest client, these business cards become critically important.

Now, this process suffers from permanent disruptions. The big printing press is out of order for half a day. The films for order no. 4711 are of bad quality and have to be sent back to the customer for rework. A special paper that has been ordered separately is not delivered on time, Mr Jones (see above) enters the premises with a very urgent order. And the planning person, who may be the only one to overlook the whole process, is ill.

At that moment, the extent of the company's dreadful process state becomes obvious, The order, for which the required paper lacks, is delayed. To process Mr Jones's rush job, another order is interrupted and taken from the printing press. The salesperson hurries through the workshops to determine the state of his orders. And the production costs are skyrocketing ...

What are the reasons for such a scenery? On one side, there is the know-how of the employees: They may be printing experts, but they never learned production planning. On the other side, appropriate organizational structures are lacking. There is no fast and secure information and feedback process across the boundaries of departments. And last not least, there is no technical (read: software) support. Conventional software systems for the printing industry are targeted at order calculation and processing, but not at production planning and control.

Delivering orders to the customer in a timely fashion seems impossible under such circumstances. But, processing orders fast and on time could be a decisive competition advantage for European printing companies. Combined with a cost-oriented production planning competitors from low-wage countries in Eastern Europe, South Africa or South East Asia could be deterred. Today, more and more large orders are lost this way.

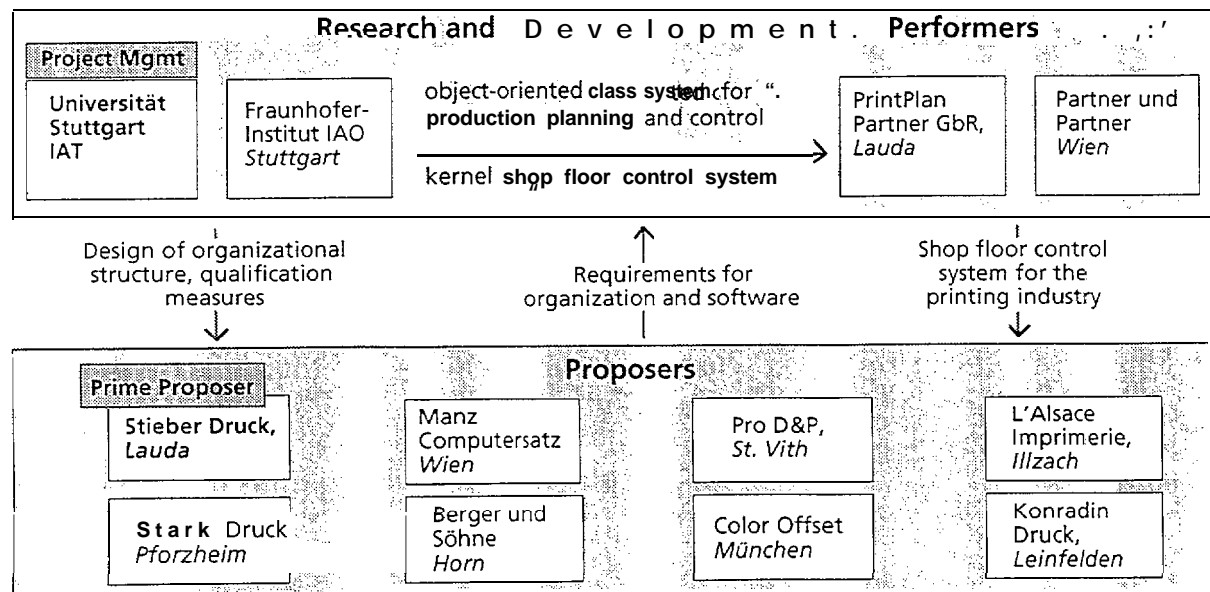
Based on the experiences of the R&D performers (namely the Institut für Arbeitswissenschaft und Technologiemanagement of the University of Stuttgart and the Fraunhofer-Institut für Arbeitswirtschaft und Organisation) in the area of short-term production planning and control it was decided to solve these problems by introducing a shop floor control system and creating an appropriate organization for the production planning process. A graphical planning chart as the core element of a shop floor control system should be the ideal tool for the printing industry to set up production plans and to visualize the actual state of the production process. This is strongly supported by the fact that today already in many printing companies manual wall charts are used for production planning. However, shop floor control systems apt for the printing industry were not available in the market. Existing

systems for the metalworking industry are impracticable for the printing industry, as they are not able to cope with numerous disruptions and extremely short planning time frames, and require a lot of administration effort by the planning personnel in areas like stock management, which only in a few cases are of any importance.

Therefore, the PRINTPLAN project was set up with two intertwined topics: Development of a printing industry-specific shop floor control system and implementation of appropriate organizational structures for the production planning and control process. A successful introduction of a shop floor control system was expected to enable foresighted planning including simulation of alternative production scenarios and high transparency of the production process due to a close coupling to a production data collection system. As a consequence of **at-improved ability to cope with** disruptions a more timely delivery of orders was anticipated. Last not least it was required that existing software and hardware products be supported by the new software system.

The PRINTPLAN project was carried through from July 1994 to September 1996, with earlier discussions dating back to mid-1 992. It was funded by the European Commission in the BRITE/EURAM programme under the CRAFT scheme (contract no. BRE2.CT94.1337). Having an overall budget close to 960000 ECU, the project required a funding of about 460000 ECU from the European commission and an additional cash funding from the proposing printing companies of 175000 ECU to cover the expenses of the R&D performers, Given the size of these companies (none of them having more than 250 employees, with the majority below 100 employees), **this contribution represented a major investment.**

Fig. 1: The PRINTPLAN Consortium.



### 3 Technical Description and Results

The results of the project may be divided in three categories. From the organizational work done during the project and due to the intense collaboration with the project KODRUCK (a German, nationally-funded project on cooperative, decentralized business processes in the printing industry) substantial insights have been won on the organizational structures and the work flow in the printing industry. The software development part resulted in both new concepts and algorithms for production planning, especially short-term scheduling, and new methods for the software development process itself.

#### 3.1 Organizational results

Modelling and thus understanding the work flow in the printing industry was done using a participatory method for analysing business processes. With the collaboration of the people working in the printing companies, charts were drawn up showing the flow of work for any type of order that has to be handled by the respective organization. These diagrams together with other more common productivity methods (Metaplan and others) problems in the companies' work flow could be isolated and improvement measures could be devised. Of course, the focus of the discussions was on the production planning and control methods, and in some cases the foundations had to be and were laid for an orderly production planning process.

From the discussions, it became obvious that many of the problems arising during the production problems do not stem from external sources (customer or suppliers), but are home-made. This includes tedious or incomplete forwarding of information from sales to production planning, not obeying to a production plan that has been devised, but interrupting rush jobs by "super rush" jobs, or failing to report actual production progress. On the other side, enhanced transparency for the production process can be achieved through electronic shop floor control systems, including electronic graphical planning charts ("Leitstand") and efficient production data collection systems. (Bassler 1996)

Important information for the software requirements specification and the subsequent development of planning algorithms was won from the analysis of the technical production process. It could be shown that in most cases the production process is a low-branching converging tree. Given a somewhat simplified customer order for the production of a book or brochure, the production structure may be represented as shown in fig. 2.

In the beginning, the customer order is partitioned into several production orders, of which one will produce the envelope, the others each one part of the contents (e. g. a single-

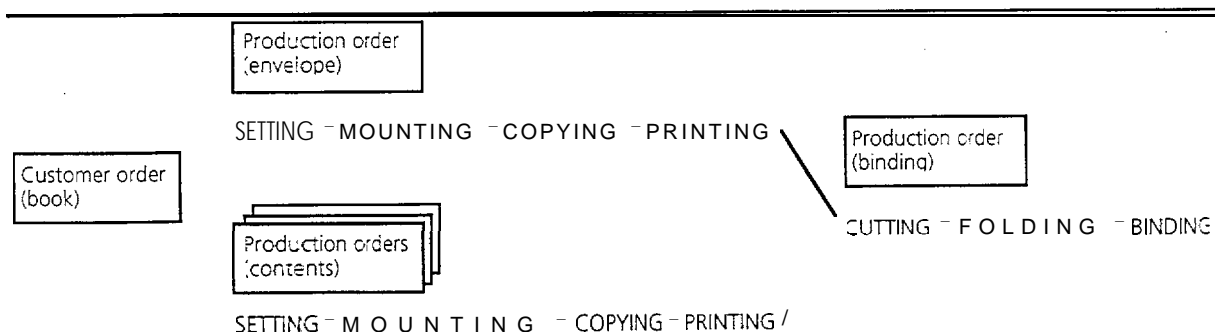


Fig. 2: Print production structure as a converging tree (Brenner 1995, 13)

coloured part for the text, a four-coloured part using special paper for photographs and so on). All of the production orders have the same flow of **work**:

The first step is typesetting text and graphics for the envelope and the contents. The formatted and corrected text is *belichted* on film. (This step may be skipped for orders, for which the customer himself produces the films.)

**Mounting text and graphics** (if produced separately) on a large foil is the second step. This includes decisions on the final layout of the book or brochure and on the production method. Depending on the size of the product and the possibilities of the production, 8, 16 or 32 pages may be mounted on the same foil. A natural way of partitioning the order is by the number of mounting foils (and hence different sheets to be printed).

The ready-mounted foils are then *copied* onto printing plates. These plates are used in the *printing* stage to produce the printed sheets on the press.

The post *processing* stage takes the output of the different production orders and combines them to a final product. This includes folding, cutting and binding the printed sheets, and optionally other steps for special needs (e. g. pasting in an envelope for a CD-ROM).

At this level of detail, the production steps are about the same for all products of the printing industries (books, brochures, magazines etc.).

## 3.2 Software development results

First, the components making up the PRINTPLAN system, and its interfaces to other, more conventional systems for the printing industry like calculation and production data collection systems are introduced (for this section cf. Bassler 1996). In the second subsection the technology underneath this architecture is presented.

### 3.2.1 Components and interfaces of the PRINTPLAN system

Short runthrough times characteristic of the printing industry, especially short-term acceptance and change of orders call for a shop floor control system with a high degree of flexibility. Those responsible for scheduling constantly need to have an insight in the current stages of the production process and should always be in the position to make alterations easily. Here the relatively small degree of complexity of production compared to other industry branches should be taken into consideration (the order of operations in the production process is mostly linear). For a more detailed discussion of the differences between the printing industry and other industries please refer to Brenner (1995).

As to the number and kind of functions a shop floor control system for the printing industry (see fig. 3) does not differ much from a comparable system for the manufacturing industry. It is the contents and details for the functional components that make the difference.

The *order import* function receives order data transmitted from the job cost estimate or PPS system and transforms the data into a suitable **form** to be then precisely planned by the shop floor control system. This may include reducing certain operations in mounting, copy or printing automatically to single sheets or even machine runs that are regularly dealt with in calculation all inclusively. This is to guarantee parallel processing of a number of sheets. Also, an automatic setting of basic time limits in single operations should be possible.

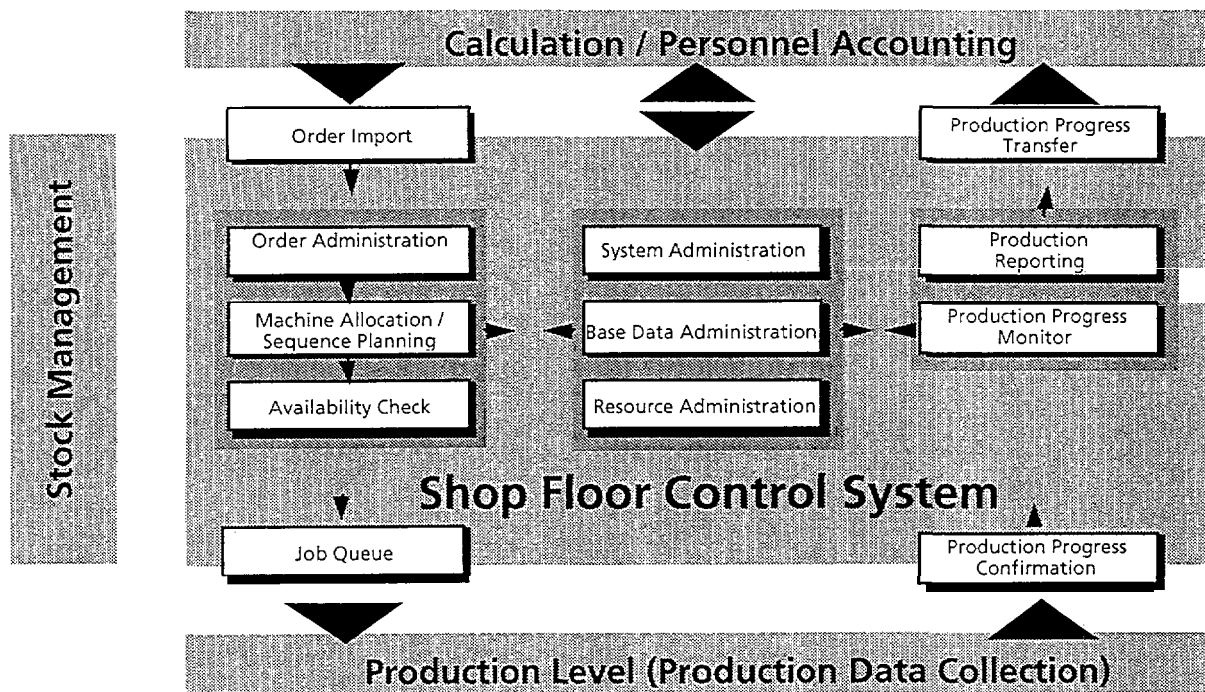


Fig. 3: Functional components of a specialized shop floor control system for the printing industry.

The *order administration* allows the changing and, where necessary, the entering of new orders. Here industry-specific intermediate deadlines (arrival of manuscripts, films or paper, expected good-for-print etc.) have to be taken into account. It should be possible to split large operations or to join operations from different orders for combined processing.

*Machine allocation and sequence planning* are the core functions of the system. The production orders (or, more exactly, the required capacities for each operation) are assigned to working places (machines) and their sequence including starting and ending times is determined. Besides simple forward and backward scheduling methods optimizing algorithms are required to make use of the flexibility of a shop floor control system.

The objective of optimizing scheduling algorithms for the printing industry is to minimize the lateness of orders by intelligently sequencing operations on each machine. This includes adjusting capacities and reaching cutbacks in the setup times. Especially an optimization of setup sequences requires an industry-specific design of the shop floor control system, because specialized printing know-how is needed. For optimizing scheduling purposes mathematical procedures may be used or stochastic methods like Genetic Algorithms, which are used in the PRINTPLAN project.

Part of this functional component is the *planning (gantt) chart tool*, which visualizes the production plan as a bar chart and displays information on the actual production progress. The planning chart consists of two parts (like in other shop floor control systems), the upper area for planning showing already scheduled operations and the lower area for waiting orders. A colouring scheme for the operations in the planning area indicates the actual state of the production.

The *availability* check is strongly intertwined with sequence planning. Whilst the latter considers capacity resources (i. e. work places/machines or personnel), the former has to ensure proper availability of raw or intermediate materials. Depending on the type of printing

company, this mainly includes stocked paper or special colours. Compared to the manufacturing industry, the availability check is of minor importance for a printing industry-specific shop floor control system.

Communicating the *job queue* to the production level is to ensure that at every work place it is known, in which sequence and with which due times the work assigned to the work place should be processed. Information about the actual times and sequences of the operations becomes available for the shop floor control system by means of the *production progress confirmation*. For the use of a shop floor control system to make any sense it is indispensable to have a timely information on the production progress. In general, this is the task of production data collection (PDC) systems. Introducing such a system makes the current method of manually written work protocols obsolete, since the data are collected in a more complete and accurate way by electronic means.

The *production progress monitor* not only processes incoming messages from the P D C system, but also supervises intermediate and final due dates. If a date is not met or production delays are detected, automatically a note for the production planning personnel or the sales department is generated.

An optional part of a shop floor control system is *production reporting*. Large portions of such a function also are to be found in cost calculation systems. Here, reports may be included like a comparison of planned and actual times and costs per work place, calculation of makespans, degree of usage per work place etc. Basing a shop floor control system on a high performance database system allows for a multitude of such reports with few programming effort.

The flow of order data through the shop floor control system ends at the *production progress transfer* interface. This function forwards data collected on the production progress to a cost calculation or personnel accounting system.

All functions of the shop floor control system depend on the data stored by the three "base functions": The *system administration* allows for changing system parameters and managing user access authorizations for every function. Company-specific calendars and capacity models are entered and maintained using the base *data administration*. Finally, a *resource administration* system offers functions for keeping up-to-date work place and material information.

The functions presented here were discussed during the PRINTPLAN project, and detailed requirements for each of the functions were specified.

A shop floor control system is not designed for operation in a vacuum. Although the PRINTPLAN shop floor control system in theory could be operated as a stand-alone system, its features and flexibility only become apparent in cooperation with other software components (see fig. 4). It cannot be the task of a shop floor control system to replace functions, which could be (and today mostly are) executed by other systems, which precede or succeed it in the flow of information. Instead, special services are requested from each of the embedding systems:

The *order calculation* system registers incoming orders with intermediate and final due dates. Necessary operations are determined and usually are assigned to some work places. A detailed catalogue of production performances allows for an exact calculation of the processing times as well as of kind and amount of materials needed.

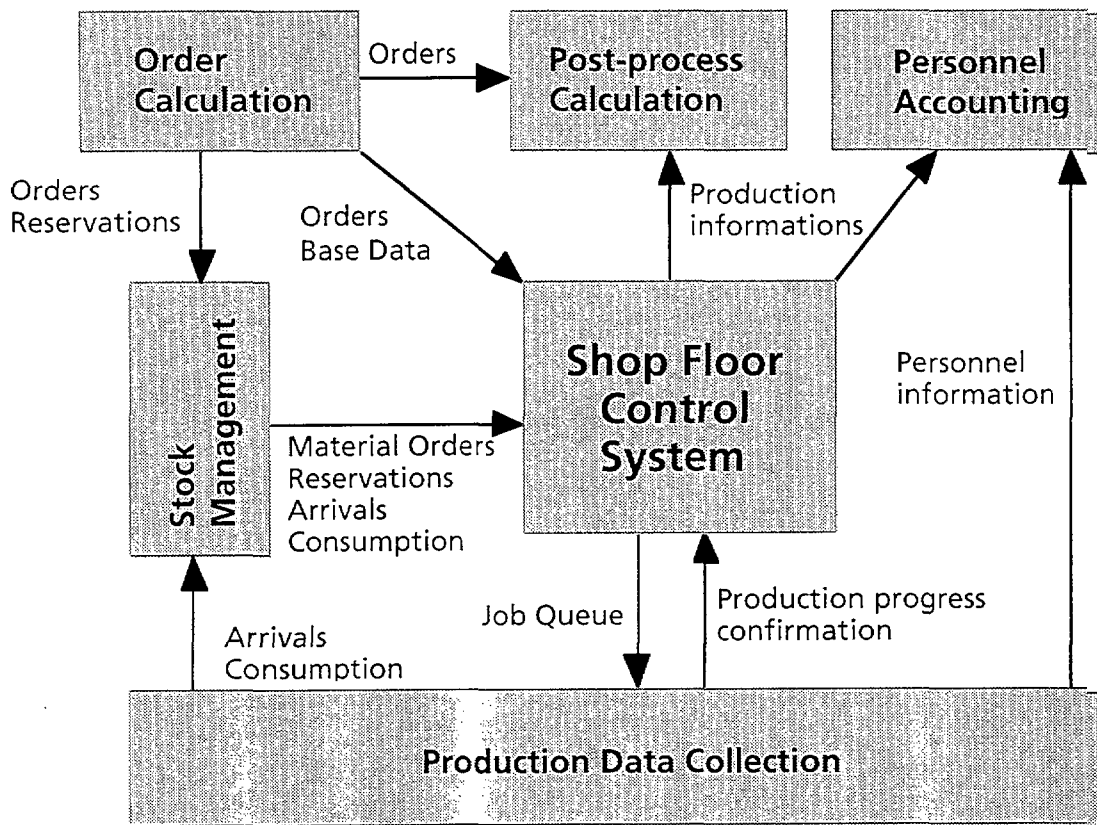


Fig. 4: Flow of information between various software components in a printing company

A stock management system keeps book on orders and reservations for material and informs the shop floor control system on actual arrival and usage of material.

Production events are, where possible, reported by a *production data collection* system. Using specialized devices at the work place, both an efficient reporting of events and a query on waiting jobs for the work place are possible.

All production data collected during the process are evaluated on an order-by-order basis by the *post-process calculation* system, and thus are available for business and sales analysis. In addition, they may be used by the *personnel accounting* system to calculate gross and net wages.

The shop floor control system must offer interfaces to these systems. Given the differences between software packages for the printing industry, even within the group of printing companies in PRINT PLAN, it was a major concern in the project to implement independent interface, which are publicly accessible (on the WWW at the address [www.wop.iao.fhg.de/wop-info/projekte/pprsintf.htm](http://www.wop.iao.fhg.de/wop-info/projekte/pprsintf.htm)). Moreover, for software companies an opportunity for a complete integration of the database is given. Pro's and con's of these interface alternatives are shown in table 1.

	“External” (ASCII) Interface	“Internal” (Database) Interface
<b>+</b>	<ul style="list-style-type: none"> <li>◦ Easy implementation</li> <li>◦ No internal system knowledge required</li> <li>◦ Interface is published</li> </ul>	<ul style="list-style-type: none"> <li>◦ Mutual information exchange between PRINTPLAN and external system possible</li> <li>◦ Complete functionality of the PRINTPLAN system available</li> <li>* Safe data transfer with full transaction protection (if ensured by database management system)</li> <li>◦ Adaptation of the PRINTPLAN system to the database of the external system possible</li> </ul>
<b>-</b>	<ul style="list-style-type: none"> <li>◦ Only restricted functionality of the PRINTPLAN system available</li> <li>- Unsafe data transfer (loss of data possible)</li> </ul>	<ul style="list-style-type: none"> <li>◦ Implementation requires more effort</li> <li>◦ Knowledge of internal system details required</li> <li>◦ Sales agreement with PRINTPLAN Partner required (includes right for distribution of PRINTPLAN system)</li> </ul>

Table 1: Advantages and drawbacks of alternative software interface structures

### 3.2.2 Implementation details

The basic approach to software development in the project was to separate the development of a reusable production planning kernel from the development of industry-specific specializations and extensions (see fig. 5). This approach proved to be fruitful in the sense that design and implementation of the core system could be done right from the start of the project based on general knowledge on production planning, and in parallel the organizational analysis and requirements specification process could be conducted.

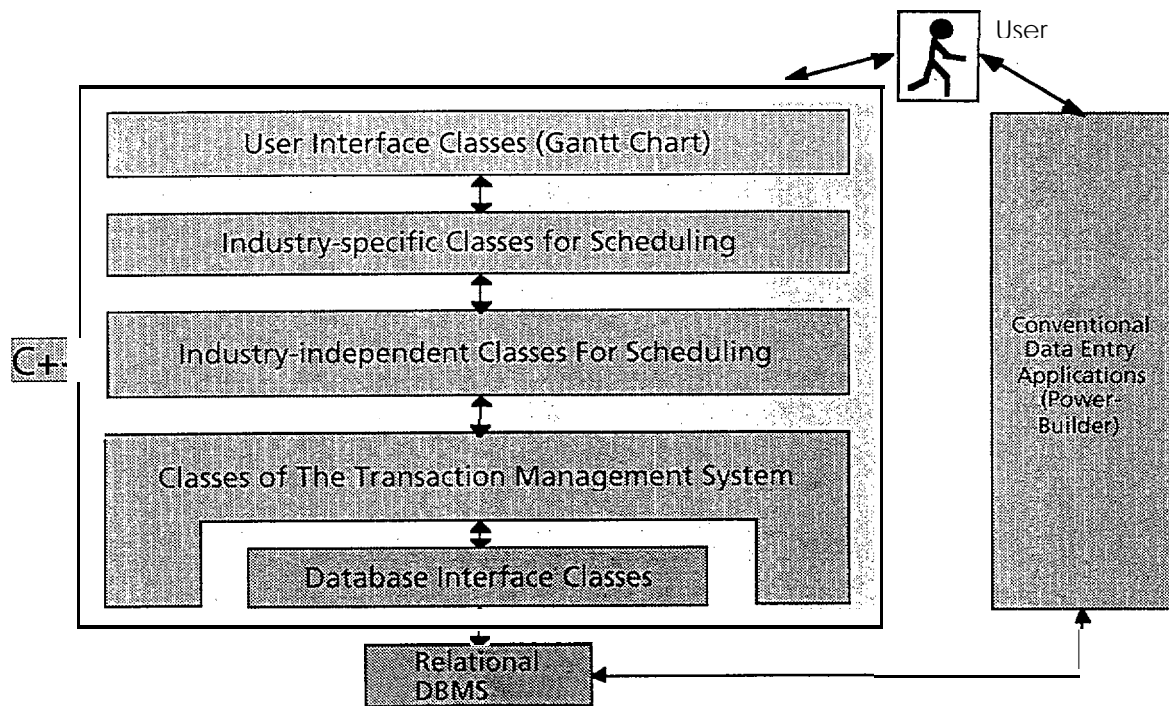
The whole class system is based on the container and utility classes of Rogue Wave's C++ Booth Components and on the graphical user interface framework XVT++. The kernel class system has been partitioned in three domains – “Basic Classes” (performing mostly database access tasks), “Application” classes (implementing an industry branch independent order scheduling mechanism), and “User Interface Classes” (implementing a graphical user interface for order scheduling). Each domain is itself partitioned in class categories, applying a Smalltalk programming scheme to the implementation language C++. Each category is a set of classes with a certain functional cohesion.

The domain “Basic Classes” contains four categories:

- “General Services” (machine independent implementation of services like 64-bit integers, but also general type definitions, and debugging and error handling mechanisms),
- “Time Description” (classes for time durations and time intervals),
- “Transaction Management” (providing a database and transaction interface according to the ODMG-93 standard for object-oriented databases),
- “Database Access” (to implement access to a relational [SQL] database).

The domain “Application Classes” consists of the categories

- “Order” (a customer or production order including all operations necessary to fulfill the order),
- “Order Demand” (resource usage structures and rules, based on single resources after scheduling),



Fig, 5: Software layer structure for the PRINTPLAN system

- "Resource" (production resources like staff, machines, material),
- "Time Relation" (timing constraints for orders as edges of an order precedence graph),
- "Shop Floor Control Unit" (the core container class, which bundles all objects of a single instance of the PRINTPLAN system).

This domain may be considered the core of the PRINTPLAN system. Its architectural design is based on Otterbein (1994), however, the object-oriented design presented therein has been substantially revised during the project. For the "Order Demand" category, the revised design has been published in Reißer (1995), for the "Order" category in Krieger (1995), for the "Resource" category in Wolf (1995).

The domain "User Interface Classes" consists of the categories

- "Gantt Chart" (graphic representation of actual/planned/simulated order schedules),
- "Dialogs" (form-based dialogs of the user interface).

The domain "Application Classes" has been extended to accommodate industry-specific classes. These classes contain additional attributes, some of which have functional meaning for the PRINTPLAN system, the remainder being informational fields for display only.

A structural representation of a single customer order is shown in fig. 6. In this figure, document icons represent objects of the classes PPCN\_CustomerOrder and PPCN\_CustomerOrderItem, hexagons are for PPCN\_OrderOperation objects, small circles for PPCN\_ODInputDemand and PPCN\_ODOutputDemand objects, triangles for PPCN\_ODServiceDemand objects, and arrows for FXCN\_TimeRelationEdge objects (with the arrow direction indicating the precedence relation imposed on the connected objects). Simple lines constitute "Has-A" (whole-part) relations.

The most prominent function of a short-term production planning system is scheduling (Hars/Scheer 1990). Scheduling for PRINTPLAN means selecting a feasible sequence of operations on every machine in the planning domain, pursuing the aim of minimizing the number and extent of late deliveries. The scheduling algorithm implemented in the PRINTPLAN system is based on priority rules. Both forward and backward scheduling of orders are possible, with backward scheduling being the typical method. The time horizon for a single scheduling run may be restricted, resulting in a selection of only those orders for scheduling, which theoretically might be processed during the specified period. These orders are arranged by priority as entered by the sales department or the production planning person, and subsequently by due date. Although priorities from 1 to 99 may be used, it is advisable to restrict oneself to a few priority values, allowing for a stronger impact of due date ordering.

Orders are fed to a simple forward or backward scheduling algorithm in the sequence determined before. The scheduling algorithm (initially developed by Reißer 1995) calculates the earliest or latest operation start time, considering machine capacity (including breaks, non-working times and the load by other operations) and precedence relations within the order to be scheduled. Notwithstanding our findings on typical production structures in the printing industry as reported above, the precedence relations within a single order may be of any type.

A second approach based on genetic algorithms was taken during the project. Thereby, an optimizing scheduler was to be developed, which would take into consideration not only priorities and due dates, but also setup sequences and production cost. It would evaluate a large number of possible schedules to find a near optimum solution depending on the actual target function specified for the scheduling run. However, this algorithm could not be completed by the end of the project. Work on this algorithm and another optimizing one based on the principle of "branch-and-bound" is being continued.

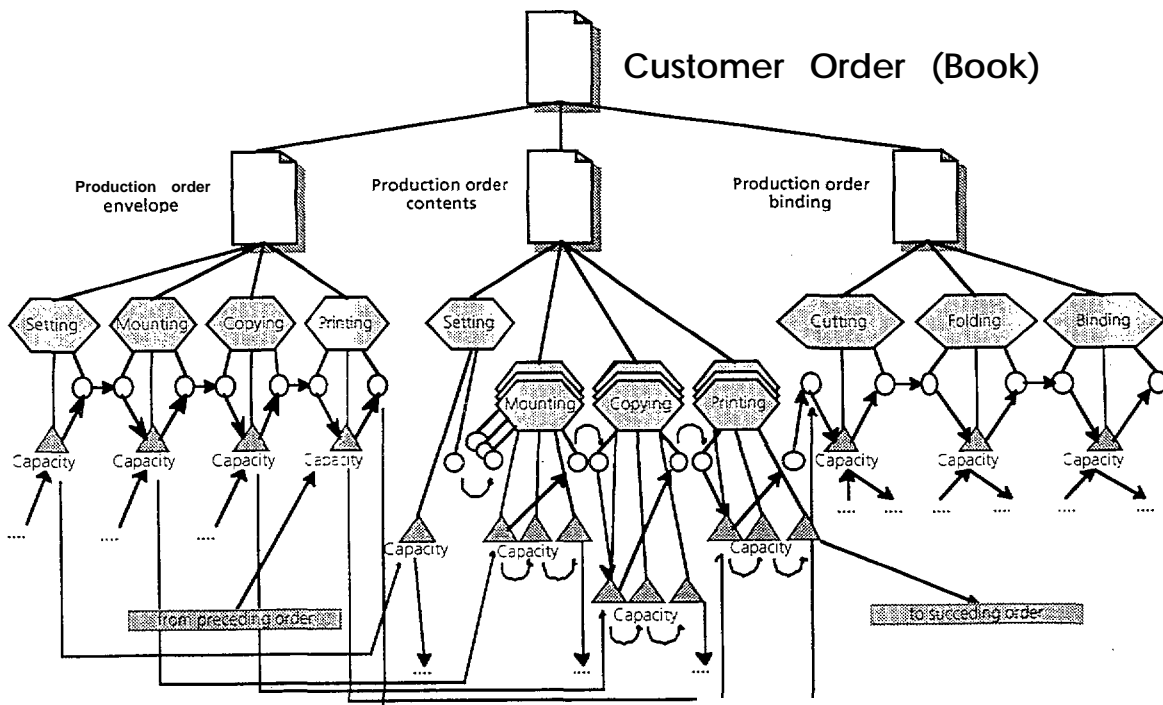


Fig. 6: Object structure for a simple customer order (cf. fig. 2)

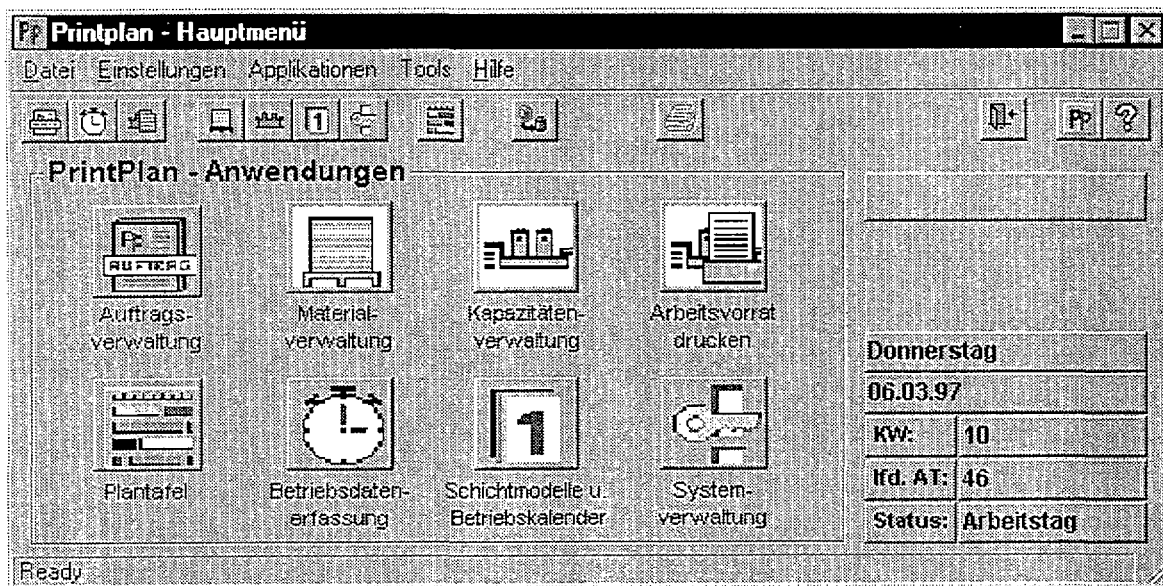


Fig. 7: PRINTPLAN main menu

For the graphical user interface, a detailed model based on the requirements specification for PRINTPLAN and current national and international standards for software ergonomics has been developed by Brenner (1995). The model describes general interaction sequences as well as the details of order representation in the gantt chart, the menu structure and guidelines for the development of the simpler data entry applications.

The main menu (fig. 7) gives access to every module of the PRINTPLAN system. These include applications for order management, material resource management, capacity resource management, and the printing of job schedules, the gantt chart, a restricted production data collection system, and entry forms for the capacity model, company calendar and system parameters.

The order management system allows for creation of simple, linear production orders and modification of the relevant information of all orders. At the deepest level of detail, a single operation is described by its earliest and latest times, processing time, scheduled times, actual times, and the capacity resource it is assigned to.

The most important tool for the production planning personnel is the planning chart (fig. 8). A kind of gantt chart, it displays scheduled operations in the upper part of the window (with one line of operations per machine), and waiting orders in the lower part. The level of detail may be changed from a view covering about 2 hours to a maximum of 3 months. Modifications of the schedule are possible by selecting a simulation mode, which is activated in the screen shot. From this view, single orders may be planned or removed from the plan, operations may be rescheduled using Drag & Drop, and the calculation of a completely new production plan using one of the algorithms described above may be started. Modifications applied when in simulation mode become only effective (and visible for other processes) upon a special action of the user. Different types of orders (e. g. assigned to different sales teams or of different technological structures) may be identified by a coloured triangle in the upper right corner of each bar.

In addition to the gantt chart view, a more condensed view has been designed and will be implemented in a future version of the system, which indicates the perceptual usage of resources in the system. As can be concluded from the screen shot, usage percentages

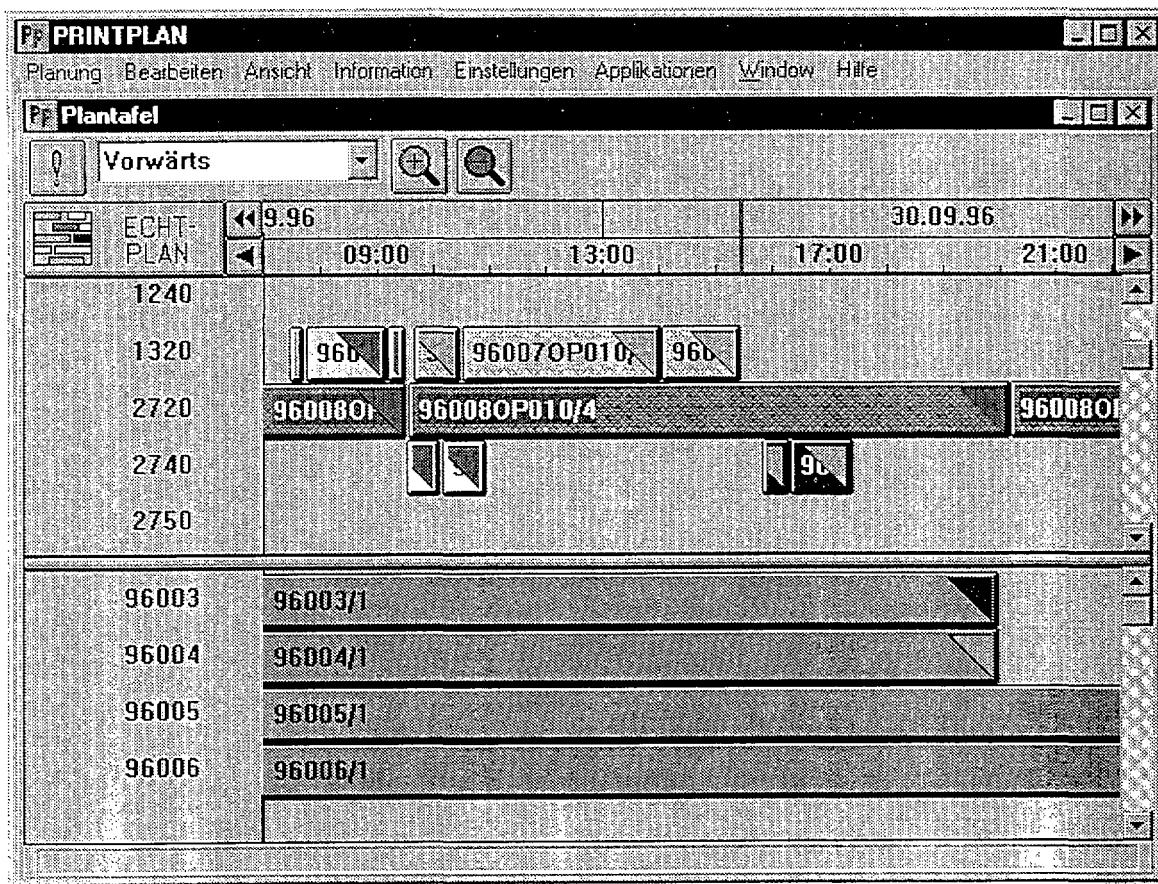


Fig. 8: PRINTPLAN planning chart

above 100 are possible. This can be achieved by assigning an overbooking ratio to a capacity resource, and allows for charging more work load on a capacity than foreseen in the capacity model, knowing from experience that a certain portion of the operations scheduled cannot be processed due to various reasons. (This is in analogy to the overbooking airline companies use to ensure maximum usage of their aircraft. )

For each machine (or, in a more general way, for each capacity resource modelled in the system), a list indicating the operations scheduled for a certain period of time may be printed or viewed online.

### 3.3 The software process

Developing a highly sophisticated planning system like the PRINTPLAN system under tight schedule and budget is not possible without a well-defined software development process. Realizing this fact led to the introduction of a separate work package for the setup of a software quality assurance plan (work package 11.0 described above). This work package delivered two results:

- A development process was defined and the necessary guidelines and control mechanisms for its implementation were developed (see the following figure).
- A development environment was created which allowed for the integration of high level design, low level design, code and documentation in a single HTML document, following Knuth's "Literate Programming" approach.

The development process is organized according to the "waterfall" process model, which – with some degree of variation – up to the present is the basis for most of the development process models (including even Boehm's "Spiral Model"). Each stage of the process is concluded by a formal review of the resulting document(s), the documents of the previous stage and the respective guidelines being the review criteria for the current stage. To achieve this, guidelines for the requirements specification, design, coding and testing of the software as well as for the conduction of reviews and inspections were introduced. However, in a university environment it proved to be very difficult to enforce the regulations, although they had been introduced in full consensus. This and the fact that the original version of the kernel class library had not been developed under whatsoever quality assurance may have contributed to the slippage of the schedule.

Under these circumstances, the development environment on an HTML basis proved to be much more effective. The software documents containing all design results and occasionally – where important – even design rationales together with the code actually implemented allowed for continuous consistency checking between design and implementation and for quick understanding by other developers. An example of such a document is reproduced in fig. 18,

Due to the design and coding guidelines, all documents adhere to the same outline, and hyperlink references are used, where related documents are important. Some of the documents even make internal use of hyperlinks. Separating the code from the embedding design and documentation text is done in a preprocessing stage immediately before compilation, C++ header and source documents are generated from the same HTML document. This approach could be fully integrated into available integrated C++ development environments like Microsoft's Visual C++ and Watcom C++. A useful extension of the concept would be to recognize unchanged header documents to make more efficient use of the automatic dependency checking features of the integrated development environments.

## 4 Conclusions

Strengthening the competitiveness of the European printing industry by reducing the overall costs induced during the production process was the overall objective of the project. Two complementary ways have been explored to achieve this: the introduction of a decentralized organizational structure for the production planning process, and the development of a flexible, efficient software system to support this process.

Based on experiences from other industry branches, a big step has been done towards the availability of a specialized production planning system for the printing industry. A marketing joint venture, PRINTPLAN Partner, has been founded by the proposers to complete the development of the planning system, and to promote its usage throughout the industry. Although a fully functional system embedded in the business process of the project partners could not yet be established, a successful day-to-day usage is anticipated. This expectation is supported by the high resonance the project and the first software prototype evoked in the printing industry of several European countries.

Evidence for the usefulness of a strongly decentralized production planning process could not be found. In fact, this would be in contrast to the aim of producing a near to optimal master schedule for the whole production process. Instead, decentralizing certain competence, e. g. the decision on optimal setup sequences on the printing press to the foreman of the printing shop, seems a promising way to optimize efficiency in the production process.

## 5 Acknowledgements

We thank Dr G.-A. Kemmner of Abels & Kemmner, Herzogenrath (D), for his valuable advice as a PTA in critical stages of the project. His in-depth knowledge of the production planning process and his fairness towards all of the project partners helped to settle down the conflicts, which inevitably arose during the project.

We thank Dr A. Martin of the European Commission and his colleagues, Ms Richards, Mr Ponthieu and Ms Binheiro, who accompanied the project and helped keeping the (also inevitable) bureaucracy to a minimum.

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## 6 References

Bassler, Thomas (1 996): "Termintreue und Optimierung der Kosten durch einen druck-spezifischen Leitstand. " In: **Deutscher Drucker 3/1996**, Jan **18, 1996**, pp. WI O-WI 5,

Brenner, Christian (1 995): **Software-ergonomische Gestaltung eines Fertigungsleit-stands für die Druckindustrie.** Diploma thesis, University of Constance, 1995.

Hars, Alexander, August-Wilhelm Scheer (1 990): "Entwicklungsstand von Leitständen. " In: **VDI-Z 132 (1 990) 3**, pp. **20-26.**

Krieger, Armin (1 995): **Abbildung eines objektorientierten Modells für die Auftragseinplanung auf eine relationale Datenbank.** Study report, Faculty of Informatics, University of Stuttgart, 1995.

Otterbein, Thomas (1 994): **Eine objektorientierte Architektur für Leitstände zur Feinplanung.**Diss. University of Stuttgart. Berlin, Springer 1994.

Reißer, Stephan (1 995): **Produktionsplanung auf einem Bedarfsgraph in einem objekt-orientierten Leitstand.** Diploma thesis no. 1249, Institute for Parallel and Distributed High Performance Computing, University of Stuttgart, 1995.

Wolf, Christian (1 995): **Die objektorientierte Modellierung von Ressourcen im Rahmen der Entwicklung einer Fertigungsplanung.** Study report, Faculty of Informatics, University of Tübingen, 1995.