FEDERAL UNIVERSITY OF SANTA CATARINA
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AN APPROACH TO CONCEPTUALIZE LEARNING ENTERPRISES IN THE MANUFACTURING SECTOR

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To my parents,

for their support and the example of their lives;

To my husband,

for his love, understanding and encouragement;

To my son,

for his existence.

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CONTENTS

LIST OF ACRONYMS

AMR	Advanced Manufacturing Research
AMRF	Automated Manufacturing Research Facility
AMT	Advanced Manufacturing Technology
BIBA	Bremen Institute of Industrial Technology and Applied Work Science at the University of Bremen
BMFT	German Federal Ministry of Research and Technology
CAx	Computer-Aided
CAD	Computer-Aided Design
CAE	Computer-Aided Engineering
CAM	Computer-Aided Manufacturing
CAPP	Computer-Aided Process Planning
CAQ	Computer-Aided Quality
CIM	Computer Integrated Manufacturing
CNC	Computer Numerical Control
CSCW	Computer Support for Cooperative Work
DSMC	Distributed Shop Floor Monitoring and Control
DSS	Decision Support System
DTI	Department of Trade & Industry
ECLA	European Community - Latin America
EIS	Executive Information System

ESPRIT	European Strategic Programme for Research and Development in Information Technology
EU	European Union
FIFO	First In First Out
FLAMME	Flexibility and Advanced Manufacturing Methods
FMS	Flexible Manufacturing System
GT	Group Technology
INTO	Integration of Technology and Organization for Quality Production
IT	Information Technology
JIT	Just-in-Time
LAN	Local Area Network
LE	Learning Enterprise
MES	Manufacturing Execution Systems
MESA	Manufacturing Execution Systems Association
MIS	Management Information System
MOM	Manufacturing Operations Management
MOPS	Manufacturing, Organization People & Systems
MRP	Material Requirements Planning
MRP II	Manufacturing Resource Planning
NBS	National Bureau of Standards
NC	Numerical Control
PFA	Production Flow Analysis
PLANLEIT	Leitstand for the Shop Floor Control
PPC	Production Planning and Control
SFC	Shop Floor Control
SMC	Shop Floor Monitoring and Control
SME	Small- and Medium-Sized Enterprise
SMMETT	Small- and Medium-Sized Mechanical Enterprise Technology Transfer
SPRINT	Strategy Programme for Innovation and Technology Transfer
TQM	Total Quality Management
US	United States of America
VPA	Virtual Production Area
WAN	Wide Area Network

ABSTRACT

The work presented discusses the necessity for Learning Enterprises to cope with the increasing globalization and customization of products and processes as well as the urgent need for an environmental awareness required within manufacturing companies. It states the need for a revision of the production philosophy as well as the management and organizational structures currently adopted in most enterprises of the manufacturing sector. The work also includes a study of three production management elements, which can be used as catalysts in obtaining Learning Enterprises: Virtual Production Areas as an organizational element; Distributed Shop Floor Monitoring and Control Systems as a technological element and Human Networking through Human Communication Management as an element for the management of dynamic human systems.

The outcome of the study in each of the areas identified above is thus integrated into a systematic procedure giving rise to a generic reference model for the conceptualization of a Learning Enterprise. The approach presented focuses on small batch size manufacturing enterprises as well as one-of-a-kind producers.

RESUMO

O trabalho realizado discute a necessidade de 'Learning Enterprises' para fazer frente às crescentes globalização e customização de produtos e processos assim como a urgente necessidade de uma conscientização ambiental por parte das indústrias de manufatura. É abordada a necessidade de uma revisão da filosofia de produção e das estrutras organizacionais e gerenciais adotadas atualmente pela maioria das empresas do setor de manufatura. O trabalho também inclui um estudo de três elementos que podem ser utilizados como catalisadores para a obtenção de 'Learning Enterprises': Áreas Virtuais de Produção, representando o elemento organizacional; Sistemas Distribuídos de Planejamento Fino, Monitoração e Controle da Produção, como o elemento tecnológico e a 'Human Networking' obtida pelo Gerenciamento da Comunicação Humana, como o elemento necessário para o gerenciamento de sistemas dinâmicos centrados no homem.

O resultado do estudo realizado em cada uma das áreas identificadas acima é, então, integrado segundo um procedimento sistemático originando um modelo de referência genérico para a concepção de uma 'Learning Enterprise'. A abordagem apresentada enfoca empresas de manufatura fabricantes de pequenos lotes e de produtos 'one-of-a-kind'.

1. OVERVIEW AND THESIS

Industrial production currently faces an increased trend towards globalization and customization of products and processes. On the one hand, there is a growing involvement of experts from different areas of the world in the design and production process trying to deal with the increasing complexity of the products. On the other hand, there is a customer-oriented product tendency implying an increasing variety of products associated with a decrease in the batch size down to one-of-a-kind products. At the same time, a significant part of the population is becoming aware of environmental impacts. Consequently products are put to the test concerning their material, processes, recyclability and life-cycle.

In order to remain more competitive, the enterprises will therefore have to be able to adapt rapidly and continuously to market influences. Especially the manufacturing of one-of-a-kind products (Hirsch, 1992) requires a high flexibility in the product design and a fast adaptability in the production processes (Ahlers, Lutz-Kunisch, 1991).

Completing the frame, the expectations as to the high quality of products and processes, as well as the reliability of due dates and the consideration of the cost aspects, make production management a not-so-easy job.

Aiming to be fast and agile enough to react to these global trends of ever-changing customer expectations, cooperation even among competitors - intra and interorganizational - and the need to create environmentally friendly products and production systems, traditional organizational and management structures have to be broken, giving rise to a balanced system

(Camarinha Matos and Afsarmanesh, 1995). The coordination, flexibility and integration of organizational, technological and human aspects required by such balanced systems mean that new strategies and structures must be developed other than the conventional ones which are based on a numerous hierarchical levels of authority, strong division of labour and on rigid, pre-defined and fixed procedures.

This thesis focuses on the need for new strategies and structures to cope with the current trends, and outlines a proposal based on concepts from knowledge of manufacturing organizational structures - as the domain of application -, Information Science and Technology, combined with the notion of living in social systems and the nature of communication.

The contribution of this work lies, therefore, in the construction of a system view of a production organization - from now on named 'Learning Enterprise' (LE) - encompassing technological, organizational and human elements. More specifically, it presents the development of a generic 'Reference Model' for the configuration of virtual production areas (VPAs) supported by distributed shop floor monitoring and control systems (DSMC) and integrated by human networking, defining the global tasks of its components as well as the relations between the components and the whole.

As an illustration, this work also includes pointers to complete the multidisciplinary characteristics scenario of a Learning Enterprise. Nevertheless, this work differs from the mainstream literature on manufacturing. Unlike most publications from the 'Computer Integrated Manufacturing' community, it does not emphasize the use of computers as an end effect. Rather, it focuses on and provides means for the coordination of problems regarding the ways that can be applied to execute coordination tasks.

This work addresses the role of people studying Group Technology (GT), people responsible for human-centered challenges and developers of computer support for the shop floor, such as shop floor monitoring and control systems. The proposed model is also intended to be used by scholars and researchers as well as managers and consultants providing them orientation concerning future activities, research and development in the field of this new production philosophy in so far as the model progressively consolidates.

1.1 The Domain: Manufacturing

The word 'manufacture' is, at best, fascinating in its origins and , at worst, something of a misnomer (Malone, 1994). The word derives from Medieval French circa 1567 via Latin. The Latin words 'manu' and 'factus' mean, simply, hand-made. Curiously, that is not what is understood by the word manufacture today. In fact, it is understood almost the opposite: not made by hand, but rather by machines (which may not be connected in any way to human action). There is a need to develop a clear understanding with regard to *manufacturing* - its historical and continuing evolution.

The literature is rich in references to the progressive development in manufacturing. Stephanou and Spiegl (1992), for example, present a detailed and very interesting overview of the manufacturing environment, describing the history of science, technology and manufacturing. It begins with primitive man and the prehistoric era, passes through the Bronze, Egyptian, Greek and Roman Eras, continues with the Middles Ages, the Renaissance and the rebirth of science and reaches the Industrial Revolution, the twentieth century, the systems era and the information explosion ending with the computer revolution in manufacturing. Each step in this evolutionary chain has led to a paradigm shift.

This works is limited to presenting one of the most significant shifts in manufacturing paradigms in recent years: that of sharing work and knowledge instead of dividing them!

Agile Manufacturing

It is well known that a pin maker divided the making of pins into several separate operations and greatly increased his output. The concept of the division and subdivision of labour, idealized by Adam Smith and theorized in his book 'The Wealth of Nations' (Smith, 1776) was later on reinforced by one of the greatest men of the whole manufacturing history: Frederick Taylor.

While 'Taylorism' has been practiced all over the world as a successful production management method during past decades, since the beginning of the eighties it has become questionable to apply (or to maintain) this strategy on the shop floor or anywhere else. Of those who have commented on the errors of Taylorism, perhaps few have read his works. Although Taylor did not think that operators would be able to scientifically analyse the operations they performed, he was not opposed to their suggestions:

> "It is true that with scientific management the workman is not allowed to use whatever implements and methods he sees fit in the daily practice of his work. Every encouragement, however should be given him to suggest improvements, both in methods and implements" (Taylor 1911, P. 128).

What is the lesson to be learnt? Even unnoticed by some, Taylor has planted a seed that only nowadays has begun to bear fruit: the involvement of the workers in the process, thus helping to provide the needed flexibility and agility required by manufacturing to cope with the increasing trends of globalization, customization and environmental awareness.

These trends are pushing industry to deal with customer-oriented products. That means, in end effect, that contemporary manufacturing industries are undergoing a major paradigm shift away from the mass production (Tayloristic) paradigm towards a new one. This new market reality is what Warnecke (1992) calls 'post mass production paradigm' and what is known in the US under 'agile manufacturing' (figure 1.1-1). In spite of the strong influence from the German School, this work adopts the American term, 'Agile Manufacturing', because it was published prior to the German one and, also due to the dissemination power of American technology, it has become a widespread term in the scientific community.

In Agile Manufacturing the aim is to develop agile properties (Kidd, 1994a and b); this agility will then be used for competitive advantage, for its capacity to rapidly respond to changes occurring in the market environment and through the people's ability to use and exploit a fundamental knowledge resource. The term 'Agile Manufacturing' was first introduced by Nagel and Dove (1991); the reader is referred to their work, as well as to Kidd (1994a and b) and Goldman, Nagel and Preiss (1995).

In this work an agile framework for enterprises is proposed by integrating technology, organization and people in what the author calls the Learning Enterprise. Furthermore an approach is suggested to conceptualize a Learning Enterprise for the manufacturing sector making use of elements of the triadic model of the Learning Enterprise.

The next sub-section deals with some trends that have contributed to the paradigm shift of mass production to agile manufacturing.

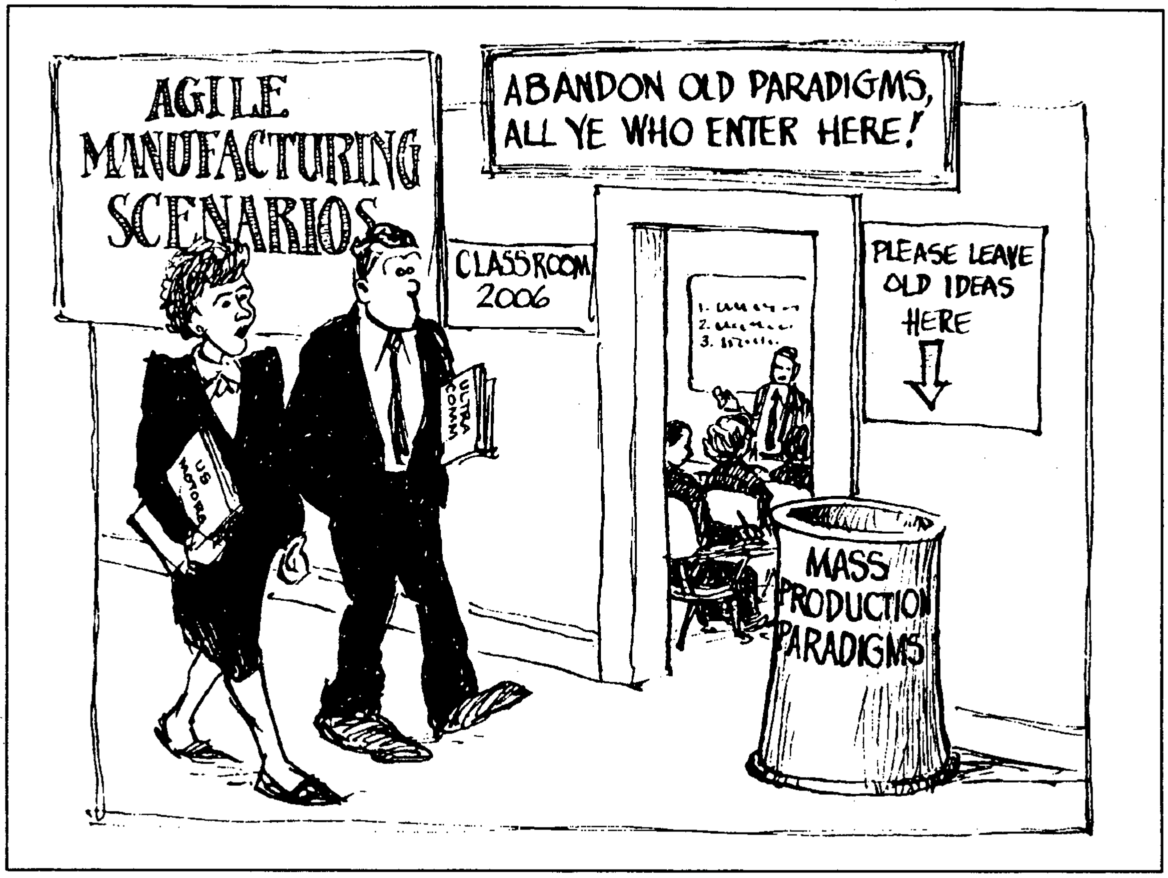


Figure 1.1-1 Agile Manufacturing (Nagel and Dove 1991, P.13)

1.2 Globalization, Customization and Environmental Awareness

The means of production are increasingly accessible throughout the world, regardless of national boundary: production technology, financial capital, marketing information, engineering capabilities, etc. Today products are being designed in Italy, engineered for production in Germany and produced in Brazil. Reflections of a study group (Crom, Pereira Klen et al. 1994) show that fueled by advances in information technology and improving communication infrastructures, this trend will continue at an accelerated rate. And they ask: to support globally distributed manufacturing, what capabilities do the managers, the employees and the production management systems need to have?

The world is experiencing an explosion of product variety available to consumers today. Remember Henry Ford saying "consumers can have any color automobile they want as long as it is black!" The Japanese are now introducing new model cars in three years, from concept to showroom (Womack et al. 1990). Think of the computer business. There are thousands of software applications, each one turns your portable PC into a different, customized product. Because the production methods and technologies are more flexible, companies are better able to produce what customers want, when and where they want it. Once again it is asked: to support this new customer orientation, what capabilities do the managers, the employees and the production management systems need to have?

Government policies are bringing the cost of protecting the environment back to companies who most affect the environment. The Green Dot program in Germany is an example whereby manufacturers are expected to recycle their products and bear the associated costs. Recyclability is now an essential design criteria at BMW, Mercedes and Volkswagen. Whereas ten years ago a producer saw his responsibility ending with after sales service, more and more producers today are managing the entire life-cycle of their product, from raw material back to raw material. Yet again they ask: to support this new environmental awareness, what capabilities do the managers, the employees and the production management systems need to have?

These global trends call for a complete reexamination of the whole approach to production management methods, strategies and structures rather than continue focusing on perfecting methods or systems that implicitly assume that the manufacturing environment consists of one company, one location producing disposable products for stable mass markets. Increased globalization, attention to customers and sensitivity to the environment demand a more holistic view of business, seeing them as part of a broad network of activities. The new reality in production management is that products can be designed, developed and produced virtually anywhere.

On the one hand, from an interorganizational view, this leads to the configuration of virtual enterprise or extended enterprise (Nagel and Dove, 1991; Goldman, Nagel and Preiss, 1995) whose success is based on flexibility, speed and the emerging paradigm of Agile

Manufacturing to align and integrate processes with business partners in order to provide customers with exceptional value. On the other hand, from an intra-organizational view, it can be said, analogously, that this leads to the configuration of virtual production areas (VPAs). This work will consider the intra-organizational aspects related to the configuration of VPAs. Considering that a great part of the subsidies for the realization of this study came from research projects, they will thus be briefly presented, as follows.

1.3 Project Environments

The next three topics contain a description of three projects that have played an important role in this thesis. The first one concerns the VEMAG Project which has served as a kick-off incentive for the main ideas and the work described in this thesis. In the sequence, the PLANLEIT Project entitled 'Leitstand for the Shop Floor Control' is presented; it represented the basis for the acquisition of a technological understanding regarding shop floor monitoring and control. At last, the FLAMME project is described: contacts and visits at several industries, as well as the result of the project have reinforced some of the aspects and have given the required subsidies that have led to the development of this work.

The VEMAG Project

Vemag is a medium-sized company that produces machines for the food industry in the north of Germany. After identifying the need for challenge, the top management decided to run a cooperation project with BIBA (Bremen Institute of Industrial Technology and Applied Work Science at the University of Bremen) in order to:

- improve the reliability of product due date; and
- reduce the throughput time.

The project, which ran in 1991, had as main target the following areas:

- production planning and control;
- order progress; and
- manufacturing organization.

By intensive team work, the project has carried out a detailed analysis of the company and the main contribution of the project for this work lies in the study related to the modifications of the work organization on the shop floor. The existing restrictions for the formation of group technology (GT) cells and all the consequences resulting from them, have led the author to think about an alternative to overcome such difficulties. The company shop floor was the first 'laboratory' of this thesis.

The PLANLEIT Project

PLANLEIT was run from August, 1991 to September, 1993, and was funded by the German Federal Ministry of Research and Technology (BMFT). The objective of the joint research project was to design and evaluate user-friendly, task appropriate and efficient shop floor monitoring and control (SMC) systems.

The companies involved were small batch size and one-of-a-kind producers, such as the Meurer Maschinen GmbH company whose shop floor was the second 'laboratory' of this work.

Meurer was founded in 1969 and, with a staff of 4, has initially produced modular construction kits and parts for a German manufacturer of printing presses and extruders. Soon they began with the use of shrink-film packaging technology. In 1972 the company presented the first fully automatic film packaging machinery for shrink-film and stretch-film. They built new extensions for the production and administrative divisions. Further, the program was extended by cast-board packaging machines.

Nowadays, counting on more than 300 employees, they are working to adapt the range of products to the needs of the market. Therefore, together with the other project partners, their interests in Planleit were mainly:

- the specific request profile for the application field should be performed and, at the same time, the cost of adaptation should no longer be several times the price of the system;
- the user interface should be task-appropriate and user friendly;
- specific methods for planning, monitoring and control, deduced from the experience and knowledge of the employees, should be incorporated into the system. The functions should be effective in finding quickly efficient solutions to problems.

Together with two software-houses, the involved universities and research centers tried to fulfill the companies' aims. The project has reached its target to a very high degree, and the results can be found in the final report (Bullinger and Hirsch, 1994).

It is not the aim of this work to design or develop SMC systems, but to give subsidies for their adequate evaluation, selection and implementation as well as for the creation of a supporting environment for the utilization of SMC systems in the Learning Enterprise. To this end, use will be made of the shop floor control task model developed during the running of the project, as well as the experience gained through some companies' analysis (for instance by means of the analysis of the 'as-is' situation, the determination of weak points, the development of a 'should-be', etc.) and through research on SMC systems in the German market.

The FLAMME Project

Contract number RA237, from the SPRINT Programme manufacturing engineering sector that deals with advanced manufacturing technology aspects, is also known under the codenames SMMETT (Small- and Medium-Sized Mechanical Enterprise Technology Transfer) and FLAMME (Flexibility and Advanced Manufacturing Methods).

The projects, complementary to each other, had as main objectives:

- to improve the process of technology transfer from technology centers to small- and medium-sized enterprises (SMEs);
- to carry out a comprehensive survey of the state-of-the-art in flexible manufacturing systems (FMSs) and
- to compile and issue guidelines on how to install and use FMSs by SMEs.

Within the SMMETT project, new technology transfer tools and schemes were investigated in cooperation with international partners and evaluated as to their suitability for the introduction of FMS. Parallel interviews in over 40,000 companies were carried out in order to determine the usage rate of modern technologies, computers and other relevant data. The project results showed that enterprises strongly need support in introducing their production management systems and optimizing their methods (Pereira Klen, Vöge and Hirsch, 1994).

As a continuation of this project and based upon its conclusions, the project FLAMME, which ran from September, 1992 to June, 1994, was carried out in order to find further solutions to the stated problems. By means of awareness sessions and consulting actions, 70 enterprises were investigated in order to:

- make them aware of modern manufacturing methods and equipment;
- analyse, on-site, their technological and organizational level;
- propose a personalized action plan and technical assistance

with a view to improve the efficiency and flexibility of their manufacturing processes.

One of the companies investigated was LDW - Lloyd Dynamo Werk -, a medium-sized company situated in Bremen, Germany, which produces electric motors in a great variety. In the early seventies, the whole manufacturing area was organized to process-oriented work shops. Due to divergent process lead times and quality demands of the different types of motors, as well as the implementation of a centralized and somewhat inflexible system for production planning and control (PPC), the expected reduction of throughput time could not be achieved.

Triggered by exchange of experiences with other SMEs and awareness sessions, organized during the course of the project, about modern approaches in work organization and task-appropriate computer support, the management started to think about reorganizing the manufacturing area. Hence, the LDW shop floor was the third 'laboratory' of this thesis.

After analysing the results of the enterprises investigation, it became clear to the project consortium of SMMETT and FLAMME that the original goals of the projects to support SMEs, in increasing their flexibility and production efficiency by introducing FMS, had to be broadened. FMS is only one of the possible ways to optimize certain areas of manufacturing concerning quality, costs and throughput time. It was pointed out by the project that much greater potential for optimization are the areas of work organization, information management on the shop floor, total quality management, as well as training and qualification of staff (Pereira Klen, Vöge and Hirsch, 1994). This conclusion has served to justify the choice of the technological, organizational and human enablers that jointly support the conceptualization of a Learning Enterprise for the manufacturing sector.

1.4 Outline of the Thesis

Overview and Thesis

This chapter briefly discusses the historical and continuing evolution of the manufacturing and the new paradigm of 'agile manufacturing', followed by some considerations regarding new trends such as globalization, customization and environmental awareness. Before deliberating the present research topic, project environments that have had their impact on the work done for this thesis are also presented, as well as the description of the chapters.

Organization and Management Structures

The literature review presents an analysis of the semantic evolution of the organization and management structures, comprising some historical facts, the ideas of some pioneer scholars, the influence of manufacturing technologies, as well as the state-of-the-art regarding a new kind of structure, based on the concepts of learning and knowledge. Furthermore, some considerations are made with regard to this new structure.

Systematic Procedure

Here, firstly three elements are discussed separately in details: (1) the organizational element, focusing on virtual production areas, (2) the technological element, focusing on shop floor monitoring and control systems, and (3) the human element, focusing on human networking. Afterwards, the representatives of the three elements are integrated in a systematic way resulting in the development of a generic reference model for the conceptualization of a Learning Enterprise for the manufacturing sector.

Implementation: Incremental and Innovative Applications

This chapter shows concretely a way in which a company can go towards becoming a Learning Enterprise. Based on real facts of companies and people experienced by the author during the last five years, the case study is presented in form of a novel acquiring therefore a hypothetical character.

Conclusions

Finally, the main contributions of the study are presented, followed by some identified limitations and suggestions for further research and development.

2. ORGANIZATION AND MANAGEMENT STRUCTURES

Among the various definitions that can be found in the literature regarding organization and management (Viola, 1977; Schoderbeck, Schoderbeck and Kefalas, 1980; Bowers, 1976; Trewatha and Newport, 1982; Heyel and Menkus, 1986; Dutton, 1965, Mintzberg, 1979), the ones from Kast and Rosenzweig (1970) stand out due to their objectivity and clarity. They state that organizations are:

1. goal-oriented, i.e. people with a purpose;
2. psycho-social systems, i.e. people working in groups;
3. technological systems, i.e. people using knowledge and techniques; and
4. an integration of structured activities, i.e. people working together.

Management, according to these authors, is defined as involving the coordination of human and material resources toward objective accomplishment and characterized by four elements:

1. toward objectives;
2. through people;
3. via techniques; and
4. in an organization.

That means that management needs an organization to act in at the same time that an organization needs management to achieve its goals in an effective way. They are complementary to each other, like body and soul, and will therefore be treated jointly due to their strong interdependence.

The organizational structures are normally segmented in two directions: (1) the vertical one, which is represented by the hierarchy of authority and hence directly related to the management hierarchy and (2) the horizontal one, related to the division of labour, or better said, the way in which the divided work is brought together or grouped in some manner in order to obtain a better coordination of effort. This process of grouping or combining jobs is referred to as departmentalization and is classified in six categories: business functions, work processes, geographic area, product or service, customer and matrix organization design (Trewatha and Newport, 1982).

While in horizontal segmentation the choice of the departmentalization depends on each case - no one form of departmentalization is best in all situations (Trewatha and Newport, 1982) - vertical segmentation is present in all organizations (Kast and Rosenzweig, 1970) differing only in the degree of their vertical divisions of labour and the extent to which it is made explicit and formalized. Even in recent studies, which have directly influenced this work, such as the one from Savage (1990), regarding new organization and management forms, the hierarchical authority structures remain, although much flatter.

This kind of structure will thus be described, as follows, in five main evolutionary steps: (1) the facts of its origin, (2) people who have contributed to speed up its dissemination, (3) the influence of advanced manufacturing technology, (4) the trends towards a balanced system, and (5) the development of a framework to support such system.

2.1 Once upon a time...

... prior to the eighteenth century 'manu' 'facturing' (in the real sense of the word, i.e., hand-made) was the only kind of production that was known. The artisans of technology were simultaneously responsible for the product development and design, planning and manufacturing (Pereira Klen, Vöge and Hirsch, 1993a) as well as sales and after-sales activities, carrying out what is known today as 'Concurrent Engineering' (Winner et al., 1988). The products were almost all customer-oriented; mass production and what is nowadays understood as 'factories' were rare.

...there was a peaceful (?) revolution that began in England around 1760 and spread out all over the world, empowering the development of science and the disseminating of mass production through the manufacturing of clothing, shoes and other items thanks to the invention of the steam engine.

... there was a Frenchman, called Perronet, who carried out a time and motion study. In 1760, he concluded that the standard rate of output (for No. 6 pins) should be 494 pins per hour of labour (Chandler and Dalms, 198?).

...in the year 1776, the book *The Wealth of Nations* (1776) by Adam Smith presented the theory of division and subdivision of labour in which the manufacturing process structure was broken, like a molecular structure, into 'indivisible' activities forming a sequence of simple steps, each one being performed by one person who would dedicate all his life to the task of doing this job and nothing else.

...the English mathematician Charles Babbage carried out in 1820 a time and motion study and concluded that the appropriate standard (for No. 11 pins) should be 721 pins per hour (Babbage, 1963).

... between 1881 and 1911, an engineer named Taylor classified the work into tasks and task elements and wrote the book *Principles of Scientific Management* (1911), reinforcing Smith's theory of division and subdivision of labour.

...in the 1880s and 1890s, the managerial activities also began to be divided and subdivided hierarchically (Savage, 1990): Louis Brandeis was representing shippers in hearings on the railroads' petition for rate increases in US. He argued that the railroads should first apply the ideas of scientific management to see whether they could, in this way, achieve savings that would make rate increases unnecessary. In January 1911, Brandeis filled a powerful brief claiming that the railroads might save as much as 1 million dollars per day by better management (Buchele, 1977). His brief attracted worldwide attention and...

... that was the last link that was missing to build the most famous organizational and management structure ever noticed (figure 2.1-1).

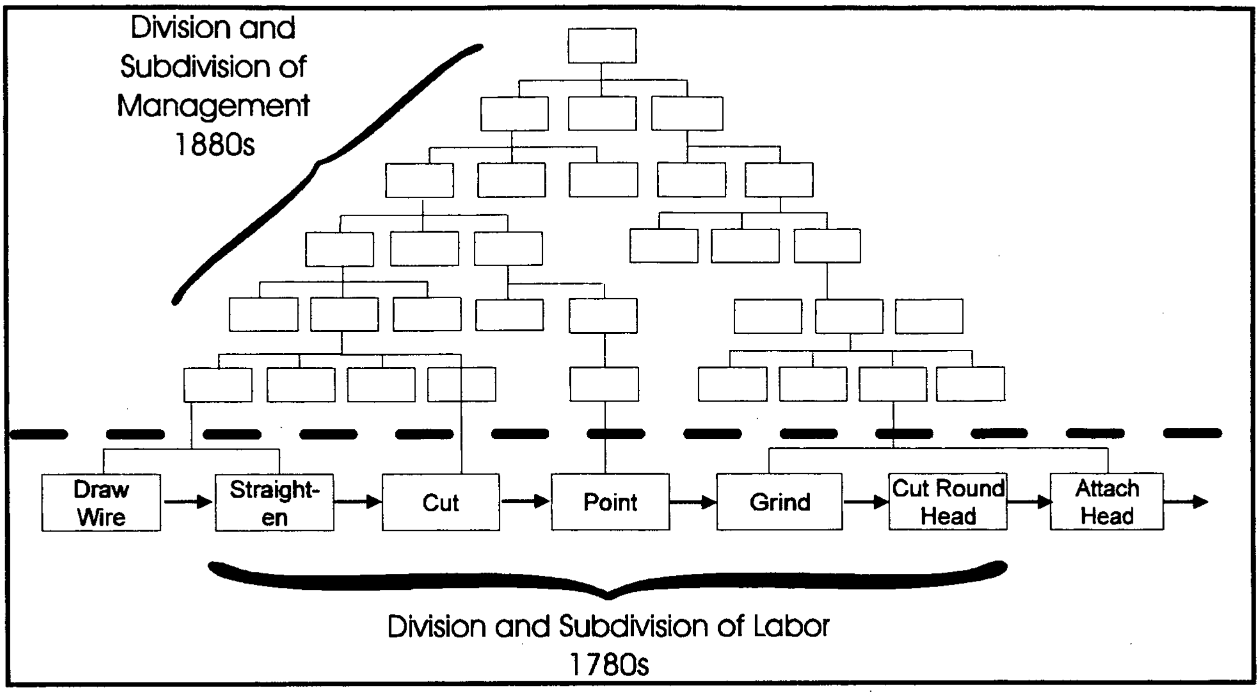


Figure 2.1-1 Development of the organizational and management hierarchical structure (Savage 1990, P. 97)

2.2 Hierarchical Structure

The conception of the organizational and management hierarchical structure was not a intentional event, but a consequence of the study and work of some people. The most significant contributions came from three men, so different and at the same time so similar - coincidentally all of them contemporaries: an American engineer, a French industry manager and a German sociologist.

The American Engineer

Frederick Winslow Taylor was a mechanical engineer whose ideas were strongly influenced by a paper delivered in 1886 by Henry Towne to the American Society of Mechanical Engineers. The paper, entitled 'The Engineer as an Economist', asked engineers to build a management literature of 'Science and Practice' (Dessler, 1976).

So, the 'Father of Scientific Management' began to develop his theories. Based on his pragmatic point of view, he presented the principles of scientific management divided into four categories (Taylor, 1911):

1. Developing a science for each element of a man's work, which replaces the old rule-of-thumb method. That means: by means of a scientific study, finding the best way.
2. Scientifically selecting and then training, teaching, and developing the workman, whereas in the past he chose his own work and trained himself as best he could. That means: now, finding the best man, using the best methods and training him.
3. Heartily cooperating with the men so as to insure all of the work being done in accordance with the principles of the science which has been developed. That means: making use of an incentive-basis-payment to reward the worker.
4. An almost equal division of the work and the responsibility between the management and the workmen with the management taking over all work for which they are better fitted than the workmen, while in the past almost all of the work and the greater part of the responsibility were thrown upon the men. That means: workers working and managers managing.

Much has been discussed about this theory, and probably the misunderstanding of some was the triggering point to the following Taylors testimony* regarding what is and what is not scientific management:

> "Scientific management is not any efficiency device, nor a device of any kind for securing efficiency; nor is it any branch or group of efficiency devices. It is not a system of figuring costs; it is not a new scheme of paying men; it is not a piecework system; it is not a bonus system; it is not a premium system; it is no scheme for paying men; it is not holding a stopwatch on a man writing things down about him; it is not time study; it is not motion study nor an analysis of the movements of men; it is not the printing and ruling and unloading of a ton or two of blanks on a set of men and saying, 'Here's your system; go use it.' It is not divided foremanship of functional foremanship; it is not any of the devices which the average man calls to mind when scientific management is spoken of. The average man thinks of one or more of these things when he hears the words 'scientific management' mentioned, but scientific

* Testimony of Frederic Taylor at hearings before the Special Committee of the House of Representatives to Investigate the Taylor and Other Systems of Shop Management, January, 1912, P.1387.

> management is not any one of these devices. I am not sneering at cost-keeping systems, at time study, at functional foremanship, nor at any new and improved scheme of paying men, not at any efficiency devices, if they are really devices that make for efficiency. I believe in them; but what I am emphasizing is that these devices, in whole or in part, are not scientific management, they are useful adjuncts to scientific management, so are they also useful adjuncts of other systems of management."

Once again use is made of Taylor's words to present his reflection about his work and its consequences (Copley, 1923) :

> "I was a young man in years, but I give you my word I was a great deal older than I am now, what with the worry, meanness and contemptibleness of the whole damn thing. It is a horrid life for any man to live, not to be able to look any workman in the face all day long without seeing hostility there, and feeling that every man around you is your virtual enemy. These men were a nice lot of fellows, and many of them were my friends outside the works. This life was a miserable one, and I made up my mind to either get out of the business entirely and go into some other line of work, or to find some remedy for this unbearable condition."

The French Industry Manager

Henri Fayol, a Frenchman mining engineer was for 30 years the general manager of a coal and steel company. Seen by many scholars as being the first to write a complete theory of management (Buchele, 1977), he developed his system from his executive point of view.

The 'process school', attributed to Fayol, divides management into a five-component process involving 14 universal principles. They are (Fayol, 1949):

Functions:

1. Planning the organization's tasks.
2. Organizing the people, money, and material necessary to perform these tasks.
3. Commanding the people assigned to the tasks.
4. Coordinating their activities to ensure proper direction
5. Controlling the processes, procedures, and people involved.

Principles:

1. Division of work.
2. Authority and responsibility.
3. Discipline.
4. Unity of command.
5. Unity of direction.
6. Subordination of individual interest to general interest.
7. Remuneration of personnel.
8. Centralization.
9. Scalar chain.
10. Order.
11. Equity.
12. Stability of tenure of personnel.
13. Initiative.
14. Esprit de corps.

Fayol's principles already contain some principles that are concerned with the improvement of human relations. Regarding the human relations management and the behavioral system school, the reader is referred to the contributions of various scholars, such as Robert Owen, George E. Mayo, Georg Homans, McGregor and Argyris, as well as the Hawthorne Studies.

The German Sociologist

Max Weber, a prolific writer and man of many interests, was impressed with the effectiveness of the government offices in his time, and he sought to draw from them a model for efficient organization of large-scale activities (Buchele, 1977). From his intellectual point of view, he developed the theory of bureaucracy. This term was not used in the popularized sense of red tape and inefficiency (Dessler, 1976). For Weber, bureaucracy was the most efficient form of organization, and could most effectively be used with the complex organizations that arose out of the needs of modern society. He describes bureaucracy as having (Dessler, 1976):

1. a well-defined hierarchy of authority,
2. a division of work based on functional specialization,

3. a system of rules covering the rights and duties of position incumbents,
4. a system of procedures for dealing with the work situation,
5. impersonality of interpersonal relationships,
6. selection for employment and promotion based on technical competence.

Taylor's pragmatic point of view, Fayol's executive viewpoint and Weber's intellectual point of view were complementary to each other. The dissemination of the resulted division of labour and management structure was worldwide. The structure seemed to be complete - in its essence -, sufficient - for its time - and hermetic - as a whole. And maybe it was. At least for a period!

But the action of external factors such as the advent of information technology (IT) aided by computer systems (Cax) and even the behaviourial challenge of the market have been directly influencing this structure.

2.3 Advanced Manufacturing Technology

The term Advanced Manufacturing Technology (AMT) refers to the manufacturing technologies which span a continuum from 'stand alone' to linked to *integrated* (Meredith, J.R. and Nallan, C.S., 1986). When planning, design, manufacturing, material handling and support systems (such as purchasing, cost accounting, etc.) are all linked together through computer control, the factory is said to have achieved *full integration*, called computer integrated manufacturing (CIM) (Matthew, J.L, 1990).

During the last twenty to twenty-five years the images of the 'Factory of the Future' (Meredith, 1987; ESPRIT, 1990) have, to an increasing extent, been dominated by expectations of the AMTs all operating under central computer control, and based on Computer Integrated Manufacturing (CIM) discussions held in the 1980s. During the same period of time, however, experiences have shown that results were less than expected (ESPRIT, 1990).

For instance, John Deere in US, who has developed his own CIM project during the eighties (Doumeingts et al. 1995), discovered, after much reflection, that it had simply computerized and automated operations as they existed in a manual mode, i.e. he had computerized the contradictions, confusion, and inconsistencies of its existing operations (Savage, 1990). Lardner (1984) recommends simplifying existing operations before introducing heavy computerization. And that is why Deere later incorporated notions of 'Just-in-Time' (JIT) and 'Total Quality'. By the way, it is important to mention that among the new manufacturing technologies, not all are computerized but nevertheless go under the rubric of advanced or high technology (Meredith, 1987).

AMT was highly important during the seventies and the eighties and will continue be during the nineties, but this time with a great difference: the predominant blindness provided by the technical challenges, which gave priority to Information Technologies (IT) and automation without taking into account essential views such as social and human aspects, will give rise to a more balanced system. In such an environment, technological, organizational and human aspects are considered complementary elements to each other and the notion of learning and knowledge plays a decisive role. In the next subsection, the description of the evolution of organization and management structures continues relating the state-of-the-art of the enterprises from a new era: the knowledge era (Savage, 1990).

2.4 A Cognitive Environment

Up to the present, labour and management have by and large concerned themselves with the technical side, striving to break down the manufacturing organization into a purely logical, mechanistic set of functions. It is not surprising that most of the manufacturing people are just technocrats which look for technical or rational solutions, largely ignoring the human and social aspects of the problems.

There is however a growing realization that there is more to an organization than a mere set of functions. Based on the conclusive support offered by authors like Goldratt and Cox (1993), Goldratt (1994), Savage (1990), Gottschalch (1991) and Hamacher (1991) the author understands that the logical sequence of the semantic evolution of the organization and management structures must be based on a triadic model, taking into account the organizational-social-technological view (figure 2.4-1). So, aspects like the simplification of existing operations and processes before introducing computer-aided solutions must be considered, as well as the people involved in the running of the enterprise, their interaction with the available technology and with each other and the overall effect that these interactions have on the enterprise within a changing environment. Fundamental for this new production strategy is the concept of *learning*, which will be explained in short in the following subsections.

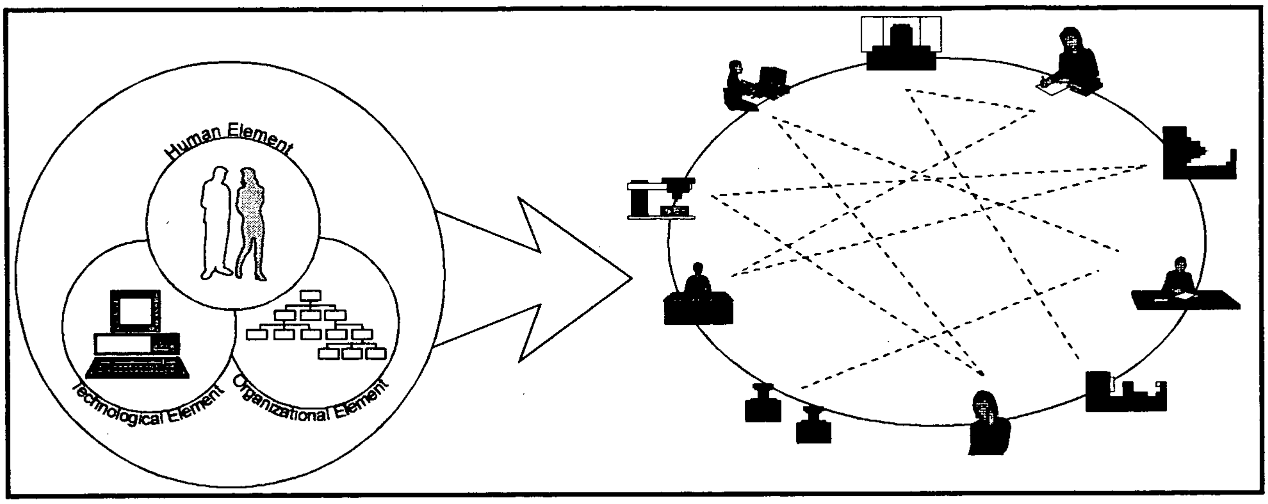


Figure 2.4-1 Triadic model to support organization and management structures

2.4.1 Individual Learning

The literature is rich in theories of individual learning based on cognition. The strong psychological focus of most of these theories has led to studies that seek to understand the human behaviour. Neergaard (1994) summarizes what different authors define as individual learning:

"Individual learning takes place through changes in the total content of the human memory (March and Simon, 1966). More precisely, by means of the process of constructing or restructuring knowledge structure (Dixon, 1993, 1994). These changes are controlled by the cognitive systems (Feigenbaun, 1970, March and Simon, 1966)."

Other authors, for example, Argyris and Schon (1978), Argyris (1976), Cyert and March (1963), Bougon (1992) and Eden (1992) have also been occupied with different theories concerning cognition in human problem solving and learning.

In considering the organizational context Neergaard (1994), who presents a very interesting and complete literature review about *learning*, classifies individual learning in two manners: the formal and the informal one. He describes them as 'official and non-official mechanisms' that influence the learning of a single decision maker. In his work, a good understanding of the way an individual learns is presented, both in an informal and formal manner in an organization, and some processes by which this learning occurs are also presented, as well as an exploration of the factors which impede or facilitate individual learning in an organization. As a result of his review, Neergaard classifies individual learning in two perspectives (Riis and Neergaard, 1995) which will be later shown as forming part of his four-perspective model of learning in organization: the individual behaviour perspective (having an informal dimension) and the decision support perspective (having a formal dimension).

According to the objectives of this work the formal and the informal manners of individual learning also play an important role. In this context the *formal* manner contributes two important topics: (1) how the problem solving situations influence individual learning and (2) how the knowledge of the decision maker can be made public (Duncan and Weiss (1979), Hall and Fukami (1979)).

Riis (1978) considers the decision maker's learning process to define individual learning as

"... a dynamic process of adaptation and reflection during which changes take place in the individuals likelihood of choosing certain courses of action, e.g., based on his/her belief as to their effect." (Riis 1978, P. 144-146)

According to Riis and Frick's (1991) simple model of the decision maker's learning process, learning occurs when three elements are present: choice situation, action taken and outcome. Furthermore, they state that methods for storage and retrieval of experiences are essential for reusing experiences. Concerning public knowledge, Riis (1992) presents three possibilities of the ways information technology (IT) can stimulate and support the individual decision maker in the workplace:

1. Information technology capable of quickly and accurately retrieving and duplicating all relevant data and information;
2. Information Technology capable of generating simple graphic presentations and statistical analyses. This will require an ability to assemble data and information into connected sets of experience elements;

3. Information technology capable of creating overall clarity i.e. able to assemble and combine data and information in an intelligent manner, for example, by way of rule sets and procedures.

The systematics described above concerning formal individual learning is of great relevance to this work, since it will be treated in further detail (section 3.2) with regard to problem solving situations on the shop floor. It will be thus shown how shop floor monitoring and control (SMC) systems - IT tool - can provide support for the shop floor people satisfying all three possibilities related by Riis (1992).

Formal individual learning offers more viewpoints, other than the one presented here such as the quantitative way of describing individual learning (March and Lave (1974), Riis (1978)) and the individual training and development (Pedler, Burgoyne and Boydell (1988), Caldwell and Carter (1993), Garrat (1991)), or even more literature concerning the utilization of IT (Decision Support Systems - Alter (1980); Knowledge Based Systems - Turban (1990); Information Retrieval Systems - Vandenbosch (1994) and Luef (1990)).

With regard to the *informal* manner, individual learning is normally presented in a direct relation to the organizational learning. Kim (1993) talks about a 'crisis management' to describe the situation in which learning is not incorporated into a mental model. Mental models, in turn, are full of tacit knowledge (Nonaka 1991, 1994) and profoundly shape the way people perceive the world around them. Nonaka (1991, 1994) distinguishes between tacit (informal) and explicit (formal) knowledge and suggests four basic patterns for creating knowledge in an organization:

1. From tacit to tacit: where one individual shares tacit knowledge directly with another. Learning occurs through observation, imitation and practice;
2. From explicit to explicit: where an individual combines discrete pieces of explicit knowledge into a new whole;
3. From tacit to explicit: when informal knowledge is converted into formal knowledge;
4. From explicit to tacit: when the explicit knowledge is used to broaden, extend, and reframe people own tacit knowledge.

The notions of informal individual learning i.e. the one formed by tacit knowledge influence directly this work and will be further described in the section 3.3. It is of extreme importance for providing a greater flexibility on the shop floor with regard to rescheduling activities by means of short-term reaction, as well as for the coordination of decentralized and partially autonomous production areas.

Concerning yet the informal manner, other authors (March and Olsen, 1976; March, 1989, Argyris, 1977, 1990, 1991, 1993; Argyris and Schon, 1974, 1978) write about learning cycles, i.e., their model explains how individuals learn in an organizational context and how they interact in their organization and environment. For a detailed description of the 'Single-' and 'Double-Loop' Learning Cycle the reader is refereed to Argyris (1990, P.94) and Argyris (1993, P.8) and of the Complete Cycle of Choice to March (1989, P. 338).

It is not the aim of this section to make an exhaustive description of this subject, however the individual learning is important to be mentioned due to its direct relation with the organizational learning and hence with the elements that will be presented in the third chapter for the conceptualization of a learning enterprise.

2.4.2 Organizational Learning

In the literature it is not difficult to find a great deal of definitions related to organizational learning. In the following, some of them:

> "Organizational learning means the process of improving actions through better knowledge and understanding." (Huber, 1991)

> "An entity learns if, through its processing of information, the range of its potential behaviours is changed." (Stata, 1989)

> "Organizations are seen as learning by encoding inferences from history into routines that guide behaviour." (Levitt and March, 1988)

> "Organizational learning is the sum of what people learn collectively and individually in the organization and which manifests itself in changes in collective and individual behaviour." (Neergaard, 1994)

> "Organizational learning is a process of detecting and correcting error." (Fiol and Lyles, 1985)

"Organizational learning occurs through shared insights, knowledge, and mental models...[and] builds on past knowledge and experience - that is, on memory." (Argyris, 1977)

In spite of the long time that organizational theorists have spent studying 'how to learn learning', there does not seem to be a consensus about how to define the term. Garvin (1993) summarizes some of the disagreement of the current literature quotations:

1. behaviourial change is required for learning
   'against'
   new ways of thinking is enough;
2. information processing is the mechanism through which learning takes place
   'against'
   shared insights, organizational routines or memory are the adequate mechanisms;
3. organizational learning is common
   'against'
   flawed, selfserving interpretations are the norm.

At all events, it seems to be common sense to state that organizational learning is complementary to individual learning and closes the learning process circle in an organization. And the adequate combination of both leads the organization to become a learning organization (sub-section 2.4.3).

Based on Neergaard's (1994) extensive literature review, a scheme can be drawn up showing how an organization can learn:

1. In a formal manner, by means of:

- adaptation, whereby organizations exhibit adaptive behaviour through time (Cyert and March (1963), March and Simon (1966), March and Olsen (1976), Levitt and March (1988)) or small continuous adjustments (Quinn and Goold (1990), Collingridge (1992));
- management systems and organizational structures (Riis (1978 and 1992), Riis and Frick (1991), Huber (1991) and Jelinek (1979));
- learning models (Jelinek (1979), Argyris and Schon (1978), Senge (1990)).

2. In an informal manner, by means of:

- relation to corporate culture (Sackmann, (1991), Molin, (1987), Schein (1990), Walsh and Ungson, (1991));
- Learning models (Argyris and Schon (1978)).

All the ways mentioned above could be subjects for thorough descriptions. However this would not be of vital interest to the nucleus of this work. This section is limited therefore, to giving a notion of what organizational learning is, presenting some definitions and the related contradictions, as well as a summarized scheme of how an organization can learn. From this, the points focused in this work are mainly the management systems and organizational structures. The corporate culture is also of interest but it is considered in a different way from Neergaard (1994). In the following sub-section this will be further explained; moreover, the concept of a learning organization will be presented linking the previous sub-section and this one, i.e. individual and organizational learning.

2.4.3 The Learning Enterprise

Called by some authors as Learning Organizations (Senge, 1990; Garvin, 1993; Beck, 1992; Marquard and Reynolds, 1994; Mason and Lynn 1994; Burgoyne, 1992) by others as Learning Company (Pedler, Burgoyne and Boydell, 1991; Riis and Neergaard, 1995) or Knowledge-creating Companies (Nonaka, 1991) and by the author as Learning Enterprise (Hamacher, Pereira Klen, Hirsch, 1994) this new kind of enterprise arises to make possible the increasing need for an agile manufacturing.

But what is a Learning Organization? How can an enterprise become a Learning Organization? Which steps should it go through?

Authors such as Pedler, Burgoyne and Boydell (1991), Senge (1990), Garvin (1993), Marquadt and Reynolds (1994), Nonaka (1991, 1994) and Neergaard (1994) have been concerned with these questions for some time and have developed some models and procedures that should support an enterprise, so that it can become a learning organization. In the following, two of these learning models will be presented that were the most relevant for the development of the conceptual framework presented in sub-section 2.5, which is based on the triadic model of the figure 2.4-1.

The Model of Garvin

David Garvin, a Professor of Business Administration at the Harvard Business School, defines a Learning Organization as being

"... an organization skilled at creating, acquiring, and transferring knowledge, and at modifying its behaviour to reflect new knowledge and insights." (Garvin, 1993)

He developed a learning model based on five main activities. According to his model, by creating systems and processes that support these activities and integrate them into the fabric of daily operations, companies can manage their learning more effectively. The five building blocks are:

1. Systematic Problem Solving: rests on the philosophy and methods of the quality movement, relying on the scientific method for diagnosing problems (what Deming calls the 'plan, Do, Check, Act' cycle), insisting on data as background for decision making (also called fact-based management), and using simple statistical tools to organize data and draw inferences. Important for this activity is that employees must become more disciplined in their thinking and more attentive to details. Suggested are the small-group activities and the problem-solving techniques.
2. Experimentation: involves the systematic searching for and testing of new knowledge. It also makes use of the scientific method and the two main forms are: ongoing programs, especially common on the shop floor and designed to produce incremental gains in knowledge through a continuing series of small experiments; and one-of-a-kind demonstration projects, whose main characteristics are: being the first projects to embody principles and approaches that the organization hopes to adopt later on a large scale, establishing policy guidelines and decision rules for later projects, encountering severe tests of commitment from employees, being developed by multi-functional teams reporting directly to senior management, having limited impact on the rest of the organization if they are not accompanied by explicit strategies for transferring learning.
3. Learning from past experience: relies on a review of companies' successes and failures and the systematic assessment of them in order to record the lessons in a form that employees find open and accessible.
4. Learning from others: is what Garvin calls the 'not invented here' syndrome or what Milliken calls the 'Steal Ideas Shamelessly' process. The act of looking outside one's immediate

environment to gain a new perspective is emphasized here. Two ways of learning from the experiences and best practices of others are mentioned: benchmarking, as a way of gaining an outside perspective; and customers, which are equally fertile source of ideas. But whatever the source of outside ideas are, Garvin states that learning will only occur in a receptive environment.

5. Transferring knowledge: is the way of making learning more than a local affair, which means that knowledge must spread quickly and efficiently throughout the organization. Some mechanisms for transferring knowledge mentioned by Garvin are: written, oral, and visual reports, site visits and tours, personnel rotation programs (one of the most powerful methods), education and training programs, and standardization programs.

The Model of Neergaard

One of the most recent studies in the area of learning was done by Claus Neergaard at the Aalborg University, in Denmark. Neergaard (1994) has developed what he calls a 'holistic' model of learning, applying four perspectives of learning. Regarding these perspectives, he defines a leaning company as

"An enterprise having an appropriate combination of the four types of learning capable of mutually supporting one another, enabling the organization to continuously develop its preparedness for external and internal changes" (Riis and Neergaard, 1995).

To develop the multi-perspective model of learning in organizations, Neergaard has done a very detailed review of the literature of learning and has researched many organizational theorists who have studied learning (Argyris, Nonaka, Duncan and Weiss, Riis, Cyert and March, Jelinek, Hall and Fukami, Mintzberg, Schein). He has divided what he has found in the literature into four areas, each dealing with how learning can take place in an organization. These are:

- Individual learning in organizations:
  - Formal, individual learning processes directed by means of information technology, decision models and formalized knowledge.
  - Informal, individual learning processes directed through unconscious and informal behaviour.

- Collective learning in organizations:
  - Formal collective learning processes directed by formal structure and management systems.
  - Informal collective learning processes directed by corporate culture.

Neergaard has ordered the groups along two axes: (1) formal versus informal learning, and (2) individual versus collective learning, as illustrated in figure 2.4-2, and has formalized the four perspective as:

1. The individual behaviour perspective: deals with informal learning processes of an individual. It captures information about human behaviour, for instance how individuals react in given situations and under specific conditions, as well as the personal interactions among people. Attention is focused on the informal, unconscious behaviour of a single organizational member and the interpersonal interactions among a number of members of an organization.
2. The decision support perspective: focuses on formal, individual learning processes in organizations. The main interest is how an individual decision maker learns in connection with problem solving situations. This includes the use of information technology and decision models to support decision making. This perspective is mainly used to study and understand how individual learning is influenced by available information technology and its institutionalized knowledge.
3. The management systems and organizational structures: concentrates on collective learning processes as guided by formal organizational structure and by management systems through formal planning and control processes, operating procedures and reward systems. The allocation of responsibility and authority and the structure of divisions, departments and sections also regulate organizational learning processes.
4. The corporate culture perspective: represents what an organization knows, which is neither codified nor formalized in systems. The focus is on social, informal relations, collective habits, behavioural patterns and attitudes existing in an organization. Corporate culture is seen as emerging from collective learning processes and guides and shapes collective and individual behaviour.

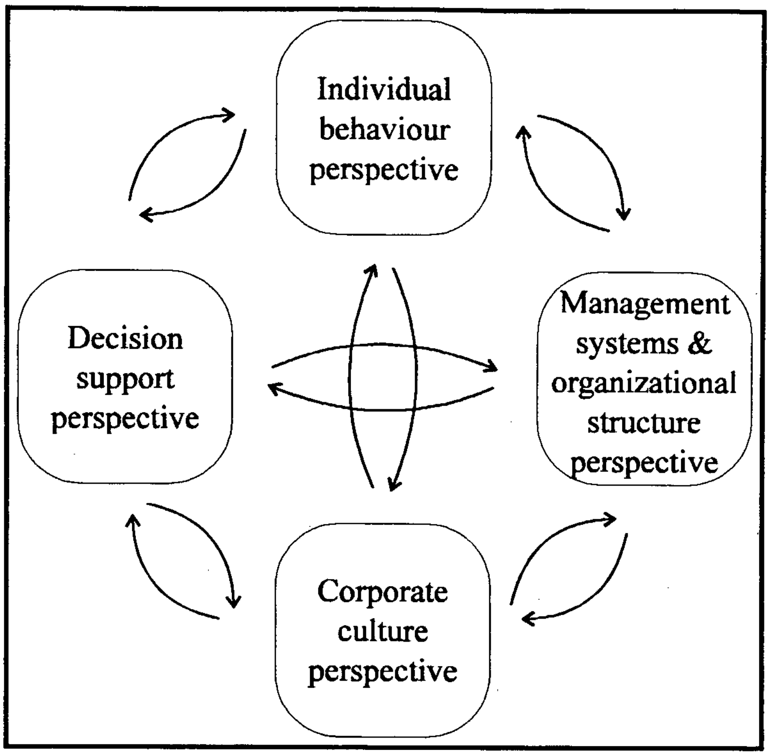


Figure 2.4-2 The Four - Perspective Model of Learning in Organizations (Neergaard 1994, P. 86)

Analysing firstly the quotations presented, Garvin bases his approach on *knowledge* and Neergaard bases his on *learning*. According to Daft and Weick (1984), knowledge is the outcome of a learning process. Maybe for that reason the model of Neergaard seems to be better structured and to present a more understandable logic than the one from Garvin which, while presenting indispensable items for a learning organization, does not necessarily convey an interrelationship among the steps.

The model of Garvin, however has the great merit of including experimentation as a building block for the acquisition of knowledge. The continuing series of small experiments, as described by him, will be later (chapter 3) characterized in this work by the configuration of virtual production areas (VPA) and will constitute one of the most important factors for the learning process inside an enterprise.

Drawing parallels to both models the following comments can be made:

- Decision making support is required: the required data should be available and IT tools could provide the needed support;

- Tacit knowledge is essential coming from inside (company's workers) or outside (market/customers and suppliers) the company;
- Individual learning should be translated into organizational learning;
- Companies' culture influences the learning process; and
- Management systems and organizational structures should stimulate the learning process.

Out of these points one can be observed and concluded: for a learning process to take place, *technological*, *organizational* and *human* elements are required. The *technological* element should support problem solving situations and hence the decision makers; the *organizational* element should build up more agile structures where delegation of responsibility and authority should take place; and the *human* element should be the building block of this triadic model making use of the individual's tacit knowledge (mental models) to improve the technological and organizational processes, as well as to spread out the available knowledge, all this supported implicitly by the companies' culture.

The next subsection will show how these three elements give subsidies for defining and conceptualizing a learning enterprise for the manufacturing sector. Furthermore some characteristics, capabilities and enablers related to such an enterprise will be presented, aiming at characterizing a frame that synthesizes technological, organizational and human elements in a balanced and organized whole and where the application areas can be segmented as being a part of a broad network.

2.5 A Conceptual Framework

No form or shape for a Learning Organization could be found either in the literature or in the real world (Neergaard, 1994). And it makes sense, since a Learning Organization is a concept that evolves. Considering that the organization is dependent on its environment at a specific time and is not committed to a particular type of a structure (Marguardt and Reynolds, 1994) it is thus possible to build a 'holistic structure'.

So, limiting the scope of this work to the manufacturing shop floor of small-batch size and one-of-a-kind producers, and also based on the literature review - mainly regarding the influence of AMTs and the cognitive environment on the manufacturing sector -, a conceptual framework is proposed to support the development of a systematic approach to the conceptualization of a Learning Enterprise (to be presented in chapter 3).

Regarding the manufacturing sector, the enterprises wish to become 'Learning Organizations' (Argyris, 1994; Garvin, 1993; Riis and Neergaard, 1995), and simultaneously wish to become 'Integrated Organizations' (Doumeingts et al. 1995). Savage (1990) has explained the meaning of the word *integration*: it is often used as a synonym for connectivity (including interoperability) and interfacing, but he points out clear distinctions among the three terms. He exemplifies saying that connecting offices or locations by means of telephone or computer networks and interfacing applications, is something completely different from integrating organizations. Connectivity and interfacing leave the organization largely as it is, while integration changes the way in which the organization works (Savage, 1990).

With the understanding of *learning* and *integration* in mind, and according to the terminology of this work, the author defines Learning Enterprise as an enterprise where technological, as well as human resources, are integrated into organizational frameworks, making use of the knowledge, the flexibility, the creativity and the motivation of the workers available to the enterprise, and utilizing the increasingly powerful information and communication technologies as well.

Learning Enterprises will therefore require that strategies and structures should be seen from a more holistic viewpoint. Trying to draw the profile of such a holistic Learning Enterprise framework, some questions have emerged:

1. What should a learning enterprise be?
2. Which capabilities should it have?
3. Which enablers are required?

The main characteristics, capabilities and enablers of a learning enterprise are summarized in the following and compose the essence of the Learning Enterprise framework (figure 2.5-1).

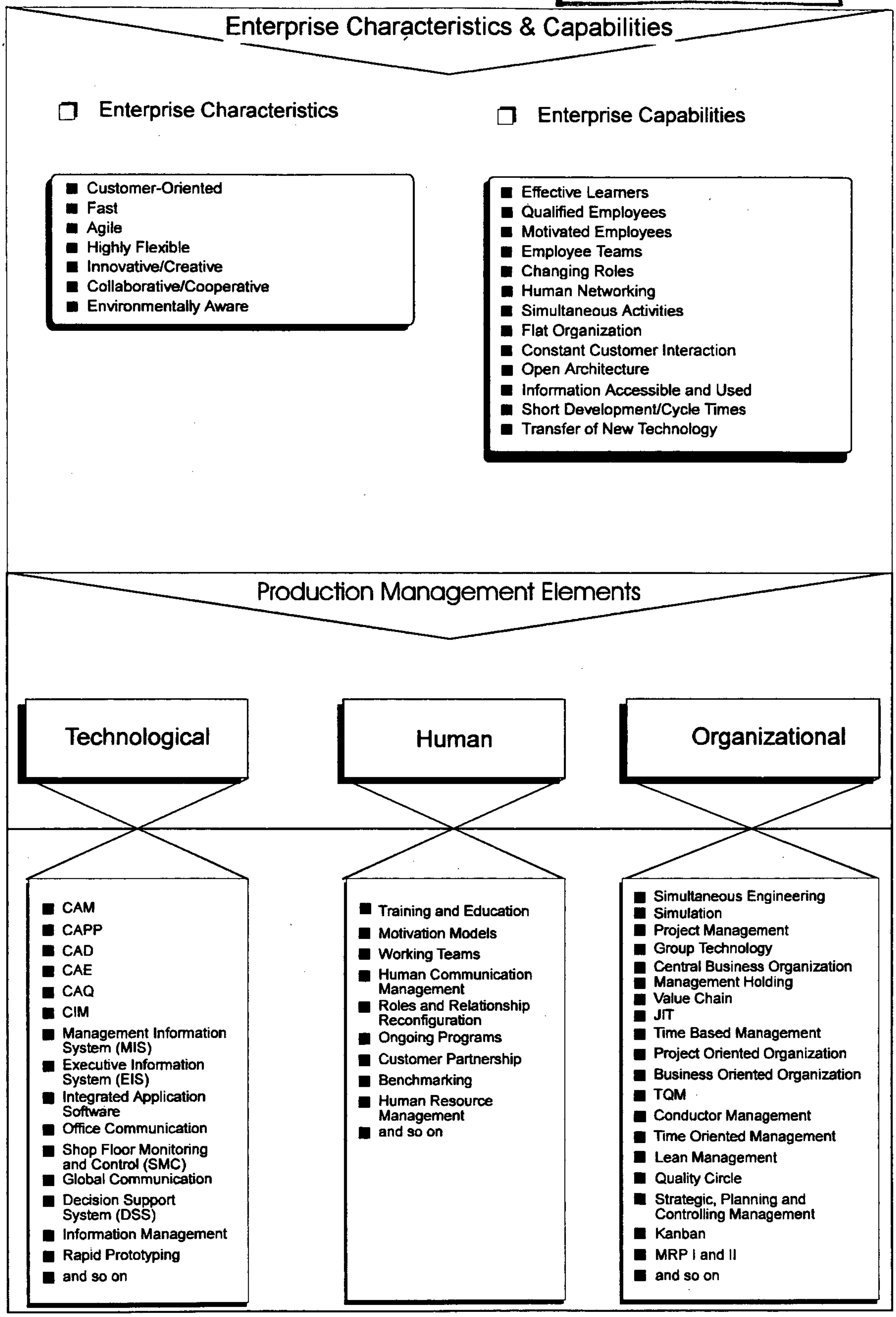


Figure 2.5-1 Learning Enterprise generic framework

2.5.1 Characteristics

In agile manufacturing, the daily confrontation with the increasing globalization, customizations and the environmental awareness influences directly the enterprise's characteristics. In order to cope with these trends the enterprise should be:

- Customer-oriented: to satisfy the customer needs;
- Fast: to respond quickly the demand for quality and highly customized products;
- Agile: to integrate flexible technologies of production with the skill-base of a knowledgeable work force, and with flexible management structures that stimulate cooperative initiatives within and between firms (Nagel and Dove, 1991);
- Highly flexible: to adapt to the dynamic organization structure;
- Innovative/Creative: to make use of all knowledge available, so as to develop core competencies;
- Collaborative/Cooperative: to support the reconfigurable, computer/human-networked emerging structures;
- Environmentally Aware: to prove that they had really 'learned' how to deal with new environmental and technological requirements.

2.5.2 Capabilities

Analysing the literature review, some capabilities were identified as being necessary in a Learning Enterprise. The main capabilities will be outlined as follows:

<u>Effective Learners</u>

In a dynamic organization structure, people are required to put themselves into a 'learning mode' (Savage, 1990) in order to maintain self-generation and knowledge growth. By learning, enterprises' focus will shift from 'control' to 'commitment', from 'monitoring' to 'motivating', from 'commanding' to 'conducting' and from 'line management' to 'management of human networking' (Hamacher, 1991).

The Learning Enterprise requires a flexible work force, capable of shifting job descriptions and skills as the situation warrants. The dynamic and adaptable behaviour required from the employees needs to be supported by adding value activities.

Qualified Employees

Thanks to a little but increasing change in the managerial way of thinking, qualification programmes are nowadays spreading more and more in the business environment. As a result of qualifying employees, more efficient use of new technologies, quicker implementation, higher initial productivity, lower implementation costs and higher employee motivation and satisfaction level have been noted (Pereira Klen, Vöge and Hirsch, 1993b).

For the successful introduction of a new production philosophy, as well as for the implementation of new information technologies, qualified employees are required.

Motivated Employees

In the last years, the aim of the production philosophy was so strongly focused on adding values to products, that people had little importance (Gould, 1993). The Learning Enterprise philosophy still adds value to products, but people matter too. Each employee is seen as a proactive part of the total enterprise effort, using his skills and motivation to bring success to his team and to the enterprise.

The values in question are not gained through a training course or through wall posters, but are nurtured and grown over time through personal interaction and adding value activities. A propitious environment for motivated employees should be cooperative and collaborative and one in which communication skills should be developed. A well-known representative of these characteristics is the teamwork.

Employee Teams

Katzenbach and Smith (1993a) define a team as 'a small number of people with complementary skills who are committed to a common purpose, set of performance goals, and approach for which they hold themselves mutually accountable'.

The knowledge and capability needed to find and take advantage of opportunities in the rapidly changing business environment require that people work in teams (for a more detailed discussion see sub section 3.3.2: cross-functional teams). The practice of teamwork encourages listening and responding constructively to views expressed by others, giving others the benefit of the doubt, providing support and recognizing the interests and achievements of others (Katzenbach and Smith, 1993a); it is also an excellent way to improve collaborative and cooperative participation., promoting individual performance, as well as the performance of the entire enterprise, and all of these stimulate learning - individual and organizational-. In this way, responsibilities and autonomy must be delegated to the team. They should discuss, decide, and do real work together. Besides that, leadership roles must be shared.

Changing Roles

The role theory is a social science theory that describes human social behaviour in terms of two abstractions: roles and interactions among roles. Briefly stated, it views individuals as occupying positions in organizations. Associated with each position is a set of activities, including required interactions, that constitutes an individual's role (Singh and Rein, 1992).

If somebody has a role, he also has certain organizational capabilities along with their associated responsibilities. An individual may be assigned multiple roles that not necessarily belong to the same process.

In the dynamic environment of a Learning Enterprise the combination of how and when people interact to make a product or provide a service is constantly changing in response to what each customer wants and needs. Moreover, not only processes but also people continually reconfigure their roles to produce more exactly what customer wishes.

Human Networking

According to Savage (1990), human networking involves drawing upon visions and knowledge to develop quality actions in the present, in concert with a team which recognizes, interprets, decides and implements responses to windows of opportunity that will meet both the customers' expectations and the teams' vision of the enterprise. He also says that a very important aspect for establishing and maintaining human networking is the communication between and among the virtual team members: they communicate in the present, tap their individual and collective knowledge and dialogue with their visions. And this is what is called human networking.

Learning Enterprises rely on powerful informal organizations which are, by definition, living social systems linked by human networking and human interaction (for a more detailed discussion see sub section 3.3.3: human networking through human communication network).

Simultaneous Activities

Concurrence is now acknowledged as having an important role to play in product development and manufacturing. Concurrent engineering is concerned with the simultaneous design of a product and of the processes required to produce and support it using a cross-functional team approach. It was first formally defined in 1986 as (Winner et al., 1988): "a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule, and user requirements."

A definition offered by the Concurrent Engineering Research Center in West Virginia emphasizes more the teamwork and the cooperative dimensions: "Concurrent Engineering is a systematic approach to the integrated development of a product, and its related processes that emphasizes ... team values of cooperation, trust, and sharing in such a manner that decision making proceeds with large intervals of parallel working ... synchronized by comparatively brief exchanges to produce consensus."

The Learning Enterprise will require that all the parts of the enterprise work simultaneously to seize an opportunity. This includes all the functions and activities, not only engineering and manufacturing, but marketing, finance, human resource management and all other departments. It also implies that people and teams throughout the enterprise will need to be in constant communication, updating others on their work, and being updated. This will require individual skills and adaptability, supportive management methods, and a technological communication infrastructure (Nagel and Dove, 1991).

<u>Flat Organization</u>

The traditional hierarchical structures are under great pressure. Recognizing the energy-sapping of top-heavy management, many enterprises are delayering themselves and cutting management positions. Executives are learning to lead with fewer levels of management below them.

However, the shift from a pyramidal hierarchy towards a flatter one is not so easy. It is a gradual process that must begin with the management philosophy. The Learning Enterprise is established in this management shift principle in order to have a networked, mentored organization.

According to Gould (1993) mentoring is a process involving leadership, values, commitment, empowerment and, most of all, communication. It requires sit-down meetings within cross-functional areas, education and training - mainly in communication within the organization: listening skills, group problem solving, and other basic techniques, such as knowledge of the enterprises' products and why they are being made. Mentoring and excellent communication are typical in lean (Gould, 1993) and flat organizations.

However, it does not mean that hierarchical authority will completely disappear. Savage (1990) states: "Human networking enterprises will still have hierarchical authority structures, although they will be much flatter. Some activities will continue to be sequential and routine. There will still be some division and subdivision of labor, with certain tasks remaining narrowly defined. Top management will still have overall responsibility for the strategic direction of the enterprise, and vestiges of the chain of command and automation will survive."

<u>Constant Customer Interaction</u>

Currently, it is estimated that 20% to 30 % increase in profit margins can be achieved by involving customers in a product design (Pike, 1989). Some companies have already started to move in that direction - PS-Systemtechnick, a software house in Bremen, Germany, has developed a Shop Floor Monitoring and Control System working directly with the end customer.

The level of interaction could go all the way from specifying from a standard catalogue, up to the level of new design specifications. The greater the level of interaction between the enterprise and the customer, the greater the level of customer satisfaction will surely be, and this is one of the main goals of the Learning Enterprise.

Open Architecture

Perhaps one of the most significant developments in the last years has been the better acceptance of open computer systems by vendors, and the progress in defining standards for the computer representation and exchange of product data - all critical components of the global manufacturing tendency.

The globalization trend requires of an enterprise the capacity of constantly forming cross-functional teams - inter and intra-organizational. For these to function efficiently, quickly and effectively, the work systems and, most importantly, the communication and information systems, must be able to rapidly interconnect and be functional. Standards and open architectural principles are therefore required for an enterprise to react rapidly in order to be able to build temporary consortia, in the form, for instance, of a virtual enterprise .

Information Accessible and Used

One way flexibility can be achieved is by reducing hierarchical managerial control, setting up workers in teams and empowering them to make decisions. To support decision makers, the necessary information must be available in the right place and at the right time; dealing with unnecessary information should be avoided. The information flow within the enterprise must be efficient and transparent, it must be 'lean' (Eversheim et al, 1992, Scheel, 1990). In addition, referring to the globalization tendency, the more the enterprises work together forming extended enterprises, the greater the necessity of information exchange. This requires great extension of networks, information and enterprise integration subsystems, standardization, and training worker skills.

In the agile manufacturing, cross-functional teams and temporary consortia will need access to rapid and reliable information in order to do their work and to make decisions.

Short Development/Cycle Times

In the study about the future of the automobile industry from the Massachusetts Institute of Technology by Womack et al. (1990) the importance of the development and cycle times is clearly stated for the industrial competitiveness.

Aiming to reduce the total time required to bring a new product to the market, concurrent or simultaneous engineering activities have grown up (Nagel and Dove, 1991). The integration of the daily activities of product engineering and production process engineering overlaps these two activities so that they are conducted in parallel, at the same time, rather than in sequence, one after the other.

As an engineer, scientist and inventor, Leonardo da Vinci was able to construct with absolute fidelity what he designed himself. He was what could be called an 'artisan of the technology', being simultaneously responsible for the product development and design, planning and manufacturing, obtaining his product in a quick and efficient way.

In putting the employees working together, parallel and with the required discipline, the Learning Enterprise wants to reach a 'Leonardo da Vinci' effect, being able to respond to the rapid and continuous change of the competitive environment.

Transfer of Technology

According to Nagel and Dove (1991) the rate at which new technology and methods become available continues to accelerate, far outstripping adoption and utilization rates. They state that transfer of new technology has been the focus of much attention in the last few years because this is where large cost-reduction opportunities exist in two areas: eliminating the large hidden costs associated with the inefficient deployment processes that currently exist and in hastening the utilization of lower cost manufacturing processes and methods as they are being developed.

The importance of technology transfer can be exemplified in the manufacturing sector through numerically controlled machine tools. Their capabilities were demonstrated first in 1952 (Kief, 93/94), and the concept was relatively mature in 1965. In 1990 only about 20% of the appropriate machines in the US and 30-35% in Europe made use of this technology (Nagel and Dove, 1991).

In the Learning Enterprise the transfer of technology and the transfer of knowledge is essential to make learning more than a local affair (Garvin, 1993).

2.5.3 Enablers

In the Learning Enterprise different concepts and elements have to be synchronized and harmonized in order to achieve the required capabilities. Many elements are already available and Mertins et al. (1993) classified them into three categories: (1) technology concepts, (2) organizational concepts, and (3) economic and management concepts. Based on Mertins' et al. (1993) classification and considering the strong multi-dependence of management and organizational elements (Lorsch and Lawrence, 1967; Neergaard, 1994), the present work groups both together and complements the classification with a third component: human elements.

Thus, the enabler elements are seen under three aspects: technological implementation, organizational development and human involvement and participation.

According to the objectives of this work, an adaptation of the list by Mertins et al. (1993), containing some modifications and complementations with regard to existing enablers, will be presented below:

Technological Enablers:

- CAM
- CAPP
- CAD
- CAE;
- CAQ;
- CIM;
- Management Information System (MIS);
- Executive Information System (EIS);
- Integrated Application Software;

- Office Communication;
- Shop Floor Monitoring and Control (SMC)
- Global Communication;
- Decision Support System (DSS);
- Information Management;
- Rapid Prototyping;
- and so on...

Human Enablers:

- Training and Education;
- Motivation Models;
- Working Teams;
- Human Communication Management;
- Roles and Relationship Reconfiguration;
- Ongoing Programs:
- Customer Partnership;
- Benchmarking;
- Human Resource Management;
- and so on...

Organizational Enablers:

- Simultaneous Engineering;
- Simulation;
- Project Management;
- Group Technology;
- Central Business Organization;
- Management Holding;
- Value Chain;
- JIT;
- Time Based Management;
- Project Oriented Organization;

- Business Oriented Organization;
- TQM;
- Conductor Management;
- Time Oriented Management;
- Lean Management;
- Quality Circle;
- Strategic, Planning and Controlling Management;
- Kanban;
- MRP I and II;
- and so on...

The list of the existing enablers is enormous and the one presented above is far from complete. Furthermore the borders between the elements are permeable, i.e. sometimes there is such a strong interrelationship among the enablers that it becomes a very hard task to classify them into one or another element class. This contributes to increasing the list even more.

It is not the aim of the work to describe the enablers exhaustively; they were just pointed out in order to provide a better understanding of the amount of available resources and countless methods, techniques and concepts that can be used, developed and improved to help in the conceptualization of a Learning Enterprise.

Important is that technological, organizational and human elements should be combined in order to offer the most complete solution possible. How this combination of enablers will occur depends on many factors: production typology, people involved, as well as time and money to invest. For a strategic 'mix' of methods, concepts and techniques to succeed, the current problems of the enterprise must first be identified and later solved.

In the next chapter a survey is presented where problems identified in enterprises are pointed out and enablers are suggested to cope with them. The enablers integrate technological, organizational and human elements, and finally a methodology is suggested to conceptualize a Learning Enterprise with regard to the manufacturing shop floor of small batch size and one-of-a-kind producers.

3. SYSTEMATIC PROCEDURE

As seen in the previous chapter, diverse enablers compose the Learning Enterprise conceptual framework. To deal with all of them is practically impossible. One contribution of this work consists of the adequate choice of elements that could interact, making possible the development of an approach to cope with the market trends described in the first chapter. As the presented Learning Enterprise framework is supported by a triadic model of human, organizational and technological elements (figure 2.4-1), it seems to be reasonable to work with one component of each element, that could provide the possibility of making a systematic survey and analysis.

To make the adequate choice of these components, the author has based her survey and analysis on a detailed diagnostic questionnaire. It was developed - within the project FLAMME - in order to obtain information from enterprises regarding their current and future involvement with FMS technology, which is seen as a technology to help achieve leaner factories with better response times, lower unit costs and higher quality, under an improved level of management (O'Grady and Menon, 1986), all of them requirements of a Learning Enterprise.

Based on the consultancy experiences of the participating research institutes from seven EU member countries (France, Belgium, The Netherlands, Great Britain, Ireland, Spain and Germany), a methodology was developed for the analysis of SMEs (FLAMME, 1994). According to this method and in cooperation with the employees of the enterprises, the SMEs were examined concerning their problems and experiences with FMS and CIM technologies.

A general description of the enterprise, including its products and sales, its organization, manpower and structure, as well as its general objectives has made possible an analysis of the company production under various aspects (see appendix 1).

It was already pointed out by the SMMETT project (SMMETT, 1991) that the Europe-wide rate of employment of FMS was estimated to be less than 1%. The 70 interviewed SMEs by the FLAMME project emphasized that they are more concerned with the fields of shop floor control and manufacturing organization (Vöge, 1995).

It can be concluded that improving production efficiency and flexibility is not only a question of 'high-tech hardware', like FMS, but also organization, information management, training and qualification. It should be clear that improving flexibility in production is a stepwise approach to factory automation, with FMS as, eventually, ultimate goal.

The main weak points outlined by the FLAMME analysis regarding production management are shown in figure 3-1, and justify the components chosen in this work which are:

1. virtual production areas, as an extension of the concept of production cells based on Group Technology (related in figure 3-1 with the first bar graph 'work organization');
2. distributed shop floor monitoring and control systems (related in figure 3-1 with the second bar graph information management on the shop floor); and
3. human networking through human communication management (related in figure 3-1 with the third bar graph 'total quality management').

The above-mentioned elements will be described in the next sections.

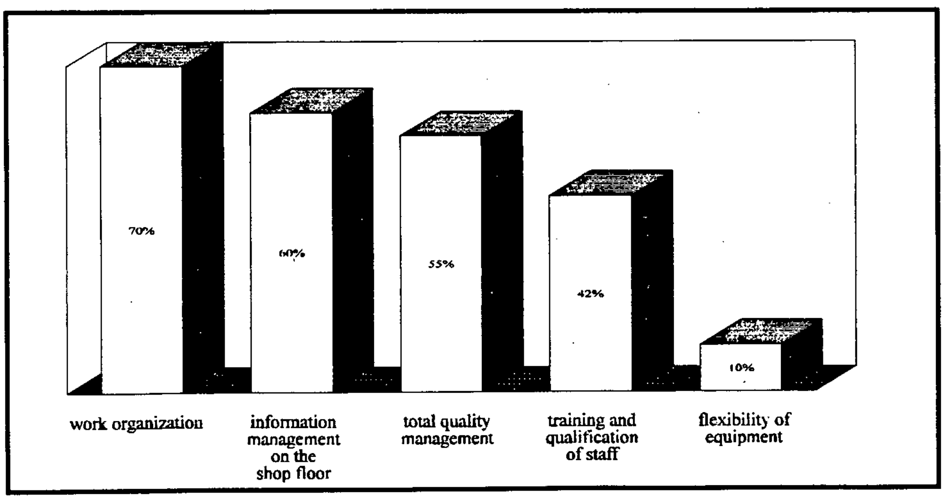


Figure 3-1. Potentials for optimization in SMEs (Pereira Klen, Hirsch and Vöge 1994, P.331)

3.1 Organizational Element

People always try to understand the world around them, for instance, by relating similar facts or happenings, which are organized in categories. This can be found in the nature where animals, vegetables and minerals are grouped in genus and species or in the human culture where this science is applied in libraries, code posts, etc.

The attempt to reach a reasonable organizational status has also influenced the manufacturing sector. Some authors (Freitas, 1992; Silveira, 1994) attribute to the Russian Mitrofanov the pioneerism, during the sixties, of exploring the similarities in the shop floor in order to achieve a unique solution to many similar problems. However, there are registers (Burbidge, 1993; Lorini, 1993) that the first studies in this area were developed during the thirties and the forties. Anyway, to this production philosophy the name 'Group Technology' (GT) was given and nowadays this name is a powerful means for the shop floor work organization.

John Burbidge, one of the most experienced scientists in GT and a great disseminator of this philosophy defines Group Technology as a form of product organization in which machines and direct workers are totally divided into 'Groups', and the parts and products to be manufactured are totally divided into 'Families', each of which is completed in its own particular group, with no back-flow (vertical), or cross-flow (horizontal) of materials between groups (Burbidge, 1993). When GT first started to develop, it was seen as an 'end', or final objective. However, people soon realized that it merely constituted a beginning. GT is, therefore, not a technique as an end, but a powerful tool to support diverse others manufacturing technologies (Meredith, 1987).

Among the manufacturing technologies supported by GT, the implementation of manufacturing cells is the main application of GT nowadays (Silveira, 1994). Many different types of cell formation methods in GT have been developed, depending on the input data representation available and used (Irani, Cohen Cavalier, 1992; Arvindh and Irani, 1994): matrix methods, cluster analysis, overlapping clusters, multivariate statistics, pattern recognition, travel chart clustering, graph theory, mathematical programming, visual analysis, classification and codification methods, production flow analysis, etc. Some of these methods are more outdated than the others. The result of a survey carried out by the author (Kuhlmann, Maßow, Pereira Klen and Vöge, 1991; Pereira Klen, Spatz, Vöge, 1994; Meyer, Spatz, Vöge, 1994) shows that the combination of the visual analysis and the production flow analysis methods are those most preferred in industry.

Such methods constitute just the first step towards the formation of a manufacturing cell. For a detailed cell design analysis Chen and Irani (1993) and Arvindh and Irani (1994) take into account various subproblems in the design of a cellular manufacturing system, such as machine duplication, intracell layout and Intercell layout. Silveira (1994) states that after grouping the parts in families and assigning the corresponding machine groups to the families, the next steps consist of forming multifunctional work groups and inserting into the operational environment activities such as product development, planning, controlling and maintenance, as well as materials.

According to Harvey (1983), Sundaram (1987), Gaither, Frazier and Wie (1990), Burbidge (1993) the main advantages and disadvantages of the implementation of manufacturing cells are:

Advantages:

- It reduces throughput time: because the machines are close together giving low stocks, low stock holding costs and better customer service;
- It lowers material handling cost: because machines are closer together;
- It increases product quality: because groups complete parts and that means fewer rejections;
- It reduces set-up time: because of the similarity grade among the parts processed in one cell;
- It facilitates the automation: by means of simplifying the product process;
- It supports skill development: work in groups stimulates the involvement and participation of workers;
- It supports autonomy: since the parts are to be completely manufactured or assembled in a cell, which facilitates the decision-making in the shop floor level.

Disadvantages: if the parts can be completely divided into families and assigned to machine groups without exception, and the introduction of new products as well as the design or process modification is done in such a way that it does not involve a cell redefinition, the disadvantages of the manufacturing cell are:

- the modification of the shop floor layout that will incur various associated costs (days without production, electric and hydraulic installations, etc.); and
- the partial utilization of production means (expensive machines for instance).

But if there are constraints to such independent cell formation, for instance, by means of bottleneck machines that process a large number of parts from two or more cells, or 'exception' parts that require processing on machines assigned to two or more cells (Chen and Irani, 1993), the disadvantages are much more compromised. Strategies were developed to try to overcome these problems:

- Duplicating machines (McAuley 1972, Seifoddini, 1989, Kern and Wie 1991);
- Redesigning the parts or rerouteing the external operations to alternative machines within a cell (Nagi et al. 1990);
- Subcontracting the parts (Kumar and Vanneli 1987, Kusiak and Chow 1987, Kern and Wie, 1991) or
- Permitting intercell flows (Rajagopalan and Batra, 1975 and Harhalakis et al. 1990).

The first and second strategies are interesting if the industry disposes of a 'closed' product specter, that is, if only known-parts have to be redesigned or rerouted or if the machines have to be bought to attend a specific demand for the known-parts. Very little product variation is allowed after applying these strategies, in order to maintain the character of independence of the cells.

The third strategy is to be considered: if the subcontracting is realized with other industries, the associated costs must be analysed. The product variation is allowed without restrictions since the subcontracting is done outside. If the subcontracting activity refers to another cell, this is nothing more else than intercell flows, which is the next strategy suggested.

So, the only strategy described above that violates the traditional cell definition (note that Burbidge (1993, P.542) affirms that "if there is not a total division of all production facilities into groups, and if back-flow and cross-flow are permitted, then one will not obtain the advantages of GT and the form of organization achieved is NOT GT", or manufacturing cell in the manufacturing context) is the last one. In this case, product variation is also allowed without restrictions.

Considering that (1) the trends of globalization, customization and environmental awareness described in chapter one lead to great product variety and (2) the outside subcontracting activities are not required by many industries (mainly when there are resources and capacity available in the industry), the intercell flow seems to be the remaining strategy. But if this strategy does not characterize manufacturing cells, how can this problem be overcome?

In the next subsection the concept of virtual manufacturing cell is presented as an alternative to some of the problems not solved by the traditional manufacturing cells.

3.1.1 Virtual Manufacturing Cells

As a result of what was stated in the previous subsection it can be concluded that the classical GT definition is not flexible enough. This conclusion led some researchers to an abstraction level that permitted them to begin thinking about a new type of GT manufacturing cell, that they called 'virtual manufacturing cell' (Simpson et al., 1982; McLean et al., 1982).

Having its origins in specific control problems encountered in the design phase of the Automated Manufacturing Research Facility (AMRF) project of the American National Bureau of Standards (NBS), the virtual manufacturing cell, according to McLean et al. (1982), is no longer identified as fixed physical groupings of shop floor equipment, but rather as a computer process, data and dynamically changing set of workstations on the shop floor, as presented in figure 3.1-1. Hence, the virtual cell extends the concept of GT cell by allowing the time sharing of workstations with other virtual cells that produce different part families, but have overlapping resource requirement.

To achieve this kind of cells the development of a cell architecture containing three hierarchical control levels is proposed by the AMRF: (1) task analysis and reporting, responsible for interpreting the commands from the shop floor level and for reporting status back to that level, (2) routing and scheduling, which utilizes the output data from level 1 to generate routines specifying the equipment required, the sequence in which they will be visited and the time the batch will be expected to remain at each station, as well as to generate a schedule determining the actual time when each resource or workstation will be required and when it will be returned to the shop, and (3) dispatching and monitoring, responsible for the formatting and issuing of orders to

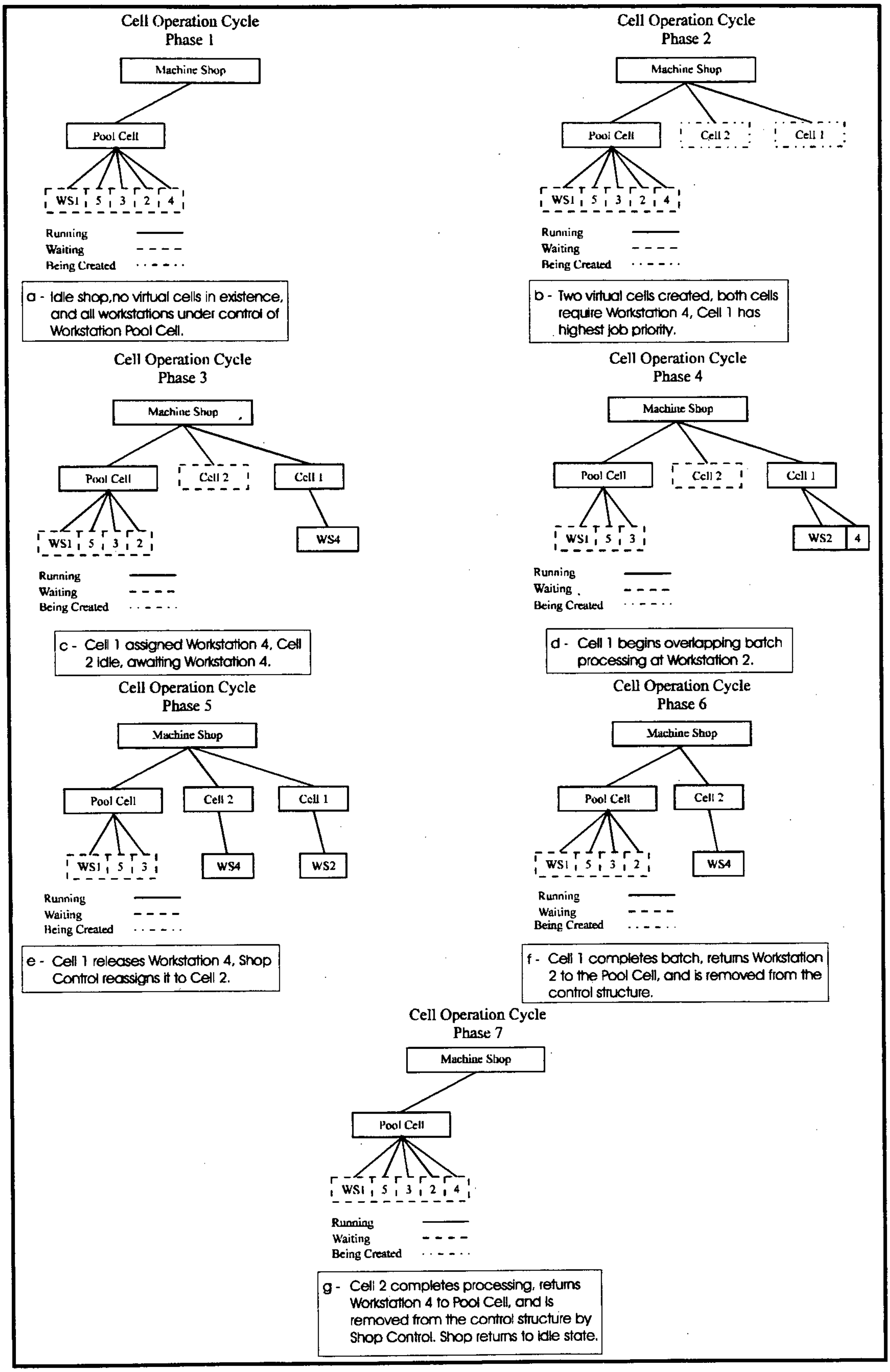


Figure 3.1-1 Pioneer virtual manufacturing cell concept (McLean et al. 1982, P.212)

workstation level systems to move, process, assemble, inspect or store materials and support equipment as well as for tracking the progress of dispatch orders.

Similar to the AMRF concept, Drolet et al. (1989) present the concept of virtual cellular manufacturing system, defining virtual cell as a grouping of workstations recognized within data files and processes in the computerized controller, which do not involve physical adjacency of the workstations as in classical GT based cellular layouts. Based on an envisioned environment the authors describe a virtual cell controller as being responsible for the formation of the virtual cell by means of taking over the control of the required workstations and setting up communication between them. When the need for a specific virtual cells ends, the virtual cell controller is terminated and the workstations return to local control. To achieve the status of such a virtual cell a scheduling architecture is suggested. This consists of three phases: (1) loading, which utilizes scheduling rules to produce a list of priority jobs from the MRP output and/or the current confirmed customer order list, (2) virtual cell creation, where an optimal subset of workstations is assigned to each job and (3) resource allocation, that includes requesting, withholding and delivering related resources to the selected workstations. For the first phase an expert system is proposed, for the second phase a network based algorithm and for the third phase a negotiation protocol.

As an evolution of this kind of decision architecture, multi-agent systems supported by standard negotiation protocols are finding application in the shop floor scheduling and control (Ferstl and Mannmeusel, 1995; Weigelt, 1994; Rabelo and Camarinha-Matos, 1994; Kotschenreuther, 1991). Considerations regarding hierarchical and non-hierarchical agents network is made by (Ferstl and Mannmeusel, 1995). The relation of these systems with virtual organization is made by Rabelo and Camarinha-Matos (1994) who suggest a multi-agent control architecture (utilizing Distributed Artificial Intelligence) to support decentralized scheduling of a consortium, which is defined by them as being a dynamic and temporarily logical clustering of enterprise activity agents to execute a whole production order. Moreover the authors state that the number of consortia is equivalent to the number of prepared production orders to be executed.

A significant variation of the original concept of virtual cell is presented by Irani, Cavalier and Cohen (1993) and Tönshoff and Glöckner (1994). The former present a hybrid layout based on cellular layout and functional layout. Thus, machines shared by several cells are assumed, retained in functional sections if these cells can be located close to each other. According to them, this adjacency of the cells allows the machine groups for the part families to be virtual, i.e. the handling system links machines in adjacent cells in order to define the cell for a part family without demanding rigid physical relocation to group the machines. A similar hybrid layout is suggested by (Tönshoff and Glöckner, 1994). The main difference is that the latter propose the effective implementation of a physical cell only if the corresponding logical one is constantly required.

Taking an overview of the whole, some points are to be emphasized:

- The attempt of NBS has the great merit of being the pioneer in the 'virtual' field. However, the concept presented does not support autonomy and delegation of responsibility on the shop floor since, by definition, the lower level systems from the hierarchical control structure cannot by themselves move a job out of the packet given to them by a higher level. The reason for the failure must be reported as feedback to the next higher level, where action is taken. Another point is that in spite of the virtual cell being defined as a step of an evolutionary process, that begins with the GT cell and the automated cell, it does not seem that they take into account the advantages obtained by GT, since they emphasize the cell definition only regarding the system control software (Simpson et al., 1982).

- The scheduling architecture from Drolet (1989) also does not make use of the GT advantages and therefore creates for each order a virtual cell to process it, similar to the multi-agent control architecture from Rabelo (1994) that generates as many consortia as prepared orders to be executed.

- Irani, Cavalier and Cohen (1993) propose a very interesting approach taking into account the layout design while defining GT cells. Based on mathematical programming and graph theory, they developed an algorithm to optimize GT cell formation based on the possibility of intercell flow. In doing so, they facilitate machine sharing between adjacent cells - which the author considers as a very important step in the configuration of a virtual cell - but they did not give subsidies (such as resource management information, coordination strategy, etc.) for the configuration of a virtual cell. Furthermore the nonadjacent intercell flow is not considered.

- The method by Tönshoff and Glöckner (1994) presents firstly implementing a computer system to allow the configuration of the logical cells, and secondly realizing a reorganization on the shop floor by means of formatting a physical cell. To the author, the most reasonable sequence is firstly the shop floor reorganization and secondly a computer support implementation.

In the next subsection the new concept of virtual production areas will be presented as an attempt to minimize the deficiencies imposed by the virtual cells above-described. This constitutes the proposed organizational element of the triadic model of the Learning Enterprise for the development of an approach to conceptualize Learning Enterprise in the manufacturing sector.

3.1.2 Extending the Concept: Virtual Production Areas

It may be appropriate to begin with the taxonomy of the suggested term. The words, carefully chosen, aim at giving the readers the correct notion of what the author intends to present in this subsection: *virtual*, because they will not be restricted to a given physical space; *production*, to emphasize that manufacturing as well as assembly are to be considered; and *areas* - perhaps because English is not the author's mother tongue - because the word 'cells' has for the author the connotation of 'prison', i.e. a closed, limited and fixed space.

It has already been explained at the beginning of the section 3.1 that, no matter how carefully groups and families have been planned for GT, there will still be cases where temporary intercell flow is necessary. Nevertheless, in the classical point of view, attempts to transfer work to and from other groups should be avoided because such movements are very difficult to schedule and control, and are a major cause of low manufacturing reliability (Burbidge, 1993).

To cope with these constraints the Learning Enterprise offers the possibility of a dynamic, agile and adaptable behaviour in the form of virtual production areas, where intercell flow is allowed and subsidies for an adequate schedule and control are given.

The new concept of virtual production area (VPA) introduced in this work highlights the ability to reconfigure temporally the shop floor layout, which was previously designed according to GT principles and optimized with regard to coherent criteria, allowing intercell flow even among nonadjacent GT cells being supported by schedule and control facilities.

In this way, the configuration of VPAs permits that some classical GT rules can be broken without loosing or eliminating the benefits and advantages obtained with GT (improvement of the material and information flow on the shop floor). Furthermore, layout design aspects should be incorporated while formatting GT cells, such as the flexibility provided by the functional layout and handling systems (Irani et al. 1993) which facilitates machine sharing, or the consideration that one worker can attend to more than one workplace, facilitating worker sharing. Summarizing, it can be said that the layout planner should always be aware of the possibility of some kind of resource sharing (machines, tools, support equipment, workers, etc.) in order to achieve the most efficient shop floor layout and should remember that many factors can force intercell flows (machine breakdown, bottleneck machine, introduction of new parts, etc.).

In comparison with the original definition by AMRF, the VPA is not a logical cell in the sense of being generated by a system control software; nevertheless it is a logical process since it is created by mental models (Gottschalch, 1991) normally developed by the foremen who are supported by shop floor schedule and control capabilities, i.e. the necessary information which is available on the shop floor.

The necessity for the configuration of a VPA always appears when a production order cannot be completed by just one GT cell. Thus, the needs of each individual 'exception' order are considered by the foreman responsible for the related order who analyses the internal and external cell resources (technological and human). Furthermore, through a horizontal coordination level (see section 3.3), the possibilities of forming a VPA to address the 'exception' order requirements are discussed and the most suitable one is chosen. For this to succeed, short-term planning, monitoring and control activities must be available on the shop floor in the sense of autonomy and complete responsibility.

Consequently the feasibility of a VPA depends on the involvement of two other components: (1) a technological element that will provide the required information and (2) a human element to process and interpret the information and to make decision. The next two sections describe these components. Firstly, shop floor monitoring and control systems are presented as a way to perform a shop floor information system. Secondly, the concept of human networking is suggested for the coordination activity indispensable for the configuration of a VPA.

3.2 Technological Element

According to the APICS dictionary (Wallace and Dougherty, 1992), shop floor control (SFC) is a system for utilizing data from the shop floor to maintain and communicate status information on shop orders (manufacturing orders) and on work centers. In Brennan (1994) the basic activities of a shop floor control system are categorized into four activities: short-term planning, execution, monitoring and control.

There could be some discussion as to whether these are complete or 'correct' definitions, particularly in view of the vast range of manufacturing circumstances that exist. They may well require adaptation to encompass the full range of related functions for a particular organization. Such a discussion would merely serve to highlight the difficulties associated with a concise and acceptable definition of the problem area covered by the term 'Shop Floor Control'. So, once again the absence of a common international terminology leaves us with a large number of expressions - often used as synonyms in spite of differences in their definitions- such as shop floor scheduling, short-term planning and control, detailed scheduling, and so on.

In this work the term used is *shop floor monitoring and control -SMC -* (an approximate translation of the German term 'Werkstattsteuerung'/'Leitstand'), as a system responsible for the implementation of short-term planning and scheduling activities, dispatching, execution, monitoring and control as well as the allocation of resources in the forms of labour, tooling and equipment to the various orders on the shop floor. Generally the needed input is provided by production planning and control systems (PPC systems), which are responsible for long-term planning activities, as well as by data collectors, which give the feedback of the shop floor status. Legacy systems (Seabra Lopes and Camarinha-Matos, 1995), i.e. already existing systems in the industry, may also be used as input data for the SMC system; in this case, interfaces must be provided.

The shop floor monitoring and control system is therefore not a module of the PPC system, but a system that is supposed to close the gap between the planning and execution phases of manufacturing system. The global architecture of a shop floor monitoring and control system adopted in this work is based on Boonstra and van Langen (1992, P.53) and Bullinger and Hirsch (1994, P.45) and is represented in figure 3.2-1 with its possible interfaces.

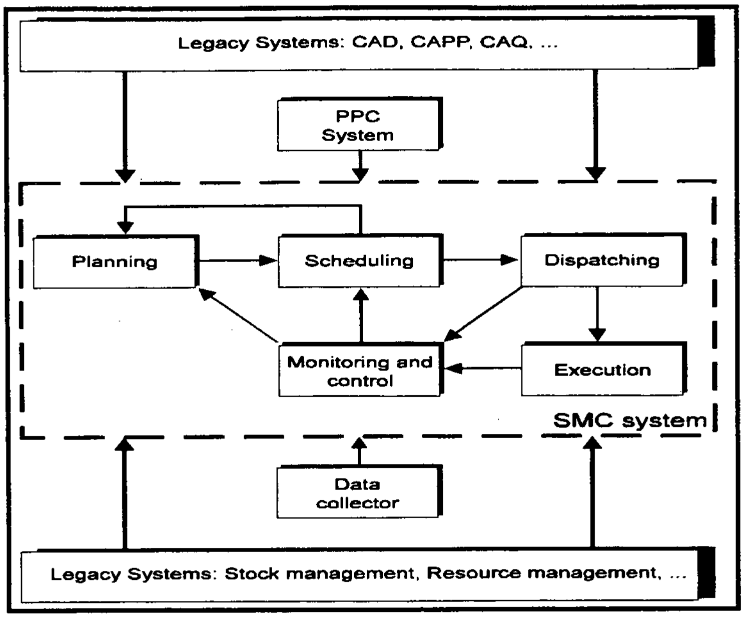


Figure 3.2-1 The global architecture of a shop floor monitoring and control system and its interfaces

The evolution of the technological support on the shop floor has an interesting history. Beier (1991) tells that at the beginning of the twentieth century the foremen had only some designs and a bill-of-material at hand. Making use of them, the foremen should plan and schedule the orders that came from the design department, mostly in accordance with a verbal due date.

With the development of some convenient methods, for instance the possibility of copying neutral work plans and orders, the REFA Method has announced a new era for the shop floor: flow cards, work plans, material and time/payment cards have led to a substantial challenge in the shop floor. On the one hand, it was possible to better organize and coordinate the even more complex products and their associated material flow. On the other hand, the even greater deal of paper on the shop floor transformed the pragmatic foreman of the manufacturing and assembly area into a bureaucrat dealing with a large amount of cards inside his office. Gradually the office walls were used to hang the contents of the card box showing a chronological dependence. This chart, nowadays well known as 'Gantt' chart - the earliest and best known type of control chart , named after its originator, Henry L. Gantt-, shows the activities to be done, the order in which they should be done, the time that they take and their due date.

Even with the improvements occurred in recent years with the wall charts, they remain problematic, to be applied in the production of small batches and mainly one-of-a-kind products (Heeg, Meyer, Pereira Klen et al., 1994). The frequent modifications in the sequence of order processing and the difference in the processing time of orders or operations involve a constant up-dating of the chart, which results in a great expenditure of time and money.

The computer support arrived in the mid-eighties, and since then the electronic chart has made further differences in functionality and software developers i.e., only in Germany, the birthplace of such systems, there are around fifty systems on the market (Vöge, 1995). These systems, from now on called SMC systems (Shop Floor Monitoring and Control systems), were classified by Hoff et al. (1993) and Vöge (1995) into categories. The classification of von Hoff was adopted by Vöge and modified from three to five categories. According to the objectives of this work, the classification from Vöge will be adopted (figure 3.2-2).

3.2.1 Categories

The first category, 'electronic chart', is responsible for short-term planning, scheduling and monitoring activities. It originated from the improvement on the wall charts and was developed for the serial and line production. The systems available in this category represent 17% of the total, and correspond to the first generation of SMC systems.

SMC Systems Categories		Name of the systems	Percentual of the total
I	Electronic Chart	AHP, BS-1000, DROPS, FELIX, ICAM, infor, SHIPS	17%
II	Quasi a PPC Module	DAT, DASS, DIAPROD-FLS, ECI-FLS, factory tower, FASIM-X, FDS, INTEPS-FLS, LOGO-LS, Master-Plant, OPS, PROVISOR, ProMon, rwt-GFL, Strato, Wille 2	36%
III	Stand-alone system for shop floor planning and scheduling	ADICOM, Workstream, Factor, FELIS, FMS-300, Hydra, PROCAM, PIUSS, Schedule	21%
IV	Total-conduct system	ABB, becos, HBF, AIX-FLS, MCL-PRO/LS, Observer, Leitwerk, PAS-PLAN	19%
V	Planning and Scheduling instrument for decentralized manufacturing areas.	IDS, MAO-FLS, ooL	7%

Figure 3.2-2 Association of SMC systems (regarding to the German market) to the categories (Vöge 1995, P. 22)

The 'quasi a PPC-module' category represents the systems that were developed as a complement of the PPC (Production Planning and Control) systems to support the PPC activities on the shop floor. The main function of these SMC systems are the optimization of the plan generated in the PPC level, the verification of resource availability, as well as the representation of documents (designs, bill of material, work plan, etc.) - either visual, on the computer screen, or electronic, to allow data transfer. Most of the available systems (36%) fall under this category.

In the next one, 'stand-alone system for shop floor planning and scheduling', the modular characteristic of these systems is a very important point. They are 'built' from different applications that are put together making these systems very configurable and autonomous. Some of these systems, for example those which have an 'order management' module, do not need a PPC system, being able to work as a 'stand-alone' system. They correspond to 21% of the systems on the market and are applied mostly in classical organization forms (process and line layout). In accordance with this category it can be found in the United States the Manufacturing Execution Systems (MES) model, developed by the Advanced Manufacturing Research (AMR) (see appendix 2).

With 19% of the systems, the 'total conduct system' category was conceived to attend the process industry which works with a large number of pieces, fixed times and little process variation, supporting logistic production.

The last category, 'planning and scheduling instrument for decentralized manufacturing areas' originated from research projects (Hars and Scheer, 1993; Habich, 1990) aiming at developing a tool to support decentralized process layout and production cells. Systems in this category are few - just 7% - and the requirements concerning them are many. Most of the research and prototype development of this category carried out in the recent past or at present is restricted to the academic environment (Drolet et al. 1989; Habich 1990; Tönshoff and Glockner, 1994; Ferstl and Mannmeusel, 1995) and this explains the few systems on the market. In addition, a so called 'coordination level' is needed to synchronize the activities of the decentralized areas. Maßberg (1992) speaks about centralized and decentralized synchronization; Hirsch and Kuhlmann (1992) and Hirsch, Kuhlmann and Maßow (1995) speak about vertical and horizontal harmonization (sub-section 3.2.4).

Considering that the main goal of this work is the development of an approach with the aim of supporting the configuration of a virtual production area, it is reasonable to state that the fifth category of the SMC system classification is very significant, due to its character originally decentralized, and will be therefore the subject of further study. The second and third categories are also important, due to their strong and intensive presence in the market and, despite the limitations regarding their application in decentralized and partially autonomous areas, if adequately analysed, evaluated and selected, some of the systems of these categories can also be implemented in a decentralized way taking into account that the sense of responsibility and decision-making is demanded on the shop floor. This consideration gives greater flexibility in the utilization of available systems on the market, as well as allowing an incremental application of the approach presented in this work.

From here on, systems from any of the categories II, III and V, that can be applied in a decentralized way, will be called 'distributed shop floor monitoring and control systems' (DSMC). The first and fourth categories do not meet the objectives of this work - since they were conceived for serial and line production as well as process industry - and will not be considered.

The next two subsections present the functionalities of SMC systems and how these functionalities could be better utilized and improved in order to develop DSMC systems to support the configuration of VPAs.

3.2.2 Functionalities

A functional model of a SMC system (figure 3.2-3) was set up by characterizing the main functions and the organizational structures of the shop floor level (Pereira Klen, Vöge and Hirsch, 1993b; Bullinger and Hirsch, 1994), based on the current literature and on customer's requirements. Eight main functions were identified as being very important for a SMC system. Using the developed model, nine SMC systems - previously analysed and preselected in a market survey - were analysed by means of software presentation and direct dialogue with the developers. That is why the survey did not concentrate on the detailed functionalities of the systems but on their concept, possibilities of implementation, innovative aspects and development perspectives.

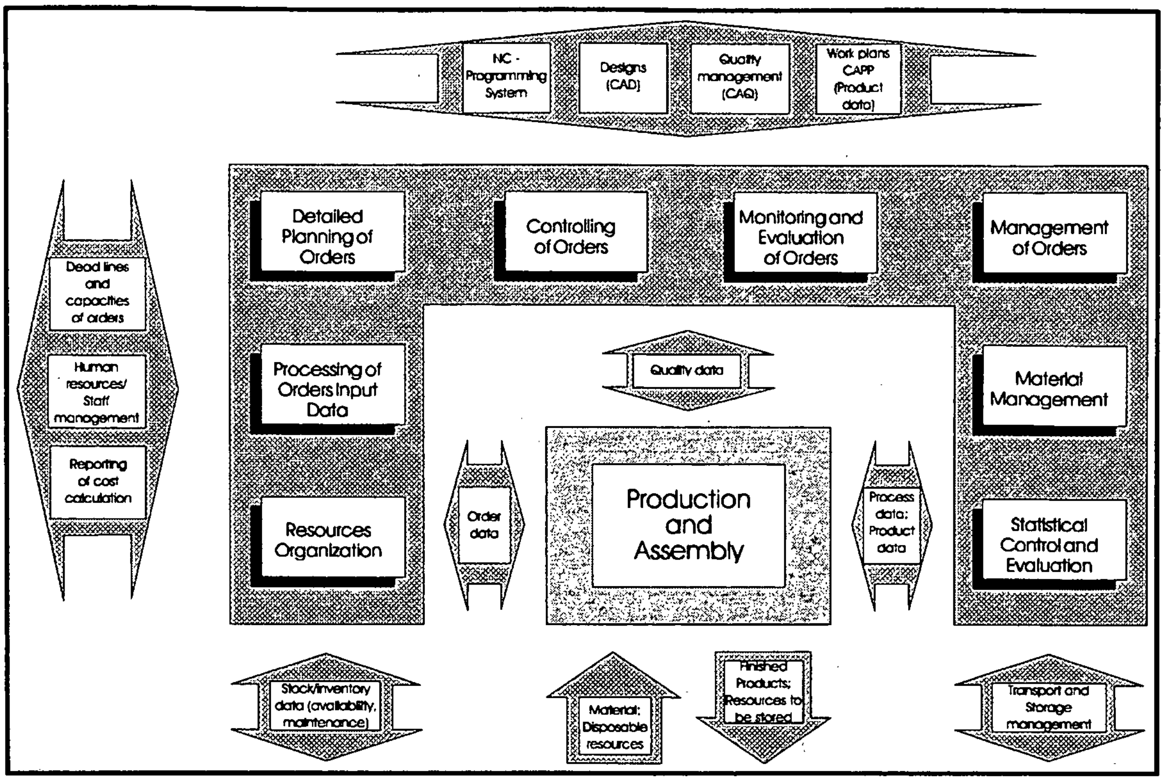


Figure 3.2-3 Shop floor control task model (according to Pereira Klen, Vöge and Hirsch, 1993b; Bullinger and Hirsch 1994, P.53)

The functionalities have also been analysed by the attentive eyes of some foremen who were involved in the project. This was made possible by means of comparative tests (Vöge, 1995) carried out in the CIM Application Laboratory* implemented at BIBA.

The functions will be presented below, associated with some screen drafts developed by the author during the definition phase of the task model (Pereira Klen and Vöge, 1992), and in accordance with the requirements and wishes expressed by the project partners from industry. In other words, it can be said that the individual learning of the industry people was jointly used to propose some modifications and improvements in the existing SMC systems, thus generating an organizational learning in this area that constitutes an effort to become a Learning Organization.

Resource Organization

In order to plan and to schedule the manufacturing orders on the shop floor, the necessary resources must be available in the manufacturing or assembly area in the right place and

* The laboratory enables manufacturing companies to test tools and techniques such as shop floor monitoring and control systems in a real time environment.

at the right time. The resources to be considered are: workers (despite the much greater importance of the people in the shop floor, SMC systems see the workers as a formal resource), machines, tools, fixtures, work places, transport means, work material (depending on each industry).

Considering that sometimes some resources are required by different orders at the same time, the availability of the resources must be investigated (note that sometimes it is possible to have the overlapping of resources, for instance, when a worker works at two machines simultaneously). Summarizing, the resource organization function should provide information about the status of the resources for the orders and should also support their implementation by means of (figure 3.2-4):

- verification of physical availability,
- reservation for a determined order,
- determination of the date of supply,
- verification of their functional capability and
- taking them to maintenance, when necessary.

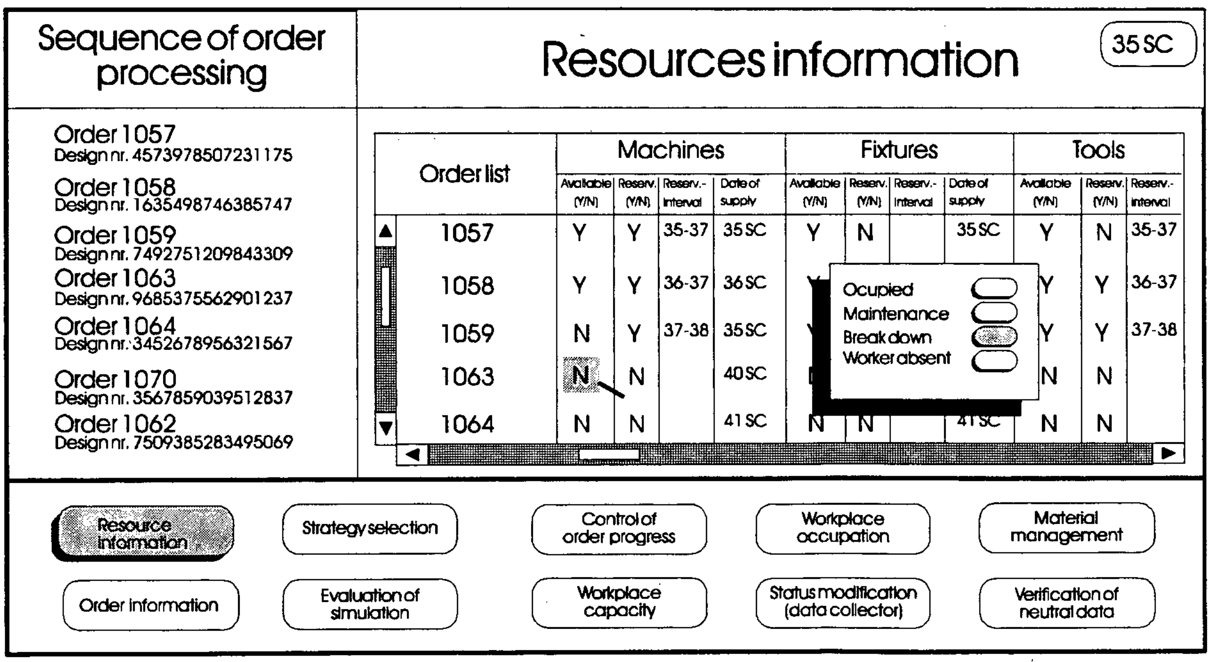


Figure 3.2-4 Resource organization

Processing of Orders Input Data

If the SMC system has interfaces with other systems, such as a PPC system, the input data of the SMC system concerning the manufacturing orders must be transferred to the SMC system. In the case of a stand-alone SMC system, the data must be given directly in the SMC system. At all events, the information required for manufacturing orders is:

- earliest start date and latest end date,
- planned capacity (equipment, work force, etc.),
- description of the operations (process time, production processes, required tools, etc.),
- bill of material (quantity, batch size, order and design number, etc.),
- NC program and the related information and
- standards and work plans.

Depending on the case, not all information described above is available or even required. It is a task of the system users to define what kind of data is important and needed on the shop floor or not. Unnecessary information must be avoided in order to make the system agile and to increase the transparency of the data for the users on the shop floor. Figure 3.2-5 translates the manufacturing order information requirements of the foremen of an industry analysed during this study.

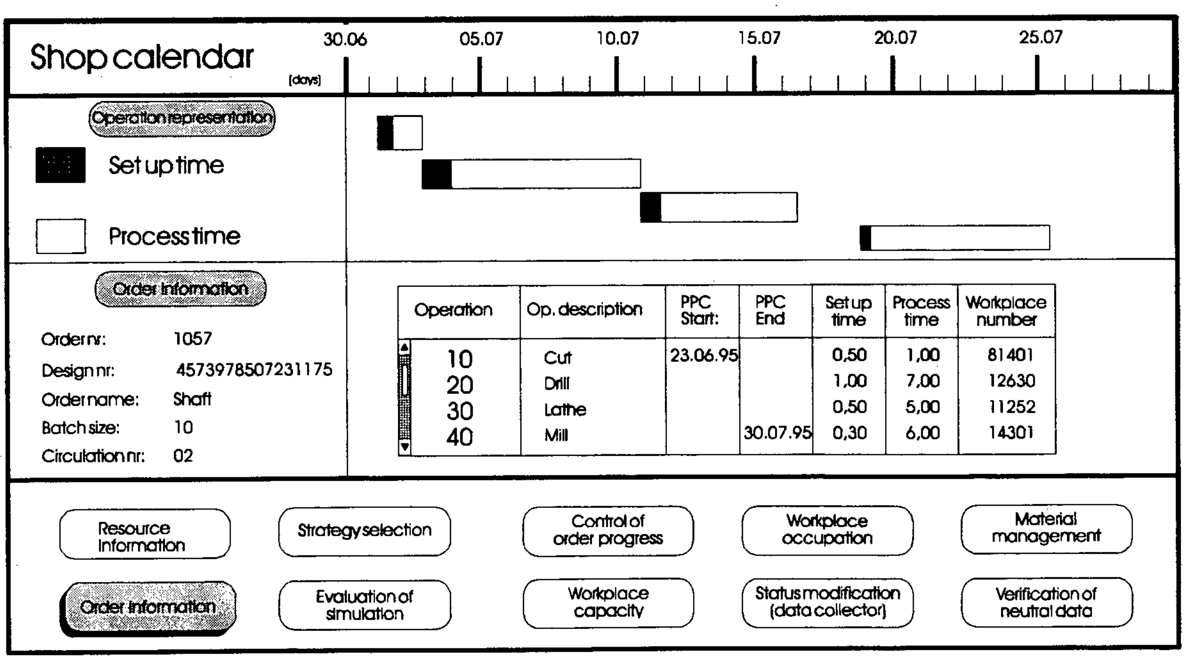


Figure 3.2-5 Representation of order information

Detailed Planning of Orders

This function is responsible for the detailed scheduling and the dispatching of orders and operations. In order to allow a consequent schedule, it is necessary to update the shop floor situation. This is made possible by the function 'management of orders'.

The logic used to assign priorities to operations or orders represents the different strategies that can be used for dispatching: FIFO (first in first out), due date rule, bottleneck rule, etc. (figure 3.2-6). The detailed planning can be automatic, or can interact with the user. If it is an automatic planning, the user still has the possibility of making modifications, corrections or even of planning another variant after the software simulation. For the planning to succeed, only the alternatives in which the resources are available are considered (the module resource organization provides these information). It must also be possible to fix an operation or an order that, if desired, should not be rescheduled, and the possibility to compare the different strategies simulation should also be offered by the system. The criteria for this comparison and further information with regard to the orders depend on industry requirements. Figure 3.2-7 shows some of them.

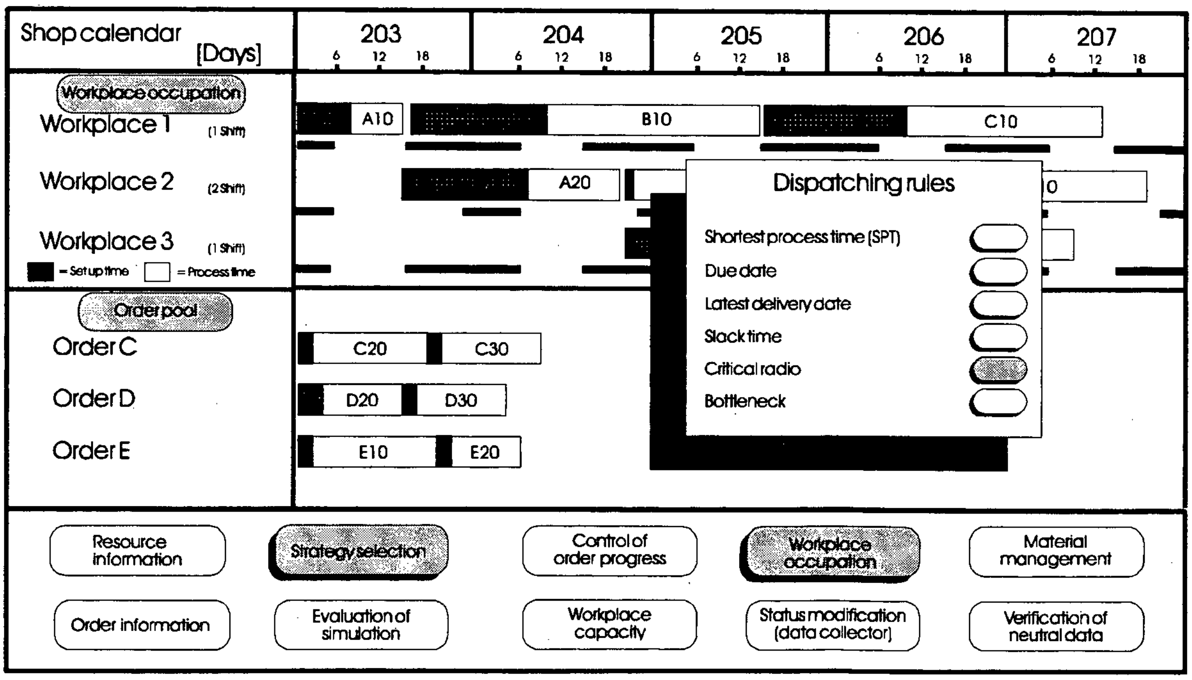


Figure 3.2-6 Sequence of order processing concerning workplaces occupation and strategy selection

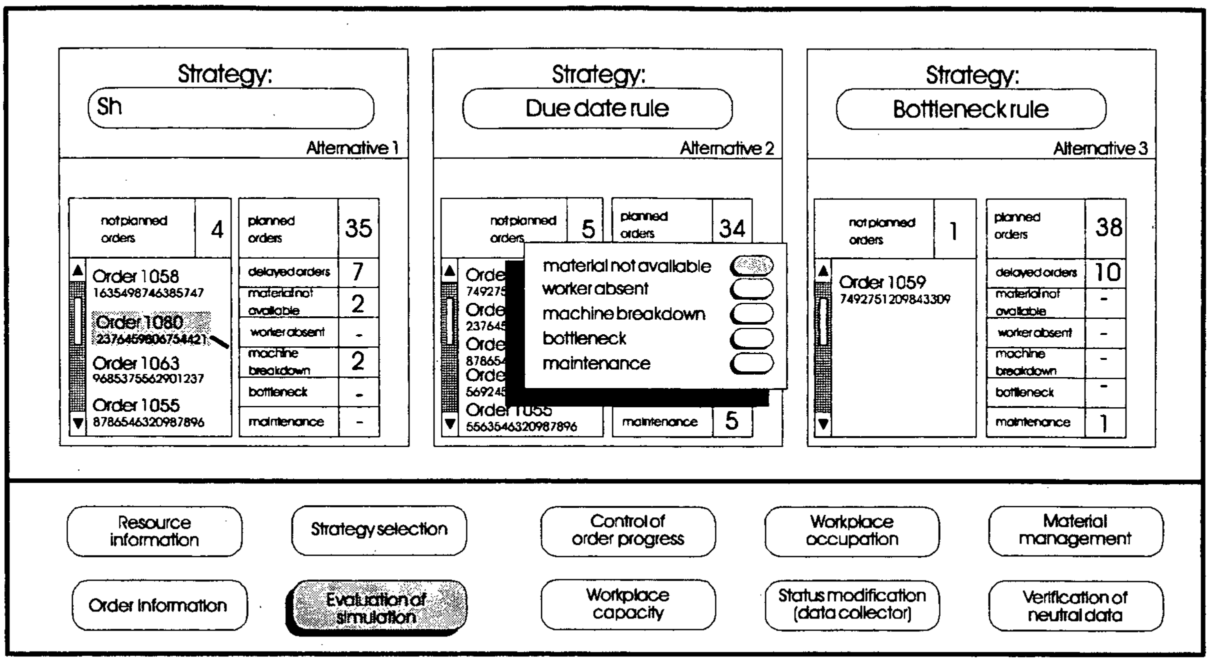


Figure 3.2-7 Comparison of strategies simulation

Controlling of Orders

The control of the orders comprises the following activities:

- order release,
- order control and
- reaction to plan modifications.

In the order release, a signal (for example blanket releases) is sent to the shop floor authorizing the production or shipment of material which has already been ordered. This can happen, for instance through the print of the required work documents on the shop floor.

Order control is responsible for following the order progress on the shop floor by means of short and fast feedback from the shop floor with regard to some 'key' operations/orders, as well as the observance of dates, throughput time and quality data. The graphic presentation occurs in the 'monitoring and evaluation of orders' function where the operations of an order can be presented, showing the relationship between planned performance and actual performance (figure 3.2-8).

In the case of occurrence of unexpected events (equipment failure, urgent new orders, etc.) or when the feedback from the shop floor reveals a delay or an advance in an order or operation, this involves a plan modification. The rescheduling is done in the 'detailed planning of orders' function and can include tasks like overlapping and splitting.

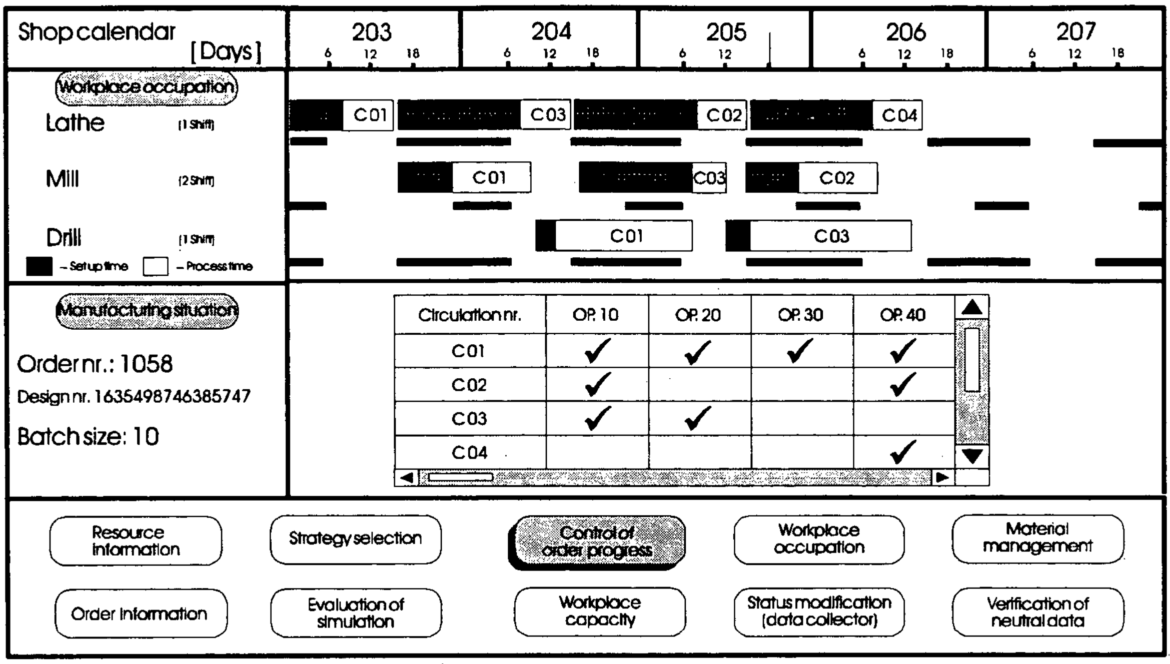


Figure 3.2-8 Control of order progress

Monitoring and Evaluation of Orders

This function is composed of traditional 'follow-up' activities and also makes possible an alphanumerical and/or a graphic representation of relevant data (of orders, equipment, etc.). With this representation, the data can be analysed and evaluated by the foremen, supporting them in decision making. In order to keep the data updated, important data must come from the shop floor, for instance, via data collectors. Figures 3.2-9 and 3.2-10 show some alternatives that were identified as very interesting for such a function. In 3.2-9, besides the Gantt chart containing information about operations and the associated time horizon, there is also information about the machines' capacity by means of balk diagrams; in 3.2-10 the shop floor is represented in an innovative 'machine chart' that shows the machines being manufactured on the shop floor with the corresponding order/operation, as well as further information about them.

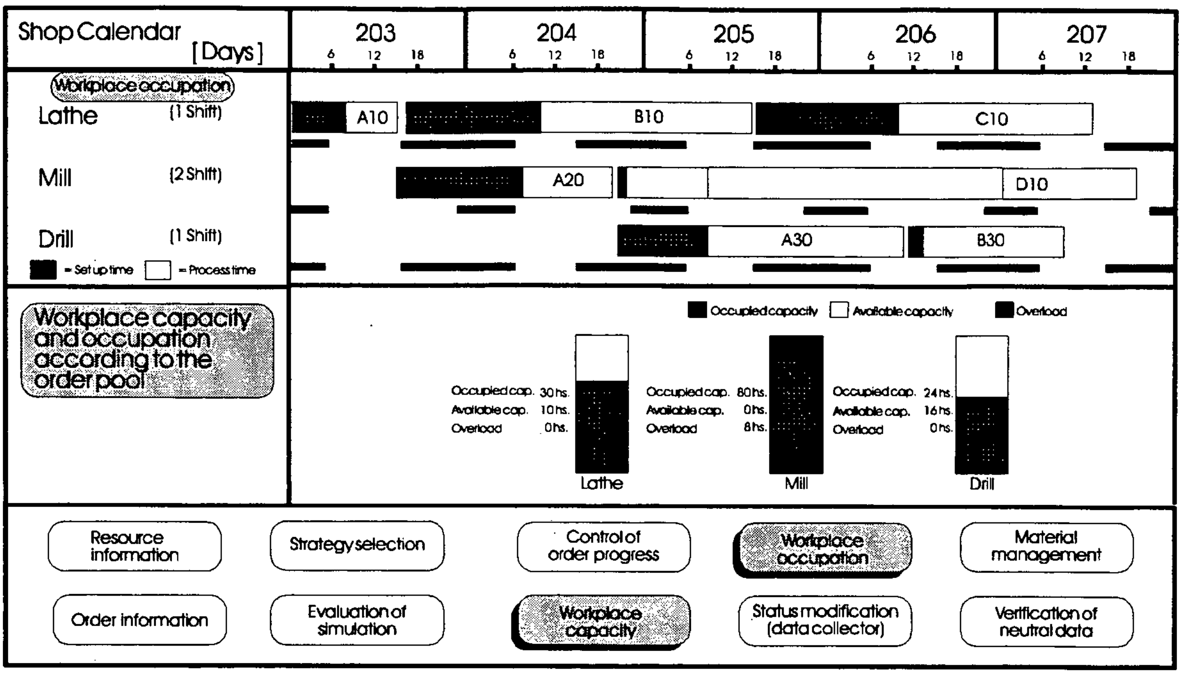


Figure 3.2-9 Representation of workplace capacity and occupation

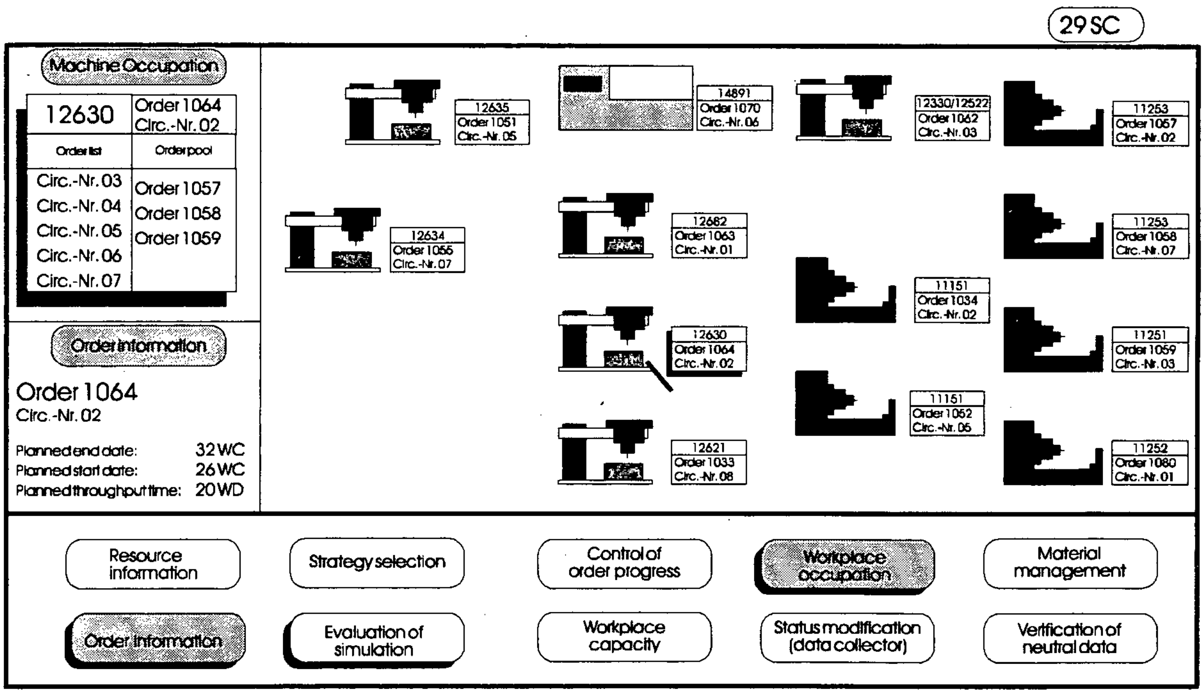


Figure 3.2-10 'Machine chart'

Management of Orders

This module is required to store, modify and manage data resulting from neighboring systems that will be used by the module's detailed planning, control and monitoring and evaluation of orders. Depending on the industry requirements, it must be specified which data really make sense to transfer to the SMC system. Once again it is convenient to mention that the effectiveness of the system does not depend on the amount of the information it has, but on the kind of information it has. This statement is valid for order data (date and time information, batch size, bill-of-material, etc.) as well as for neutral data (available machine capacity, work/shop calendar, neutral work plan, shift plan, etc.).

Material Management

Due to its importance, material for parts has its own management module. For an efficient shop floor control, it is necessary to get information not only about the planned material availability but also about its physical availability. In the case of unavailable or insufficient material besides the rescheduling it must also be possible to intervene in the material acquisition process. This can occur through the access to an inventory management system or a direct connection with the supplier. The necessary communication channels should be provided.

This functionality works together with the module's resource organization and detailed planning of orders. The main activities of this module are (figure 3.2-11 presents some of these activities):

- verification of physical material availability,
- reservation of material for scheduled orders,
- identification of parts and material,
- planning and control of material shipment,
- registration of the inventory status
- communication with suppliers,
- ordering of required material.

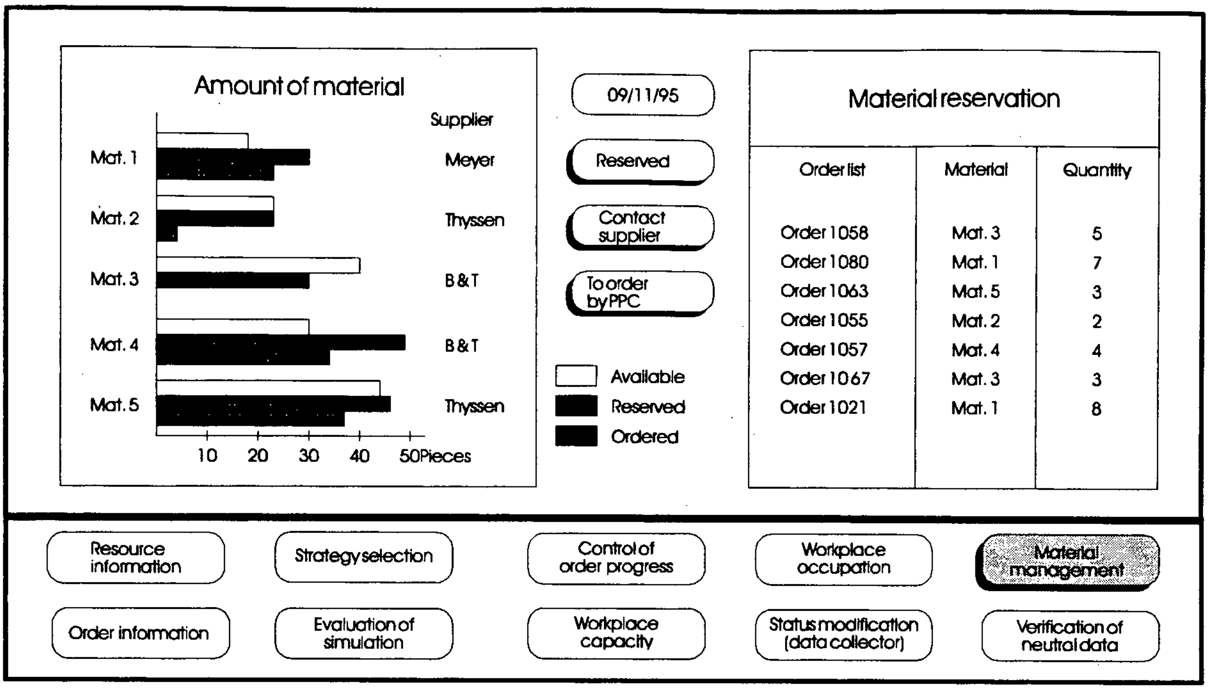


Figure 3.2-11 Verification of material availability

Statistical Control and Evaluation

Even after selecting and giving priority to the information that should be transferred to the SMC system, this still constitutes a great amount of data. In order to support end users of the system (foremen or blue-collars) in analysing and evaluating the weak points on the shop floor, such as bottleneck or source of disturbance, the statistical control and evaluation module is suggested. This module can be the starting point for significant challenges such as a reorganization of the shop floor or even a technical development. The use of a relational database facilitates the application of this module.

3.2.3 Distributed Shop Floor Monitoring and Control Systems

Shop floor monitoring and control (SMC) systems were developed to support people involved in the production, e.g., foremen and blue-collar workers with the tasks of detailed planning, scheduling, monitoring and control of orders.

On the one hand, decentralized and partially autonomous production areas, such as production cells, require the decentralization of planning and control activities; in this case DSMC systems can be helpful means. On the other hand, the reconfiguration of production cells in virtual production areas, due to the needs of each individual 'exception' order, requires a high level of information exchange, communication and coordination as well as a harmonious integration of the process chain and between data and functions (Pereira Klen, Vöge and Hirsch, 1993a, Maßberg, 1992).

For this to succeed, DSMC systems should strengthen their functionalities with respect to the following modules (figure 3.2-12):

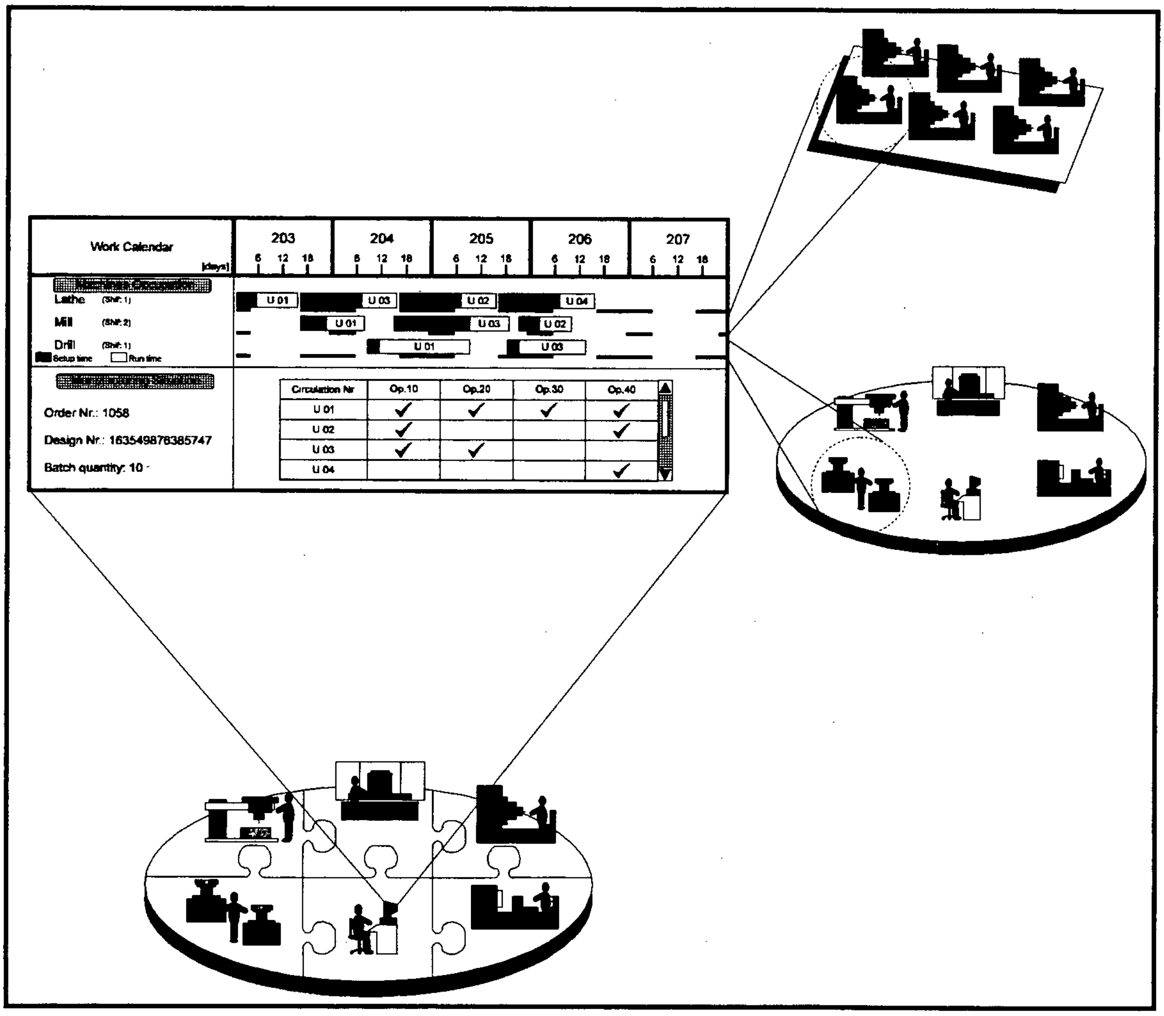


Figure 3.2-12 DSMC system (according to Maßberg 1992, P.60)

1. Resource Organization: to provide information access to the decentralized and partially autonomous areas, regarding not only the internal resources but also the external resources, in order to make possible the configuration of a virtual production area. This means that DSMC systems should allow the access of resource information to different decentralized and partially autonomous production areas at the same time.

2. Monitoring and Evaluation of Orders: this can be seen as an aid for decision-making, which increases shop floor transparency by means of information regarding orders and machines, giving subsidies for the user for making decisions. The information can appear in form of Gantt chart, bar diagrams, network plan, tables, etc..

But to support the configuration of a flexible structure, such as a Virtual Production Area, the acceptance and utility of a DSMC system depends not only on their functionalities; it depends much more on the coordination and integration of functions and information.

At the shop floor level this represents the need for a synchronization of the decentralized and partially autonomous production areas. Two coordination possibilities are to be considered and will be presented in the next subsection.

3.2.4 Coordination levels

This is a subject of great importance for the configuration of virtual production areas. Considering that such areas are formed due to the requirements of specific (or 'exception') orders, for instance when order operations must be manufactured or assembled in more than one decentralized area, there must be a way to coordinate these activities without resulting in a shop floor chaos.

Authors (Maßberg, 1992; Hirsch and Kuhlmann, 1992; Hirsch, Kuhlmann and Maßow, 1995; Bullinger and Hirsch, 1994) are unanimous about two coordination levels. The coordination functions, however, differ in some aspects.

Hirsch and Kuhlmann (1992) decompose production planning and control into hierarchical structured planning levels suggesting a change from the classical 'deterministic' scheduling and capacity planning towards a layered, revolving production planning and control, consisting of decentralized independent planning, a control level for autonomous manufacturing facilities and the centralized superior planning level. For this, they classify the approaches of harmonization in: (1) number of planning levels involved: harmonization can be performed both horizontally, i.e. within one planning level, and vertically, i.e. between two or more planning levels; and (2) technique of harmonization: by constraints, by intervention and by reciprocal synchronization.

Furthermore, vertical harmonization or the centralized coordination should not be performed and supported by a single system, but should be integrated into the rough planning system, i.e. the PPC system, and should consist of the following functions: process planning, as well as scheduling and capacity planning which is divided into five subfunctions: time frame scheduling, simultaneous scheduling and capacity planning, production order release, subcontracting and cooperative coordination. Horizontal harmonization or decentralized coordination includes the function of information transfer and cooperative synchronization. Figure 3.2-13 shows the planning and control modules of the above production coordination system. In this figure, the term 'Autonomous Production Area' corresponds to what the author designates in this work as 'decentralized and partially autonomous production areas'. The reader is referred to figure 3.4-5.

It is important to point out that the authors suggest both for cooperative coordination (centralized) and for the cooperative synchronization (decentralized), the use of computer-supported cooperative work (CSCW), with the aim of attending a conference with planners concerned.

Maßberg (1992) makes a similar description of the coordination levels of DSMC. This includes the centralized and the decentralized-oriented principle for the synchronization of DSMC (figure 3.2-14).

Centralized coordination, is accomplished by means of adapting the existing PPC functions through the installation of external software modules in form of an extra coordination level; this leads to a hierarchical PPC structure composed of three levels: PPC system, coordination system and DSMC system. The main functions of the central coordination system are: determination of the work flow planning of the orders coming from the PPC system; planning of order date; verification of capacity; allocation of the orders to the production cells; order control and data feedback to the PPC system.

Decentralized coordination is based on the information access to external resources, i.e. resources from different decentralized areas, which Maßberg calls 'reorganization of competencies' - and the author designates as 'reconfiguration and changing of roles' - and on a detailed planning algorithm to support order's scheduling concerning more than one decentralized area.

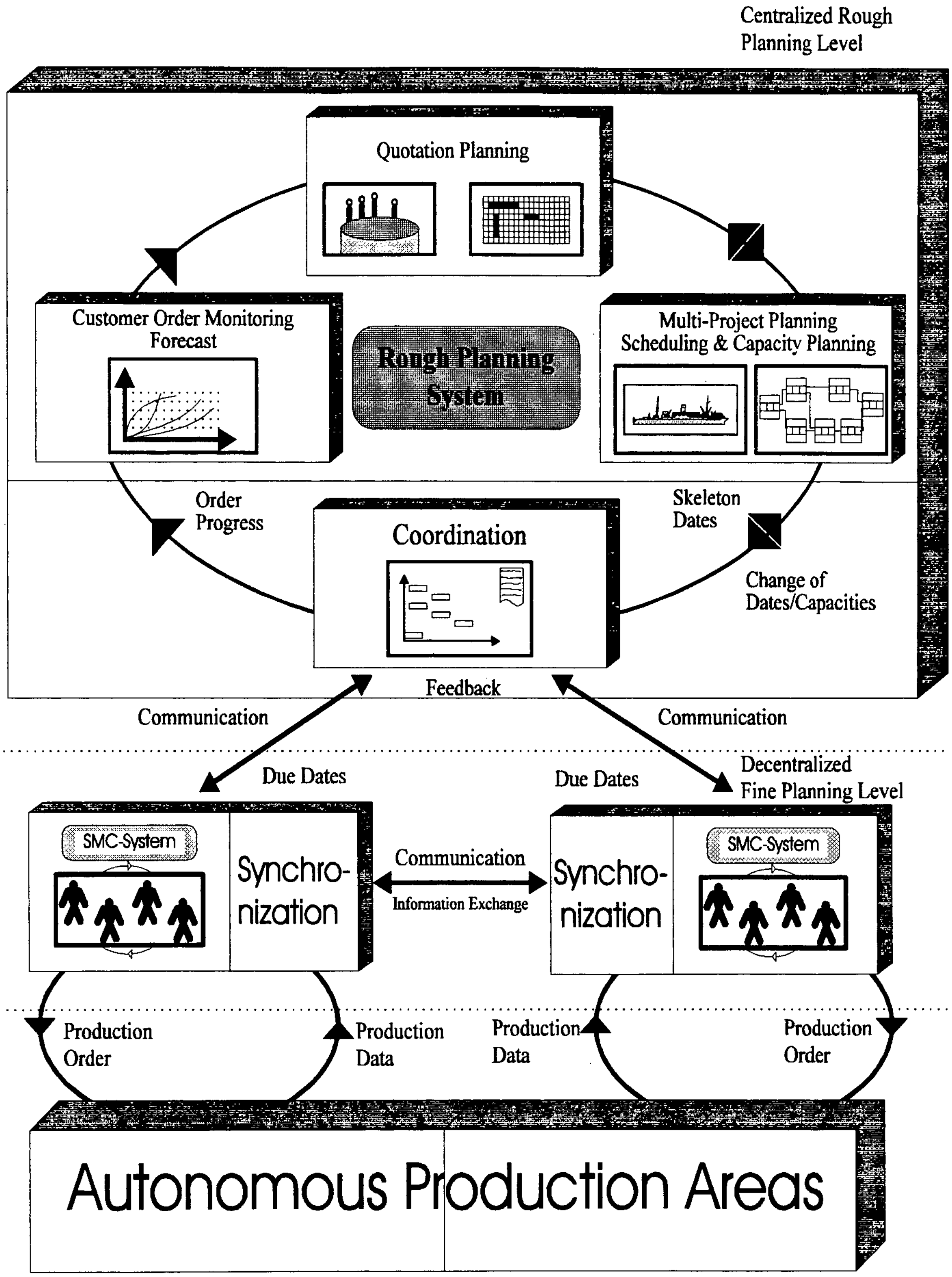


Figure 3.2-13 Planning and Control Modules of Production Coordination System (Hirsch and Kuhlmann, 1992)

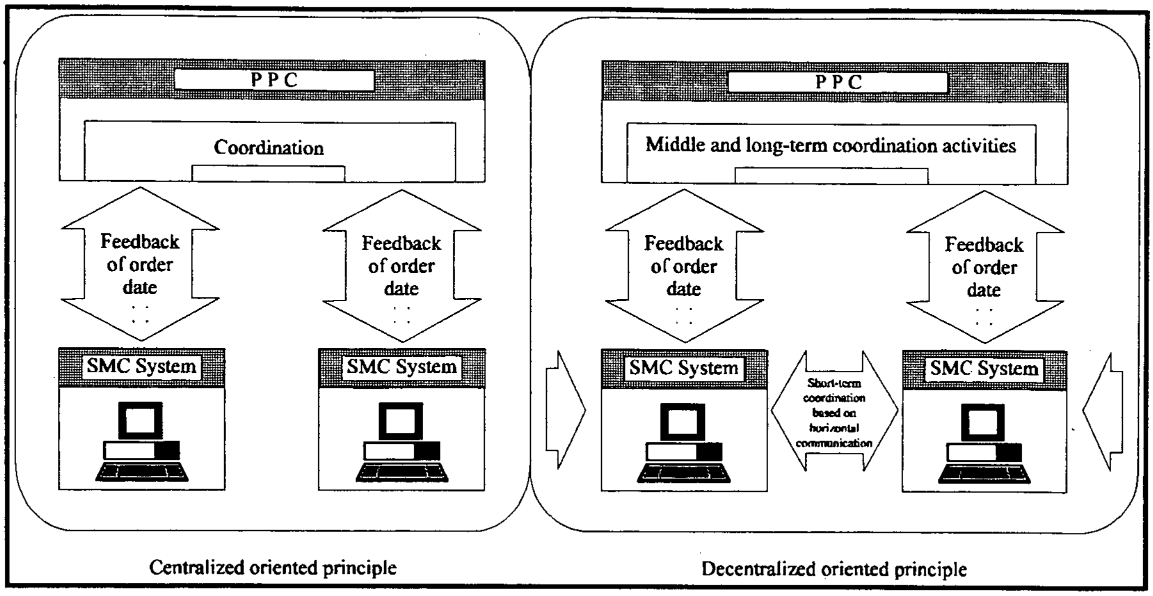


Figure 3.2-14 Coordination possibilities with regard to DSMC systems (Maßberg 1992, P. 51)

Other authors, who have also discussed this subject in relation to multi-agent systems and negotiation protocols, are Rabelo and Camarinha-Matos (1994) as well as Ferstl and Mannmeusel (1995).

In an exhaustive research (market and literature) carried out by the author mainly, but not only, in Germany, just one system was found on the market that has at its disposal a coordination mechanism from DSMC systems. This occurs through the superimposition of a coordination level over the DSMC level. The so-called horizontal coordination is however not implemented (Hars and Scheer, 1991).

The present work also takes into account two coordination levels (figure 3.2-15):

- Centralized coordination: by means of a distribution module which is responsible for the allocation of orders to the more suitable decentralized and partially autonomous area. The allocation criteria may be related, for example, to the location of the greater number of resources required for an order.
- Decentralized coordination: based on the transition from steep hierarchies to human networking supported by human communication management.

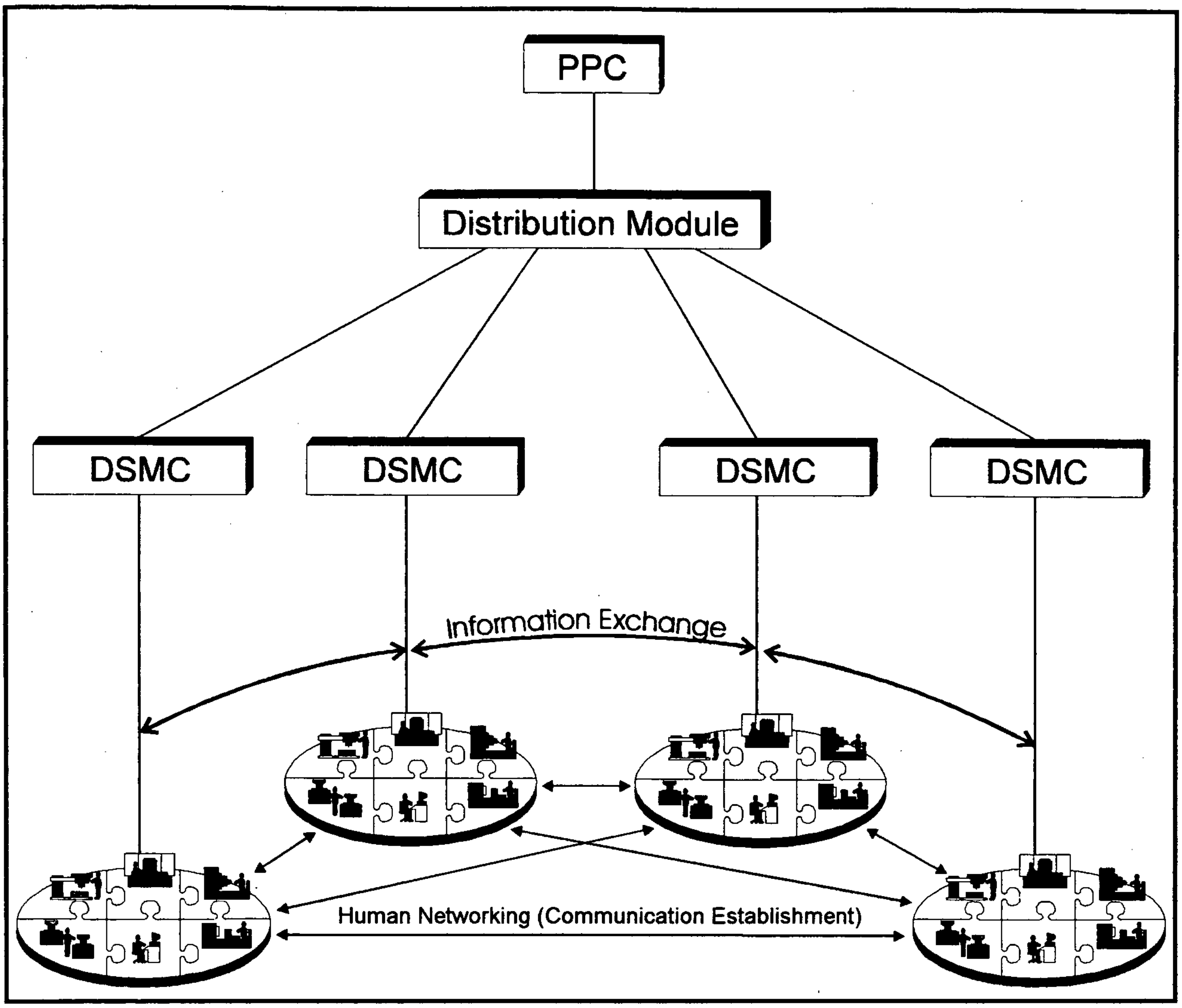


Figure 3.2-15 DSMC systems' coordination levels

In spite of the importance of centralized coordination and consequently the development of a distribution module, this work concentrates its efforts on the shop floor and therefore will consider the environment as being deterministic. In doing so, only decentralized coordination will be subject of this study, and will be described in the next section.

3.3 Human Element

In the beginning of the eighties the UTOPIA project, run in Scandinavia, was a project concerned with the human importance and influence in the manufacturing environment

(ESPRIT, 1990). A Danish/Swedish research team consisting of both social scientists and computer specialists collaborated closely with the Unions of Printers in Sweden. The objective was the development of a demonstration example showing that in a highly skilled labour force, more democratic decision making and a high level of health and safety are compatible with high product quality.

In Germany, similar themes are present in the social-shaping approach to manufacturing technology which has been developed in the last years. For example, Germany, together with Britain and Denmark, formed a consortium to develop the ESPRIT Project 1217 (1199) 'Human-centred Systems' (ESPRIT, 1990). The objective of the project was to produce human-centred CIM components, in which human skills and their application are optimized in harmony with leading-edge computerized manufacturing technology.

At present, two important and significant programmes in Europe are: the 'Manufacturing, Organization, People & Systems' (MOPS) Programme, funded by the Department of Trade & Industry (DTI) - England - and the 'Integration of Technology and Organization for Quality Production' - INTO (EU860), funded by the EU (Gillis, 1994).

Also important to be mentioned is the collaborative research activity between the European Union and the Latin America, within the two ECLA (EC-Latin America) projects of CIMIS.net and FleySys which have coined the term *balanced automation* to give the idea of an appropriate level of technical automation, as opposed to both the purely anthropocentric or the total automation approaches (Camarinha-Matos and Afsarmanesh, 1995).

This brief literature review shows how recent and relatively new is the attempt to put together social and technical scientists or even to make organizational-technological-human/social considerations within the enterprise in order to achieve a higher degree of internal as well as external equilibrium.

This means that there has never been, until recently, an awareness of real human methodologies, real human capabilities which underpin the actual use of computers. People have various way of speaking, of counting, of memorizing, of parsing sentences, of decoding messages, of approaching logic, or of organizing. Malone (1993) states that people have in their minds what can be described as 'facture': the manner in which something is made (and hence, *manufacture*). Other more systematic authors (Gottchalch 1991, Argyris 1994) call it *mental models*.

Mental models cover what Nonaka (1991, 1994) describes as 'tacit knowledge', i.e. the knowledge usually highly personal and deeply rooted in the individual's action and commitment, and therefore less formalized than explicit knowledge that is defined as being formal and systematic (public available). On the shop floor, tacit knowledge, or rather, the individual learning of the workers and foremen, is their experience, their detailed and up-to-date knowledge, their strategies, rules, problem-solving methods and decision-making processes developed over many years to cope with the not so frequently transparent shop floor situation (Bullinger and Hirsch, 1994).

For Gottschalch (1991) the background of the shop floor people is the most important point in order to make decision and develop plans in such a constantly changing and conflicting environment. He also states that the cognitive performance required to overcome short-term planning and scheduling activities on the shop floor is only possible when based on a mental model.

According to the objectives of this work, use will be made of workers' mental models, i.e. their available individual learning (tacit knowledge) due to two main reasons: (1) the people on the shop floor are able to perform a short-term reaction to overcome unexpected conflicts, providing a greater flexibility in the rescheduling activities and, extending their abilities in participating and negotiating, (2) they are also able to coordinate decentralized areas, if they are adequately supported. The next subsections describe how such support may be given.

3.3.1 Organizational Culture: Awareness of a Challenge

According to Deal and Kennedy (1982), organizational or corporate culture represents the organization's value system, strongly influenced by top management; corporate culture typically indicates how the organization regards its customers, suppliers, competitors, its environment, and its employees. Neergaard (1994) affirms that corporate culture is perceived as tacit amongst members and learnt and understood as the 'shared programming' of people within an organization. Furthermore, he states that it can be considered as a learnt way of perceiving, thinking and talking about problems which are learnt and transmitted to employees of an organization in an informal manner.

Thus corporate culture that refers to employees relies on their main value, i.e. their individual and collective knowledge that translates the whole organizational learning. Considering that normally all shifts bring with them value changes, the latest manufacturing paradigm shift, agile manufacturing, has brought with it also some value changes. In other words, the scale degree of certain aspects has considerably increased. Regarding the shop floor people, some of these aspects are especially important: motivation, participation, autonomy and delegation of responsibility, qualification, negotiation, as well as communication and information.

These aspects are very important at this point because the set of these concepts constitutes the basis for the establishment and good performance of cross-functional teams, which is the way to conceive VPAs and to 'link' decentralized and partially autonomous areas. The concepts mentioned will be briefly discussed, as follows, to illustrate the way in which the author understands them in this particular context. Thereafter cross-functional teams will be presented in the following subsection.

Motivation

In speaking of values, motivation comes at the right time. The culture of a Learning Enterprise adds value not only to products but also to people are encouraged to contribute to the enterprise goals. The ways of motivating employees were classified by social scientists (Strauss and Sayles, 1967; Deep, 1978) into five categories:

- Directiveness: based on the use of authority and economic rewards;
- Paternalism: based on fatherly treatment of employees;
- Compromise: based on give-and-take between superior and subordinate;
- Competition: that pits employees against one another for promotions, pay increases, and other benefits; and
- Participation: based on worker involvement in making decisions concerning the job.

On analysing the categories, some comments can be made: (1) directiveness motivates people only to produce the minimum necessary not to get fired; moreover, it creates frustration and other undesirable side effects. (2) paternalism might make people happy, but it is not very likely to provide through-the-job satisfaction. (3) Compromise is presented by the social scientists as the most realistic approach but at the same time as a negative form of motivation because both sides must settle for conditions they do not really want; furthermore it rarely furnishes any motivation to increase production. (4) Competition has only limited effectiveness as a motivation device on jobs where there is little opportunity for promotion or where seniority prevails; excessive competition may disrupt teamwork and lead to frustration and a host of undesirable side effects. (5) Participation is presented as the best form of motivation since it provides the greatest opportunity for individuals to satisfy their needs and develop their personalities, although it does not work equally well in all situations. For the conceptualization of a VPA the most suitable form of motivation is the last one.

Participation

The great advantage offered by this motivational approach is that workers are asked to participate in joint decision making with the manager/leader to the extent that they are capable of, and interested in, such involvement. This desirable attitude has been called by various authors 'spontaneous cooperation' (Mayo, 1945) and 'Theory Y' (McGregor, 1960). Other authors (Bartels, 1993; Vöge, 1995) have made considerations about participation under the focus of its regulation (formal and informal), form (direct/indirect, real/authentic, total,/partial/pseudo) and intensity (permanent/casual temporary/non-casual temporary/conforming to law).

With regard to shop floor two aspects are very important: (1) for effective participation to take place, significant responsibility must be given to the worker and (2) time-pressured deadlines (often the case of a shop floor) constitute a big danger for the participation since it may avoid democratic discussions of alternatives. Below, the responsibility aspect will be considered, and thereafter some mechanisms (qualification, negotiation, core competence and communication) to overcome the difficulties caused by time-pressure deadlines will be described.

Autonomy and Delegation of Responsibility

It is commonly accepted that the main difference between centralization and decentralization is the way in which decision making is organized and done: at one location or at several locations. If decentralized production areas are being studied it sounds acceptable to state that the decision should take place directly on the shop floor. In order to satisfy this premise, autonomy must be given to the workers involved and responsibility must be delegated.

Strauss and Sayles (1967) describe delegation as a form of job enlargement, since it gives the worker a sense of being his own boss and exercising control over his own environment.

Thus, it seeks to provide participation, and tends to offset the monotony and lack of autonomy that technology has built into many jobs. The exercise of autonomy and sense of responsibility may occur individually or collectively, in form of a group or team. Deep (1978) affirms that group decision making has certain advantages over decision making performed by just one person. These advantages depend upon the characteristics of the group, the nature of the problem to be solved, and the behaviour of the group leader (if it is the case).According to Deep, group decision making may be recommended when: a number of people share the knowledge for a decision; a problem requires finding new approaches; the group challenges a distorted view; acceptance of a decision by a group is needed; and group members need to understand the decision. But group decision making is not recommended when: social pressure will lead to conformity; conflict is likely to become destructive; one or two members are likely to dominate, for instance, making decision without previous agreement of the others; and time is limited.

In considering the configuration of VPAs, group decision making is very suitable when consensus of decisions is required. In fact, of the disadvantages related, the one that could disturb group decision making on the shop floor is that one concerning the limitation of the time. In this specific case the availability of the required information on the shop floor (in time!) could compensate for this deficiency.

Qualification

The changes undergone in the manufacturing sector during the last few years resulted in challenges also in the work behaviour. Moreover social questions are forcing the workers to change from specialists to generalists. People performing well more than one activity are seen as key persons since they promote more flexibility within the enterprise.

To achieve the status of a generalist or to be able to be flexible and agile enough, workers must be 'equipped', for instance, by means of training courses or education and development programmes. The main objective is to shape skills and abilities that will form the profile of an 'agile' worker, i.e. the worker that is prepared to act in an agile manufacturing environment. In Bullinger (1992) an exhaustive study regarding personal development and qualification can be found.

Once the author heard a very interesting comment on how to justify the necessity of qualification in industry. The foreman said: "Ask him (the boss) if he would allow a worker who does not have a driver license to drive his expensive Mercedes....In the same way (considering that the 'obvious' answer was *no*) he should not allow a worker to operate an expensive CNC machine without being qualified for that!"

Negotiation

There are some methods to manage conflicts: Deep (1978) classifies them as follows:

- Win-lose: when one side's gain depends on the other side's loss;
- Win-win: when both sides gain from the solution;
- Avoidance: when the conflict is ignored or one moves away from it;
- Smoothing: when differences are downplayed or mutual interests are emphasized;
- Forcing: when a solution is imposed on one side either by the other side or by an outsider;
- Bargaining: when both sides agree to a compromise; and
- Confrontation: when a conflict is managed through face-to-face problem solving.

For Deep, the conflicts that he refers to are those between individuals or groups. In spite of the great importance of managing conflicts - even because it is essential to maintain teamwork - the conflicts that will be considered in this work are more objective than subjective. This means that the conflicts are the ones originated from the production, i.e. the production conflicts when planning and scheduling production orders. Conflicts in this case are mostly unexpected events (machine breakdown, missing of material, and so on) and, regarding the configuration of VPAs, can also be the need for an external resource. These are therefore the conflicts that the shop floor people will have to deal with.

Making use of Deep's terminology, in this work the confrontation (face-to-face situation) will be utilized aiming at reaching a win-win resolution or to agree to a compromise. This set of actions will be referred to as *negotiation*.

Communication and Information

Communication is the act of transferring information. If good communication is desired, this means that the amount and the quality of information must also be good. The increase and the change of responsibilities and activities on the shop floor require better communication and consequently better available information.

The effectiveness of decision-making depends on the availability of reliable, accurate and timely information. On the shop floor, foremen are experts in collecting information. Actually, they do it all the time as part of their ongoing responsibility. But the amount of information is enormous and therefore adequate computer support on the shop floor such as an SMC system can be helpful.

The ownership of shop floor information is the indispensable step to establish communication among the decentralized areas in order to configure VPAs. And in this work communication is the main mechanism to link the organizational and technological elements previously described in the sections 3.1 and 3.2. Hence, the management of human communication will allow the coordination of decentralized and partially autonomous production areas through human networking, i.e. bilateral communication will give rise to networked communication. This will be further discussed in subsection 3.3.3.

3.3.2 Cross-Functional Team

Firstly it is convenient to establish the difference between a team and a working group. According to (Katzenbach and Smith, 1993a) the distinction is based on performance results. While a working group's performance is a function of what its members do as individuals, a team's performance includes both individual results and what they call 'collective work-products'. A collective work-product is defined by the authors as what two or more members must work on together.

In the case of the shop floor, considering that members of decentralized and partially autonomous production areas (the traditional GT cells) as well as the ones that will take part of VPAs work jointly to manufacture and/or assemble a determined product, it is clear that *teams* are required instead of *groups*.

But what kind of teams are to be considered? Among the literature in this field, that has increased tremendously in the last eight to ten years (Dyer, 1977; Shonk, 1992; Katzenbach and Smith, 1993b; Wellins, Byham and Dixon, 1994; Vogt and Murrell, 1990), the author has chosen the terminology and classification of Wellins et al. (1994) as the most adequate to be adopted in this work. They classify the teams into two main categories: fixed work teams and cross-functional teams.

Fixed work teams are organized around a product or service and can be divided into two subclasses: (1) nature work teams and (2) redesigned work teams. Drawing up parallels with the activities that are carried out on the shop floor, it can be said that the first ones can be found when the production type is, for instance, process layout or line flow where nature teams would be the 'drilling' team or the 'milling' team or even the 'electronic card assembly' team. Redesigned work teams can be found where a work reorganization is required, as it is when implementing GT cells.

Cross-functional teams are responsible for solving a problem, coordinating and making decisions. They are also divided into two subclasses: (1) fixed cross-functional teams and (2) temporary cross-functional teams. In the fixed ones members of work teams meet periodically in order to coordinate, plan and make decisions that will influence the environment of their domain. The temporary ones are defined either for special projects (to plan a new performance management system, to work out the challenge of a product, and so on) or to improve a organizational process, as well as to develop a new product. Concerning the shop floor, temporary cross-functional teams can also be formed in order to make possible the manufacturing/assembly of an 'exception' part (which cannot be done in just one GT cell).

Normally the adoption of cross-functional teams follows the implementation of work teams. And this occurs in the case of the configuration of VPAs where almost of all categories described above are required. Firstly, redesigned work teams must be conceived in order to support the decentralized and partially autonomous production areas. Afterwards, cross-functional teams - both fixed and temporary - give the needed subsidies for the formation of VPAs.

The cross-functional teams are of special importance to the decentralized coordination desired in this work. In this context, the fixed cross-functional teams are from now on designated by the author as *mentored* teams, because their members are the 'intellectual mentors' of the VPAs, and the temporary ones are called *virtual* teams, because they exist only virtually and only for a short time.

Considerations about mentored teams can be summarized to include the following points:

1. They are normally formed by the foremen responsible for the decentralized areas who meet (the frequency depends upon the company; it can be, for example, once a day or once a week) to 'negotiate' aspects concerning the 'exception' orders and hence to coordinate the synchronization of the decentralized areas.
2. To this team belong the representatives of the areas that have some chance to interact with another one, i.e. where resource sharing or overlapping are possible. There exist however limitations regarding the distances, which should not be so great that such meetings become difficult. The sense of 'great' is relative and should be considered separately by each enterprise.
3. These teams operate normally without a formal leader, establishing their own schedule, making decisions and assuming the responsibilities for their action.
4. Members of the teams are well informed and work towards a common objective, making it easier to establish communication and to form human networking.
5. In some cases people who do not belong to the shop floor such as suppliers, customers, people from the design department may also occasionally be a member of the team.

Virtual teams are formed according to negotiation processes conducted by the mentored teams. The main aspects regarding them are:

1. They are formed by the 'human' resources required for the manufacturing/assembly of an 'exception' production order and work together only casually, nevertheless, have a common goal: the complete production of an order.
2. The size of the team depends upon the number of resources required for the production of an 'exception' order.
3. A virtual leader organizes the virtual team and this leader is normally the foreman who is responsible for most of the VPA resources.
4. Communication among the members is also networked and information exchange is stimulated.

After describing the teams which will allow the synchronization of the decentralized areas and consequently the configuration of VPAs, the next subsection presents the way in which the team members interact.

3.3.3 Human Networking through Human Communication Management

The elements described in the sections 3.1 and 3.2 are established and required entities for Learning Enterprises. With this understanding, they can be treated as technoorganizational building blocks. But how should these building blocks be integrated into an effective enterprise ?

It is generally accepted that an elaborated and detailed formal organization is a favourable way to configure different organizational entities into an enterprise. The advantage of the formal organizations is undoubtedly their transparency in assigning tasks, responsibilities and decision paths to specific entities. However, they are always in danger of being outdated or of becoming rigid, and hence, of resisting changes. This is contrary to the concept of Learning Enterprise. The Learning Enterprise does not rely on formal organizations but on powerful informal organizations within the enterprise. Informal organizations are, by definition, living social systems linked by human networking (Savage, 1990) and human interaction. Living social systems are highly adaptable to external needs and therefore very flexible. Hence, informal organizations are the most appropriate backbone for the Learning Enterprise.

If healthy informal organizations (Hamacher, 1991) are chosen over elaborated formal organizations as the backbone for the Learning Enterprise, the social mechanism should carefully be considered in order to build them up. Such mechanism is treated by Savage (1990). He introduces the concept of human networking as a type of organization that characterizes the management shifts from the steep hierarchies of the *late industrial* era to the *early knowledge* era. According to Savage, the knowledge era has the knowledge as source of wealth and five conceptual principles are to be considered: peer-to-peer networking, integrative processes, work as dialogue, human time and timing and virtual task-focusing teams. All of these principles contribute to achieving human networking. Moreover, Savage states that human networking is essentially *dialogue*: with the past, making use of individual and collective learning; with the present, through communication among and between the team members; and with the future, when the people have dialogues with their visions.

Since human networking is dialogue, it can be concluded that good communication supports learning. It is well-known that communication is the basic mechanism to encourage human interaction, human networking and to build up the linking element for human relations (Luhmann, 1987). But this does not mean that the provision of communication channels alone is sufficient to obtain healthy and effective informal organizations.

Effective communication for a Learning Enterprise and, specially in this case, for configuring VPAs requires an explicit management and a definitely layered set of conventions, since it will be the way to perform a coordination strategy in order to avoid the chaos on the shop floor and to prevent workers from becoming 'indecision'-makers. Here it is important to mention that decentralization requires flexible coordination and this can be achieved by human networking through human communication management. Figure 3.3-1 shows such a layered structure of requirements for human communication management (Wersig, 1989; according to Hamacher, Pereira Klen and Hirsch, 1994, P.83).

An appropriate IT-infrastructure, like broadband-networks, LAN's, WAN's and multimedia facilities, merely constitutes the bottom level of communication management. In this area IT will provide powerful enabling technologies such as DSMC systems; but these technologies must be complemented by a set of additional conventions represented in layers 2 to 7.

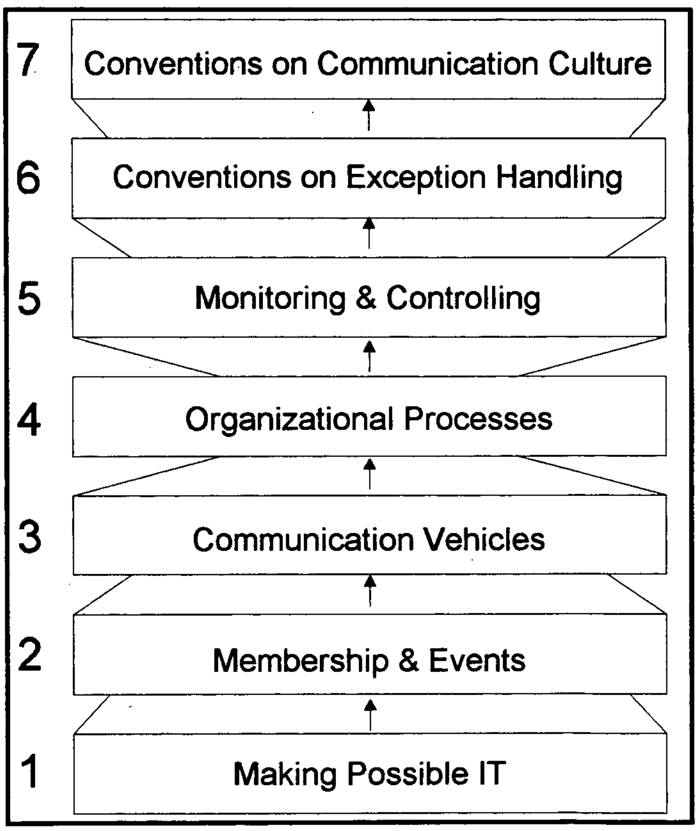


Figure 3.3-1. Required layers for human communication management

On the second level, enterprise-specific conventions which are a legal part of a communication network are needed. They are usually the triggering events for communication, like order receipt, contract negotiation, strategy decision, as well as the usual distribution rules to initiate an appropriate communication. For the configuration of a VPA, the triggering event is the acknowledgment of having received an 'exception' order.

The preferred common vehicles for communication must be defined at the third level, which means the forms, document-types or more general tools and media used in a communication process. As communication is always a kind of action, it requires an appropriate media to express requests, comments and results. Simulation models are also communication vehicles insofar as they are designed to promote mutual understanding. In the case of VPAs, two are the vehicles required: (1) an internal notice to inform the interested people that an 'exception' order has arisen and to confirm the necessity of (2) a meeting with the mentored team members. Two considerations must be made: firstly, the internal notice can occur either informally, where the foreman who received the 'exception' order calls upon the other ones, or formally, e.g. by means of e-mail messages. It depends on each enterprise and each case. Secondly, periodical meetings should already be scheduled by all foremen, although holding them is conditioned by the internal notice.

On the basis of a defined set of common communication vehicles, conventions on the organizational processes within an enterprise will form the fourth layer of the communication management structure. Organizational processes here mean a set of interrelated tasks and functions to be used in specific situations. This can be seen as the specified reservoir of coordinated and proven actions for specific requirements and thus as a basic rule set to assign roles in a cooperative interaction process (Singh, 1992). It can be said that it is here where coordination takes place. During the meetings each one will be a node of the human network, utilizing individual, collective and organizational learning, by listening, thinking, observing and sharing knowledge and visions in order to suggest and implement the best solution for a specific situation.

The function of the four layers described above is to make communication possible and support it in an orderly way. This alone is not sufficient since the communication process has continuously to be monitored and controlled according to the dimension of the goal to be achieved. Informal communication processes are not free from structural deficiencies and resistance. Thus, it should be continuously observed whether the structures are still in line with the enterprise goals or whether emphasis should be placed on overcoming unintended developments. This is the aim of the fifth level which, according to the objectives of this work, verifies the effectiveness of the VPAs, i.e. if short-term planning and scheduling are being carried out in a reasonable way and in line with the start and due dates.

On the sixth level, conventions should be specified as to circumstances that permit deviation from the normal processes and how the allowable range of tolerances is to be defined. This level is essential for a Learning Enterprise, so that environmental changes can face the situation of deviation from normal processes, and also develop a new and modified process. Therefore, conventions on allowable tolerances are useful and necessary. On the shop floor level this is directly related to autonomy and delegation of responsibility. To the workers/foremen must be given autonomy to make decisions concerning deviation and modifications. For example, on the one hand, the delay of one order can mean that other four orders will be delivered on time; on the other hand, these four orders may not be so important as the first one. This kind of conflict should be solved on the shop floor, and therefore conditions must be provided in order to allow decision making there.

The top level for managing communication in informal organizations is formed by the conventions on the desired communication culture. This means a set of super-conventions to guide, control and reflect the change of conventions on the lower levels. This is the function of the seventh level, which embodies the organizational culture as an overall reference. Since everything in life can be decodified thus the enterprise's culture can be considered as a vast communication system, i.e. the way in which the enterprise acts reflects directly on the workers activities since it is a powerful means of communication.

This description of requirements for proper communication management shows that human networking through informal organizations is probably one of the most important elements for an adequate production management in Learning Enterprises, and hence for a flexible coordination of decentralized and partially autonomous production areas. But it shows, as well, that this requires deep knowledge of the mechanism in social systems.

Until now representatives of organizational, technological and human elements have been explored, as far as possible, individually as building blocks for the conceptualization of a Learning Enterprise. In the next section their interrelationships will be described in a systematic procedure.

3.4 Integrating Technology, Organization and People

Normally, people who want to apply theories on the shop floor have to deal with existing factories; fresh applications are quite scarce. It is difficult to make experiments since the on-going production should be disrupted as little as possible, if at all. Therefore strategies must be developed to migrate from an existing to an improved situation, while disturbing the production minimally.

Benefits of an integrated approach should be demonstrated for the people who run the enterprise. A way to do so is to develop a reference model to be used as a guideline for the improvement process. In this section a procedure will be presented describing the main steps and related activities required for the configuration of a VPA. However it is very important to mention that the success in applying a generic reference model depends on how it is adapted, i.e. for each specific case the generic reference model must be 'translated' into a specific model, expressed even in the local terminology. That means that the specific model has to be mapped onto the existing work organization, as well as resources and systems available. Consequently, adaptations should and must be made in the proposed reference model, which serves as a generic guideline orienting the configuration of VPAs.

Figure 3.4-1 shows the model developed by the author on the basis of the experience gained through the direct participation in several projects carried out in Germany regarding the improvement of production efficiency on the shop floor. The model is composed basically of four main steps:

1. Awareness
2. Analysis and Conception
3. Detailed Conception
4. Realization

The first phase is the kick-off for the initialization of an improvement process. It depends mainly on the consciousness of the need to change. It is also in this phase where a project team is composed in order to define the goals of the project, to manage the activities required for challenges and improvements and to define a time schedule.

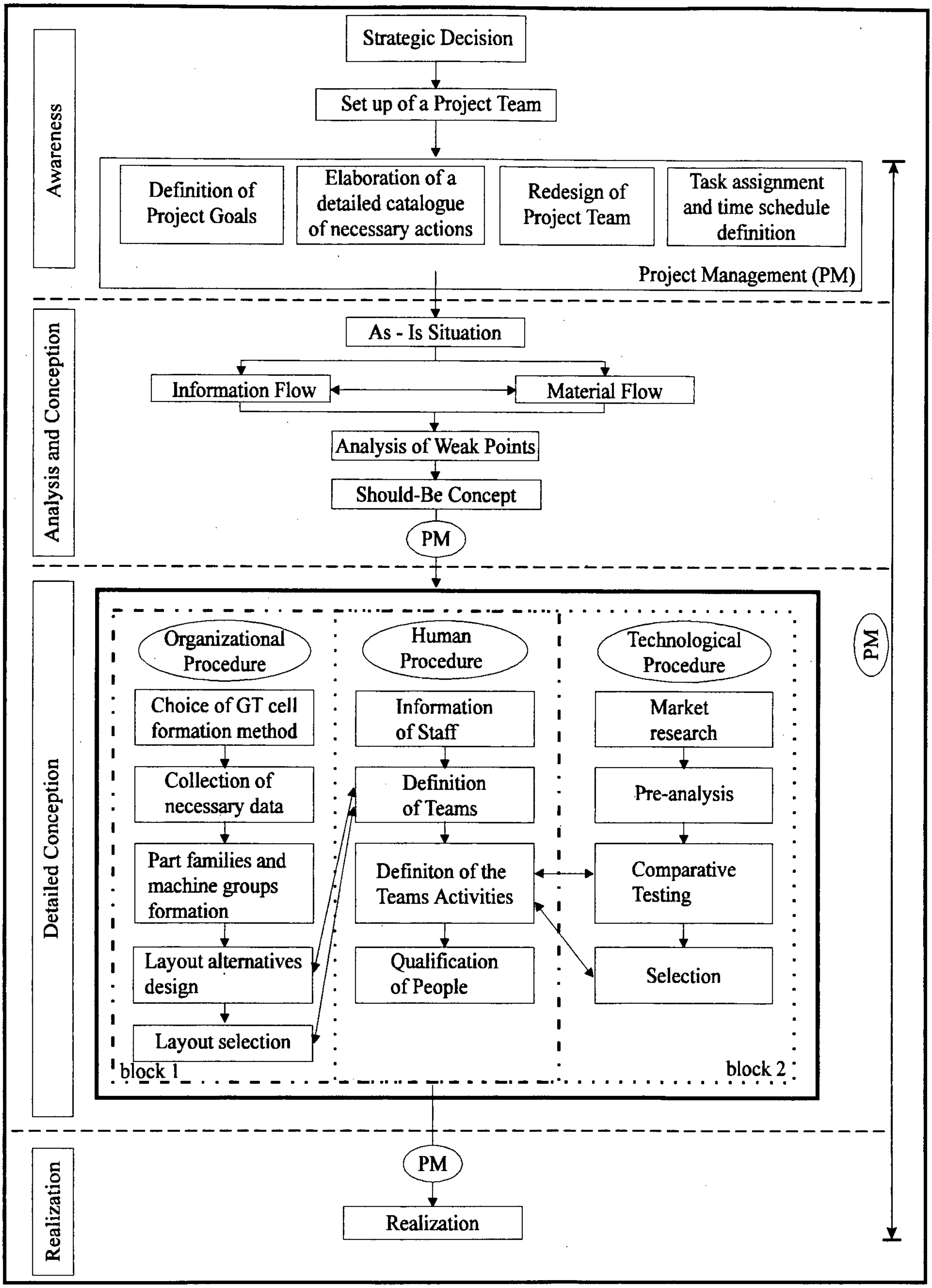


Figure 3.4-1 Reference model for the configuration of a Virtual Production Area within a Learning Enterprise environment

In the second phase, the area to be covered by the project is analysed regarding its current situation, its weak-points and a rough 'should-be' concept is suggested.

A detailed concept is then described in the third phase concerning the organizational, human and technological procedures.

Finally, in the fourth phase the concept is implemented and the project management activities are directed towards the evaluation of the previous phases and the analysis of the goal achievement.

The model is presented in a sequential manner. Sometimes, however, activities may be carried out in parallel. This occurs mainly in the detailed conception phase where organizational and human procedures or human and technological procedures are strongly dependent on each other. The four main steps will be presented in the following with their related activities.

3.4.1 Awareness

It is formed by three main activities:

Strategic Decision

The wish to change or to implement some new ideas or to stimulate improvements, i.e. to implement a new *project*, is normally a strategic decision in an enterprise. It involves work, time, commitment and, obviously, money. It is unrealistic to think that modifications, challenges or improvements of the nature of those suggested in this work will occur without expenses. Layout design or redesign, introduction of a task-appropriate computer support on the shop floor and qualification of the personnel imply that investments must be made. The managers responsible for such kind of decision must be aware of all implications that a new project brings, in order to contribute to the good performance of the project and, consequently, to achieve the desired goals.

Set up of a Project Team

After identifying the need for a new project, a project team should be drawn up. Normally, the managers who have decided on the project suggest some people (for instance, two or three) to compose the team that should be composed of experts on the problem to be solved.

In this case working with either consultants or research scientists is suggested. It is also very interesting and important when a manager, responsible for strategic decisions, also takes part in the project team. It would be optimal if he/she could be present in all meetings but, based on the experiences made, this is practically impossible. Nevertheless, his/her participation, at least in some decisive meetings, is crucial for the flow of the project.

Project Management

The management of the project begins with the first meeting of the project team and ends only after the successful realization of the project goals. It includes:

- the definition of the project goals: here the goals are explicitly defined either in a quantitative way (reduction of X% of the throughput time, increase of the production in Y%, etc.) or in a qualitative way (improvement of the work organization, more efficiency with the use of new technology, increase of employee satisfaction, etc.). The area(s) to be covered by the project is (are) also defined.
- the elaboration of a detailed catalogue of necessary actions: based on the goals and the area(s) defined previously, the members of the enterprise and the experts develop a detailed description of the tasks to be performed in order to achieve the mentioned goals.
- the redesign of the project team: this may be necessary depending on the goals and required actions mentioned above. Remember that setting up the project team was suggested by the managers of the enterprise based on a rough idea. During the first meetings, where the project is defined, it is the right time to modify and/or complement the project team. Here a technical contact should be defined. Two technical contacts are recommended: one on the side of the enterprise and other on the side of the consultancy (firm, research institute, or other).
- tasks assignment and time schedule definition: knowing the goals, the area(s) involved, the action to be performed and the people involved in the project, the only remaining task is to define by whom and when the actions will be done. Here, beside each activity, names should be put down and a pragmatic schedule should be developed according to the availability of the people assigned to perform the referred activity. It should also be determined what methods are to be used to obtain the necessary information (representation methods, techniques of moderation, etc.) and what kind of output can be expected to result from each activity (reports, questionnaires, and so on).

3.4.2 Analysis and Conception

This phase requires an intensive work of the project team. To understand how the enterprise works, the consultants/research scientists should visit the enterprise to gain a greater sensibility regarding not only the concrete things (existing functions, available documents, equipment to be used, etc.) but also the abstract ones (work environment, degree of workers involvement on the enterprise's main goal, etc.). Three main activities compose this phase:

'As-Is' Situation

Here the current situation of the enterprise is analysed by the team members. An analysis is recommended of the entire path that an order has to do regarding (1) its information flow, i.e. from the elaboration of an offer, passing through the design and process planning department, the shop floor up to its delivery, as well as (2) its material flow, i.e. from the material store, through the shop floor, up to the delivery. In order to do that as precisely as possible, people of the involved area should explain how information and material flow in the enterprise, i.e., they should describe their function within the enterprise. Sometimes members of the project team who belong to the enterprise can answer these questions; sometimes they cannot. Therefore it is very useful to interview people directly related to the area(s) being analysed.

Various techniques, other than interviews, are also used: questionnaires, observation, analysis of existing documents, conferences and so on. There are, however, methods specially developed for the purpose of representing the organization flow that make use of some of the techniques mentioned above, such as the PS-Method (Scheel, 1990) showed in the figure 3.4-2. Briefly explained, the method makes use of stickers to represent the people, their functions as well as the resources and instruments required to perform the related function. The main advantages of the PS-Method are: the facility to learn how to use it to represent exactly what the users want to express, the possibility of documenting well the results and the chance to practice teamwork during the elaboration of the work.

At the end of this activity, a document should be elaborated containing the 'as-is' situation (as shown in 3.4-2, for example) and the necessary comments for the complete understanding of the context even by people who did not take part of this action. The documentation is a very important stage implicit in most of the activities of the presented approach.

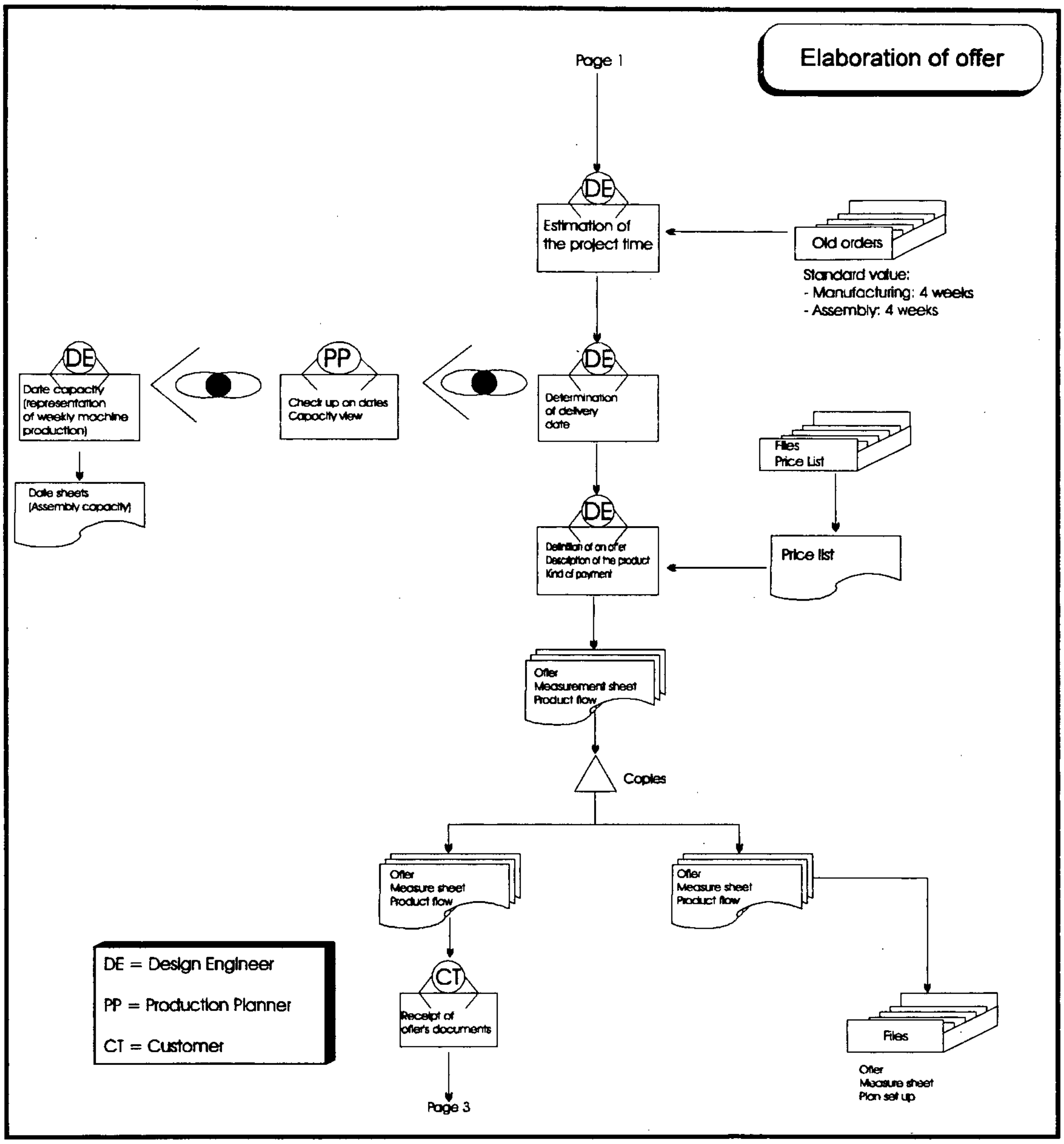


Figure 3.4-2 'As-is' situation represented by the PS-Method (Esser, Pereira Klen and Vöge, 1992a)

Analysis of Weak Points

The 'as-is' situation document is the basis for the analysis of the weak points of the enterprise. It can be surprising how people live with the problems, knowing that they exist and just doing nothing to solve them. In one of his several consultancy actions, Argyris (1994) concluded that normally the culture of the company made it unacceptable to get others into

- Layout selection: in this stage, the alternatives are analysed, optimized and the one which offers the most advantages is chosen. Afterwards, the layout is implemented. For a very detailed description regarding the implementation of cellular manufacturing see Silveira (1994).

Human Procedure

The human procedure is a very strategic one and therefore is placed on the middle, between the organizational and the technological procedures. Ideally the human procedure should accompany the others (see figure 3.4-4), i.e. the shop floor people should be active during the whole process. As mentioned before, the involvement of the 'end-users' has an excellent feedback, as it allows (Pereira Klen, Vöge and Hirsch, 1993b):

- quicker implementation,
- more efficiency with the use of the new philosophy/technology,
- higher initial productivity,
- lower implementation costs and
- higher employee satisfaction level with the results of the innovation.

The human procedure has four main activities:

- Information of staff: people need more information about their work than many organizations are ready or able to give them, and they also need more social contact than exists in many formal organizations. To cope with these difficulties, informal lines of communication spring up and are often referred to as the 'grapevine' (in Brazilian companies it is known as 'rádio peão'). While being a healthy manner of communicating, the inaccuracy of some information may cause insecurity in the work environment. Therefore, as much and as accurate information as possible should be provided in order maintain the shop floor people updated and aware regarding the modifications that may occur in 'their' domain. Although only here explicitly mentioned, the information of the staff should occur from the beginning of the project in a concise and objective way.
- Definition of teams: at this stage two actions are to be taken: (1) the redesigned work teams which will be responsible for the GT cells should be defined and (2) the potential members of the mentored team, i.e. the mentor of the redesigned work teams, should be indicated. This activity should take place parallel to, and jointly with, the layout alternatives design and selection.

trouble for the sake of correcting problems. He also affirmed that the people involved were asked to identify areas in which they could tighten procedures and reduce costs. Argyris made observations concerning two comments of these people: (1) how easy it had been to identify the target areas since they knew in advance where the worst inefficiencies might be found and (2) that fixing the areas was long overdue, that it was the right time for management to take action.

It can be concluded that despite the company's culture - that generally inhibits talking about the existing problems - people know where problems and weak points are. And they feel free to talk about it when this is desired from them and when they know that there is a real intention to overcome the problems and difficulties. Moreover they feel more stimulated and secure if these problems and weak points are identified through a teamwork. Here, a very efficient way to work out the weak points analysis is to utilize some moderation technique (Frieß and Köster, 1995) which brings clarity during the identification of the problems, as well as being very useful for further documentation..

'Should-Be' Concept

The data and information obtained will thus be used in this activity to improve the 'as-is' situation. The project team should discuss and propose some alternative ideas. Furthermore, comments and suggestions from other members of the company are also welcome. A new concept is developed containing the specification of the enterprise requirements and modern approaches concerning technology, work organization and people involvement (figure 3.4-3). It is recommended to use the same representation method utilized by the 'as-is' analysis in order to maintain a standard. The documentation of the developed concept completes this activity and the second step of the reference model.

It is important to mention that the 'should-be' concept is the first stage of a more detailed conception. It shows what to do, but how to do it, i.e. the procedures to be adopted, is described in the next step.

3.4.3 Detailed Conception

Here project management is also strongly required. Interim goals are to be defined which jointly will lead to achieve the main goal; actions must be defined to reach the interim goals; the project team may be redesigned, or rather, completed; tasks are to be assigned and a time schedule is to be proposed.

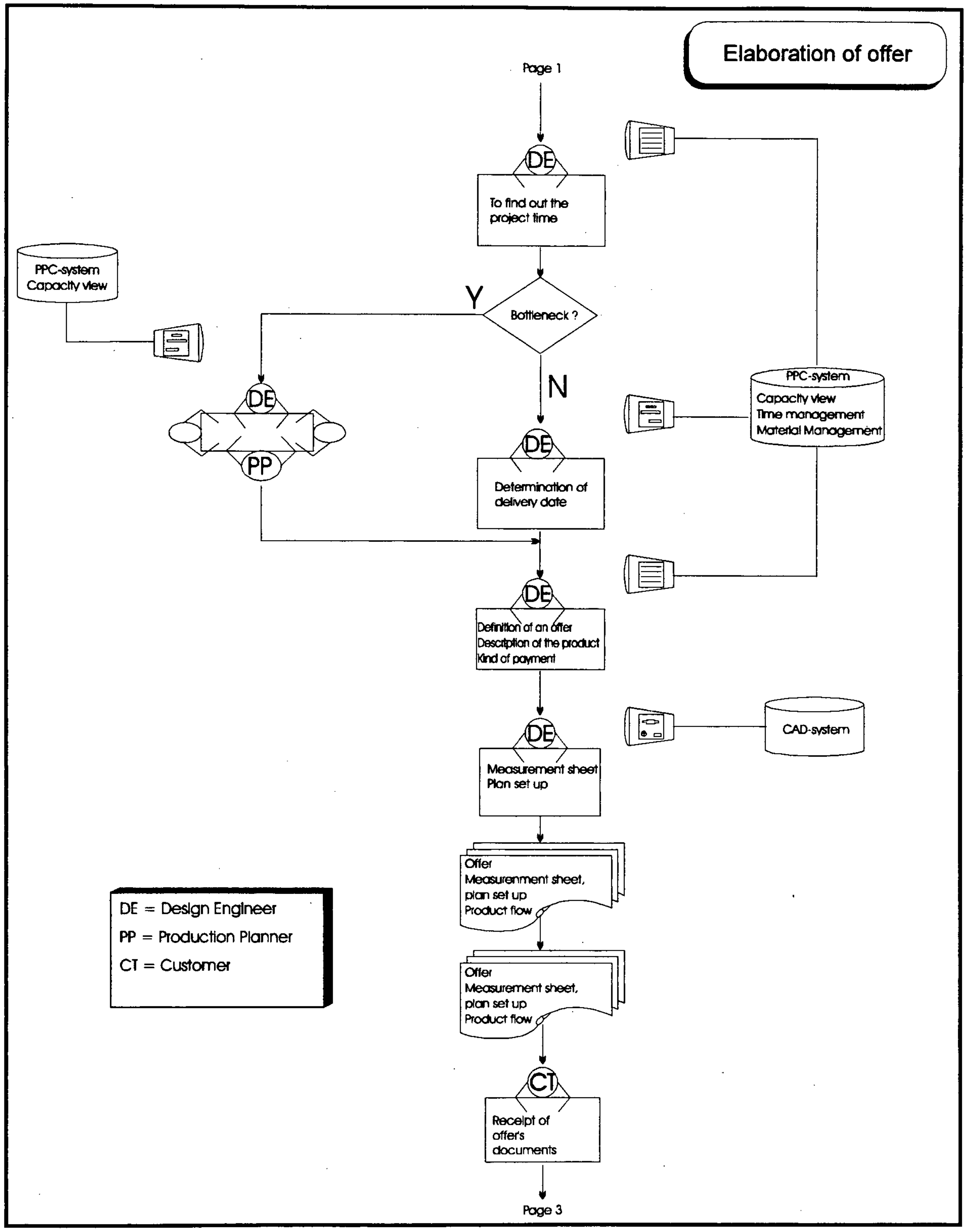


Figure 3.4-3 'Should-be' concept represented by PS-Method (Esser, Pereira Klen and Vöge, 1992b)

Up to now, the methodology suggested can be applied in any improvement project, being adapted depending on each case. From now on, the detailed concept is more specific and its activities depend on the suggestions made. At any rate, regardless of the application, the very important point of this step is that three procedures should be taken into account in order to improve the chances for the success of the project: organizational, human and technological procedures. In this work the activities described on this step have to deal with the configuration of VPAs.

Organizational Procedure

Regarding the work organization on the shop floor, five main activities are to be considered:

- Choice of GT cell formation method: among the diverse existing methods such as those mentioned in the section 3.1, the most suitable one must be chosen. Silveira (1994) recommends that the choice should be made taking into account at least the following points: (1) the diversity of components and existing equipment, (2) the accuracy of the data related to the process plans as well as to the analysed components, (3) the objective of the clustering, i.e. formation of parts family, machine groups or both simultaneously, (4) the money available to invest in this stage, (5) the accuracy level of clustering compared with the time and the costs spent in its execution, (6) the degree of decision making during the application of the technique and (7) the available computational resources.
- Collection of necessary data: the required data are directly related to the cell formation method chosen. Each method needs a specific set of input data. This stage can take a long time, because it depends on the documentation level of the enterprise, as well as on the accuracy of the data and the frequency in which they are up-dated.
- Part families and machine groups formation: at this stage, the chosen method is applied and serves as a pointer for the project team which will, based on their individual and collective knowledge, decide for the families and groups.
- Layout alternatives design: based on the previous stage, some layouts are to be outlined taking into account aspects such as (Groover, 1980; Lorini, 1993; Sundaram, 1987) machine capacity, alternatives process plans, resources sharing, physical restrictions of the company (machines foundation, electric and hydraulic installation, etc.), physical characteristics of the parts, arrangement of the shop floor hall regarding doors, corridors, stairs, and so on.

- Definition of teams' activities: since there is a reorganization on the shop floor and the implementation of a computer, with a high probability, activities and functions will also have to be redefined. Mainly in this case, where VPAs are to be configured, people must be aware of their new responsibilities and the autonomy that will be delegated to each one. Among the new activities is the participation of end-users in the comparative testing and selection of a SMC system.
- Qualification of people: the operational functions may remain the same (or not) but certainly the strategic and tactic functions will be increased. Shop floor people will have to be qualified and trained regarding not only their technological domain, specifically in this case concerning the shop floor monitoring and control philosophies, techniques and systems, as well as the basics of other applications where interfaces to SMC do exist or have to be developed, but also regarding the work reorganization and mainly how to establish human networking.

Technological Procedure

Methods and techniques which are applied to plan, monitor and control the production, as well as the information flow, have to be analysed. Specifically concerning DSMC, the very important and initial point is that the system should support human creativity, knowledge, decision-making and motivation. The possibilities and reactions of computer support on the shop floor should also be considered.

The requirements for the evaluation and selection of SMC systems comprise four main activities:

- Market research: normally conducted by the external people (consultants or research scientists), the market research should identify the available systems that could satisfy the company's needs and expectations specified as the interim goals at the beginning of the detailed conception step. For this purpose it is very useful to use a shop floor control task model (figure 3.2-3) as reference for the research.
- Pre-analysis: normally, the system's pre-selection is based on information materials from system's suppliers as well as software demonstrations and direct contact with the software developers. The pre-selected systems should then be tested, preferably in daily presentations at the suppliers. Afterwards, in a detailed inquiry, company-specific criteria are to be checked by

members of the project team. As a result, three to five systems should be selected to be tested directly by the end-users, i.e. the shop floor people.

- Comparative testing: in this stage the chosen systems should be supplied with company's specific data (information concerning orders, administration and process data, required resources and work organization) to simulate the company's situation as closely as possible. The systems should then be tested by the foremen and production managers in, for example, a two-day workshop in which capacities should be planned, scheduling conflicts should be identified , efforts should be made to reduce lead-times, and orders should be generated and scheduled in the simulated production. During this time the foremen and production managers have the possibility of comparing the advantages and disadvantages of the pre-selected systems with respect to their company's requirements. For a very detailed study regarding comparative testing see (Vöge, 1995).
- Selection: finally, a system is to be selected, taking into account previous established criteria that can be defined in an evaluation matrix, and a document listing the unfulfilled requirements should be prepared for the supplier of the selected system.

3.4.4 Realization

Once again, project management activities are required. Regarding the execution, goals and actions (physical challenge of the layout, acquisition of hardware and software, remaining qualification courses, etc.) are to be set up, the project team may be redesigned - if necessary - and tasks must be assigned, and a realization schedule should be outlined.

The process of implementing the methodology described in this section is an incremental, and at the same time, a parallel one. It may sound paradoxical, but it is not. On the one hand , there are two main 'blocks' to be considered comprising procedures that should flow simultaneously:

- block 1: organizational and human procedures, and
- block 2: technological and human procedures.

On the other hand, the effective running of the procedures may occur according to four possibilities (figure 3.4-4):

- blocks 1 and 2 run parallel,

- block 2 begins to run before the end of the running of block 1,
- block 2 begins to run only after the end of the running of block 1, and
- block 2 runs 'alone' (the shop floor was already organized according to the cellular manufacturing principles).

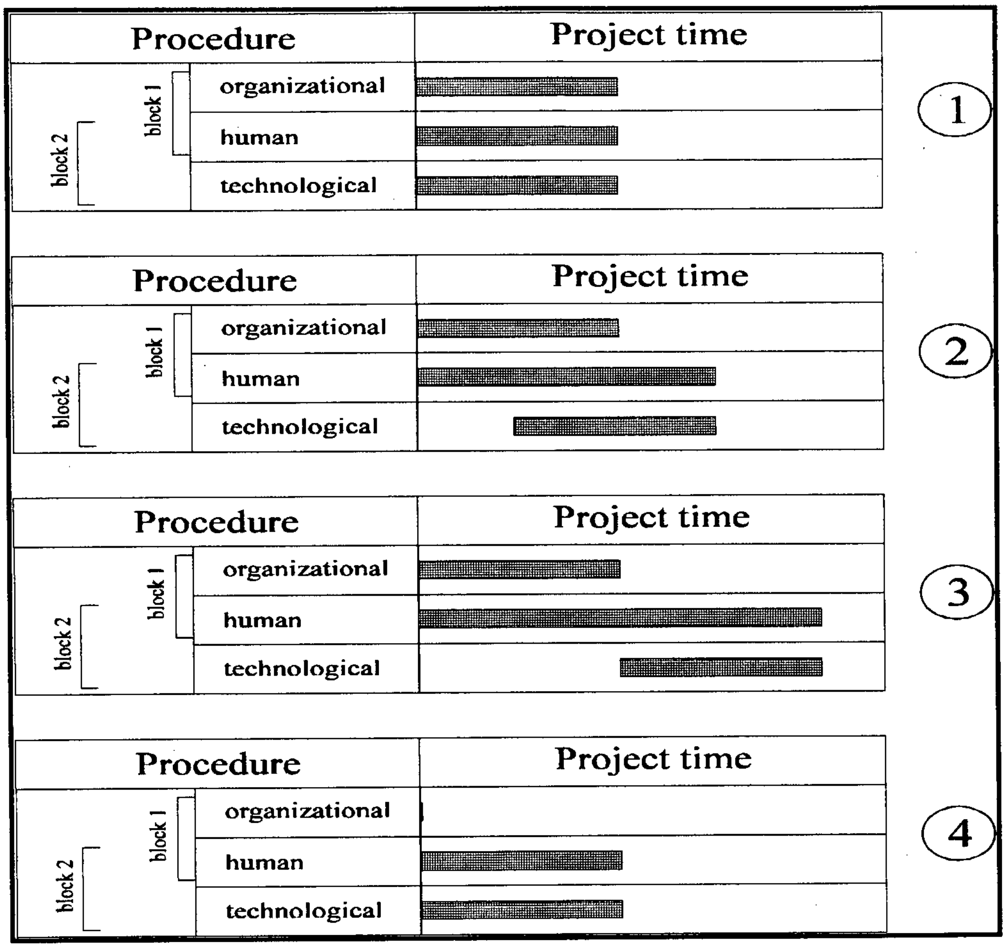


Figure 3.4-4 Time relationship among the procedures

The way in which the procedures run influences directly the realization of the concept. This choice is up to the enterprise and normally depends on the budget available for the project, the time that the people of the company can dedicate to the project, the whole time that the project should take and the interest of the strategic managers to implement it (quickly or stepwise).

Among the possibilities presented in 3.4-4 the second and third are the most likely to occur: firstly because the investment of money and enterprise people is more diluted in time and consequently it is easier to 'sell' the idea to the strategic managers; secondly because the managers will have interim results to analyse and evaluate if they are in line with the proposed goals. The first possibility implies that money (the amount of which is strongly dependent on each case and on each enterprise) should be available in a short-period time as well as requiring great dedication of time from the people involved. Although it is feasible, enterprises that are willing to face these conditions will rarely be found. The fourth one is only recommended if the cellular manufacturing principles were adequately applied, taking into account the aspects related in the block 1. After all, introducing new technologies without caring about qualification and organizational structures will not lead to success. It is also important to mention that during the realization step, existing hardware as well as interfaces to legacy systems should be analysed and, if adequate, utilized and implemented. To complete the methodology, it is suggested to adopt, on a long-term, some 'feedback arrows indication' in the reference model presented in figure 3.4-1 in order to increase the subsidies for a more effective process evaluation.

Summarizing what has been presented in this section it can be said that the integration factor, as shown in figures 3.4-1 and 3.4-4, is the human element. The people on the shop floor, the way they perceive their environment, how they interact with it, the roles they carry out on their job and how they interact with one another are the building blocks of the whole model.

Figure 3.4-5 shows how the idea of configuring a VPA can be realized after implementing the systematic procedure described above. On the first level decentralized and partially autonomous production areas are supported by DSMC systems which supply the shop floor with the necessary information (internal and external to the decentralized areas). On the second level, a mentored team is formed, triggered by the arrival of an 'exception' order in the shop floor. The members of this team establish a human networking and, by means of negotiation, support the configuration of the VPA that appears on the third level supported by a virtual team.

In the next chapter a case study will be presented in order to shape the systematic procedure presented.

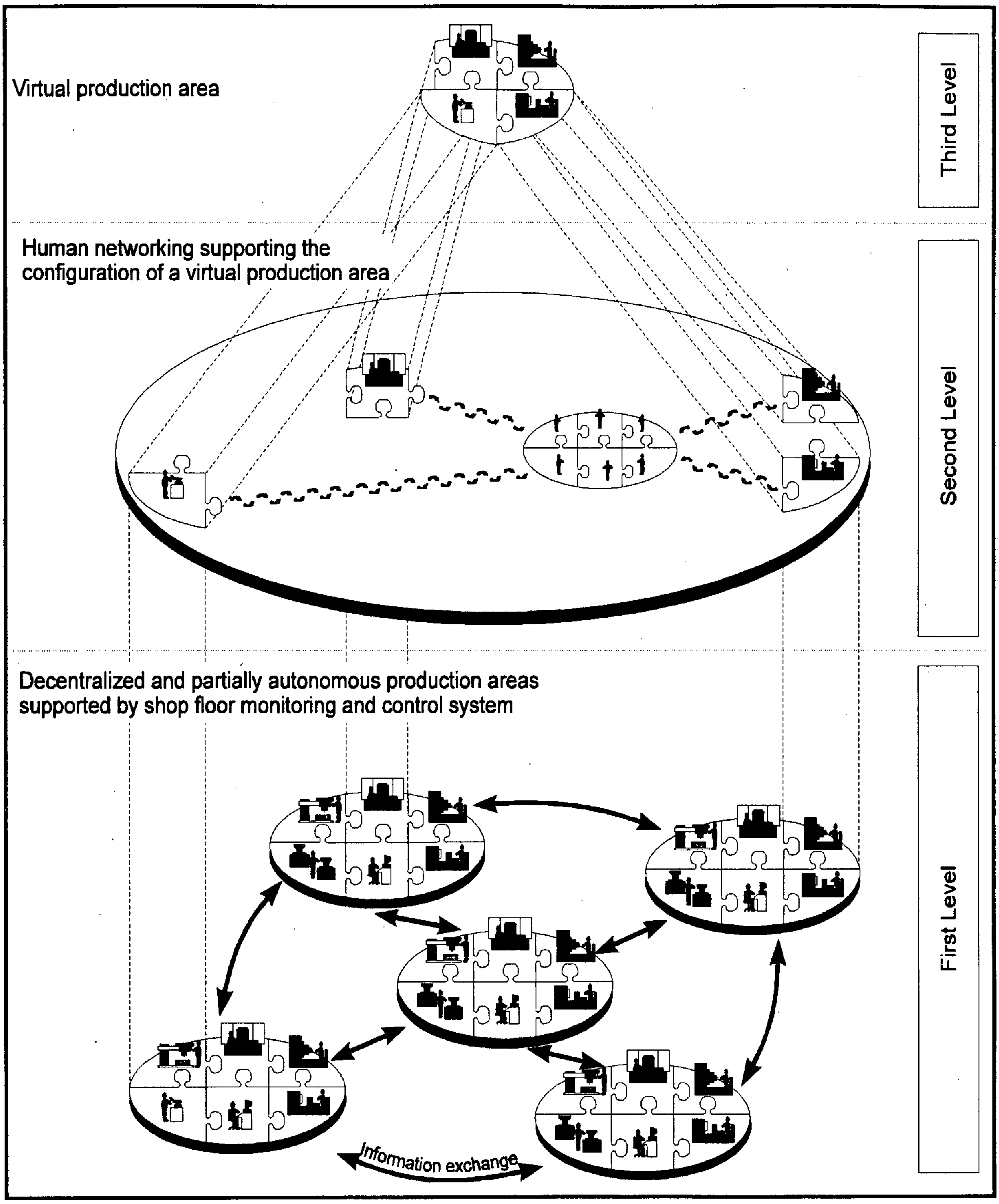


Figure 3.4-5 Configuration of a VPA

4. IMPLEMENTATION: INCREMENTAL AND INNOVATIVE APPLICATIONS

The development of the systematic procedure presented in previous chapter was strongly influenced by the activities that the author has carried out as an 'external' (research scientist) project team member of some projects realized in Germany from 1991 to 1994. The literature review has also contributed as a complementary approach, as well as giving the required scientific basis for the experience acquired in practice.

The maturation process of the reference model was long, and has required from the author a certain level of abstraction since there is no documented case study of a learning enterprise (Neergaard, 1994). Nevertheless, some German enterprises have been involved in improvement processes (Kuhlmann, Maßow, Pereira Klen and Vöge, 1991; Esser, Pereira Klen and Vöge, 1992a and b; Pereira Klen and Vöge, 1992; Pereira Klen, Spatz and Vöge 1994; Meyer, Spatz and Vöge, 1994), which could be classified as fragments and facets of the concept presented in this work.

Since the methodology presented is a descriptive one - and not an analytic one - the picture in words of all cases would be too extensive. Thus, a hypothetical case will be presented utilizing mostly real facts in order to:

- present a continuous flow of the methodology exploiting the didactic element of the presentation of the reference model, and

- make comments about the main events that occurred during the work with the enterprises, and to conclude by showing the methodology's feasibility, utility and limitations.

This justifies why this fourth chapter was named 'incremental'. But why was it named 'innovative'? Firstly, because it presents the implementation of a new methodology and secondly because it will be presented as a short novel. After all, this whole work has to deal with people interacting with living social systems. The implementation could only be done in this way!

It is important to mention that three 'bridges' did the connection between the real and the imaginary world. These bridges are the projects: Vemag, Planleit and Flamme (see section 1.3). The novel, based on these projects, is composed of seven chapters and is narrated by Eddie Klein, the production manager of the firm TRIPOD. The case is derived from the experiences of real companies and real people. As written, it is hypothetical, and the names used are fictitious.

4.1 Part 1: Introduction

It is ten o'clock on a wonderful sunny day. I had better say 'one more' wonderful sunny day in Brazil. What a country...

And here I am, at the International Airport of Florianópolis. The plane is late; it should have arrived at 09:40. But it does not matter. The delivery gives me the opportunity to think about the whole last year and the challenges and transformation that happened to Tripod and to myself. Actually, how did everything begin? Oh, yes...

- "You can come in, Mr. Klein", says Soraya. - Mr. Klein, did you hear me? I said you can come in. Mr. Girondi and Mr. Wendhausen are waiting for you.

- Oh, thank you, Soraya, I hurried to say.

I was just thinking about what they wanted from me, what they really wanted from me. Since I was promoted to production manager I felt as if I were in a test tube. Girondi and Wendhausen looked at me as if I were an experiment. I must say this is not what I would call a pleasant situation.

- Good morning, Eddie. Come in!

My thought was abruptly interrupted by Girondi's strong and imposing voice.

Marcello Girondi is a small, stout and amazing man; he is about 67 years old and has an incredible energy. His Italian offspring is easily identified: if not by his big nose then by his way of 'talking with hands'.

Actually, the first settlers arriving on the coastal area of the State in the XVII century were the Vincentians, followed by the Azorians and the Madeirans in the XVIII century.

From the XIX century, there was a new flow of immigrants. This time involving Germans, Italians and Slavics. And that is when Girondi's family came to Brazil.

Also the family of Gerd Wendhausen -the majority partner and the CEO of Tripod - chose Santa Catarina as its second home, fleeing from the horrors of the first World War.

I, myself, have also Italian and German ancestries: Eddie Furlanetto Klein - what a name for a Brazilian guy!

- Guten Morgen, Eddie. Take a seat, please, says Gerd Wendhausen, showing me the chair where I should sit.

It is really difficult to understand how two so different people can come together all these years. Tall, smart and, like most Germans, blond with blue eyes, Gerd is around 65 years old and is well known in the firm for his insight as well as his calm and slow way of speaking.

- You must be very curious about our meeting, aren't you?, Wendhausen continues.

Of course I am curious. More than that. I am curious and impatient. I do not have time to spend deciphering charades. Do they know what is happening on the shop floor? Russo, my manufacturing supervisor, is going crazy due the last 'urgent' order we received this week. As it was not enough, the sales department let me know this morning that Aidas refused our proposal and will order their vacuum sausage stuff machine in China because of their price and earlier delivery date. Is it possible? Aidas is just 300 km far from Tripod and they order their machines in China! What is wrong?

But I just answer: - A little bit, trying to sound casual.

- During these last months, Marcello and I have been observing you, begins Wendhausen.

I shift uneasily in my chair.

- We both agree, continues Girondi, that you are the right man. You know, Eddie, modern factories are required to respond efficiently to market targets. We want Tripod to become a factory of this kind. What people nowadays call 'agile manufacturing'. And we also want you to make this possible.

He keeps on talking, but I do not hear anymore. I am shocked! Do they have an idea about what they are asking me to do? I do not think so. They are talking with the wrong guy. Yes. It must be a mistake.

I cannot even deal with urgent orders in my shop floor or a 'simple request' of the neighbour firm and they ask me to develop a strategy 'to respond efficiently and quickly to market targets'. I must be dreaming!

- ... and as we have decided to retire, says Girondi, you will assume the factory starting from next Monday.

- But you do not have to feel alone, adds Wendhausen. Two weeks from now, you will receive the visit of a German consultant - Prof. Fritz. He will stay here for a while in order to give you some ideas and to help you in your first steps. He has lived in Brazil for two years and still has many contacts here. Don't worry: he is updated regarding the Brazilian manufacturing sector.

Great!!! First they put a bomb in my hands, and after that they call a German Professor to detonate it.

4.2 Part 2: The external consultant

Now I know why Garfield hates Mondays. I also do.

- The German consultant has arrived, says Soraya, who became my secretary.

I look through the window and I identify him quickly. No Brazilian would wear an undershirt at 30 degrees or even carry a chessboard jacket .

I distract myself for a few minutes looking at the workers arriving with their bikes. It is one more wonderful sunny day. Joinville, situated in the North of Santa Catarina and where Tripod has its headquarters, stands out nationally for the quantity of people that make use of bikes to go to work. It is healthy, cheap and does not pollute the atmosphere. By the way, where did I put my old bike?...

- Guten Morgen, I say, trying to utilize the only two German words that I have learnt during the last years living together with Wendhausen. Would anyone believe that my ancestries are really German? I do not think so.

- Guten Morgen, answers the Professor, giving me his hand and his business card.

My first impression of him is very good. I calculate he is about 57 years old. He is the kind of people who could be a salesman, a politician, a consultant or a Professor. I think he has chosen right! He does not stop talking and sometimes it is difficult to filter the amount of information and new ideas that he generates. He is surely a man with many years of experience - professional and life experience. I learned to respect him.

4.3 Part 3: Awareness

- Tripod is a medium-sized company that produces machines for the food industry. The machines are exported worldwide and consist partly of standardized groups of components. According to individual customer demands, however, a great part of the required machines are customized ones and the company can be classified as a small batch size and one-of-a-kind producer (Hirsch, 1992).

This is where the company's strength lies, due to its comprehensive know-how. But there are also weakness inherent in the production concept, mainly due to simultaneous processes with constant information deficit in the production-related areas.

The firm was founded in 1965 and then comprised four employees. Today it employs 268 people and has a yearly turnover of US$ 30 million. Due to the quick expansion, the organizational adaptation and communication infrastructure have been neglected. Recently, however, the company management perceived the problem and decided to modernize. As the required know-how was not available in the company, it was decided to cooperate with an external consultant that I want to introduce to you: Prof. Fritz....

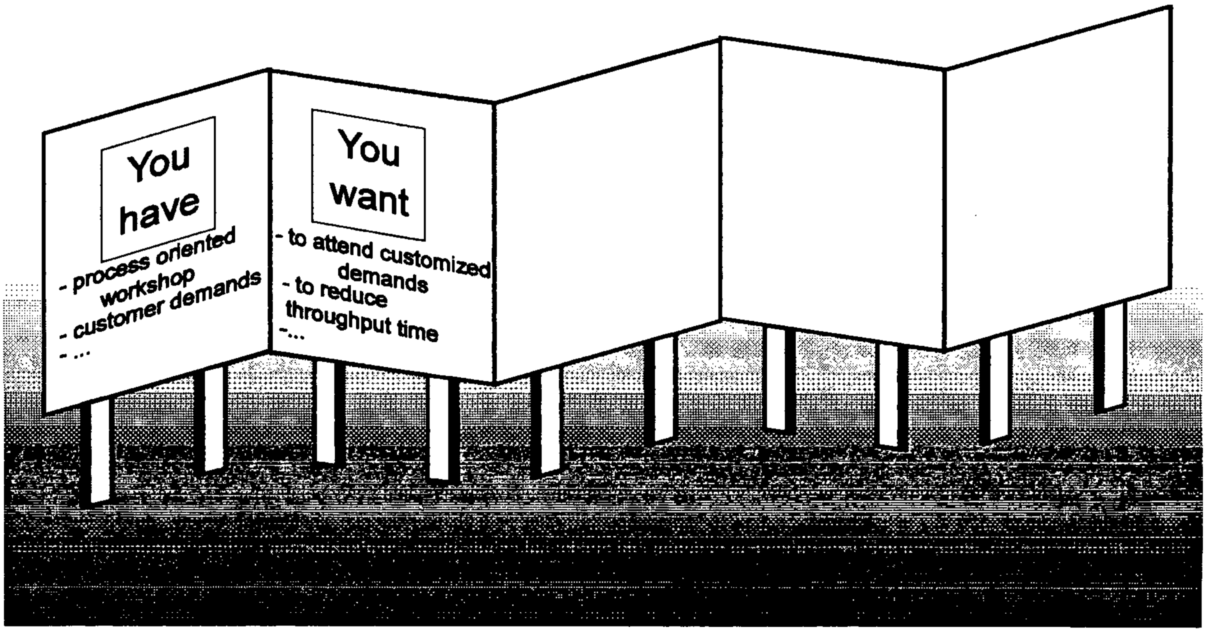
...with this brief explanation, I introduced Prof. Fritz to the project team, formed by:

- Russo, the manufacturing supervisor,
- Oscar, the assembly supervisor,
- Cecilia, from the PPC department,
- Ivan, from the workers council,
- Prof. Fritz, as the external consultant and
- myself.

Ivan was quite surprised as he was invited to take part on the team. It was new for him and, to tell the truth, it was not the culture of the company. But I must admit I liked the idea and it had a very good repercussion among the workers. They felt themselves really represented in a firm action.

The first meeting of the project team occurred on Thursday, after three days' intensive work with Prof. Fritz in which he had an overview of TRIPOD. After my first words, I gave Prof. Fritz the chance to speak:

- Bom dia, como vamos? - Prof. Fritz began talking in Portuguese and that influenced the team positively. - Let me please give you a synthesis of what I have seen and analysed during the last days. - He begins writing on the blackboard:



You have:

- the whole manufacturing and assembly areas of the firm organized in to process-oriented workshops,

but also

- strong individual customer demands

that leads to

- strong divergent process lead times and quality demands for the different types of machines

planned by

- a centralized and inflexible PPC system

combined with

- information deficit on the shop floor

and a

- complex information and material flow

resulting in

- decreasing shares of market

as well as

- less motivated staff.

It was not easy to admit that he was right...

You want:

- to attend the customized demand

while

- reducing throughput time,

and

- increasing the transparency on the shop floor.

After writing, he looked at us and asked:

- You know the firm better than me. Where do you think the real problems are?

Oscar began: - The components come always late to me. I cannot assemble anything in time.

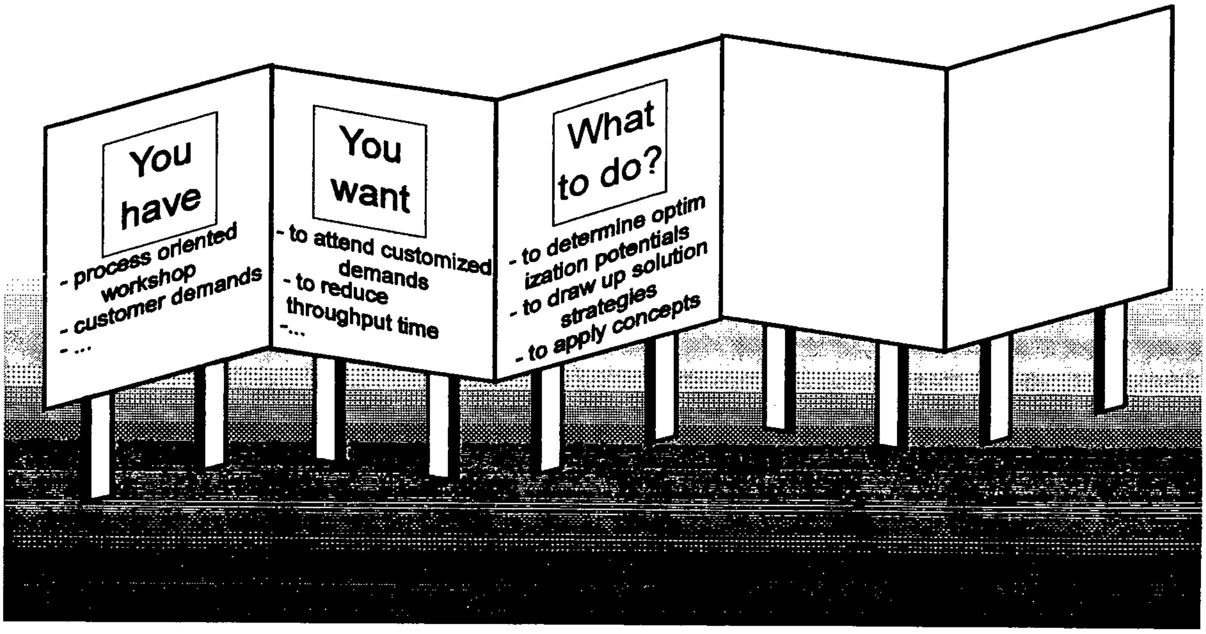
Russo answered: - How can I send you the components in time if we cannot produce them in time? Unexpected events cannot be planned and a fine scheduling exists only in my mind...

Cecilia completed Russo's thought: I am very sorry, but I cannot make miracles with my PPC system...

Ivan said: - You cannot forget that the motivation of the workers is low. They have more than enough paper on the shop floor but paradoxically, almost no information.

We talked about the problems nearly the whole day. In the late afternoon, Prof. Fritz began again to speak:

- I am sure that this discussion was very fruitful for all of you. You are aware of the problems of the firm and you want to improve. That's great! He went towards the blackboard and completed what he had begun early in the morning. He wrote:



What to do?

- To determine optimization potentials;
- To draw up solution strategies; and
- To apply concepts.

After that, he ended the meeting until the next morning.

On the next day, when I came in, Russo, Oscar, Ivan and Cecilia were already there talking about the optimization potentials. Then I realized that they really 'live' the firm.

We spent the day elaborating a plan of activities to be carried out in order to improve the manufacturing and the assembly areas, which we identified as having the much greater optimization potential. The interfaces to these areas should also be analysed and therefore during the task assignment some people other than the project team were also designated to help, performing the required actions.

It was common sense that the two main problems on the shop floor were (1) the complex and confusing material and information flow, resulting in too long a throughput time as well as (2) the massive information deficit. Consequently, the actions to be done had to do with the work organization and the possibility of a computer support on the shop floor in order to provide the required information, as well as to giving subsidies for short-term planning and scheduling. Actions were planned, such as the analysis of the PPC system functions and interfaces available in the firm, a survey of the existing equipment on the shop floor, and so on. But for me, the most interesting action had to deal with the elaboration of an **as-is** analysis, the determination of its weak points and the development of a **should-be** concept.

It was surely a very hard week, but it was worthwhile. I even found my old bike!

4.4 Part 4: Analysis and Conception

The 'as-is' analysis has been realized taking into account the sequence of the order processing and the two target points: (1) work organization and production planning and control. This analysis was really very useful for the workers to find out about the flow of the firm. Some of them were surprised with the amount of weak points that were discovered, as well as the related reasons could be identified, just 'looking at' the analysis representation.

By the way, we have made use of the PS-Method (Scheel, 1990) to represent the organization flow. For that, Prof. Fritz has provided us with a three day course explaining the potentialities of the methods as well as the techniques used to realize it. We have made use of interviews and observation - note that when I say 'we' I mean Cecilia and myself, who have conducted the great part of the 'as-is' analysis supported always by the 'local expert' from each analysed area.

The analysis comprised eleven functions directly related with the order processing in the firm: (1) inquiry entry, (2) elaboration of offer, (3) order entry, (4) technical office, (5) process plan, (6) Manufacturing, (7) Control, (8) warehouse, (9) electrical department, (10) project office from the electrical department and (11) assembly (appendix 3).

On average we have done two interviews in each area. In the first one we have tried to get as much information as possible. In each of these interviews, Cecilia and I have both done some notes and afterwards we have jointly represented - the better we could - the information and material flow analysed (when I say material flow I mean the 'rough' one, i.e. the way the material flows from the warehouse up to the delivery. The 'fine' material flow, i.e. the one related to each production order was also analysed, but in a later step - during the detailed conception - in order to orient the formation of decentralized and partially autonomous production areas). Having the draft in hands, we had the second interview in which corrections and complementations were made. At this time, most of the weak points were already identified and a list was set up with the main problems pointed out. During the whole process the people were very receptive and collaborative. I think that this has to do with the information program idealized by Prof. Fritz and put into action since the beginning of the project. The 'project newspaper' (appendix 4) brought to the workers the information they wanted. They felt themselves 'inside' the project. The repercussion of the newspaper could be perceived during our interviews.

After three months the final version of the 'as-is' situation containing the graphical organization flow representation and some comments about it as well as the description of the weak points generated the first interim report (Esser, Pereira Klen and Vöge, 1992a).

Based on the results of the 'as-is' analysis and the identification of the weak points the project team has developed a 'should-be' concept (appendix 5) under the orientation of Prof. Fritz who has shown us modern approaches in work organization and task appropriate computer support for the shop floor. This activity took more time than I expected: two and half months. It is not easy to run a project having other thousand things to do. And if we consider that each team member had the same problem...

The main goal of the 'should-be' concept was to find a way to remove the weak points. Consequently, the introduction of a SMC system was considered and the workers and foremen were involved to explain their requirements regarding such a tool. As a result, some screens were developed (figures 3.2-4 till 3.2-11) jointly with the system end-users. The 'should-be' concept was documented in a report with the graphical representation and a text explaining the new flow and the suggested modifications to overcome the weak points (Esser, Pereira Klen and Vöge, 1992b).

Time goes by so quickly... The project has began six months ago. Since then we have not yet increased our share of the market, but something has changed. The interest of the workers in the project shows that their motivation has increased. That is already a great step forward...

4.5 Part 5: The Arrow

- Hi! What is up? - I ask while entering the meeting room.

- Why are you laughing? - I continue.

- Good morning, Eddie! - Cecilia greets me.

- Hi, Eddie! - says Oscar trying to stop laughing.

- Ivan asks me: - Do you know 'Mr. Russo'? - and point at Russo, who is very well dressed wearing a made-to-measure suit.

- This is his 'should-be' version - completes Oscar.

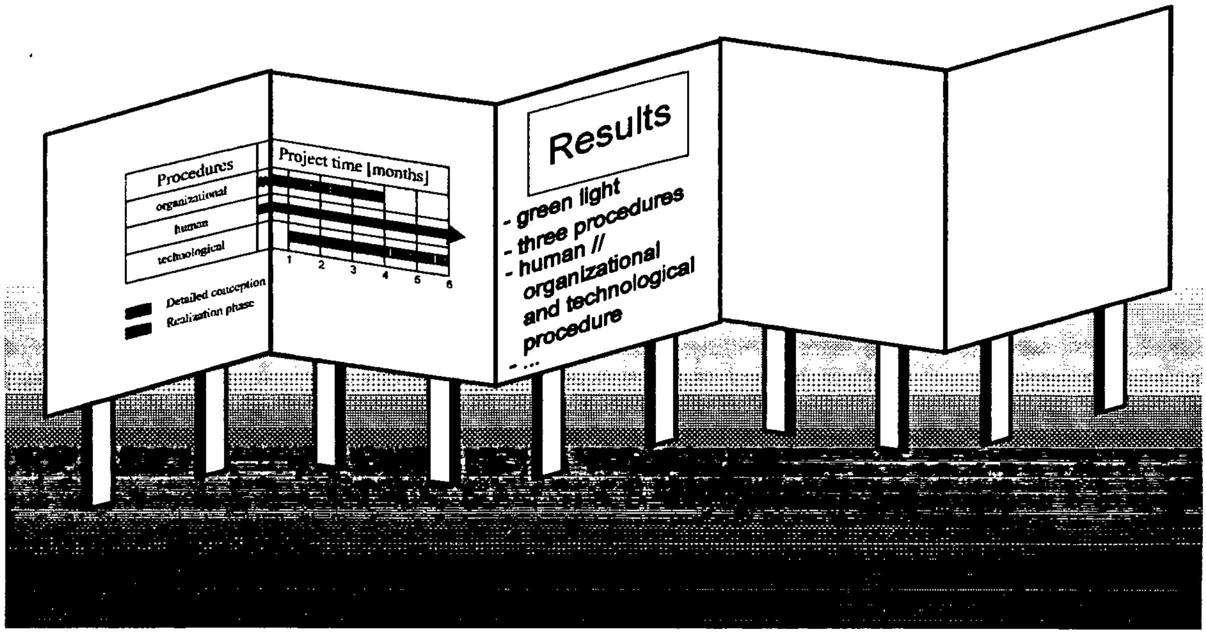
- Oh, don't pay any attention to them, Eddie, says Russo. - By the way, do you like my suit? I have this afternoon free. It is the civil marriage of my youngest daughter.

- You look great - I say. I must confess that I feel very well seeing how they are involved with the project. Also in the daily fun we can note it...

Prof. Fritz is also present and although he understands a little bit Portuguese I guess he did not understand the joke or, I had better say, the 'Brazilian sense of humor'.

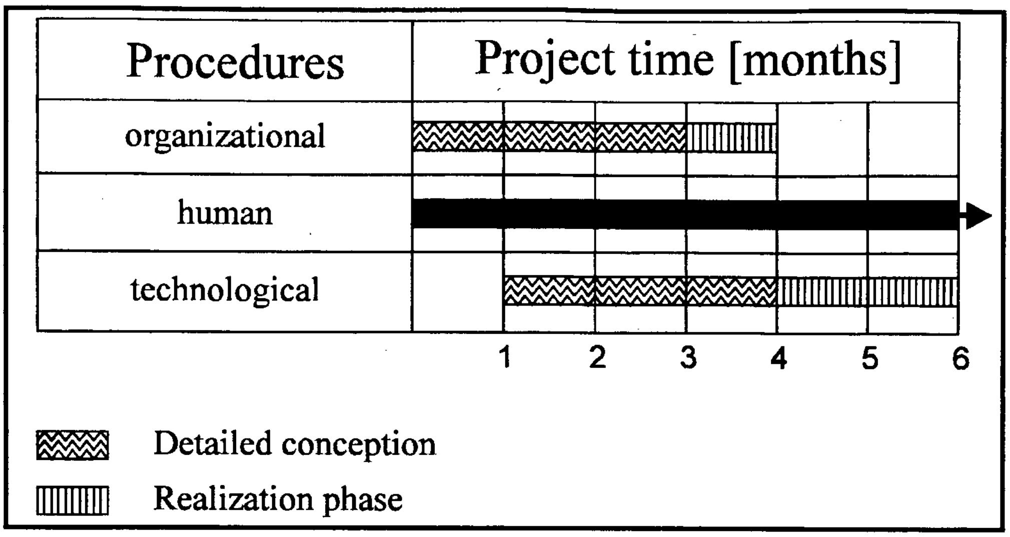
The second day of this very important meeting (the financial director was present...) ended before lunch. I am alone in the room looking at the blackboard scribbled with notes, drawings, comments and the arrow...

On the right hand side of the blackboard, a list summarizes some results of the meeting:



- The project has a green light from the financial department. Cost studies should be carried out;
- The detailed conception comprises three procedures: organizational, human and technological;
- The human procedure runs parallel to the organizational and the technological one and constitutes the flexible interface of the procedure integration;
- The implementation should occur immediately after going through the procedures.

Regarding the last statement on the blackboard, this means that our realization phase will be divided into two parts, since we have chosen to begin with the technological procedure before ending the organizational one and considering that both will take approximately the same time. Incidentally, we planned that the organizational and the technological procedure should take three months each one. For the development of the organizational procedure we have planned one month, and for the technological procedure two months. Furthermore, the technological procedure should begin one month after the beginning of the organizational procedure. That means that the detailed conception and the realization steps would take entirety six months altogether. The human procedure will have its most intensive phase while going through the organizational and technological procedures. But activities related to qualification of the staff, motivation of the workers, and so on, cannot be represented in a graph or any other limited device. It should not stop with the end of the project and this is what the arrow tries to represent. As Prof. Fritz drew the arrow on the blackboard he asked us if we could understand what he was trying to say. Everyone nodded; some comments were made with respect to the arrow. It is incredible how this new kind of thinking and acting is already intrinsic in the corporate culture.



4.6 Part 6: Detailed Conception and Realization

- How long do you need yet, Daniel? - I ask to the supervisor of the external firm contracted to implement the machine modifications on the shop floor.

- Not much longer, Eddie - he answers. We are almost ready. We just have to adjust the 3416-08 beside the 3416-16, and that's all.

- Don't forget that in a few hours it's New Year's Eve, I complete.

- Don't worry, I won't forget!

We took the workers free week between Christmas and New Year to make the needed changes in order to disrupt the production as little as possible. An external firm has done the physical layout modifications under the attentive supervision of Russo and Oscar. I was also present as much as I could be, but my administrative functions prevented me from being here all the time, as Russo and Oscar have done. But I am sure the external people were in good hands. Both knew everything about the shop floor and how the organizational procedure had run. After all they were the key people in this procedure.

To form the part families and the machine groups we have made use of the production flow analysis (PFA) method and the visual analysis. Concerning the latter, the know-how of

Russo and Oscar was essential. From them came also the suggestion to analyse just a part of the product spectrum - the most significant, of course - as well as most of the restrictions. I really didn't know that there were so many restrictions in such a 'small' shop floor. In spite of the need, some equipment could not be moved due to, for instance, their foundation or their peripheries or even the associated costs related to the new place planned for them. The most critical ones were the CNC-machines that should not be moved, unless it should be absolutely necessary.

Altogether, 6,724 production orders containing 46,427 operations were analysed; the production orders have a maximum of 24 and an average of 6.9 operations (Kuhlmann, Masow, Pereira Klen and Vöge, 1991). With the data obtained, five layout alternatives were developed (appendix 6) which have formed the basis for the optimized 'should-be' layout. Thus, we had at the end six layout variants that were analysed and evaluated according to the following criteria (Kuhlmann, Masow, Pereira Klen and Vöge, 1991):

1. Number of small equipment (conventional/small machines) that will not have to be moved;
2. Number of big equipment (CNC/big machines) that will not have to be moved;
3. Utilization of existing workers' know-how;
4. Integration of additional activities to the cell;
5. Access to the equipment (consideration of the transport paths);
6. Possibility of intermediate storage inside the cell;
7. Number of machines in each cell;
8. Flexibility regarding machines and workers (resources sharing);
9. Expansion possibility of the cells (for future acquisition of equipment, for example);
10. Number of processes that comprise cell (milling, drilling and so on); and
11. Number of workers.

The sixth layout ('should-be' layout) was the best one according to the criteria established by us in which the main aspects where the second and the eighth ones. Due to so many restrictions and 'ifs' we are conscious that there will be intercell flow among the five cells. Therefore we have made a study considering how many GT cells a part will have to visit (appendix 7) in order to help the shop floor teams (mentored and virtual teams) to have an overview of what is waiting for them. Furthermore, the designs of the 'should-be' concept regarding its transport paths, possibilities of intermediate storage and resource sharing (workers and equipment) hang everywhere on the shop floor (appendix 8) since it was decided that the sixth layout would be the 'should-be' layout. A big design of the 'should-be' layout was hung on the doorway of the shop floor hall. This quite simple initiative had an excellent feedback. Once more the workers felt themselves inside the project: they could see, for instance, on which team they would take part and could contribute suggesting some activities that they could carry out. Some of them have even been here during their free week to take part of the implementation of the layout changes. Some have only observed; others have even helped the external firm! By the way, the external firm received from Russo and Oscar a complete list with the equipment to be moved, their weight and measures, as well as a detailed stepwise procedure describing how the sequence of the modifications should occur (appendix 9).

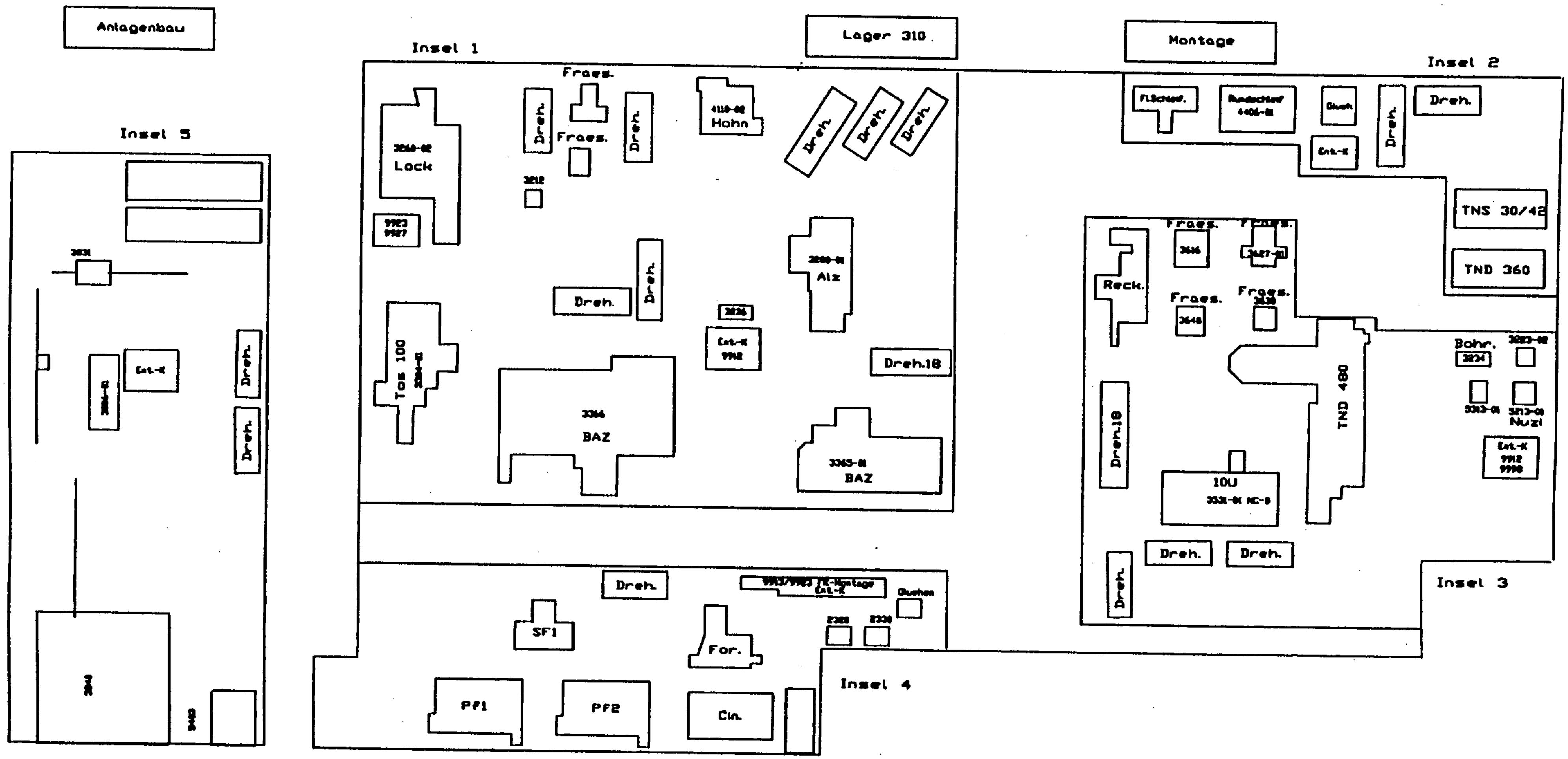
And that's where I am now. Looking at the 'should-be' layout hanging on the doorway with their five decentralized and partially autonomous production areas.

- Hey, Eddie. We are ready, says Daniel. - We are going home!

- Happy New Year! say Russo and Oscar at the same time.

- Happy New Year, guys! I answered.

SHOULD-BE LAYOUT



4.7 Part 7: Back to the Airport

Parallel to the organizational procedures, the work teams were defined. Each team has a mentor, i.e., the one who will be the member of the mentored team and will decide for the formation of a VPA, since we all are aware that intercell flow is inevitable (appendix 7). The mentor was chosen by the redesigned work team members, i.e. the ones who will work in a GT cell. Normally the criteria were the experience and accumulated knowledge of the workers, as well as leadership and management competence. As the team's activities were defined, some training courses were carried out, most intensively regarding the use of computers, that was quite new for most of them, but also regarding electric and hydraulic principles, as well as operation of CNC-machines.

Concerning the computer course, there were different reactions: the older workers felt themselves not so sure as the young ones. But that was not a rule! The most enthusiastic pupil was Manuel the foremen of the assembly area who is 59 years old.

The implementation of the computer support to the shop floor ended last week. We counted on the experience of research scientists of the local University. They conducted a market research and pre-analysed nine SMC systems firstly (appendix 10). This took them three months. Afterwards the project team analysed the nine systems and chose three of them that seemed to satisfy our specific needs. These systems were then installed at the University and the project team, jointly with some workers and foremen, i.e., the end-users of the system, have tested them in a two-day workshop. The workshop was repeated three times by the research scientists. Each time five people of our firm have been involved. In the total, fifteen people took part in the workshop. Based on an evaluation matrix (appendix 11), the systems were assessed by us and the most suitable one was chosen.

The major problems of the system implementation were the input of data (sometimes missing data, other times data that were not so reliable) and the developing of the required interfaces. This took us a great deal of time and, to tell the truth, not all interfaces are ready. But the very important point is that the most necessary information is available on the shop floor. I think we are on the right way...

...- Varig flight number 126 coming from Sao Paulo has landed - the announcement has brought me back to the reality...

- Good morning Mr. Girondi! Good Morning Mr. Wendhausen..., I say

- ...I am very pleased to see you again. I have a lot of things to tell you during our trip to Joinville. Please, come in, - I say opening the door of my car, - Prof. Fritz is waiting for us at TRIPOD.

What a wonderful Summer day...

5. CONCLUSIONS

The work presented discussed the aspects related to the configuration of virtual production areas as an approach for the conceptualization of a Learning Enterprise. Beyond technological considerations concerning the shop floor monitoring and control systems with regard to their implementation - in a decentralized way - and their utilization - as a shop floor information system -, considerations regarding aspects like 'virtualization' and effective involvement of workers in the whole process imposed on the work a multidisciplinary character of emerging elements in a holistic environment. Consequently, an exhaustive and definitive study was not the aim of the work. More than that, probably the main contribution of this work lies in giving rise and triggering further research towards conceptualizing Learning Enterprises, since this is just an attempt to give direction to a complex problem.

Some other contributions of this work are:

1. Development of a Learning Enterprise generic framework supported by a triadic model based on technological, organizational and human elements. This conceptual framework was then focused with the justified choice of one component of each element constituting the basis of the approach, developed in this work, to the conceptualization of Learning Enterprises for the manufacturing sector.

2. Definition of a Learning Enterprise concept, based on the understanding of *learning* and *integration*, as an enterprise where technological as well as human resources are integrated into organizational frameworks, making use of the knowledge, the flexibility, the creativity and

into organizational frameworks, making use of the knowledge, the flexibility, the creativity and the motivation of the workers available to the enterprise, and utilysing the increasingly powerful information and communication technologies as well.

3. Introduction of the concept of Virtual Production Areas (VPAs), highlighting the ability to reconfigure temporally the shop floor layout, which was previously designed according to GT principles and optimized with regard to coherent criteria, allowing intercell flow even among nonadjacent GT cells being supported by schedule and control facilities.

4. An analysis of the state-of-the-art concerning virtual production areas (VPAs), shop floor monitoring and control (SMC) systems, as well as anthropocentric systems, that allowed:
   - the collection of information and the analysis of some experiences in implementing technological, organizational and human elements in the manufacturing sector in order to:
     - document real case studies,
     - establish parallels (convergencies and divergencies),
     - establish a support plan for the industrial restructuring under technological, organizational, as well as human and social aspects, proposing supporting strategies and methodologies as a guideline for the implementation of some Learning Enterprise's principles in the industry, and
     - establish priorities for the studied elements in terms of required research, development and implementation;
   - a survey of the work being done at research centers and universities focusing on this problem;
   - a suggestion of a mechanism for the coordination of distributed shop floor monitoring and control systems where a *distribution module*, which allocates the orders to the more suitable decentralized and partially autonomous area, is responsible for the centralized coordination and a *human networking*, supported by human communication management, is responsible for the decentralized coordination;
   - a suggestion of a terminology and the conceptualization of some important aspects associated with the concept of Learning Enterprise.

5. Development of a methodology for the configuration of a virtual production area by means of supporting decentralized and partially autonomous production areas by (1) distributed shop floor monitoring and control systems and by (2) human networking coordination. This means

that on the first level, decentralized and partially autonomous production areas are defined based on GT principles, optimized according to the knowledge of the people involved acquired during the learning process (individual and/or collective), and supported by distributed shop floor monitoring and control systems. Within this environment, the integration element, which is responsible for the decentralized coordination, is the human element. It establishes communication and information exchange, giving rise to a second level, where human networking supports the mentor team making possible the configuration of a VPA, which is effectively implemented on a third level with the aid of the virtual team.

6. Characterization of concrete manufacturing industry cases in form of a short novel in order to validate the proposed methodology making use of a didactic method which provided a continuous flow presentation to the implementation.

There are, however, some limitations and difficulties in adopting the methodology suggested in this work. These were identified during the realization of the study and some of the main obstacles found are the:

1. Difficulty in convincing enterprise managers of the benefits of an integrated approach utilizing elements of the triadic model;

2. Limitations of the existing shop floor monitoring and control systems regarding, specially, the coordination functions - both on the vertical and horizontal level; and

3. Continued pragmatic non-existence of systems with autonomous tendency which could be useful on an experimental basis for a detailed analysis.

The approach presented in this work was an attempt to propose incremental steps in form of practical solutions. The solutions comprised short, middle and long-term implementations such as the application of technology group techniques, the introduction of shop floor monitoring and control systems and the consideration of human and social aspects, respectively. But effective development of strategies and methods for the conceptualization of Learning Enterprises is still in its infancy. Other approaches and an even deeper study of some aspects mentioned in this work should be subject for future research. Topics to be studied include:

1. Validation of the reference model by domain experts: the model covers many domains that are traditionally the field of experts in Industrial Engineering, Social Science, Computer Science,

etc. Their re-thinking of the configuration of virtual production areas in the context of Learning Enterprises, as suggested by the reference model, could result in pointers for validating the reference model.

2. Development of an SMC system for VPA environment, to be used as a powerful information system on the shop floor, taking into account the whole process required for the configuration of VPAs.
3. Development of SMC system interfaces and specification of the required input data: in order to take as much advantage as possible of the SMC systems' potentialities, interfaces to suitable systems (CAD, CAPP, and so on) should be realized and criteria for the specification of the input data should be developed.
4. Study of economic and flexibility aspects regarding production systems such as virtual production areas.
5. Analysis of enterprises' cultural aspects as determining factors and essential elements of the VPA model.
6. Study of the influence of engineering activities (design, process planning, and so on) on the shop floor, i.e., within decentralized and partially autonomous production areas, in view of configuring VPAs.
7. Development of appropriate work time and payment models considering the new workers' activities resulting from the new concept presented in this work.
8. Analogous study concerning the configuration of virtual enterprises and related coordination possibilities involving the utilization of Decision Support Systems (DSS) for the synchronization of distributed business processes.

The topics described above merely highlight some alternatives that can lead to future research and development. Others, deriving from the present study, could arise as a consequence of specific interests.

"We have not succeeded in answering all our questions.
Indeed, we sometimes feel we have not completely answered any of them.
The answers we have found only serve to raise a whole new set of questions.
In some ways we feel we are as confused as ever.
But we think we are confused on a higher level and about more important things."
(Anonymous)

APPENDIXES

APPENDIX 1

COMPANY ANALYSIS QUESTIONNAIRE (FLAMME, 1994)

SPRINT FLAMME

Company Analysis Questionaire

AIMME BIBA CETIM EOLAS PERA T.N.O. W.T.C.M.

Company: Date: ..../......../....... Page: 1

Part A: Specification of Organisation

A.1 Sector

1.2. Please x:

- O Electrical engineering
- O Mechanical engineering
- O Automotive (supplier) industry
- O Process industry
- O Other

A.2 Size of company, number of employees
Please specify: total .... employees

A.3 Distribution of employees by department and area; Please specify:

	Academics	Technicians	Professionals	Administration Employees	Foremen	Specialists	Semi-skilled	Trainees	Other	TOTAL
Design										
Work preparation										
Production										
Marketing										
Purchasing										
Administration										
....										
....										
TOTAL										

A.4 Turnover (annual)
Please specify:............ ECU through products
.... ECU through replacement parts
.............ECU throught repairs
.... ECU through other services

A.5 Level of (planned) investment for development, new technologies, training and further training
Please specify:............ ECU

A.6 Type of organisation, please outline:

A.7 Marketing method

Please x:

- O Direct marketing
- O Through branches/subsidiaries
- O Suppliers
- O Supplier of order-related service

A.8 Type of product

Please x:

- O Manufacture and assembly
- O Assembly only
- O Job shop
- O Engineering

A.9 Flexibility of design in relation to customer changes and/or production changes

Please x:

in terms of deadlines:
- O Low
- O Medium
- O High

in terms of technology:
- O Low
- O Medium
- O High

A.10 Flexibility of operations scheduling in relation to customer changes and/or production changes

Please x:

in terms of deadlines:
- O Low
- O Medium
- O High

in terms of technology:
- O Low
- O Medium
- O High

A.11 Flexibility of production in relation to customer changes and/or production changes

Please x:

in terms of deadlines:
- O Low
- O Medium
- O High

in terms of technology:
- O Low
- O Medium
- O High

A.12 Stock in DM

Please specify:- Raw materials ....
- Production materials ....
- Semi-finished goods ....
- Work in progress ....
- Finished goods ....

A.13 Wage costs

Please specify:............. ECU/ .... ECU

A.14 Describe briefly the market position of the Company

Please specify:

A.14a Please estimate, on a scale from +2 (significant increase) to -2 (significant decrease) the following trends:

	+2	+1	0	-1	-2
- Demand trend					
in the previous three years:	O	O	O	O	O
in the coming three years:	O	O	O	O	O
- Turnover trend					
in the previous three years:	O	O	O	O	O
in the coming three years:	O	O	O	O	O
- Profit trend					
in the previous three years:	O	O	O	O	O
in the coming three years:	O	O	O	O	O
- Personnel trend					
in the previous three years:	O	O	O	O	O
in the coming three years:	O	O	O	O	O

SPRINT FLAMME	**Company Analysis Questionaire**	AIMME BIBA CETIM EOLAS	PERA T.N.O. W.T.C.M.
Company:	Date: ..../......../.......		Page: 4

Part B: Product Specification

B.1 Product classification
Please specify:

____

____

B.2 Product variety
Please x:
- O Customer specific
- O Generic products with customer specific variants
- O Standard products with variants
- O Standard products without variants

B.3 Product structure
Please x:
- O Single part products
- O Multiple part products with a simple structure
- O Multiple part products with a complex structure

B.4 Number of variants
Please x:
- O None
- O 0<X<10
- O 10<X<100
- O 100<X<1000
- O X>1000

B.5 Product life cycle
Please x:
- O O<X< 1 year
- O 1 year <X< 5 years
- O 5 years <X< 10 years
- O X> 10 years

SPRINT FLAMME	Company Analysis Questionaire	AIMME BIBA CETIM EOLAS	PERA T.N.O. W.T.C.M.
Company:	Date: ..../......../.......		Page: 5

B.1.a Name the most important product groups of your factory in 1991/92 (by turnover).

1:... approx. .... %
2:... approx. .... %
3:... approx. .... %

SPRINT FLAMME

Company Analysis Questionaire

AIMME BIBA CETIM EOLAS PERA T.N.O. W.T.C.M.

Company:

Date: ..../......../.......

B.6 Total number of parts (parts bought in and parts produced in-house)
Please specify:Total: ....;
for a representative product: ....

B.7 Proportion of in-house production
Please specify:Total: ....
for a representative product: ....

B.8 Number of bought in parts
Please specify:Total: ....
for a representative product: ....

B.9 Number of intermediate products (semi-finished products, in intermediate stores, for example)
Please specify:Total: ....

B.10 Number of end products
Please specify:Total: ....

B.11 Number of new products per year
Please specify:Total: ....

B.11a Please evaluate each of the following statements regarding the future development of the product structure of this factory:

Please Cross:	Tend to Increase	Remain approx. Constant	Tend to Decrease
The range of different products will			
The number of variants of our products will			
The unification of our products through standardisation and compliance with standards will			
The production for stores of our products will			
The economic life (period of saleability) of our products on the market will			
The proportion of bought in services will			
The average batch size will			
The number of rushed orders will			
The capacity utilisation of our production facilities will			
The stocks of semi-finished goods and bought in parts will			
The fluctuations of orders and capacity loading will			

SPRINT FLAMME	Company Analysis Questionaire	AIMME BIBA CETIM EOLAS	PERA T.N.O. W.T.C.M.

Company: Date: ..../......../.......

Part C: Specification of Order Completion

C.1 Type of order initiation
Please x:
- O Production to single order
- O Production to multiple orders
- O Production for stores

C.2 Orders in hand
Please x and specify:
- O Hours
- O Days
- O Weeks
- O Months
- O Years

C.3 Planning horizon
Please x and specify:
- O Hours
- O Days
- O Weeks
- O Months
- O Years

C.4 Work tasks per order
Please specify:max.: ....
min.: ....
average: ....

C.5 Content (duration) of work task
Please specify:max.: ....
min.: ....
average: ....

C.6 Generation of total products per day
Please specify:max.: ....
min.: ....
average: ....

C.7 Release of new product orders per day (orders in hand in production)
Please specify:max.: ....
min.: ....
average: ....

C.8 Completed orders per day
Please specify:max.: ....
min.: ....
average: ....

C.9 Type of feedback

Please x:
- O Online
- O Batch (frequency: ...... per day)

C.10 Batch size

Please specify: max.: ....
min.: ....
average: ....

C.11 Type

Please x:
- O Anonymous
- O Customer Order
- O Predominantly Customer Order
- O Predominantly Programmed Order
- O Programmed Orders

C.12 Do short-term order changes occur?

Please x:
- O Yes
- O No

C.13 If yes, why, and what are the consequences?

Please specify:

....

....

C.14 What is the relative significance of the following factors in determining the sequence of orders:

Please x:

Customer deadline:
- O Low
- O Medium
- O High

Product:
- O Low
- O Medium
- O High

Customer:
- O Low
- O Medium
- O High

C.15 Meeting of customer deadlines

Please x:
- O Low
- O Medium
- O High

SPRINT FLAMME	**Company Analysis Questionaire**	AIMME BIBA CETIM EOLAS	PERA T.N.O. W.T.C.M.
Company:	Date: ..../......../.......		Page: 9

C.16 Does a JIT relationship exist between

- O The Company and its customers
- O The Company and a supplier
- O Both

C.17 If yes, what was the experience of the relationship?
Please specify:

....

....

C.18 Are these average delivery times very different? If yes, why?
Please specify:

....

C.19 How long are the order completion times? (From delivery of raw materials to despatch)
Please specify: max.: ....
min.: ....
average.: ....

C.20 How long are lead times for bought in parts/raw material?
Please specify: max.: ....
min.: ....
average.: ....

C.21 What is the breakdown of the total order completion time?
Please specify: Planning: ....
Design: ....
Order processing: ....
Manufacture: ....
Assembly: ....

C.22 What is the breakdown of the delivery time (in %)?
Please specify: Tooling up time: ....
Time in stores: ....
Transport time: ....
Production (process) time: ....

C.23 Are there process-related times in stores?
Please specify: O Yes
O No

C.24 If yes, can these be eliminated or reduced?
Please specify:

....

....

Part D: Specification of Manufacturing, Assembly, Materials Flow and Quality Assurance

D.1 Type of Manufacturing Organisation
Please x:
- O On-site manufacture
- O Workshop production
- O Assembly line production
- O Production islands
- O Flexible manufacturing
- O Other, please specify: ....

D.2 Type of production:
Please x:
- O One-offs
- O Single batch and low volume
- O Medium volume
- O High volume

D.3 Depth of manufacture of products within the Company
Please x:
- O Low (1-3 levels of bills of materials)
- O Medium (4-6 levels of bills of materials)
- O High (7-10 levels of bills of materials)

D.4 Type of procurement
Please x:
- O External supply insignificant
- O External supply in quite high volumes
- O Predominantly external supply

D.5 Production process
Please x:
- O Re-shaping
- O Original shaping
- O Parting
- O Adding
- O Other, please specify: ....

SPRINT FLAMME	**Company Analysis Questionaire**	AIMME BIBA CETIM EOLAS	PERA T.N.O. W.T.C.M.

Company: Date: ..../......../....... Page: 12

D.1a Are there work groups in the production area of this Company?

O Yes - (please specify number) .... : .... work groups
O No

D.1b If yes, please specify whether the following statements are generally applicable or inapplicable for the production facility of this factory.

Please cross:	Generally Applicable	Generally Inapplicable
The work groups consist of a minimum of three, and a maximum of 15 workers		
All, or a majority, of workers in the respective work groups are permanently allocated to their work group		
Immediately productive activities with production machines are a part of the duties of the various work groups		
The members of the various work groups also carry out tasks that are indirectly productive (e.g. QA, Maintenance)		
The members of the various work groups also carry out administrative duties (e.g. day to day production planning, work distribution)		
All the members of the work group are qualified for all the duties allocated to the group		
The members of the respective work group carry out tasks in rotation ('Job rotation')		
There are no permanent superiors within the work groups		

D.5a In addition:

O Metal cutting
O Coating
O Alteration of the properties of materials
O Assembly

D.6 Number and structure of the areas
please specify and outline:
....
....

D.7 Properties of the areas
Please enter

Area Degree of												
Automation												
Flexibility												
Autonomy												

Legend: (-)=low, (0)=medium, (+)=high

D.8 Degree of automation (overall)
Please x:
- O Low / predominantly manual
- O Medium / (C)NC Technology, Computer Aided
- O High / (partial) integration
- O Total integration / entirely CNC production with automated material flow

D.9 Degree of autonomy (overall)
Please x:
- O Low (heavily dependent on other areas)
- O Medium (slight dependence)
- O High (independent, autonomous execution of complete tasks)

D.10 Degree of flexibility (overall), ability to react to changes in product and processes
Please x:
- O Low
- O Medium
- O High

D.11 List of machines or production facilities (conventional / computer aided)
please enter in list:

D.12 Type of process
Please x:
- O Discrete production
- O Continuous process
- O Mixed

D.13 Work model
Please x:
- O Single shift
- O Two shifts
- O Three shifts
- O Three shifts, low manning level

D.14 Type of wage
Please x:
- O Time
- O Productivity
- O Bonus
- O Other

D.15 Level of qualification and acceptance of production personnel in relation to the relevant techniques and processes
Please x:
- O Low
- O Medium
- O High

D.15a Please specify the degree to which each of the following activities is carried out by workshop personnel (ie, foremen, charge hands, technicians, machine operators, unskilled workers, etc) in the production area:

Please cross	Entirel y	For the Most Part	For a Small Part	Not at all	Inapplicable
Material/quantity planning					
Flow scheduling					
Capacity requirements planning					
Capacity compensation					
Day to day scheduling					
Work distribution					
Order supervision					
Machine programming					
Material/stores administration					
Quality Assurance					
Maintenance					

SPRINT FLAMME	**Company Analysis Questionaire**	AIMME BIBA CETIM EOLAS PERA T.N.O. W.T.C.M.
Company:	Date: ..../......../.......	Page: 15

D.15b Please specify the extent to which each of the following activities is a part of the duties of the operators of these computer aided / conventional production machines

Please cross	Entirely	For the Most Part	For a Small Part	Not at all	Inapplicable
Operation/Supervision of machines					
Re-tooling/Set-up of machines					
Tool handling/processing					
Quality supervision/control					
Maintenance/inspection					
Repair					
Adjustment of tools/installations					
Preparation of tools, workpieces and materials					
Cleaning of production facilities and workpieces					
Creation of NC programs					
Testing and correction of NC programs					

SPRINT FLAMME	**Company Analysis Questionaire**	AIMME BIBA CETIM EOLAS PERA T.N.O. W.T.C.M.
Company:	Date: ..../......../.......	Page: 16

D.16 Production disruptions
Please specify:

Type	Number	Time

D.17 Is the production facility capable of meeting the customer's requirements in relation to delivery times?
Please x: O Yes
O No

D.18 If not, how many days / weeks / months is the difference in duration between the completion date and the delivery deadline as required by the customer?
Please x: ....

D.19 Is production ahead of customer demand?
Please x: O Yes, by .... days / weeks/ months
O No

D.20 Which planning method most closely describes your planning?
Please x:
O PUSH: generate orders and execute to the finished product
O PULL: orders are generated as a result of customer enquiries or of requirements of the service (spares) department
O Other:.......

D.21 How big is the buffer or intermediate stores for raw material quantitatively or as a percentage of the weekly/daily/monthly requirement?

Please specify:

- semi-finished goods?
Please x: O Low
O Medium
O High

- finished products?
Please x: O Low

O Medium
O High

D.22 If there are large buffers and intermediate stores, then why is this so?
Please specify:
....
....

D.23 Have any endeavours been made to date to reduce or eliminate them?
If so, what were they, and what was the result?
Please x:
....
....
....

D.24 Scope of parts testing for quality assurance
Please x: O Sample checks
O .... (single piece) parts / ..... (single piece)
Manufactured parts
O All parts
O Individually
O In batch quantities

D.25 Frequency of testing
Please x: O Following each work task
O Following the completion of the work tasks in a production area

D.26 Who carries out these tests?
Please x: O Specialist workers in the respective area
O Foremen in the respective area
O Quality assurance department

D.27 Are parts taken out of the manufacturing process for testing?
Please x: O Yes
O No

D.28 Does your Company have a QA system conforming to the DIN IS0 9000 series of standards?
Please x: O Yes
O No

SPRINT FLAMME	**Company Analysis Questionaire**	AIMME BIBA CETIM EOLAS	PERA T.N.O. W.T.C.M.
Company:	Date: ..../......../.......		Page: 18

D.29 What does the term quality assurance mean in your Company?
Please specify:

....
....
....
....
....
....
....
....

SPRINT FLAMME	**Company Analysis Questionaire**	AIMME BIBA CETIM EOLAS	PERA T.N.O. W.T.C.M.

Company: Date: ..../......../....... Page: 19

Part E: Specification of EDP equipment and data management:

E1. Please enter the characteristics of the EDP equipment in the below table:

EDP Specification	EPD Used Yes/No	EDP Penetration (-) Low (o) Medium (+) High	EDP System or tools type Name see legend	Number of terminals	Loading (-) Low (o) Medium (+) High	Functional scope (-) Poor (o) Adequate (+) Good
Department						
Design						
Work Preparation						
Production						
Marketing						
Purchasing						
Administration						
....						
....						

Legend for the type of tools or EDP system:

DESIGN	Work PREPARATION	PRODUCTION	MARKETINGAD	MINISTRATION
1: Sketch	1: Manual	1: Manual	1: Manual	1: FIBU
2: Drawing board	2: Planning board	2: SFDC	2: PMS	2: Wages
3: CAD	3: PMS/host computer	3: Host computer	3: Other:	3: Other: ......
4: Other:	4: Other:	4: Other:		

SPRINT FLAMME	**Company Analysis Questionaire**	AIMME BIBA CETIM EOLAS	PERA T.N.O. W.T.C.M.

Company: Date: ..../......../....... Page: 20

E.2 Please enter the characteristics of data management in the below table:

Data Management Characteristics	Type of Data Maintenance	Networking Yes/No	Scope of Networking	Type of Networking	Form of Data Exchange Input Output
Department					
Design					
Work preparation					
Production					
Marketing					
Purchasing					
Administration					
....					
....					

Legend:

Type of data maintenance
1: documents
2: microfiches
3: PC
4: networked PC
5: other: ....

Scope of networking
1: within a department
2: supra-departmental
3: supra-company

Type of networking
1: LAN
2: WAN
3: ....

Form of data exchange
1: verbally
2: distributor / memos
3: pneumatic post
4: electronic mail
5: other: ....

E.2a In the production of this Company, are computer aided components and systems in various functional areas networked technically (by a direct cable link)?

O Yes
O No

If yes, please connect the networked EDP systems with a line:

CAD PMS

CAP CAQ

CAM

E.3 Are production forecasts generated?
Please x: O Yes
O No

SPRINT FLAMME	**Company Analysis Questionaire**	AIMME BIBA CETIM EOLAS PERA T.N.O. W.T.C.M.
Company:	Date: ..../......../.......	Page: 21

E.4 If yes, please comment:
....
....
....

E.5 How often are these forecasts and plans generated?
Please x and specify:
O .... times / day
O .... times / week
O .... times / month
O .... times / year

E.6 By what percentage does actual production deviate from planned production?
Pease specify: .... %

SPRINT FLAMME	**Company Analysis Questionaire**	AIMME BIBA CETIM EOLAS	PERA T.N.O. W.T.C.M.
Company:	Date: ..../......../.......		Page: 22

F.1 Finally, please specify whether, in your view, a significant change has taken place in your plant in the past year that was not covered by our questionnaire.
We would especially appreciate an answer if you feel that we might misinterpret data in the questionnaire without knowledge of these changes.

....
....
....
....
....
....
....
....
....
....
....
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....
....
....
....

APPENDIX 2: MANUFACTURING EXECUTION SYSTEMS

The Shop Floor Monitoring and Control (SMC) Systems, originally a German philosophy, find their equivalent in the American market under the codenames MES or MOM.

Around 1990, the Advanced Manufacturing Research (AMR), in Boston, presented its Manufacturing Execution Systems (MES) model. Julie Fraser, a senior industry analyst for AMR affirms that MES acts as an executor for the manufacturing plant, being a link between MRPII - or whatever resource planning system - and the plant floor control systems. A similar documentation of manufacturing practices is given by the Gartner Group, from Stanford, which call it the Manufacturing Operations Management (MOM).

Going deeply into the task to find the missing link on the shop floor, building a bridge in the manufacturing process between business systems and controls, AMR founded in 1992 ten MESA (Manufacturing Execution Systems Association), the objective of which is to advance awareness and understanding, knowledge, benefits and standards of execution systems in manufacturing enterprises. According to MESA*, it can be pointed:

The definition: MES is a computer software application or series of software application modules that interact directly with a manufacturing production environment.

The integrated MES functions:

---

* Gould, Lawrence, MESA International Helps Sort Out the MES, Managing Automation, p.60-63, June 1993.

- Resource Management
- Capacity Scheduling
- Maintenance Management
- Production Distribution
- Statistical Quality Control
- Laboratory Information Management
- Process Management
- Data Collection
- Plan-wide Document Management
- Process Optimization
- Systems Integrators
- Hardware Suppliers
- Others

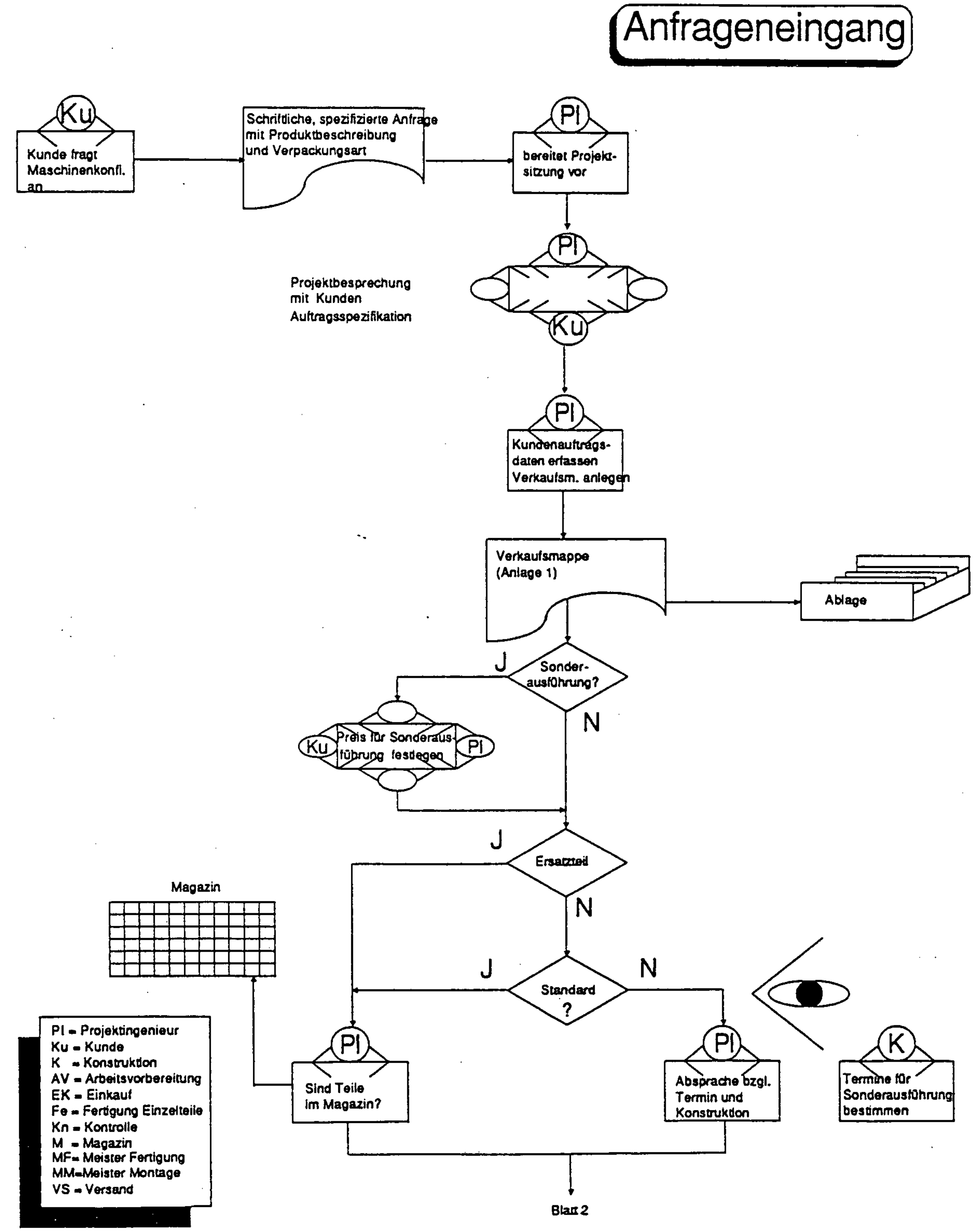
The seven guidelines regarding MES goals, components and functions are:

1. The *business goal* of an MES is the overall improvement in the manufacturing process and its supporting organizational systems on a continual basis. MESs are designed to augment the implementation of manufacturing planning systems, which are focused on product delivery, and manufacturing supervisory control systems, which are focused on the physical control of manufacturing machines.
2. The *core database* in an SME is for the management of production standard operating procedures, maintenance of production demand for the manufacture of products, and for the storage of all production activity and product genealogy data that is taken from the production process.
3. The *priority planning* function in an MES is focused on the best use of production resources, considering the current state of the production environment. An MES will manage product manufacture by balancing demand against production status in order to use time and resources effectively.
4. *Quality management* in an MES operates in two basic ways: pro-active quality controls and collection of production performance data. The implementation of pro-active quality controls is a continual process. The collection of production performance data will probably include one or more of the following: monitoring non-conformance, cycle times, and production yield.

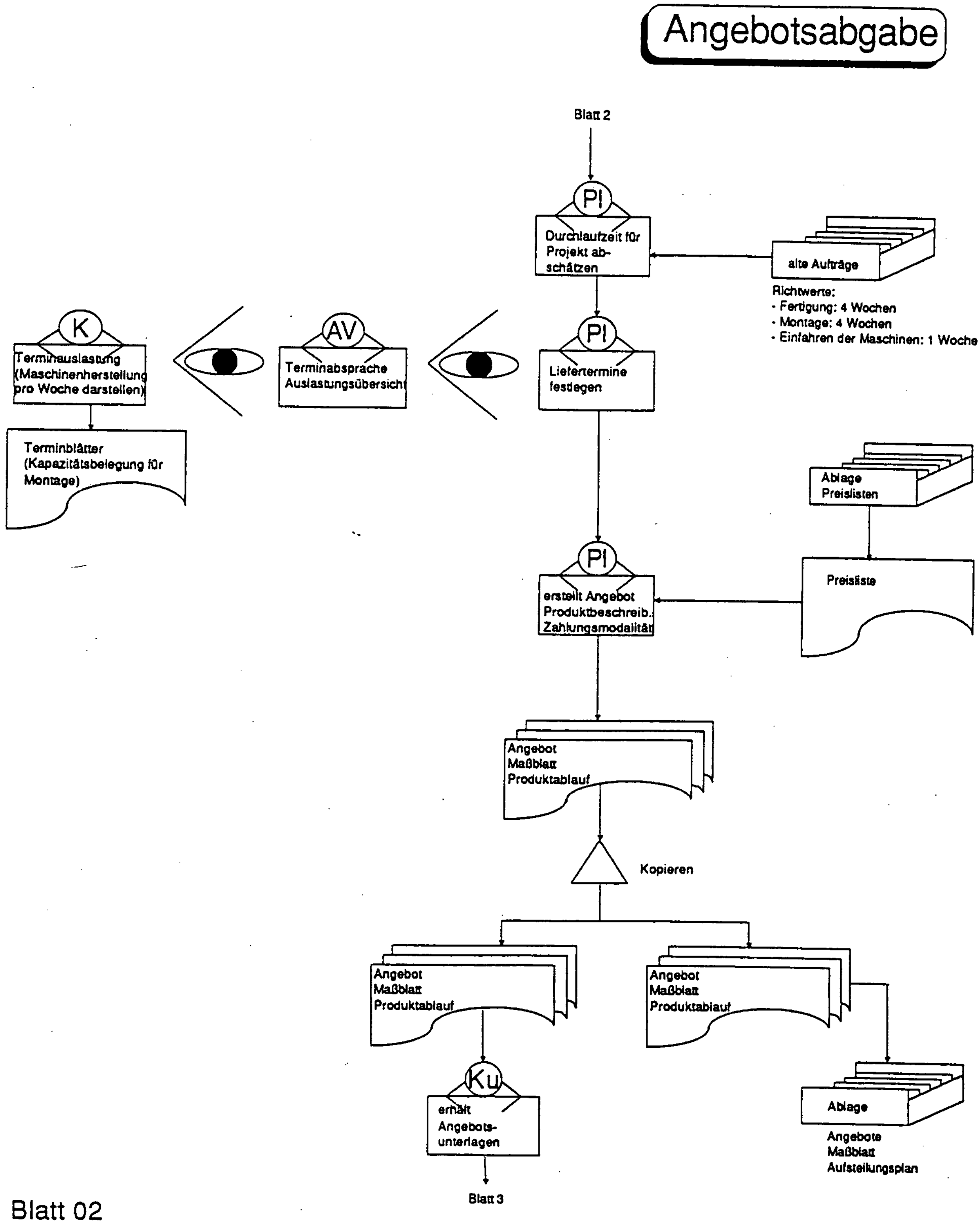
5. The *production activity* available from an MES includes work-in-process, resource and tool status, labour and run-time status, scrap and rework statistics, queue times, and material consumption.
6. The *production genealogy* in an MES provides a complete 'profile' of each manufactured product, and includes equipment used, machine settings, personnel involved, materials used, manufacture data/time/elapsed time, test results, and production deviations encountered.
7. *Integration* is the ability of an MES to share data and information with manufacturing planning and manufacturing supervisory control systems and with manufacturing execution applications. The goal is to provide enterprise-level accessibility to the MES data store.

APPENDIX 3

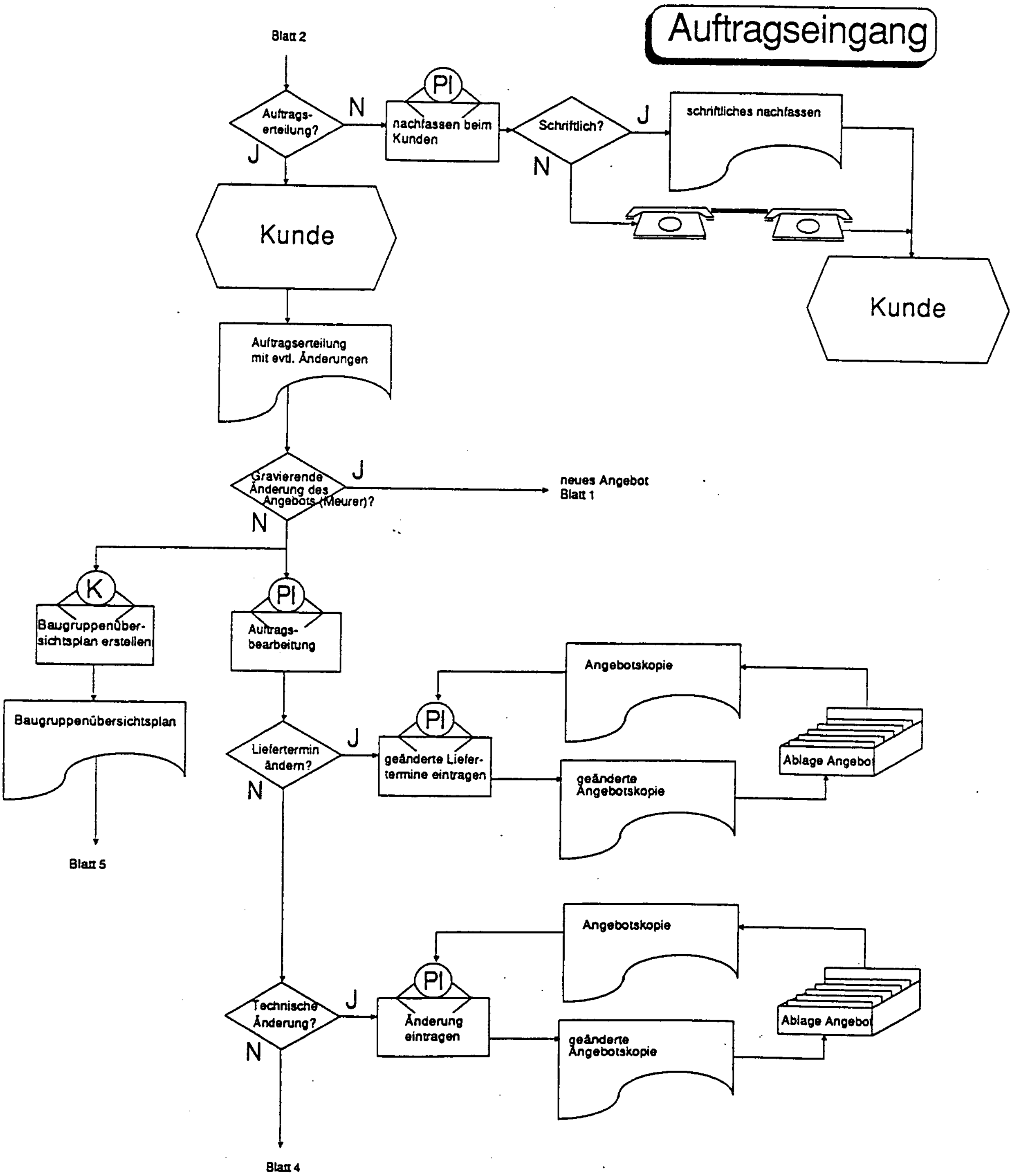
„AS-IS“ SITUATION (ESSER, PEREIRA KLEN AND VÖGE, 1992A)


Anfrageneingang
Ku
Kunde fragt Maschinenkonfi. an
Schriftliche, spezifizierte Anfrage mit Produktbeschreibung und Verpackungsart
Pl
bereitet Projektsitzung vor
Projektbesprechung mit Kunden Auftragsspezifikation
Pl
Ku
Pl
Kundenauftragsdaten erfassen Verkaufsm. anlegen
Verkaufsmappe (Anlage 1)
Ablage
J
Sonderausführung?
N
Ku
Preis für Sonderausführung festlegen
Pl
J
Ersatzteil
N
Magazin
J
Standard ?
N
Pl
Sind Teile im Magazin?
Pl
Absprache bzgl. Termin und Konstruktion
K
Termine für Sonderausführung bestimmen
Pl = Projektingenieur
Ku = Kunde
K = Konstruktion
AV = Arbeitsvorbereitung
EK = Einkauf
Fe = Fertigung Einzelteile
Kn = Kontrolle
M = Magazin
MF= Meister Fertigung
MM=Meister Montage
VS = Versand
Blatt 2

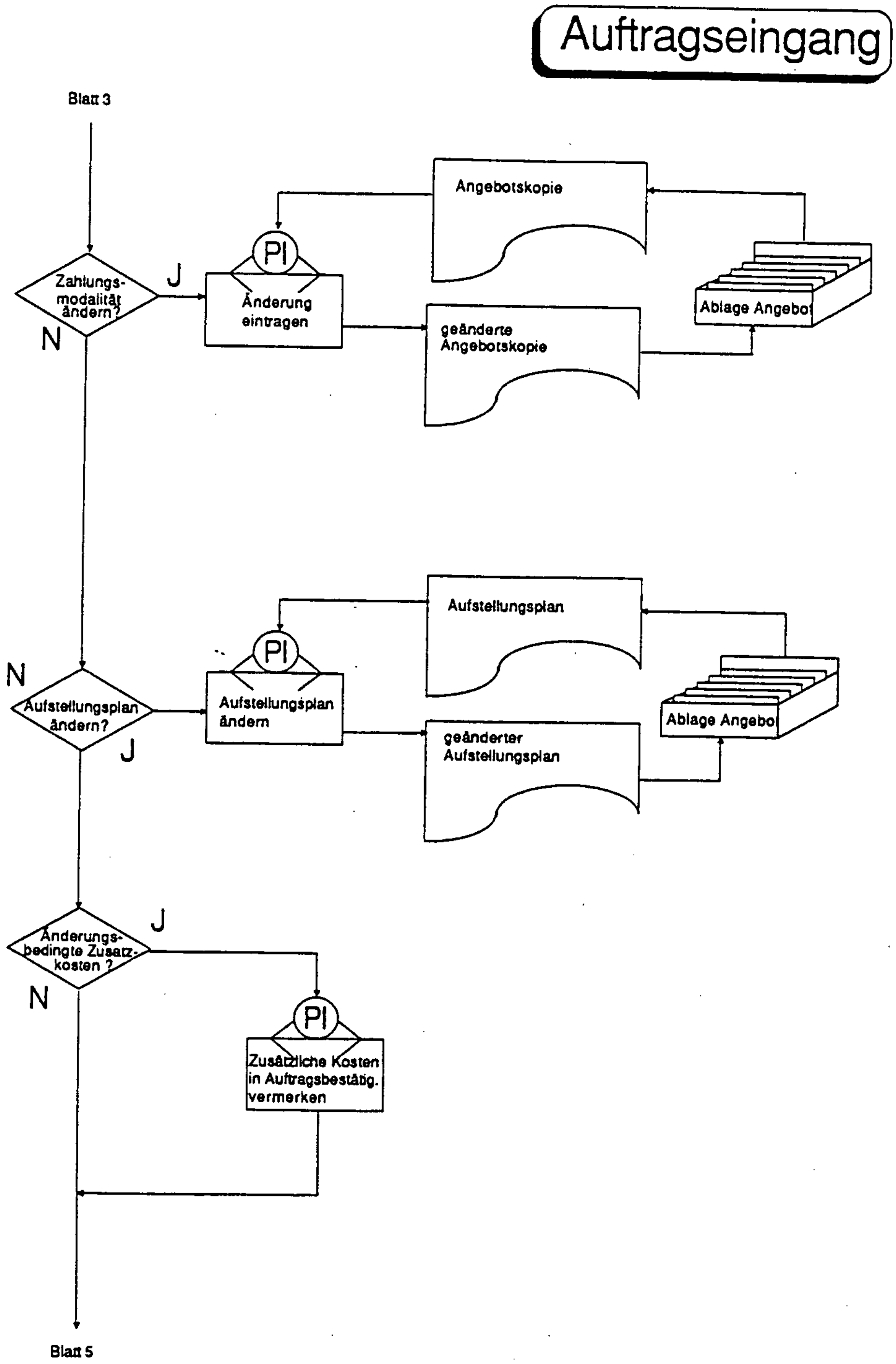
Blatt 01


Angebotsabgabe
Blatt 2
Pl
Durchlaufzeit für Projekt abschätzen
alte Aufträge
Richtwerte:
- Fertigung: 4 Wochen
- Montage: 4 Wochen
- Einfahren der Maschinen: 1 Woche
K
Terminauslastung (Maschinenherstellung pro Woche darstellen)
AV
Terminabsprache Auslastungsübersicht
Pl
Liefertermine festlegen
Terminblätter (Kapazitätsbelegung für Montage)
Ablage Preislisten
Pl
erstellt Angebot Produktbeschreib. Zahlungsmodalität
Preisliste
Angebot
Maßblatt
Produktablauf
Kopieren
Angebot
Maßblatt
Produktablauf
Angebot
Maßblatt
Produktablauf
Ku
erhält Angebotsunterlagen
Blatt 3
Ablage
Angebote
Maßblatt
Aufstellungsplan

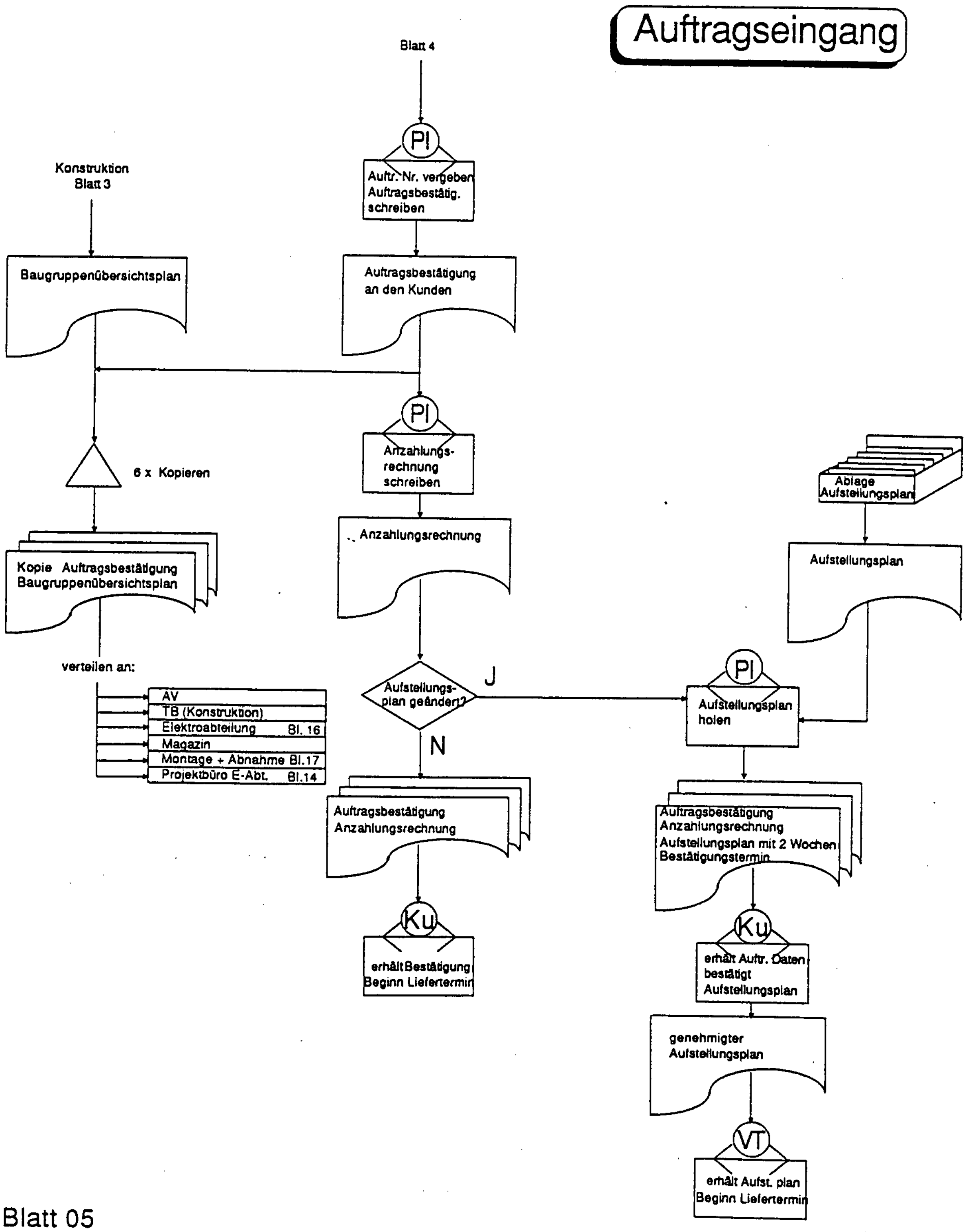
Blatt 02


Auftragseingang
Blatt 2
Auftrags-
erteilung?
N
J
PI
nachfassen beim
Kunden
Schriftlich?
J
N
schriftliches nachfassen
Kunde
Kunde
Auftragserteilung
mit evtl. Änderungen
Gravierende
Änderung des
Angebots (Meurer)?
J
N
neues Angebot
Blatt 1
K
Baugruppenüber-
sichtsplan erstellen
PI
Auftrags-
bearbeitung
Baugruppenübersichtsplan
Blatt 5
Liefertermin
ändern?
J
N
PI
geänderte Liefer-
termine eintragen
Angebotskopie
geänderte
Angebotskopie
Ablage Angebot
Technische
Änderung?
J
N
PI
Änderung
eintragen
Angebotskopie
geänderte
Angebotskopie
Ablage Angebot
Blatt 4

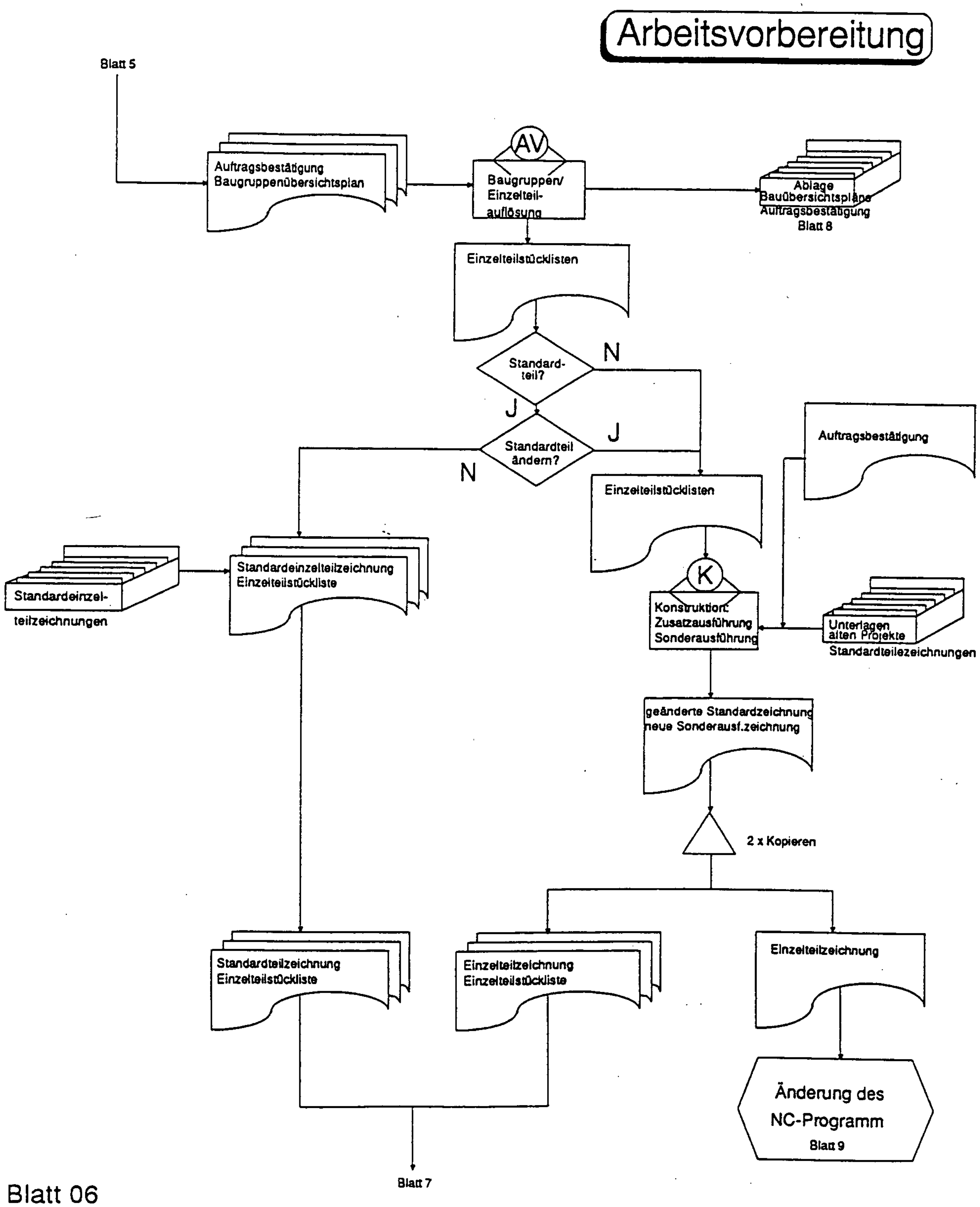
Blatt 03


Auftragseingang
Blatt 3
Angebotskopie
PI
Zahlungs-modalität ändern?
J
N
Änderung eintragen
geänderte Angebotskopie
Ablage Angebot
Aufstellungsplan
PI
N
Aufstellungsplan ändern?
J
Aufstellungsplan ändern
geänderter Aufstellungsplan
Ablage Angebot
J
Änderungs-bedingte Zusatz-kosten ?
N
PI
Zusätzliche Kosten in Auftragsbestätig. vermerken
Blatt 5

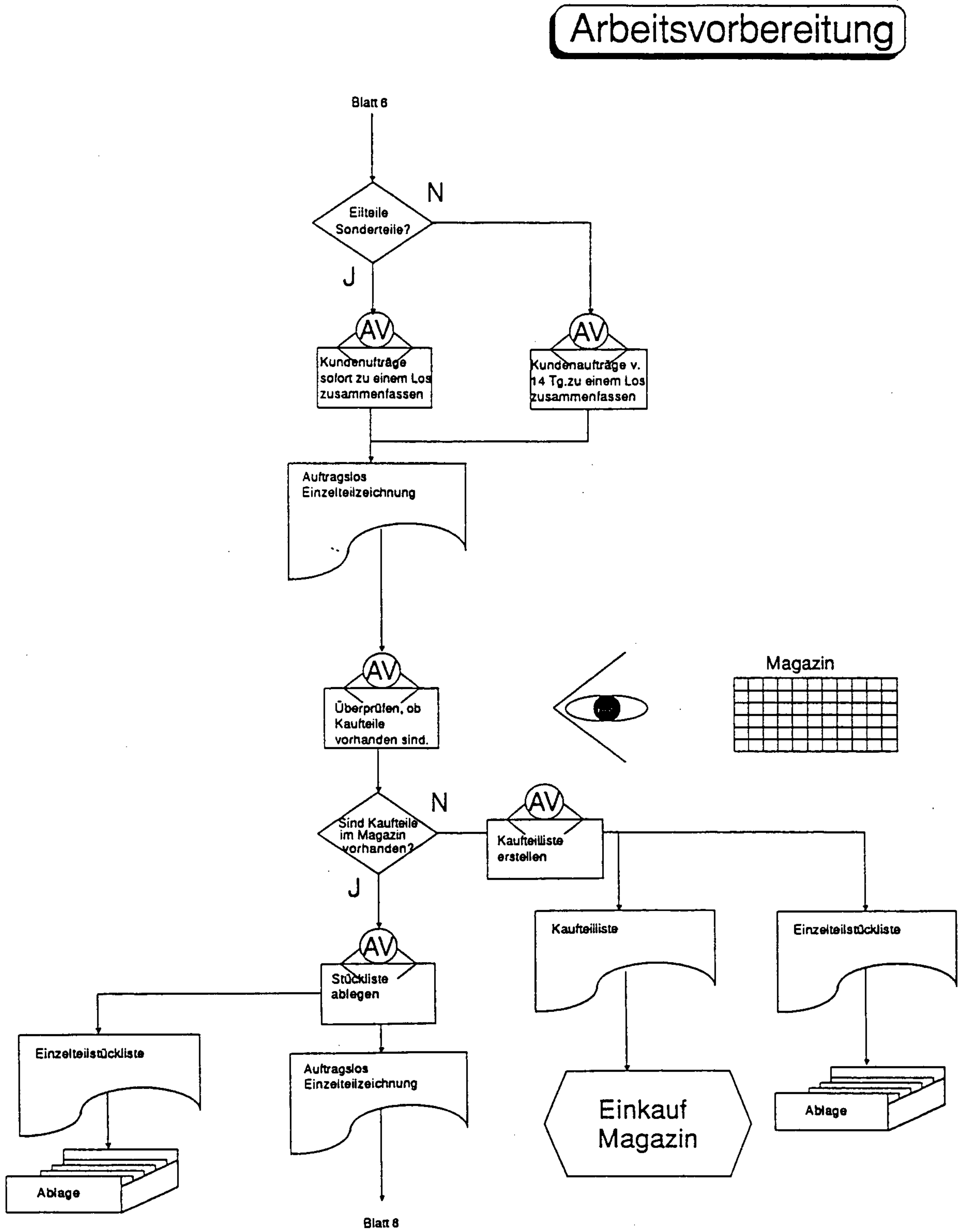
Blatt 04


Auftragseingang
Blatt 4
Pl
Auftr. Nr. vergeben Auftragsbestätig. schreiben
Konstruktion Blatt 3
Baugruppenübersichtsplan
Auftragsbestätigung an den Kunden
Pl
Anzahlungs-rechnung schreiben
6 x Kopieren
Anzahlungsrechnung
Ablage Aufstellungsplan
Kopie Auftragsbestätigung Baugruppenübersichtsplan
Aufstellungsplan
verteilen an:
AV
TB (Konstruktion)
Elektroabteilung Bl. 16
Magazin
Montage + Abnahme Bl.17
Projektbüro E-Abt. Bl.14
Aufstellungs-plan geändert?
J
N
Pl
Aufstellungsplan holen
Auftragsbestätigung Anzahlungsrechnung
Auftragsbestätigung Anzahlungsrechnung Aufstellungsplan mit 2 Wochen Bestätigungstermin
Ku
erhält Bestätigung Beginn Liefertermin
Ku
erhält Auftr. Daten bestätigt Aufstellungsplan
genehmigter Aufstellungsplan
VT
erhält Aufst. plan Beginn Liefertermin

Blatt 05

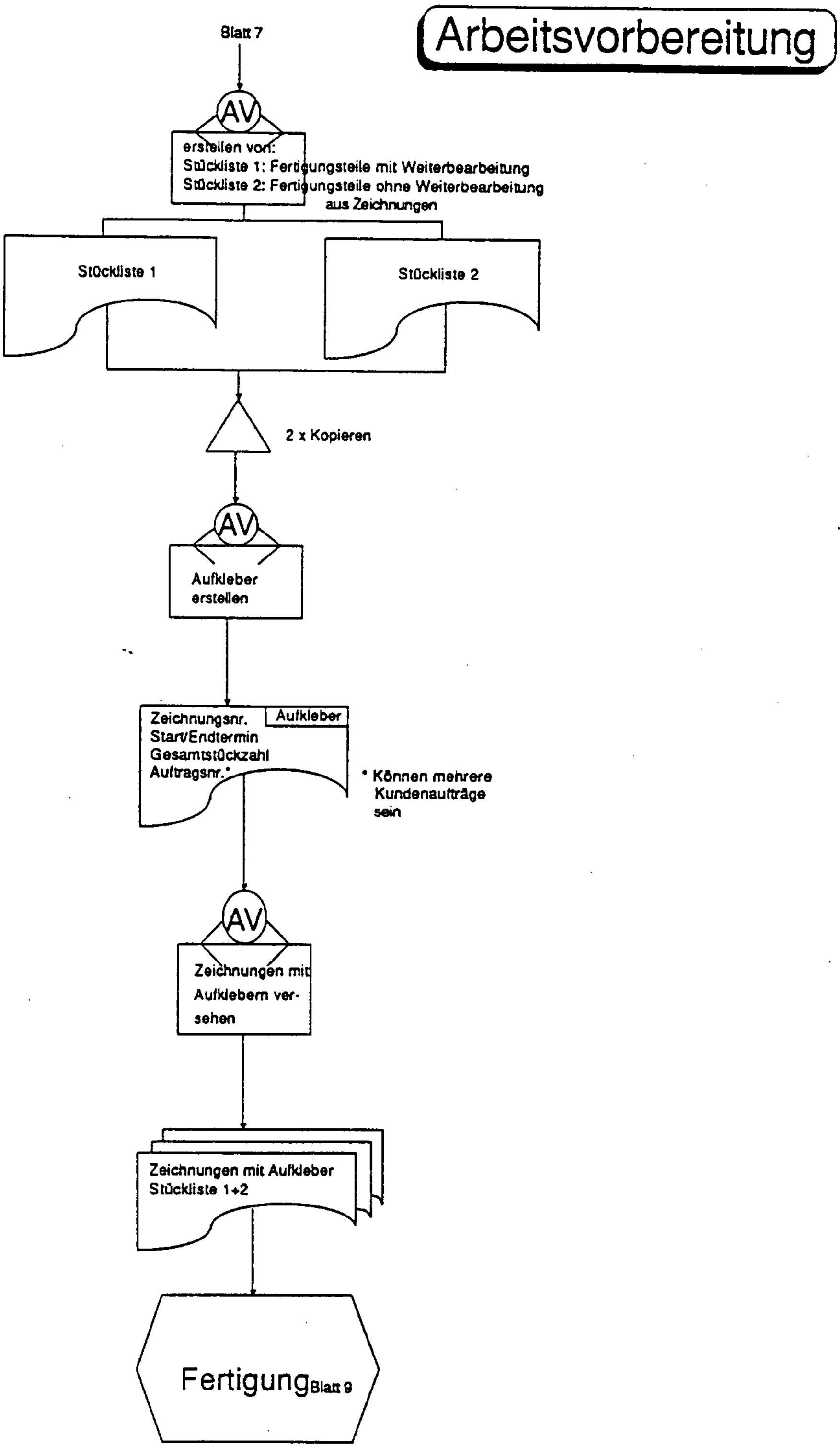

Arbeitsvorbereitung
Blatt 5
Auftragsbestätigung
Baugruppenübersichtsplan
AV
Baugruppen/
Einzelteil-
auflösung
Ablage
Bauübersichtspläne
Auftragsbestätigung
Blatt 8
Einzelteilstücklisten
Standard-
teil?
N
J
Standardteil
ändern?
J
N
Auftragsbestätigung
Einzelteilstücklisten
Standardeinzelteilzeichnung
Einzelteilstückliste
Standardeinzel-
teilzeichnungen
K
Konstruktion:
Zusatzausführung
Sonderausführung
Unterlagen
alten Projekte
Standardteilezeichnungen
geänderte Standardzeichnung
neue Sonderausf.zeichnung
2 x Kopieren
Standardteilzeichnung
Einzelteilstückliste
Einzelteilzeichnung
Einzelteilstückliste
Einzelteilzeichnung
Änderung des
NC-Programm
Blatt 9
Blatt 7

Blatt 06

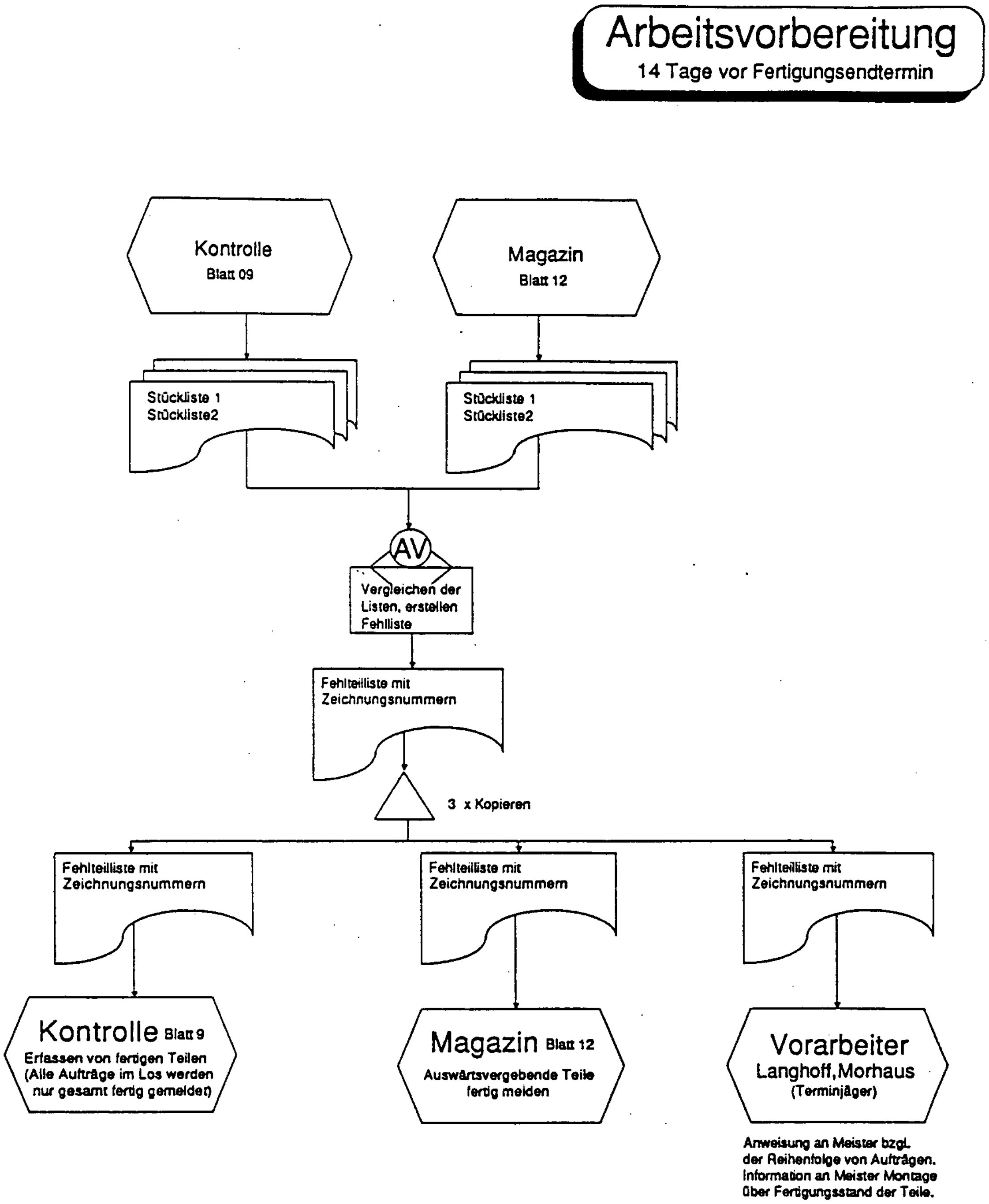


Arbeitsvorbereitung
Blatt 6
Eilteile Sonderteile?
N
J
AV
Kundenaufträge sofort zu einem Los zusammenfassen
AV
Kundenaufträge v. 14 Tg.zu einem Los zusammenfassen
Auftragslos Einzelteilzeichnung
AV
Überprüfen, ob Kaufteile vorhanden sind.
Magazin
Sind Kaufteile im Magazin vorhanden?
N
J
AV
Kaufteilliste erstellen
Kaufteilliste
Einzelteilstückliste
AV
Stückliste ablegen
Einzelteilstückliste
Auftragslos Einzelteilzeichnung
Einkauf Magazin
Ablage
Ablage
Blatt 8

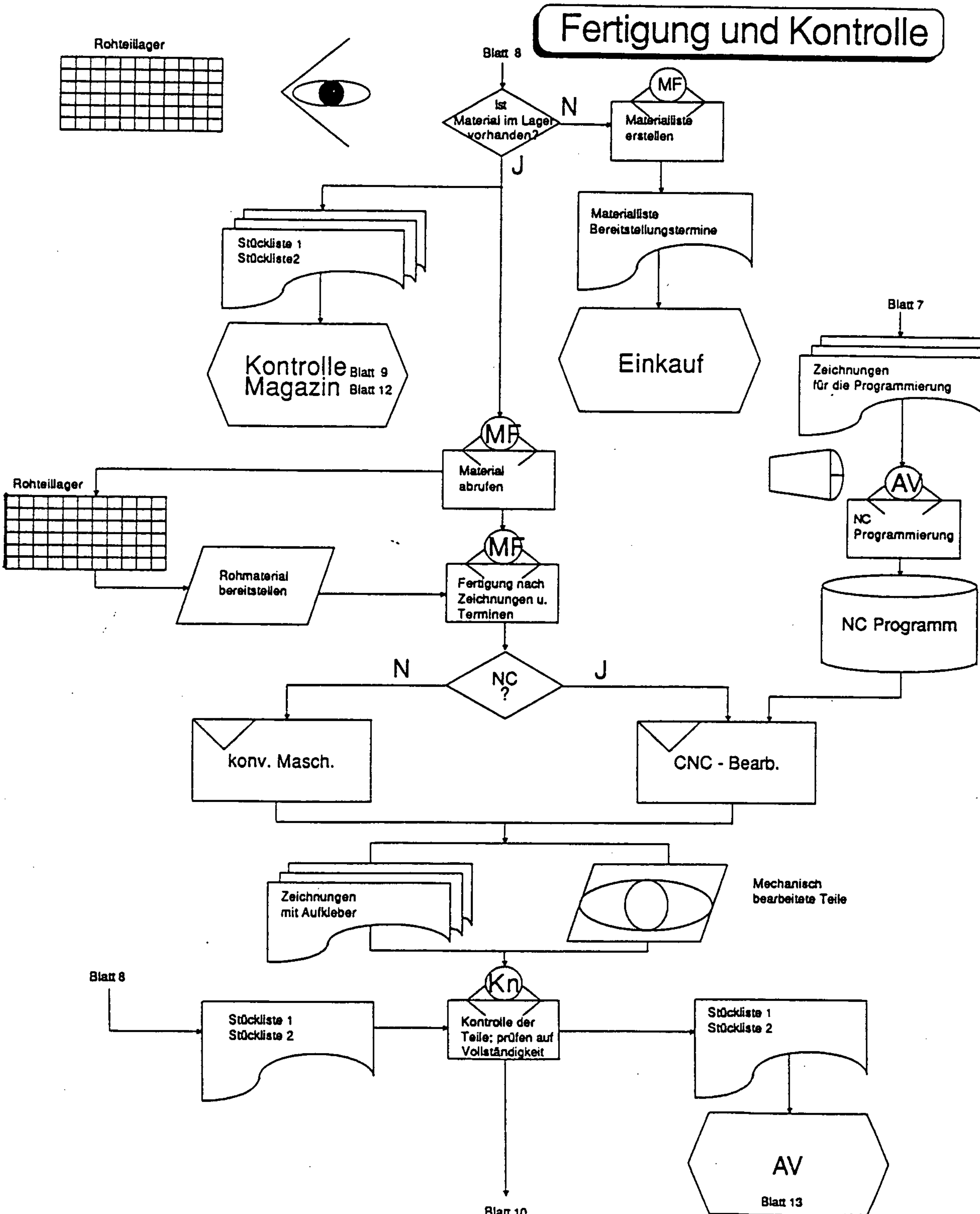
Blatt 07


Arbeitsvorbereitung
Blatt 7
AV
erstellen von:
Stückliste 1: Fertigungsteile mit Weiterbearbeitung
Stückliste 2: Fertigungsteile ohne Weiterbearbeitung
aus Zeichnungen
Stückliste 1
Stückliste 2
2 x Kopieren
AV
Aufkleber erstellen
Zeichnungsnr.
Aufkleber
Start/Endtermin
Gesamtstückzahl
Auftragsnr.*
* Können mehrere Kundenaufträge sein
AV
Zeichnungen mit Aufklebern versehen
Zeichnungen mit Aufkleber
Stückliste 1+2
Fertigung Blatt 9

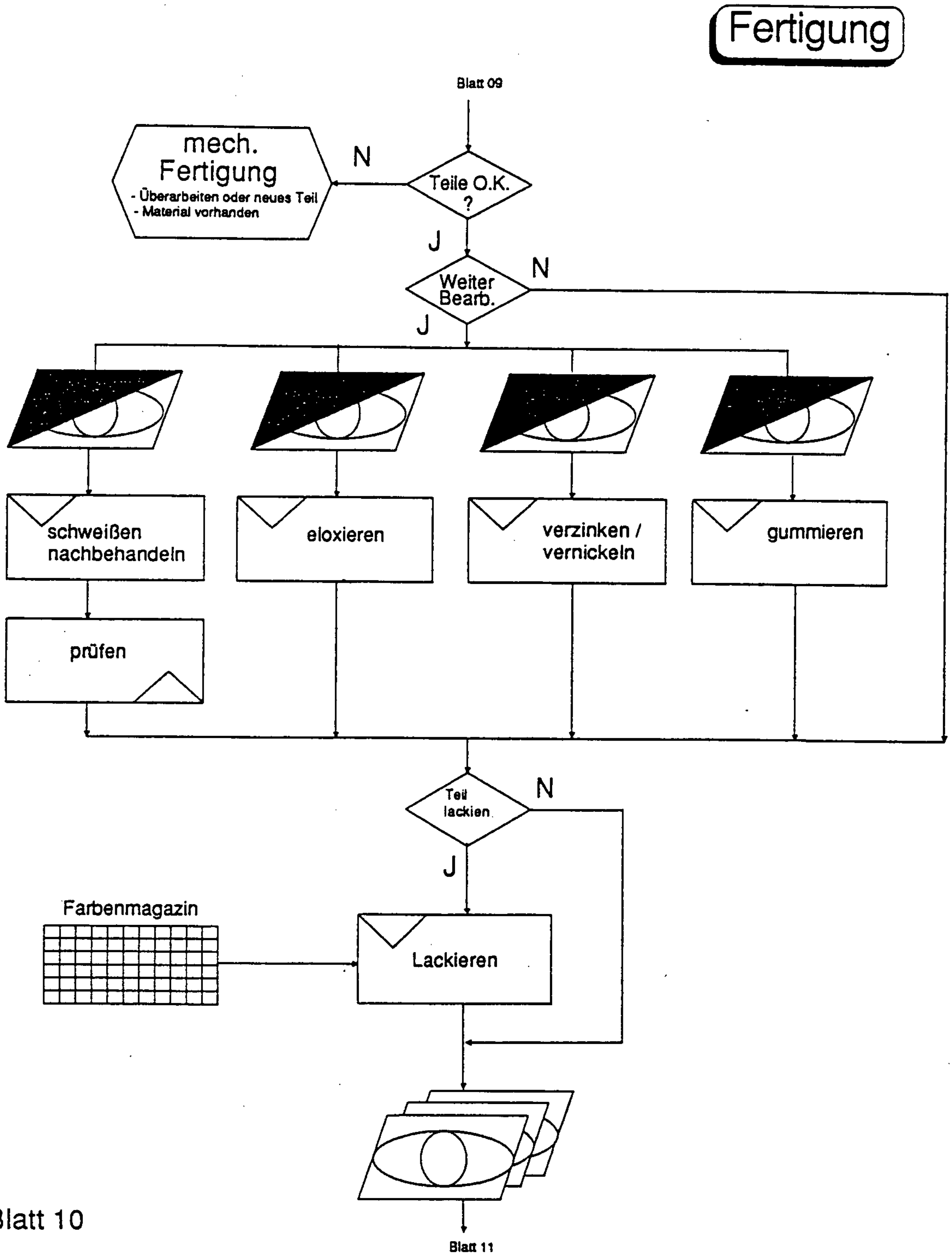
Blatt 08


Arbeitsvorbereitung
14 Tage vor Fertigungsendtermin
Kontrolle
Blatt 09
Magazin
Blatt 12
Stückliste 1
Stückliste2
Stückliste 1
Stückliste2
AV
Vergleichen der Listen, erstellen Fehlliste
Fehlteilliste mit Zeichnungsnummern
3 x Kopieren
Fehlteilliste mit Zeichnungsnummern
Fehlteilliste mit Zeichnungsnummern
Fehlteilliste mit Zeichnungsnummern
Kontrolle Blatt 9
Erfassen von fertigen Teilen
(Alle Aufträge im Los werden nur gesamt fertig gemeldet)
Magazin Blatt 12
Auswärtsvergebende Teile fertig melden
Vorarbeiter
Langhoff, Morhaus
(Terminjäger)
Anweisung an Meister bzgl. der Reihenfolge von Aufträgen. Information an Meister Montage über Fertigungsstand der Teile.

Blatt 13


Fertigung und Kontrolle
Rohteillager
Blatt 8
Ist Material im Lager vorhanden?
N
J
MF
Materialliste erstellen
Stückliste 1
Stückliste2
Materialliste
Bereitstellungstermine
Kontrolle Blatt 9
Magazin Blatt 12
Einkauf
Blatt 7
Zeichnungen
für die Programmierung
MF
Material abrufen
Rohteillager
AV
NC Programmierung
MF
Rohmaterial bereitstellen
Fertigung nach Zeichnungen u. Terminen
NC Programm
N
NC ?
J
konv. Masch.
CNC - Bearb.
Zeichnungen mit Aufkleber
Mechanisch bearbeitete Teile
Blatt 8
Kn
Stückliste 1
Stückliste 2
Kontrolle der Teile: prüfen auf Vollständigkeit
Stückliste 1
Stückliste 2
AV
Blatt 13
Blatt 10

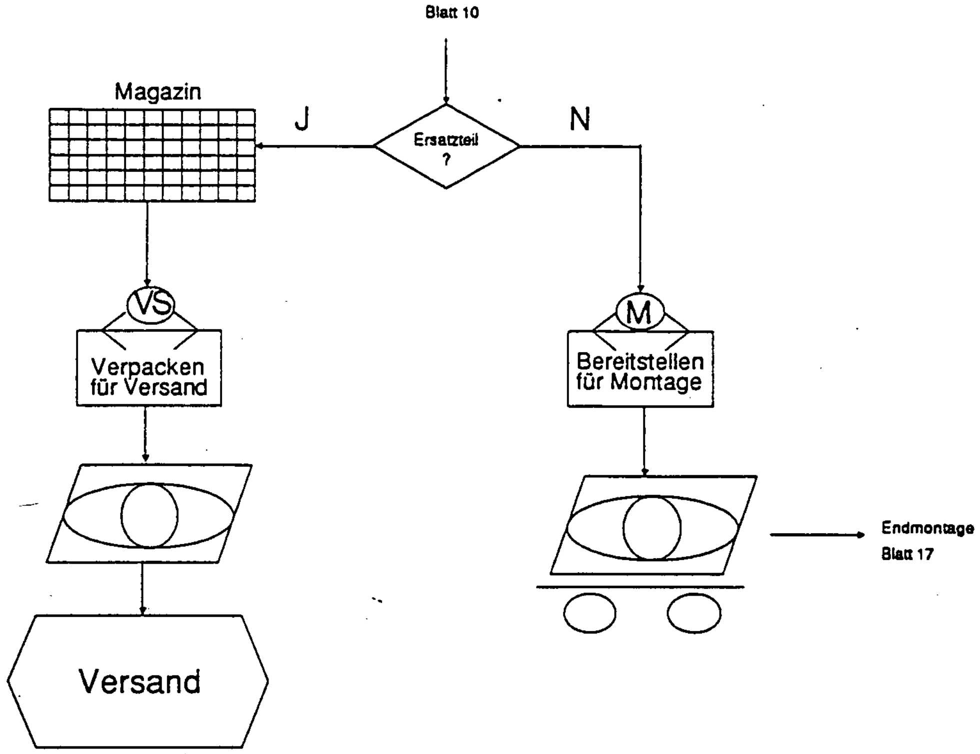
Blatt 9

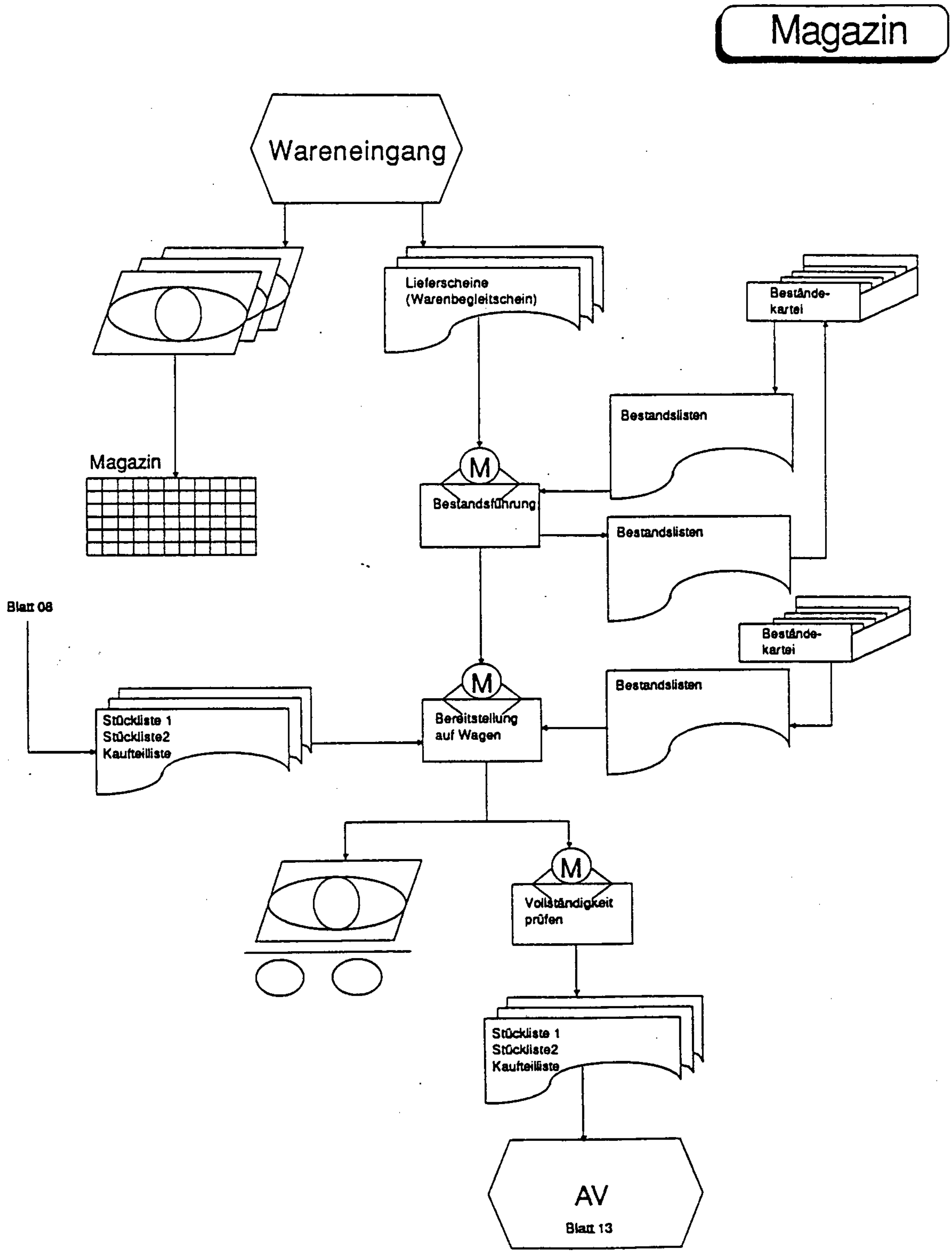


Fertigung
Blatt 09
mech. Fertigung
- Überarbeiten oder neues Teil
- Material vorhanden
N
Teile O.K. ?
J
Weiter Bearb.
N
J
schweißen nachbehandeln
eloxieren
verzinken / vernickeln
gummieren
prüfen
Teil lackien
N
J
Farbenmagazin
Lackieren
Blatt 11

Blatt 10

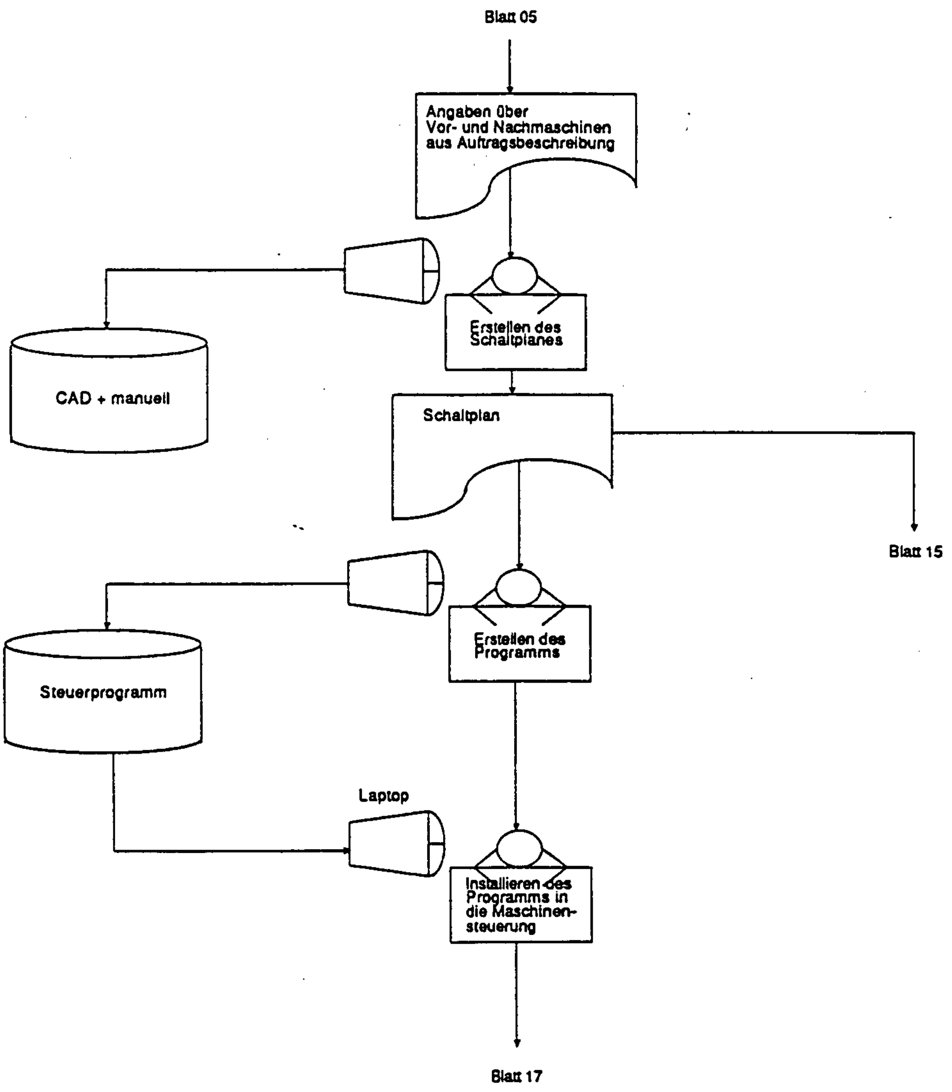
Magazin


Blatt 10
Magazin
J
Ersatzteil
?
N
VS
Verpacken
für Versand
M
Bereitstellen
für Montage
Endmontage
Blatt 17
Versand

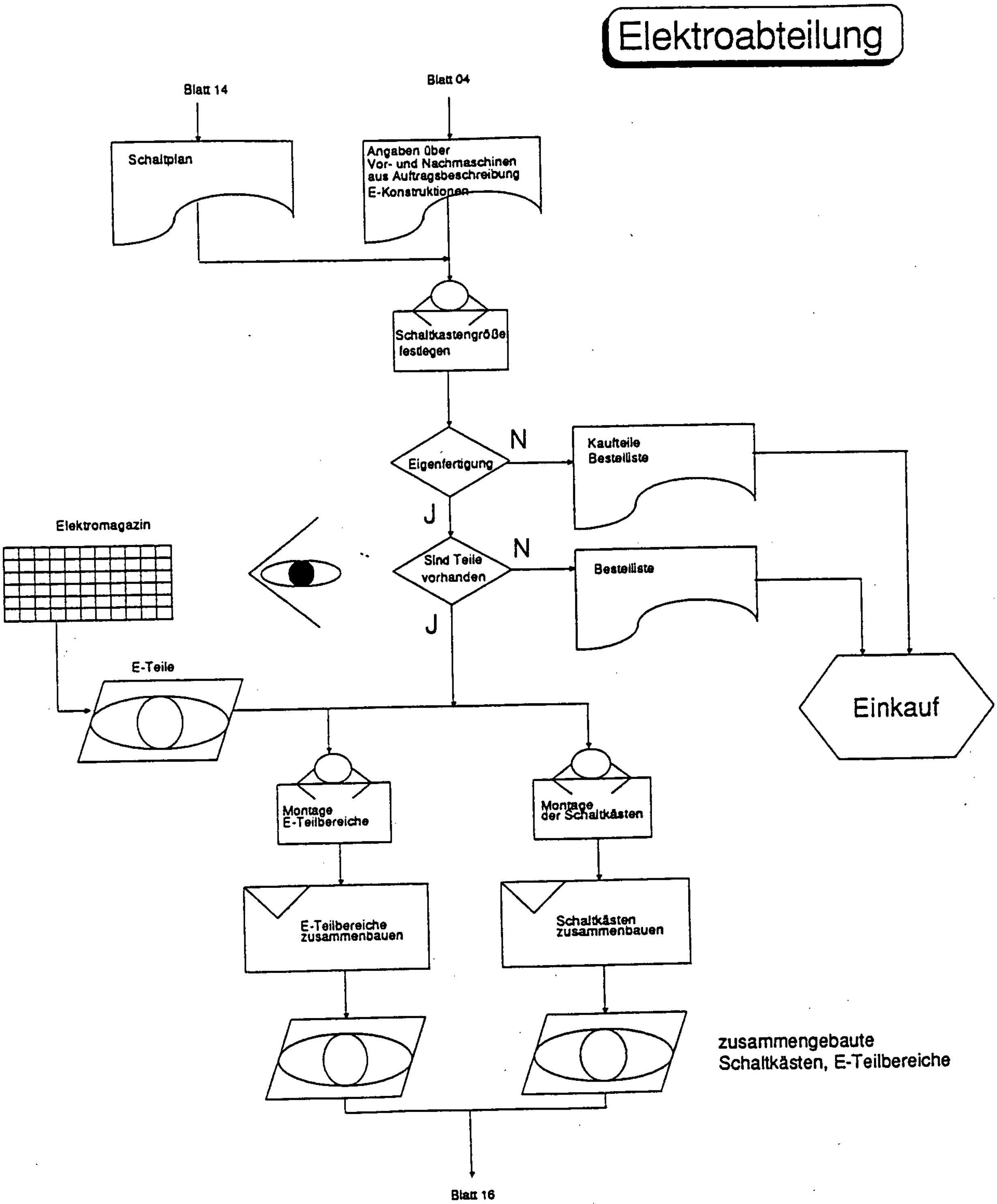

Magazin
Wareneingang
Lieferscheine
(Warenbegleitschein)
Bestände-
kartei
Bestandslisten
Magazin
M
Bestandsführung
Bestandslisten
Blatt 08
Bestände-
kartei
Bestandslisten
M
Bereitstellung
auf Wagen
Stückliste 1
Stückliste2
Kaufteilliste
M
Vollständigkeit
prüfen
Stückliste 1
Stückliste2
Kaufteilliste
AV
Blatt 13

Blatt 12

Projektbüro Elektroabteilung

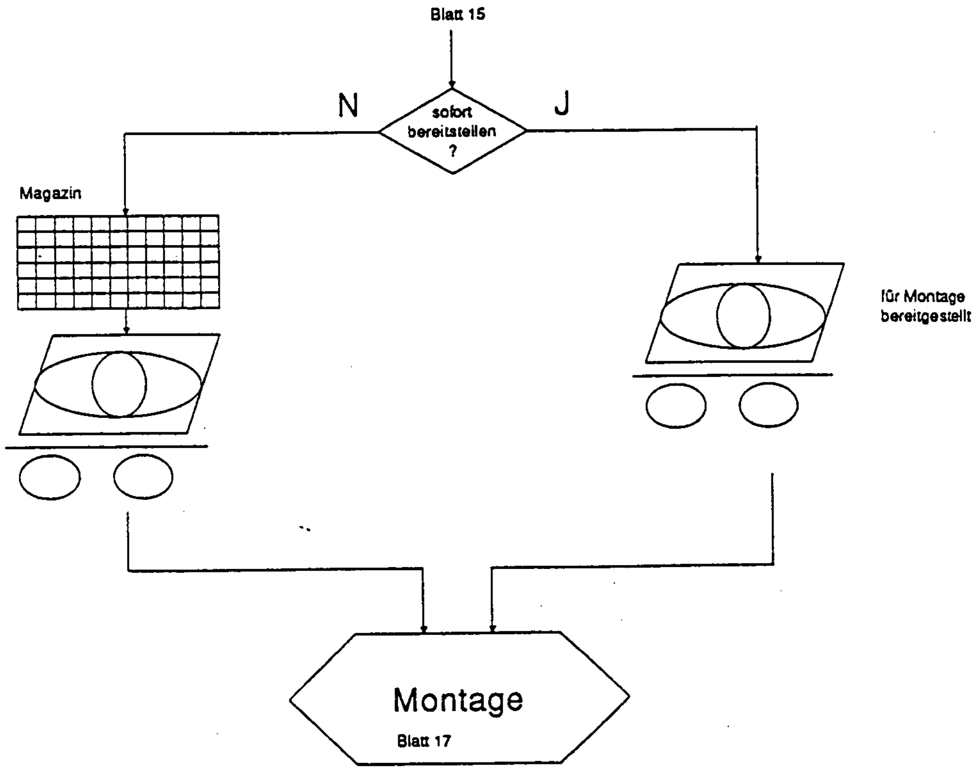


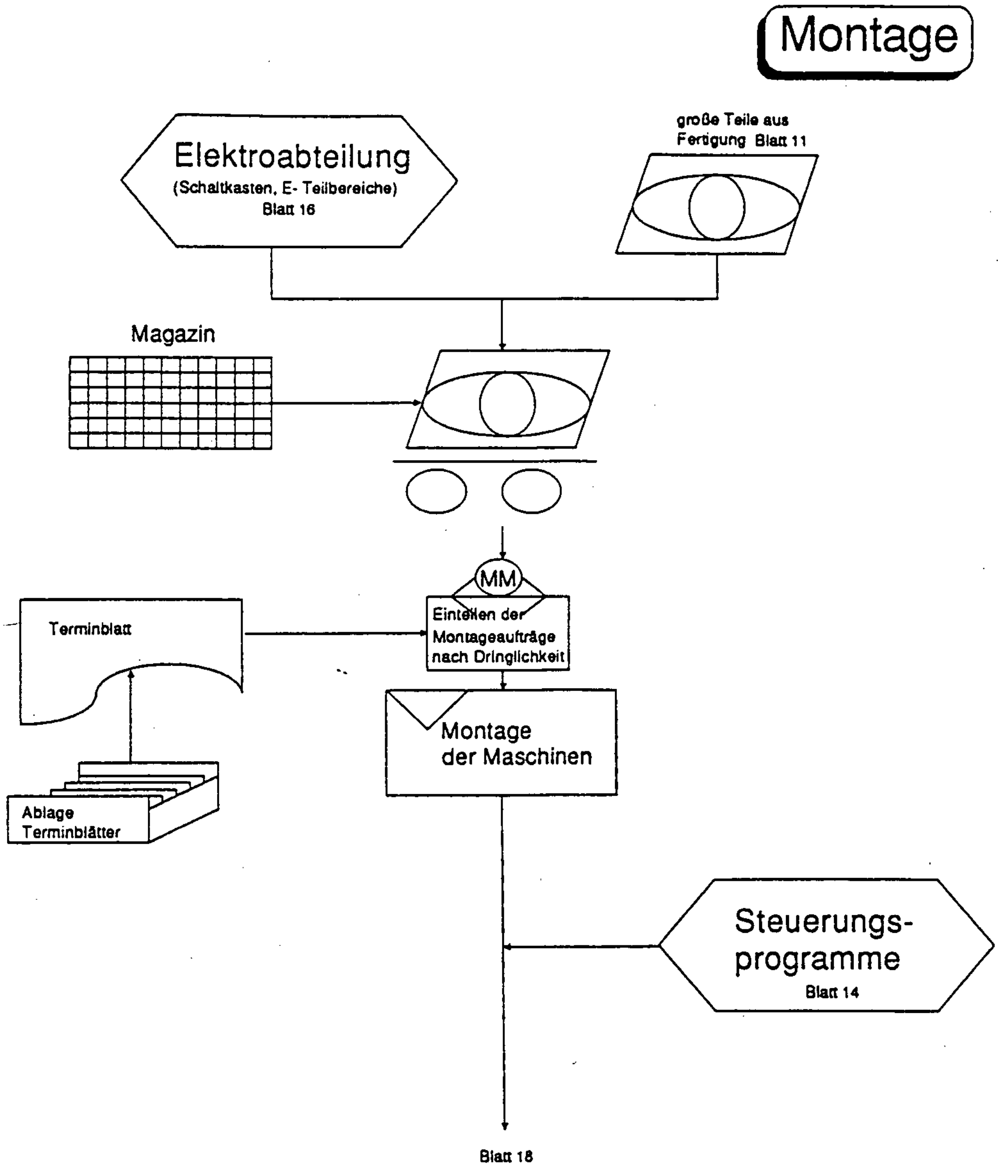
Blatt 14


Elektroabteilung
Blatt 14
Blatt 04
Schaltplan
Angaben über Vor- und Nachmaschinen aus Auftragsbeschreibung E-Konstruktionen
Schaltkastengröße festlegen
Eigenfertigung
N
J
Kaufteile Bestelliste
Elektromagazin
Sind Teile vorhanden
N
J
Bestelliste
E-Teile
Einkauf
Montage E-Teilbereiche
Montage der Schaltkästen
E-Teilbereiche zusammenbauen
Schaltkästen zusammenbauen
zusammengebaute Schaltkästen, E-Teilbereiche
Blatt 16

Blatt 15

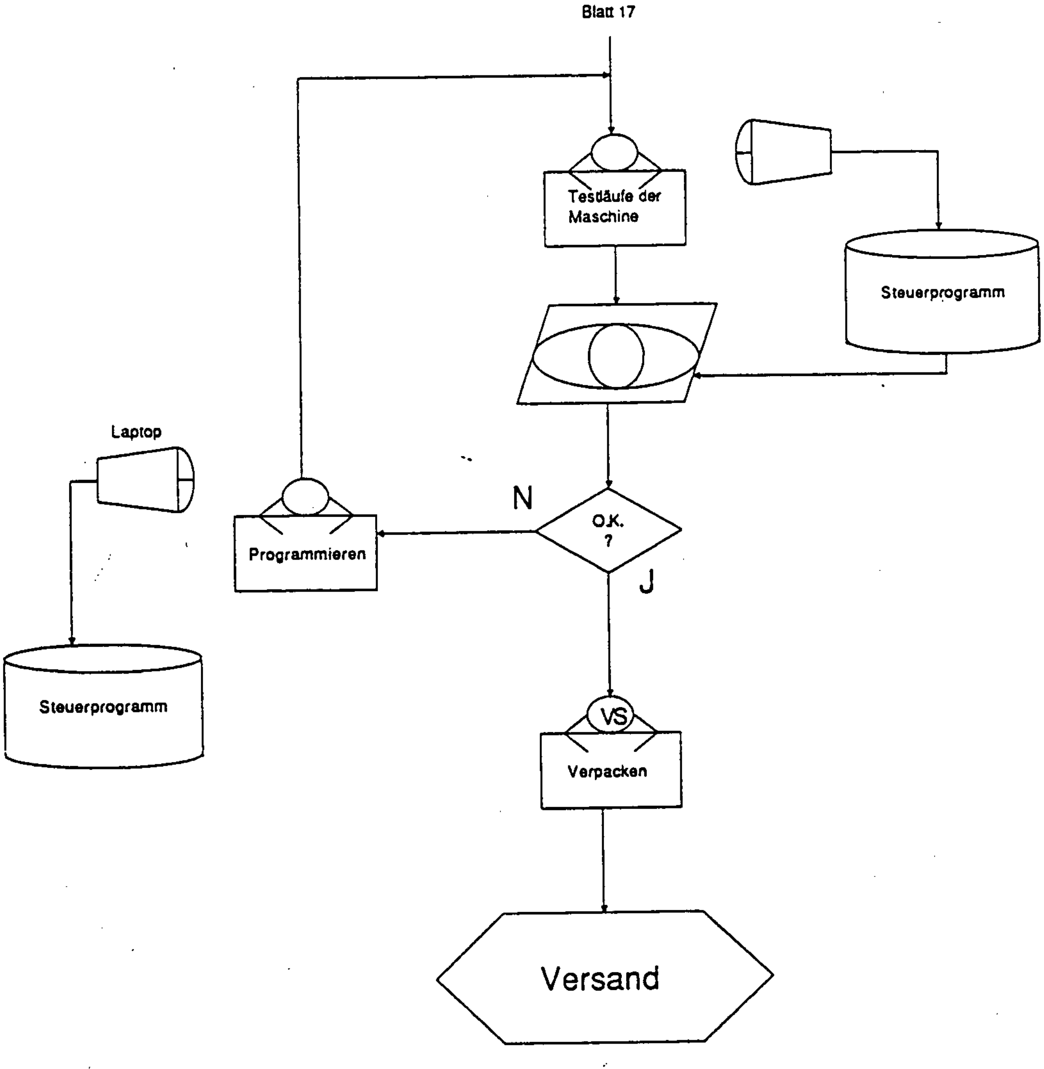
Elektroabteilung




Montage
große Teile aus
Fertigung Blatt 11
Elektroabteilung
(Schaltkasten, E- Teilbereiche)
Blatt 16
Magazin
MM
Terminblatt
Einteilen der
Montageaufträge
nach Dringlichkeit
Montage
der Maschinen
Ablage
Terminblätter
Steuerungs-
programme
Blatt 14
Blatt 18

Blatt 17

Montage und Versand



Blatt 18

APPENDIX 4

PROJECT NEWSPAPER (UNPUBLISHED INTERN PLANLEIT PROJECT DOCUMENT; BULLINGER AND HIRSCH, 1994)

Projekt NACHRICHTEN

Planleit

2. Ausgabe

Oktober 1992

Liebe Leserin, lieber Leser!

Der aktuelle Projektstand zur Zwischenpräsentation übertrifft die Planung des Antrags. Dies ist darauf zurückzuführen, daß die Auflage zum Bewilligungsbescheid eine frühere Fertigstellung von Analyse und Gestaltung in den Firmenprojekten (Ist- und Sollkonzepte) notwendig machte. Weiterhin zogen die Anforderungen aus den Firmen eine generelle Ausweitung des Forschungshauptgegenstands Planung auf Planung und Steuerung nach sich. Nach sechs Monaten war eine Marktrecherche vorzulegen. Die Arbeitspakete der Universität Stuttgart und Bremen im Antrag sahen dies etwas später vor.

Im weiteren soll nicht auf den Status innerhalb der einzelnen Arbeitspakte der einzelnen Projektpartner eingegangen werden. Auf dem folgenden Bild ist der Zeit- und Arbeitsplan des Antrags mit Blick auf die Forschungsinstitute, die Anwender und Hersteller dargestellt. Der aktuelle Stand des Vorhabens ist beschrieben. Die einzelnen Projektabschnitte (PA) sind an dieser Stelle noch einmal (siehe auch Antrag PLANLEIT) beschrieben:

-PA1: vorbereitende Aufgaben.

-PA2: firmenspezifische Beteiligungsqualifizierung, Aufnahmen Anforderungen, Gestaltungshinweise.

-PA3: wissenschaftliche Aufbereitung Anforderungen, wissenschaftliche Pflichtenhefterstellung, firmenspezifische Umsetzungsmaßnahmen.

-PA4: Entwicklung, Implementierung.

-PA5: Bewertung und Begleitung.

-PA6: Koordination, Beteiligungsqualifizierung.

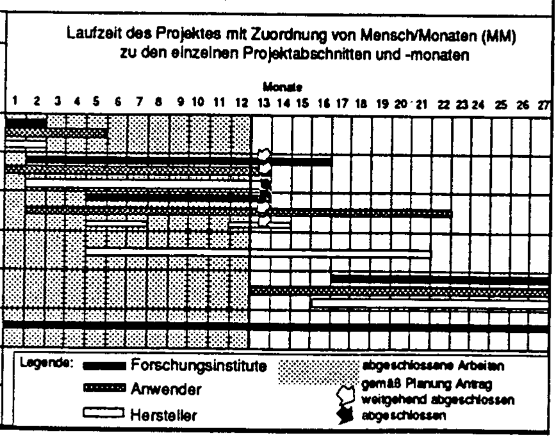
Auf Seite 2 finden Sie einen Ausblick auf die zweite Projekthälfte.

Ihr Andreas Huthmann

Integrierter Arbeits- und Zeitplan gemäß Antrag
Projektstand 31.7.92

Leitstände für die Werkstattsteuerung (PLANLEIT)
Überblick über das Gesamtvorhaben

Gliederung nach Projektabschnitten	MM		
	Forschungsinstitute	Anwender	Hersteller
PA 1	6	26,1	4,4
PA 2	61	101,5	19,2
PA 3	36	83,3	18
PA 4	-	-	48,2
PA 5	42	71,7	17,6
PA 6	61,2	-	-
gesamt	206,2	282,6	107,4
Anteil (%)	0,35	0,47	0,18



Inhalt:

Haben Sie Fragen?

Wenn Sie zum Projekt Planleit oder zu dieser Zeitung Fragen haben oder wenn Sie weitere Informationen wünschen, dann schreiben Sie uns oder rufen Sie uns an.

Wir sind auch sehr an positiven und kritischen Stellungnahmen und an Anregungen interessiert, die wir zum Teil in diesen *projektnachrichten* veröffentlichen wollen.

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Telefon (0711)970-2348
Telefax (0711)970-2300

Ausblick auf die zweite Projektphase

ls Übersicht werden folgende Ar-
eiten in der zweiten Hälfte des Ver-
undvorhabens durchgeführt :

- Beteiligungsqualifizierungsmaßnahmen,
- Handlungsorientierte vergleichende Erprobung von ausgewählten Leitständen durch die Projektmitarbeiter aus den Firmen,
- weiteres Prototyping und Erarbeitung weiterer firmenspezifischer Gestaltungsempfehlungen (Leitstand und Organisationsstruktur),
- arbeitsteilige Implementierung des Leitstandbaukastens (objekt-orientiertes Anwendungsmodell, Konfigurationswerkzeuge),
- Umsetzung organisatorischer Sollkonzepte in den Firmen,
- erweiterte Wirtschaftlichkeitsbetrachtungen und Breitenwirkungsarbeit,
- Evaluation von Beteiligungsqualifizierungs-, Organisationskonzepten und objekt-orientierten Leitstandsprototyp (nach Prozess iterativer Verbesserung),
- 2 Workshops in neuen Bundesländern (Schnittstelle PPS-Leitstand, Gestaltungsempfehlungen),
- Erfahrungsaustausch mit anderen AuT-Vorhaben.

ı Frühjahr/Frühsommer 93 wird ei-
ˈ Buchveröffentlichung der Ergeb-
sse dieses Vorhabens zum Feld
ˈitstände und Werkstattsteuerung
alisiert. Die bisherigen Zwischener-
ˈbnisse zum Stand der Forschung
ıd die Anwendererfahrungen wer-
ˈn der interessierten Öffentlichkeit
gänglich gemacht. Adressaten die-
r Buchveröffentlichung stellen An-
ender, Hersteller, Forschungsinsti-
ˈe etc. dar.

Ergebnisse der Maschinenfabrik Buckau

Die Organisation der Auftragsabläufe wurde mit Hilfe der PS-Methode analysiert und dargestellt. Da diese durch einen geringen Abstraktions- und Formalisierungsgrad gekennzeichnet ist, konnte sie von den Meistern, Facharbeitern und Fertigungssteuerern selbst angewandt werden. Nach einer kurzen Einweisung in die Methode und einigen praktischen Übungen entwickelten sie, mit Unterstützung der IPA-Projektgruppe Wismar, in Arbeitsgruppen Organigramme der tatsächlichen und geplanten Auftragsabläufe in ihren Werkstätten. Dabei wurde festgestellt, daß die Kompetenzen und Verantwortlichkeiten für den Auftragsdurchlauf im Sinne eines durchgängigen Qualitätssicherungsprozesses teilweise unzureichend oder falsch organisiert sind. Hier ist vor allem der hohe Steuerungsaufwand durch die zentrale Steuerung der Meisterbereiche zu nennen.

Durch die vorhandenen Erfahrungen der Mitarbeiter bei der Entwicklung und Einführung von EDV-gestützten Organisationslösungen wurde in Gesprächen der Projektgruppe Ansätze für ein sinnvolles organisatorisches und informationstechnisches Sollkonzept diskutiert und mit Hilfe der PS-Methode dokumentiert.

"Ich befürchte, er hat das mit der neuen Technik noch nicht ganz kapiert!"

Hauptschwerpunkt des Konzeptes ist, daß die neue Organisationsform von der horizontalen und vertikalen Arbeitsteilung Abstand nimmt, und statt dessen Arbeitsbedingungen für die Facharbeiter und Meister in der Fertigung und Montage schafft, in denen die umfangreichen Qualifikationen der Mitarbeiter entfaltbar unc optimaler genutzt werden. Durch eine optimaler strukturierte und organisierte Aufbau- und Ablauforganisation sowie die konsequente Einführung von Arbeitsgruppen werden erhebliche Durchlauf- und Liegezeitverkürzungen erwartet. Da die Maschinenfabrik Buckau ein extremer Unikatfertiger unterschiedlichster Produkte ist, muß es das Ziel sein, auf Marktlücken zu reagieren und auftragsspezifisch das Erfahrungswissen der Mitarbeiter und die vorhandenen Ressourcen einsetzen zu können. Auch die Anforderungen an elektronische Hilfsmittel zur Werkstattsteuerung sind sehr individuell. Die Art der Auftragsbearbeitung erfordert es, das zum einen Informationen an wechselnden Einsatzorten abgerufen werden können und fast alle Mitarbeiter bei Bedarf auf das zu konzipierende System zugreifen und damit arbeiten müssen. Die Art der Auftragsabwicklung fordert sehr prägnant die ständige Präsenz des Mitarbeiters bei Entscheidungen und Handlungen. Es gibt wenig festgeschriebene und rountinemäßige Handlungen und Abläufe, so daß das Erfahrungswissen und das Verantwortungsbewußtsein der Mitarbeiter von entscheidender Bedeutung ist.

Dr. Bergner
Maschinenfabrik Buckau GmbH

Einführung einer Fertigungsinsel in der Dieselmotorenfabrik Rostock

)ie Istaufnahme des Fertigungsab-aufs wurde in Zusammenarbeit mit der IPA-Projektgruppe Wismar und dem BIBA mit Hilfe der PS-Methode analysiert und dargestellt. Diese Analysemethode erlaubte eine aktive Mitarbeit der Meister, Facharbeiter und Fertigungssteuerer. Während des detaillierten Ermitteln der Abläue erwies es sich, daß die tatsächlich praktizierten organisatorischen Abäufe und Verhältnisse von den festgelegten, vorgeschriebenen, betriebsoffiziellen in vielerlei Weise abweichen. Die Kompetenzen und Verantwortlichkeiten für den Auftragsdurchlauf im Sinne eines durchgängigen Qualitätssicherungsprozesses sind unzureichend oder falsch organisiert.

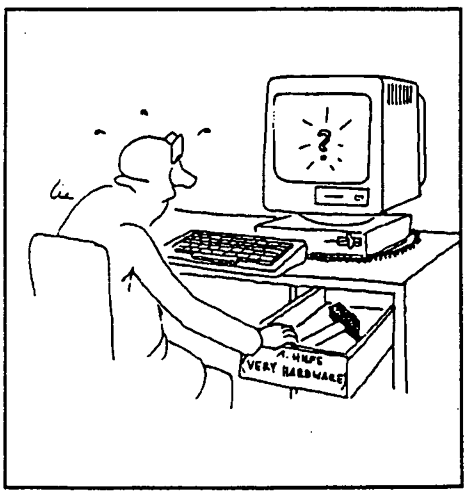
)iese Unzulänglichkeiten und Schwachstellen wurden in dem nächsten Projektabschnitt, der Erarbeitung eines Sollkonzeptes für die eitstandunterstützte Werkstattsteuerung, versucht zu beseitigen bzw. u vermindern. Kernaussage dieses Sollkonzeptes ist, daß die Meister nd Facharbeiter des Bereichs "Zynderbuchsenfertigung" nicht nur eie funktionale Unterstützung durch .B. einen elektronischen Leitstand rhalten, sondern auch organisatosch in die Lage versetzt werden, ihe Aufgaben und Tätigkeiten eigenerantwortlich wahrzunehmen.)urch eine klare Definition und Zurdnung von Aufgaben und Verantwortlichkeiten, eine praxisgerechte estlegung des Auftragsabwickungsprozesses sowie eine aufgaen- und situationsangemessene inormationstechnische Unterstützung nd Durchdringung, ist es möglich, ine Struktur und Organsationsform u schaffen, die den ausführenden litarbeitern auch die Verantwortung nd Entscheidungskompetenz im inne eines ganzheitlichen Arbeitens eröffnet. Um diese Zeile zu realisieren wurde das Konzept der Fertigungsinsel vorgeschlagen, da hiermit die Planungs- und Ausführungstätigkeiten am optimalsten zusammengeführt werden und die bisherige Arbeitsteilung, die vor allem für die NBL typisch war, abzubauen.

Parallel dazu durchgeführte Materialflußuntersuchungen führten dazu, daß die Geschäftsleitung entschieden hat, die Zylinderbuchsenfertigung als Pilotprojekt mit allen Investitions- und Strukturmaßnahmen als ein "Produktcenter" (Fertigungsinsel) zu organisieren. Die dadurch erreichbare fast vollständige Autonomie dieses Bereiches führt dazu, daß mitarbeiterbezogen zum einen die Meister entlastet werden und sich ihren eigentlichen Aufgaben widmen können und zum anderen die Motivation der Facharbeiter erhöht wird. Für das DMR kann es gleichzeitig eine Verbesserung der Termintreue und Kapazitätsauslastung und damit eine Umsatzerhöhung bedeuten.

Im Dieselmotorenwerk Rostock herrscht allgemein eine positive Grundhaltung bzgl. der Einführung neuer Technologien. Vor allem der Meister des ausgewählten Bereiches "Zylinderbuchsenfertigung" und seine Mitarbeiter sind dem Projekt positv gegenüber eingestellt. Dies wird vor allem dadurch hervorgerufen, das hier der Wunsch nach angemessenen Organisationsformen und informationstechnischer Unterstützung für den Bereich besteht. Durch die Schaffung einer offenen Atmosphäre, in der alle Beteiligten offen miteinander reden konnten, konnten sowohl entscheidende Fortschritte bei der Erarbeitung des Sollkonzeptes erreicht werden, als auch skeptische Kollegen für die Mitarbeit gewonnen werden. Um die Fortführung dieser positiven Entwicklung optimal zu gewährleisten, wurde von der Projektgruppe für die zweite Hälfte des Verbundvorhabens die folgenden Arbeitsschritte formuliert:

- Durchführung von praktischen Erprobungen von elektronischen Leitständen sowie des Demonstratorleitstandes mit Hilfe des erarbeiteten Sollkonzeptes und unternehmensspezifischer Daten,
- Diskussion der Fertigungsinsel mit Softwareherstellern und Hochschulen über die Erfahrungen mit den Systemen bzgl. der Beherrschbarkeit, Philosophie, Methodik, Funktionalität und Eignung der Systeme für das DMR,
- Mitarbeit bei der Erstellung von Gestaltungsleitlinien, basierend auf den gemachten Erfahrungen.

Herr Hückstedt
DMR GmbH



Aus: Seeber Konstruktionen: Konstruktivissmus 1

Ablauf der Projektarbeit bei der Firma Gebr. Leitz

ı der Projektarbeit seit November 991 wurden bis zum heutigen tand die folgenden Untersuchun- ən und Arbeiten durchgeführt:

ı einem ersten Schritt wurde in ei- əm ausgewählten Werkstattbereich ne IST-Analyse zum Ablauf der uftragsbearbeitung erstellt. Die nalyse wurde bewertet und im An- chluß daran ein SOLL-Konzept er- beitet. Dieses Konzept steht heute ı groben Rahmen fest, wobei be- its eine hohe Detailtiefe erreicht ırde.

achfolgend sind die einzelnen chritte im Projektverlauf ausführlich əschrieben.

achdem die Projektgruppen einge- chtet worden waren, nahmen im ktober 1991 drei Mitarbeiter der rma LEITZ am ersten PLANLEIT- orkshop in Bremen teil. Bei diesem effen wurde das Projekt, sowie die teiligten Firmen, Institute und Soft- arehäuser vorgestellt. Es ergab ch ein erster Erfahrungsaustausch ter den Projektpartnern. Weiterhin folgte eine Schulung zur PS-Me- ode.

November 1991 wurde im Hause ITZ gezielt eine Abteilung der Fer- ung ausgewählt, in welcher der T-Zustand aufgenommen wurde, r als Grundlage für das SOLL- nzept diente.

r ausgewählte Werkstattbereich die Schleiferei der Produktgruppe UFIX"-Werkzeuge. Für die Mitar- iter dieses Bereichs treten ständig ress-Situationen auf, da Nachar- iten und Eilaufträge immer wieder ngeschoben werden, ohne daß die durch entstehenden Auswirkun- n auf andere Aufträge bekannt d. Weiterhin ist es durch die hohe zahl der Aufträge in der Fertigung hezu unmöglich, einen bestimm- ı Auftrag sofort zu finden.

IST-Analyse

Der Ablauf der gesamten Auftragsbearbeitung wurde in einer ersten Grobanalyse erarbeitet. Hierzu wurden ausführliche Gespräche mit Meistern und Facharbeitern aus der Fertigung, Vertretern der Konstruktion, Arbeitsvorbereitung sowie des Vertriebs in Zusammenarbeit mit dem Fraunhofer-Institut Stuttgart durchgeführt.

Mit dem für den Bereich DUFIX-Schleiferei zuständigen Meister und Facharbeitern, Mitarbeitern aus Arbeitsvorbereitung und Fertigungssteuerung, sowie Mitarbeitern des Fraunhofer-Instituts wurde mit Hilfe der PS-Methode eine ausführliche IST-Analyse für die Auftragsabwicklung in der Schleiferei erstellt.

Während dieser Analyse wurden bereits gewisse Schwachstellen der Fertigungsplanung des PPS-Systems erkannt und im Hinblick auf das SOLL-Konzept interessante Verbesserungsvorschläge eingebracht.

Im Rahmen der IST-Aufnahme wurden die Arbeitsplätze der Schleiferei mit Hilfe der betreffenden Facharbeiter und des Meisters genau analysiert.

Die Schwerpunkte lagen auf den Kriterien

- Verfügbarkeit von Werkzeug, Spannvorrichtungen, Meßzeug usw.
- Höhe und Art der Ausschußquote.
- Möglichkeiten des Einschleußens von Blitzaufträgen, Nacharbeiten oder Neuanfertigungen.
- Fertigungsbedingtes Trennen von Aufträgen und wieder Zusammenführen nach der Bearbeitung.
- Kapazitätsabgleich mit anderen Arbeitsplätzen bei zu hoher oder zu niedriger Auslastung.
- Alternative Arbeitsplätze, die (z.B. bei Maschinenausfall) vom PPS vorgesehen sind.
- Transport zwischen den Arbeitsplätzen.

Die Arbeiten an der IST-Analyse wurden bis Ende März fertiggestellt.

Während dieser Untersuchungen fand ein zweiter PLANLEIT-Workshop in Bremen statt.

Bei diesem Seminar im Januar 199? erfolgte ein reger Austausch von Informationen und Erfahrungen der am Projekt beteiligten Firmen und Institute. Ebenso wurden bereits konkrete Fragen zur Gestaltung einer Werkstattsteuerung und zur Anwendung eines solchen Systems beantwortet.

Am 20.03.1992 fand bei LEITZ in Oberkochen eine Informationsveranstaltung statt, bei welcher das Projekt PLANLEIT vorgestellt und ein Überblick über den aktuellen Stand der Projektarbeit im Betrieb gegeben wurde. Anwesend waren hierbei Mitarbeiter aus Konstruktion, Vertrieb, Logistik, Arbeitsvorbereitung und Produktionsleitung, sämtliche Meister und Betriebsräte, sowie Vertreter der LEITZ-Tochterfirmen. Sämtliche Mitarbeiter der Firma LEITZ, die noch nicht von PLANLEIT betroffen waren, wurden dann im Rahmen von Abteilungsversammlungen im April 92 über das Projekt informiert.

Nach Abschluß der IST-Analyse in der Schleiferei DUFIX wurde eine Bewertung der IST-Analyse durchgeführt.

SOLL-Konzept

Aufbauend auf die Bewertung der IST-Analyse wurde ein SOLL-Konzept erarbeitet. Dieses Konzept steht im groben Rahmen fest, einzelne Punkte müssen jedoch noch näher betrachtet und ausgearbeitet werden.

)as SOLL-Konzept betrachtet im
vesentlichen drei Schwerpunkte:

Die Planungsaufgaben des PPS

. Die Planungs- und Steuerungsaufgaben der Werkstattsteuerung

l. Die Aufgaben eines BDE-Systems

**etelligung an der Entwicklung ei-
er Werkstattsteuerung**

ei der Aufnahme des IST-Zustan-
es, der Sollkonzepterstellung und
er Erarbeitung der Anforderungen
n das Leitstandsystem waren Mei-
er und Facharbeiter der Fertigung
eteiligt. Somit war ein Einbringen
er Ideen und Vorstellungen aller
nternehmenshierarchien sicherge-
ellt. Ebenso wurde ein reelles Bild
er Abteilung erzielt. Verbesserungs-
orschläge aus Facharbeiter-, Mei-
er- und FST-Ebene sind bereits in
as SOLL-Konzept integriert.

formationen zum Projekt wurden
n März 92 in einer ganztägigen In-
-Veranstaltung vor Facharbeitern
ler Abteilungen gegeben.

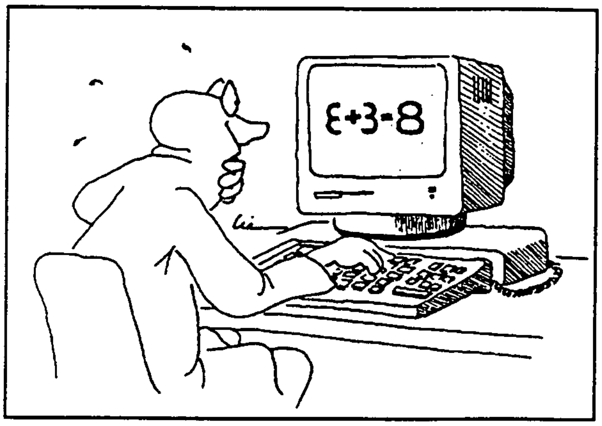
Sämtliche Mitarbeiter der Fertigung wurden in Abteilungsversammlungen zu den Zielen und dem aktuellen Stand des Projektes informiert.

Mitarbeiter der PLANLEIT-Projektgruppe, sowie Meister anderer Abteilungen und Mitglieder des Betriebsrates hatten bereits Gelegenheit, mehrere existierende Werkstattsteuerungssysteme kennenzulernen (Mehrere Systeme auf der CAT in Stuttgart, den Leitstandprototypen am IAO Stuttgart, den STRATO der Firma Digital Kienzle).

Für den Herbst 92 sind weitere Leitstand-Präsentationen bei LEITZ in Oberkochen geplant.

Der Betriebsrat steht in sehr engem Kontakt mit der Projektgruppe. Er wird ständig informiert über den jeweiligen Stand der Projektarbeit. Dabei wurden bereits Fragen des SOLL-Konzeptes erörtert, die vor allem dem Betriebsrat am Herzen liegen, wie z.B. die Einführung eines BDE-Systems.

Herr Neunteufel
Leitz GmbH & Co. KG



Aus: Seeber Konstruktionen: Konstruktivissmus 1

Stand des Vorhabens in der Firma Meurer

ırch die Beteiligung der Mitarbeiter
i der IST-Aufnahme und Schwach-
ellenanalyse sowie deren Darstel-
ıg mit Hilfe der PS-Methode konn-
n die Erfahrungen und das Wissen
r Facharbeiter und Meister um die
nauen organisatorischen und in-
rmationstechnischen Abläufe opti-
al erfaßt und dokumentiert werden.
; war feststellbar, daß die Mitarbei-
r die Möglichkeiten dieses Projek-
s nutzten, um auf Mißstände und
ızulänglichkeiten hinzuweisen und
:h bei der Erarbeitung des Sollkon-
ptes aktiv mit einzubringen. In Di-
ussionen innerhalb der Projekt-
uppe wurde mehrfach das Ziel for-
ıliert, durch klar definierte Organi-
tionsrichtlinien und ein ganzheitli-
es informationstechnisches Kon-
pt, den Gütesicherungsprozess in-
rhalb des Unternehmens zu opti-
eren.

Viele der ermittelten Schwachstellen

- fehlerhafte Zeichnungen,
- falsche NC-Programme,
- nicht verfügbares Material,
- mangelhafte Auftragsfortschrittsüberwachung

liegen in nicht eindeutig definierten Kompetenzen, nicht abgestimmten Zuständigkeiten, unzureichend festgelegten Abläufen bei der Auftragsabwicklung und fehlende Aktualität und Vollständigkeit von Informationen (Daten) begründet.

In dem erarbeiteten Sollkonzept wurde besonders die Zuordnung von Aufgaben und Kompetenzen zu einzelnen Bereichen und Mitarbeitern im Sinne einer ganzheitlichen Arbeit der Facharbeiter, Meister und Disponenten vorgenommen, sowie die organisatorischen und informationstechnischen Hilfsmittel, Richtlinien und Möglichkeiten hierfür festgelegt.

Diese durchgängigen qualitätssichernden Maßnahmen sollen die Mitarbeiter der Firma Meurer mit der Verantwortlichkeit ausstatten, in der sie häufig bereits stehen. Sie sollen sich motivierend für die Mitarbeiter und verbessernd auf die angestrebten Firmenziele

- hohe Qualität
- kurze Lieferzeiten,
- verläßliche Liefertermine

auswirken.

Herr Mönckedick
Meurer GmbH & Co. KG

Stand des Vorhabens in der Bremer Vulkan AG

ie Organisation der Auftragsabläufe urde mit Hilfe der PS-Methode anasiert und dargestellt. Nach einer ırzen Einweisung in die Methode ıd einigen praktischen Übungen ıtwickelte das Projektteam, mit Unrstützung des Bremer Instituts für etriebstechnik und angewandte Areitswissenschaft an der Universität remen BIBA, in Arbeitsgruppen Oranigramme der tatsächlichen und eplanten Auftragsabläufe in ihren 'erkstätten.

'ährend des detaillierten Ermitteln er Abläufe erwies es sich, daß die tsächlich praktizierten organisatorichen Abläufe und Verhältnisse geisse Inkonsitenzen aufweisen und omit eine Trennung von Planung ıd Ausführung verursachen. Es urde festgestellt, daß die fehlende ktualität und Vollständigkeit von Inrmationen teilweise die Durchlaufeiten durch Planungsvorläufe, und konsistente Planungen erheblich erlängert. Die arbeitsteiligen Strukren in dem Unternehmen verhinern oder verzögern häufig schnelle ıd durchgängige Interaktion. Die oteilungsbezogene Organisation ıd das damit verbundene Handeln ıtzt zu wenig die vielseitigen Qualiationen und die Einsatzbereithaft der Mitarbeiter.

eses Optimierungs- und Rationalierungspotential wurde in dem ıchsten Projektabschnitt, der Erareitung eines Sollkonzeptes für die tstandunterstützte Werkstattsteueng, versucht zu nutzen. Kernausge dieses Sollkonzeptes ist, daß e Mitarbeiter des Bereichs "Rohrrtigung und -montage" nicht nur ei- funktionale Unterstützung durch 3. einen elektronischen Leitstand ıalten, sondern auch durch einen änderten Planungsansatz organitorisch unterstützt werden, um ihre ıfgaben und Tätigkeiten eigenverantwortlich wahrzunehmen. Durch eine klare Definition und Zuordnung von Aufgaben und Verantwortlichkeiten, eine praxisgerechte Festlegung des Auftragsabwicklungsprozesses sowie eine aufgaben- und situationsangemessene informationstechnische Unterstützung und Durchdringung, ist es möglich, alle am Produktionsprozeß beteiligten Bereiche umfassend und optimal in die Auftragsabwicklung im Sinne des ganzheitlichen Arbeitens zu integrieren. Das Ganze wird durch eine veränderte Aufbau- und Ablauforganisation unterstützt, die Abteilungs- bzw. Arbeitsgrenzen aufhebt und einen ganzheitlichen Arbeitsansatz fördert.

Die Voraussetzungen und Ausgangsbedingungen für die Durchführung des Projektes sind gut. Da der Bremer Vulkan bereits im mehreren nationalen und internationalen Projekten beteiligt war und die Projektgruppe durch regelmäßige Treffen und Begleitung und Unterstützung durch den Betriebsrat anfänglich vorhandene Skepsis abbauen konnte, wurden Problembereiche und Schwachstellen erörtert, im Sollkor zept Lösungen erarbeitet und diese teilweise bereits realisiert.

Herr Paprotka
Bremer Vulkan AG

Ergebnisse der Firma AEG Lloyd Dynamo GmbH

Die anfänglichen Darstellung von Planungs- und Steuerungsprinzipien führte zu einer interessanten Diskussion in der Projektgruppe. Das Problembewußtsein der Beteiligten ist durch ihre tägliche Arbeit stark sensibilisiert, so daß neue Denkweisen initiiert und die Möglichkeit zur kreativen Mitgestaltung geschaffen werden konnten. So konnten neben den bekannten Planungs- und Steuerungsstrategien die Aufgeschlossenheit zum Denken in neue Richtungen zusätzlich gefördert werden.

Die firmenindividuelle Gestaltungsarbeit wurde durch die Erstellung des IST-Zustandes mit der PS-Methode auf eine gemeinsame Diskussionsgrundlage gestellt. Dabei wurde die Motivation zur Mitarbeit durch die verständlichen Elemente der PS-Methode gefördert. Das Erfahrungswissen in den einzelnen Werkstätten konnte auf diese Weise von allen Projektteilnehmern dargestellt und erläutert werden. Im Verlauf des Projektes wurden Mißstände in der vorhandenen Ablauforganisation erkannt, und durch eigene Lösungsvorschläge konstruktiv beseitigt. Die Maßnahmen zur Beteiligungsqualifizierung waren eine Hilfe, diesen Prozeß in den Firmen nachhaltig zu implementieren.

Während des Projektverlaufes konnte eine zunehmend positive Haltung der beteiligten Projektteilnehmer zu den Projektzielen festgestellt werden. Innovative Ideen und Wünsche sind auf diese Weise durch die Projektteilnehmer in ein neues Ablaufkonzept eingeflossen.

Wichtig für die Teilnehmer war die Erkenntnis, daß durch die Mitarbeit an solchen Konzepten über den

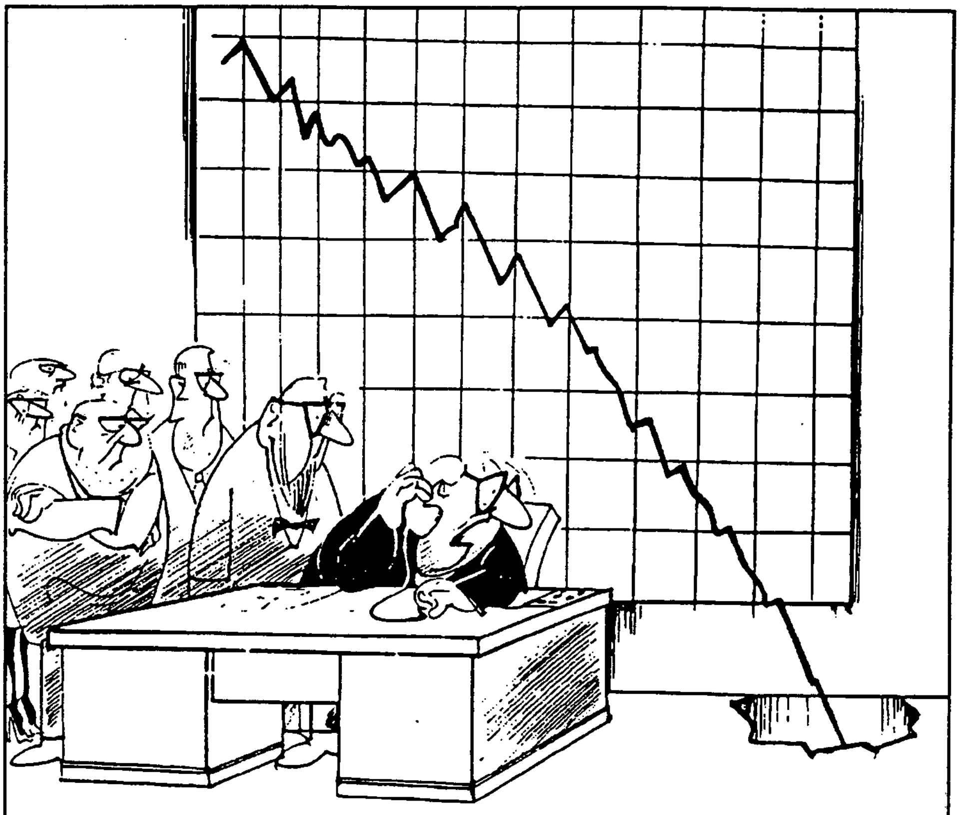
Fortsetzung auf Seite 7

Fortsetzung von Seite 6

'Tellerrand" der eigenen Anforderungen hinaus gedacht werden mußte. Das Verständnis untereinander wuchs mit zunehmender Transparenz des Gesamtablaufes.

Eine weitere wichtige Erkenntnis für die Projektteilnehmer bei der Konzeptgestaltung war die Tatsache, daß zu einem Sollablauf auch eine klare Bildung von Verantwortungs- und Entscheidungshierarchien gehört. Erst eine klare Definition von Aufgaben und Funktionen an Personen und Bereiche schafft eine Grundlage zur Anforderungsbeschreibung. Verantwortung kann dann auch funktional und instrumental unterstützt werden. Im Ergebnis gelangte man zu einem von allen Beteiligten akzeptierten, den Zielsetzungen des Projektes entsprechenden, Leitstandskonzept.

Herr Zoellner
Lloyd-Dynamo GmbH



"Wir haben Interesse an Ihren Neuen Technologien, aber möglichst schnell...!"

Projektverlauf bei der Firma Winter GmbH

Durch die Darstellung neuer Planungs- und Steuerungsprinzipien konnte eine Diskussion in der Projektgruppe angeregt werden. Hierdurch konnten neue Ansätze und Ideen der Mitarbeiter erörtert und auf ihren konzeptionellen Inhalt im internen Projektforum diskutiert werden. Das kreative Mitgestalten förderte zusätzlich die Aufgeschlossenheit zum Denken in neue Richtungen.

Die Gestaltungsarbeit wurde durch die Erstellung des IST-Zustandes mit der PS-Methode auf eine methodische Grundlage gestellt. Dabei konnte die Motivation zur Mitarbeit durch den geringen Abstraktionsgrad der verwendeten Symbole der PS-Methode gefördert werden. Das Erfahrungswissen in den einzelnen Werkstätten ist auf diese Weise von allen Projektteilnehmern selbst dargestellt und erläutert worden. Die Maßnahmen zur Beteiligungsqualifizierung waren eine Hilfe, diesen Prozeß in den Firmen nachhaltig zu implementieren.

Die verhaltene Mitarbeit beim Heranführen von Projektteilnehmern und Mitarbeitern ohne EDV-Erfahrung an neue Techniken und organisatorische Umwälzungen, konnte während des Projektverlaufes komplett abgebaut und in eine konstruktiv positive Haltung der Beteiligten umgemünzt werden. An dieser positiven Entwicklung leistete der Beteiligungsgedanke einen wesentlichen Beitrag. So konnten die Erfahrungen und Lösungsgedanken zwischen den Teilnehmern und den am Verbundprojekt beteiligten Partnerfirmen ausgetauscht und diskutiert werden.

Die Erkenntnis, daß durch die Mitarbeit an solchen Konzepten über eigenen Probleme und Anforderungen hinaus gedacht werden mußte, förderte die Zusammenarbeit und das Verständnis untereinander.

Zu einer Konzeptgestaltung gehört neben dem Sollablauf auch eine klare Bildung von Verantwortungs- und Entscheidungshierarchien. Sie ist die Grundlage einer Anforderungsbeschreibung. Die Projektteilnehmer nahmen diesen Gedanken auf und gestalteten das neue Konzept auch unter dem Gesichtspunkt der Bildung von Verantwortungsbereichen. Man gelangte zu einem ganzheitlichen, menschengerechten und effizienten Leitstandsorganisationskonzept.

Herr Wollrab
Ernst Winter & Sohn GmbH & Co.

Vergleichende Erprobung von Werkstattsteuerungen

Um die mentalen Modelle der Benutzer vom WSS-Programm zu erkunden und die Möglichkeiten zu erkennen, die Benutzer haben, ihre subjektiven mentalen Modelle vom Auftragsgeschehen in der Interaktion geltend zu machen, werden im Rahmen des Verbundvorhabens an der Universität Bremen praktische, vergleichende Erprobungen von vier oder fünf WSS-Programmen in simulierten betrieblichen Auftragssituationen durchgeführt.

- In einer gleichartigen simulierten Fertigungssituation wird ein bestimmter Auftragsbestand mit verschiedenen WSS-Programmen von Meistern und Facharbeitern vergleichend geplant und gesteuert, z.B. über den angenommenen Zeitraum einer Woche.
- Dabei bearbeiten sie in Paaren die gestellten Aufgaben der Auftragssteuerung, so daß sie sich während der Interaktion mit den Programmen über ihr Denken und Handeln äußern. Diese Äußerungen werden protokolliert.
- Jedes Paar wird begleitend beobachtet, die verbalen Äußerungen werden protokolliert, Logfiles und Screen-Dumps geben wichtige Zwischenschritte ihrer Aufgabenbearbeitung wieder. Abschließende Auswertungsgespräche über das Programm, die Interaktion, die Aufgabe, die gewählte Strategie etc. sollen die handlungsleitenden mentalen Modelle offenzulegen helfen.
- Die praktische vergleichende Erprobung abschließend, werden Workshops mit Benutzern und WSS-Herstellern durchgeführt, so daß die Kluft zwischen ihnen ansatzweise übersprungen wird und eine Verständigung und ein Erfahrungsaustausch beginnt.
- Aus solchen Workshops, Evaluationen, Erprobungen entstehen: Forderungen an die Gestaltung, Kritik an Programm und Oberfläche, Lob für gelungene Lösungen, Verbesserungsvorschläge der Meister und Facharbeiter.
- Dies läuft abschließend auf die Entwicklung von Gestaltungsleitlinien hinaus für
  * die Organisation des Verhältnisses PPS - WSS und die Gestaltung der Ablauforganisation
  * die Funktionalität des handlungsorientierten WSS-Programms
  * die Qualifizierung: wie kann/soll man ein WSS-System lernfreundlich und qualifikationsförderlich einrichten?

Markus Vöge, Dr. Gottschalch
Universität Bremen

Veröffentlichungen

Huthmann, Andreas; Bamberger, Rainer: Leitstände der Zukunft. In: 15. europäische Kongressmesse für technische Kommunikation (Online '92). Kolloquium: Integrierter Leitstandseinsatz in PPS - und BDE-Systemen; Herausgeber: H.F. Binner. Velbert: Online GmbH, 1992.

Huthmann, Andreas; Bamberger, Rainer: Pflichtenhefterstellung für Leitstände. In: Die Zukunft der PPS; Veranstaltung am Beratungszentrum Informationstechnik für mittelständische Firmen am Fraunhofer-Institut für Arbeitswirtschaft und Organisation; 3. Juni 1992, Stuttgart.

Huthmann, Andreas; Bamberger, Rainer; Laubscher, Hans-Peter: Efficient and flexible Leitstandsystems. In: Ergonomics of Hybrid automated Systems - III. Proceeding of the third international conference of human aspects of advanced manufacturing and hybrid automation, August 26 - 28, 1992, Gelsenkirchen, Germany; Herausgeber: P.Brödner; W. Karwowski. Amsterdam u.a., Elsevier Science Publishers, 1992.

Huthmann, Andreas; Bamberger, Rainer; Laubscher, Hans-Peter: Planleit-Leitstände für die Werkstattssteuerung. In: V. Kolloquium Arbeitsingenieurwesen; Kolloquium: Arbeitsorganisation und Zeitwirtschaft; Herausgeber : M. Rentzsch.

Gottschalch, H.: Meister sind mehr als PPS Feuerwehr; In: Technische Rundschau (1992) 32.

Gottschalch, H.; Vöge, M.: Leitstände im Vergleich; In: Technische Rundschau (1992) 39.

Vöge, M.: Leitstände erfolgreich einführen; In: wt Werkstattstechnik (1992) 11.

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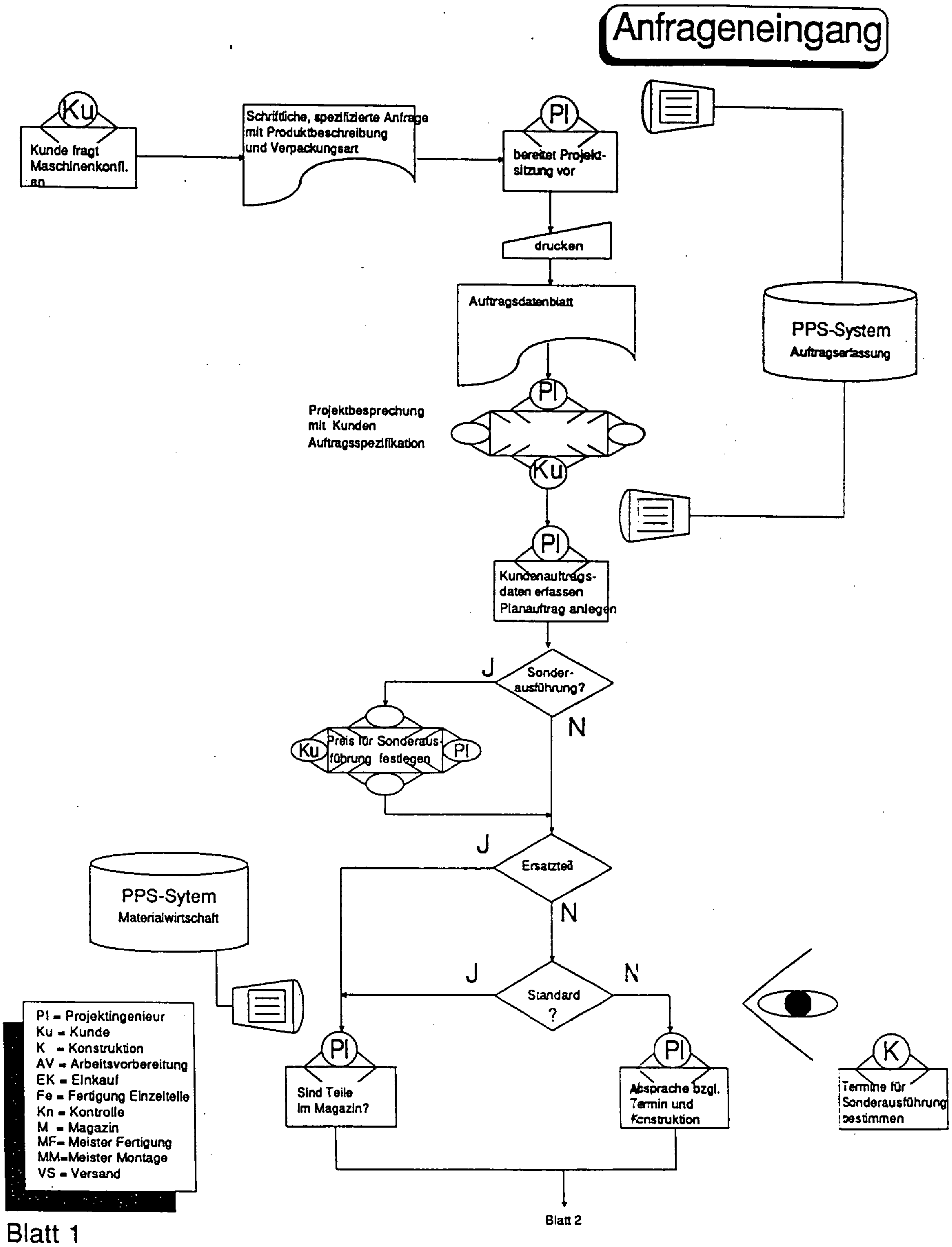
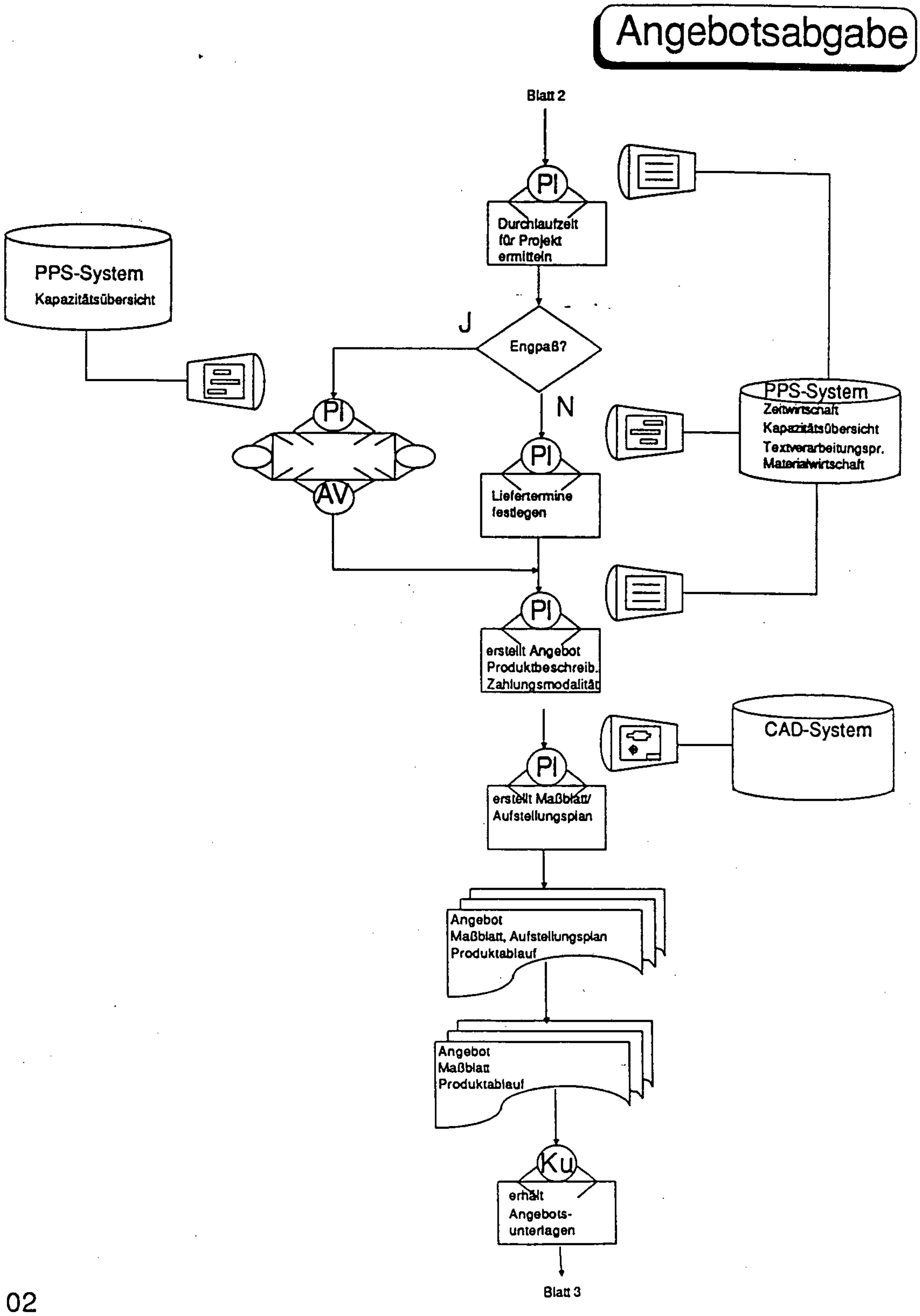
APPENDIX 5

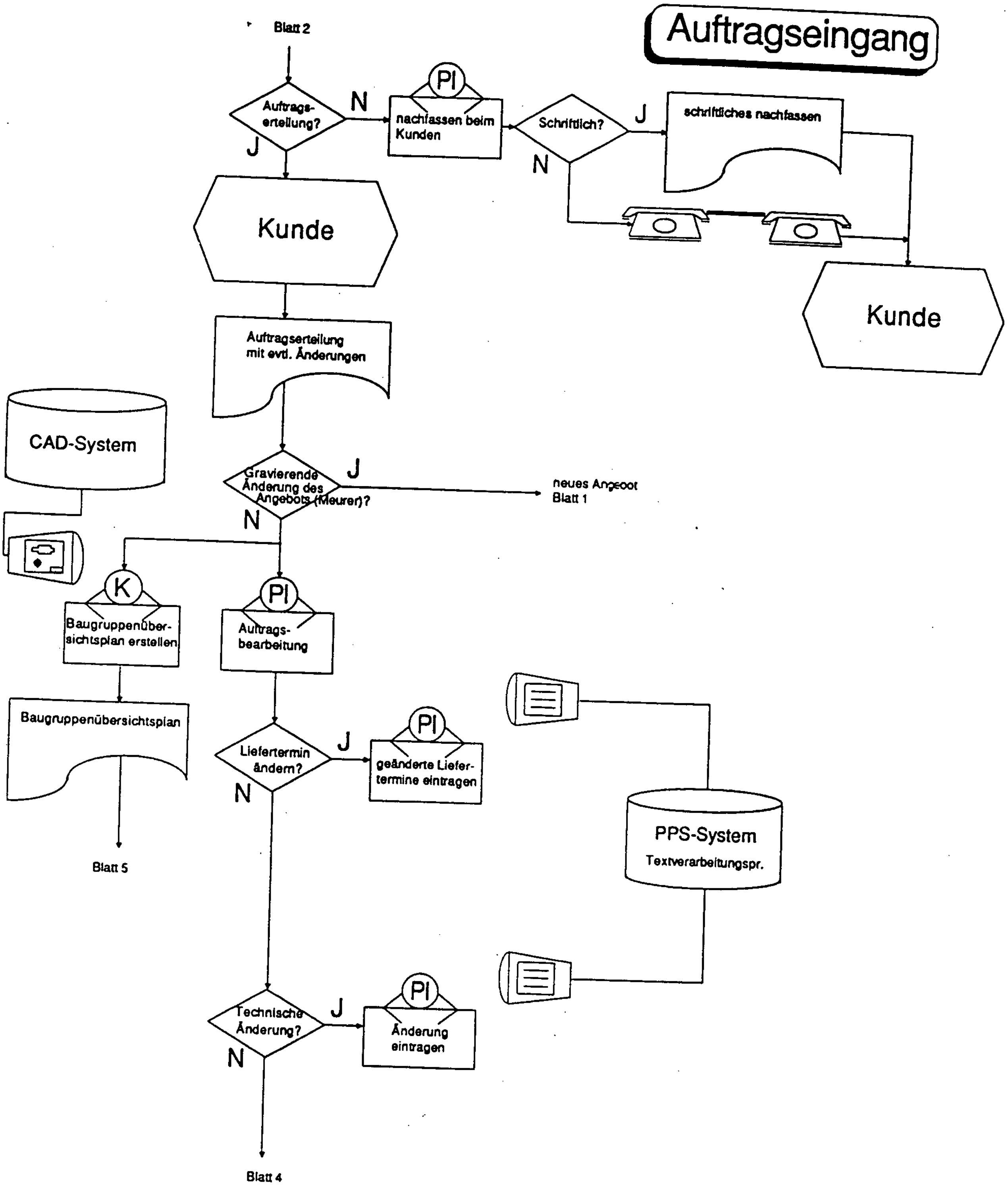
„SHOULD-BE" CONCEPT (ESSER, PEREIRA KLEN AND VÖGE, 1992B)


Anfrageneingang
Ku
Kunde fragt Maschinenkonfl. an
Schriftliche, spezifizierte Anfrage mit Produktbeschreibung und Verpackungsart
Pl
bereitet Projekt-sitzung vor
drucken
Auftragsdatenblatt
PPS-System
Auftragserfassung
Projektbesprechung mit Kunden Auftragsspezifikation
Pl
Ku
Pl
Kundenauftrags-daten erfassen Planauftrag anlegen
J
Sonder-ausführung?
N
Ku
Preis für Sonderaus-führung festlegen
Pl
J
Ersatzteil
N
PPS-Sytem
Materialwirtschaft
J
Standard ?
N
Pl
Sind Teile im Magazin?
Pl
Absprache bzgl. Termin und Konstruktion
K
Termine für Sonderausführung bestimmen
Pl = Projektingenieur
Ku = Kunde
K = Konstruktion
AV = Arbeitsvorbereitung
EK = Einkauf
Fe = Fertigung Einzelteile
Kn = Kontrolle
M = Magazin
MF= Meister Fertigung
MM=Meister Montage
VS = Versand
Blatt 2
Blatt 1



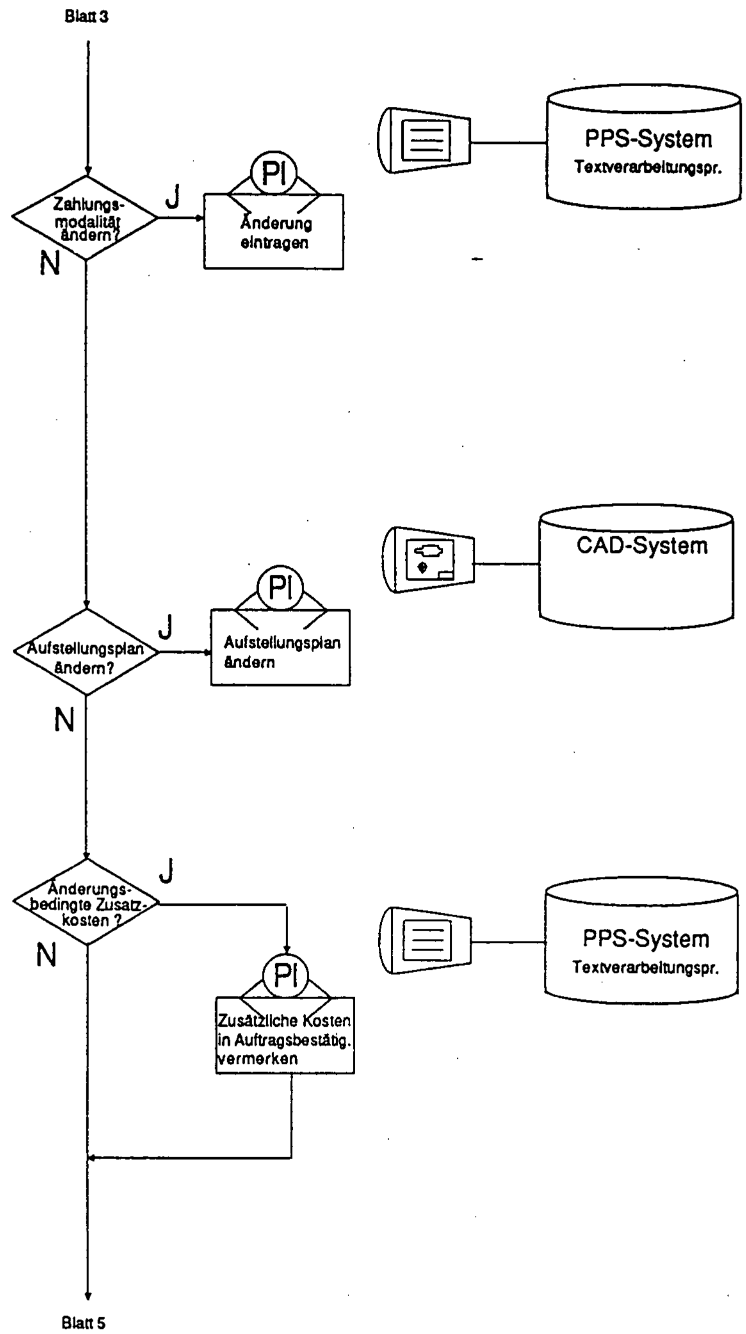
Angebotsabgabe
Blatt 2
PI
Durchlaufzeit für Projekt ermitteln
PPS-System
Kapazitätsübersicht
J
Engpaß?
N
PI
AV
PI
Liefertermine festlegen
PPS-System
Zeitwirtschaft
KapazitätsÜbersicht
Textverarbeitungspr.
Materialwirtschaft
PI
erstellt Angebot
Produktbeschreib.
Zahlungsmodalität
CAD-System
PI
erstellt Maßblatt/
Aufstellungsplan
Angebot
Maßblatt, Aufstellungsplan
Produktablauf
Angebot
Maßblatt
Produktablauf
Ku
erhält
Angebots-
unterlagen
Blatt 3

Blatt 02

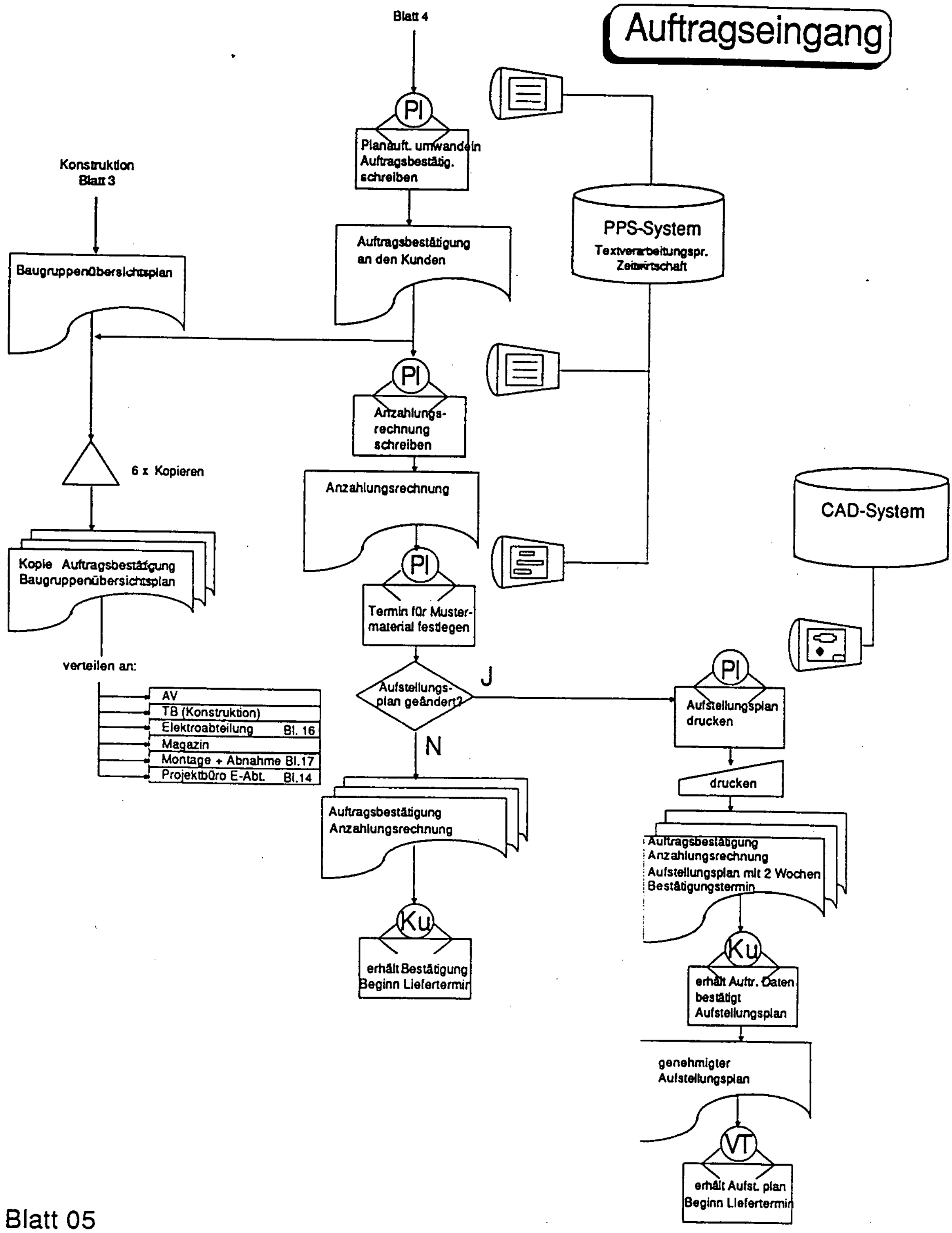

Auftragseingang
Blatt 2
Auftrags-
erteilung?
N
J
PI
nachfassen beim
Kunden
Schriftlich?
J
N
schriftliches nachfassen
Kunde
Kunde
Auftragserteilung
mit evtl. Änderungen
CAD-System
Gravierende
Änderung des
Angebots (Meurer)?
J
N
neues Angebot
Blatt 1
K
Baugruppenüber-
sichtsplan erstellen
PI
Auftrags-
bearbeitung
Baugruppenübersichtsplan
Blatt 5
Liefertermin
ändern?
J
N
PI
geänderte Liefer-
termine eintragen
PPS-System
Textverarbeitungspr.
Technische
Änderung?
J
N
PI
Änderung
eintragen
Blatt 4

Blatt 03

Auftragseingang

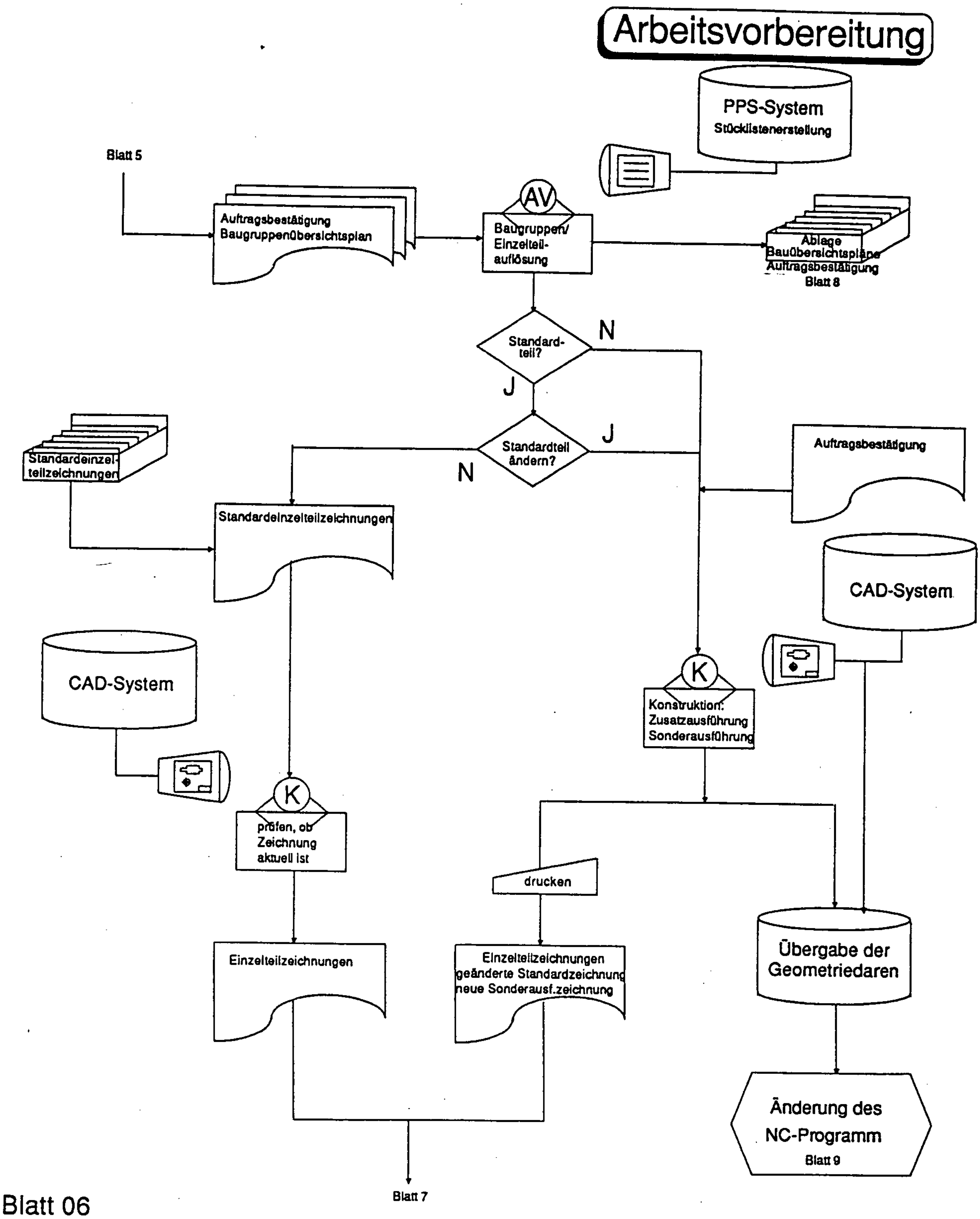


Blatt 04

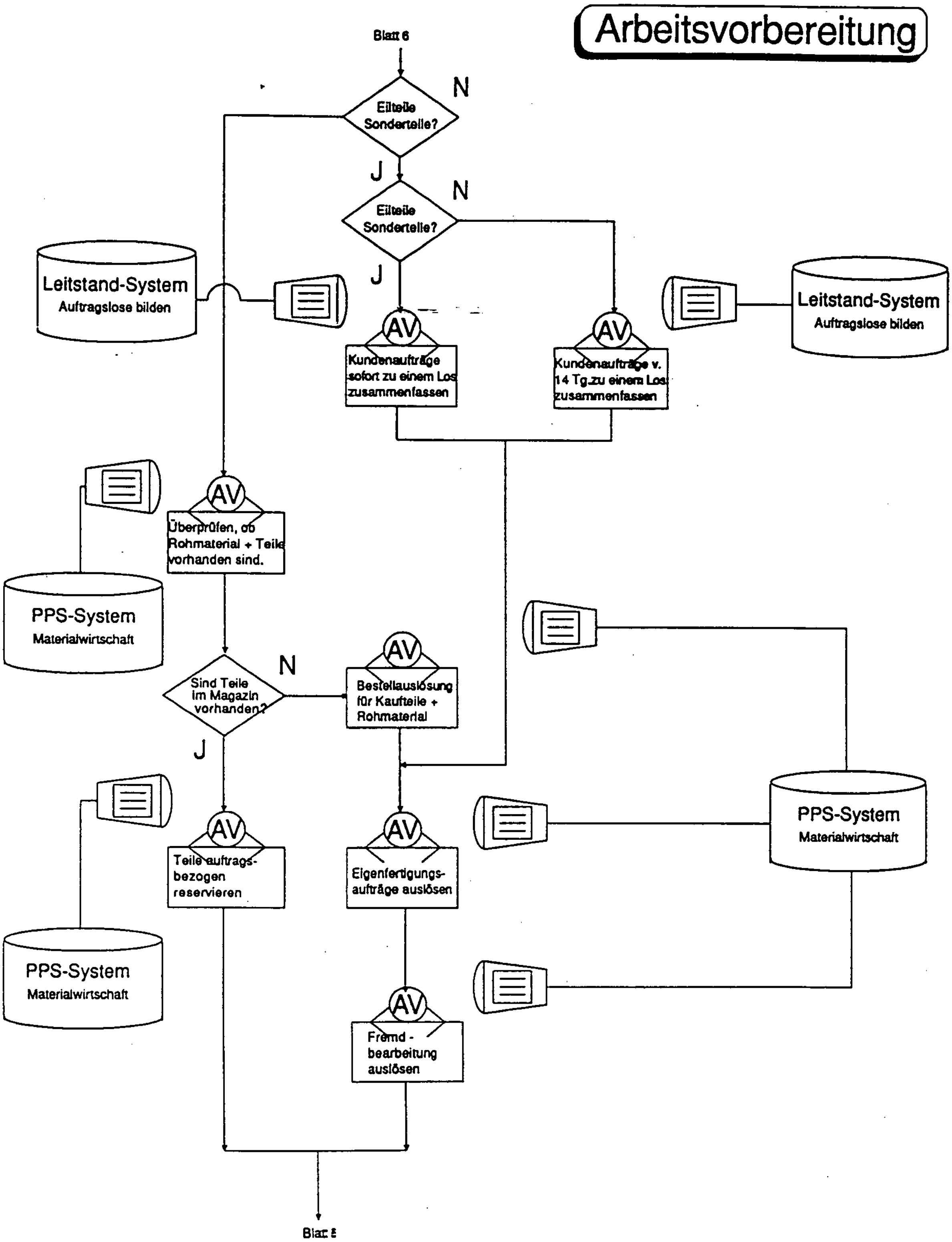


Auftragseingang
Blatt 4
Pl
Planauft. umwandeln Auftragsbestätig. schreiben
Auftragsbestätigung an den Kunden
PPS-System
Textverarbeitungspr. Zeitwirtschaft
Konstruktion Blatt 3
Baugruppenübersichtsplan
Pl
Anzahlungs-rechnung schreiben
6 x Kopieren
Anzahlungsrechnung
CAD-System
Kopie Auftragsbestätigung Baugruppenübersichtsplan
Pl
Termin für Mustermaterial festlegen
verteilen an:
AV
TB (Konstruktion)
Elektroabteilung Bl. 16
Magazin
Montage + Abnahme Bl.17
Projektbüro E-Abt. Bl.14
Aufstellungs-plan geändert?
J
N
Pl
Aufstellungsplan drucken
drucken
Auftragsbestätigung Anzahlungsrechnung
Auftragsbestätigung Anzahlungsrechnung Aufstellungsplan mit 2 Wochen Bestätigungstermin
Ku
erhält Bestätigung Beginn Liefertermin
Ku
erhält Auftr. Daten bestätigt Aufstellungsplan
genehmigter Aufstellungsplan
VT
erhält Aufst. plan Beginn Liefertermin

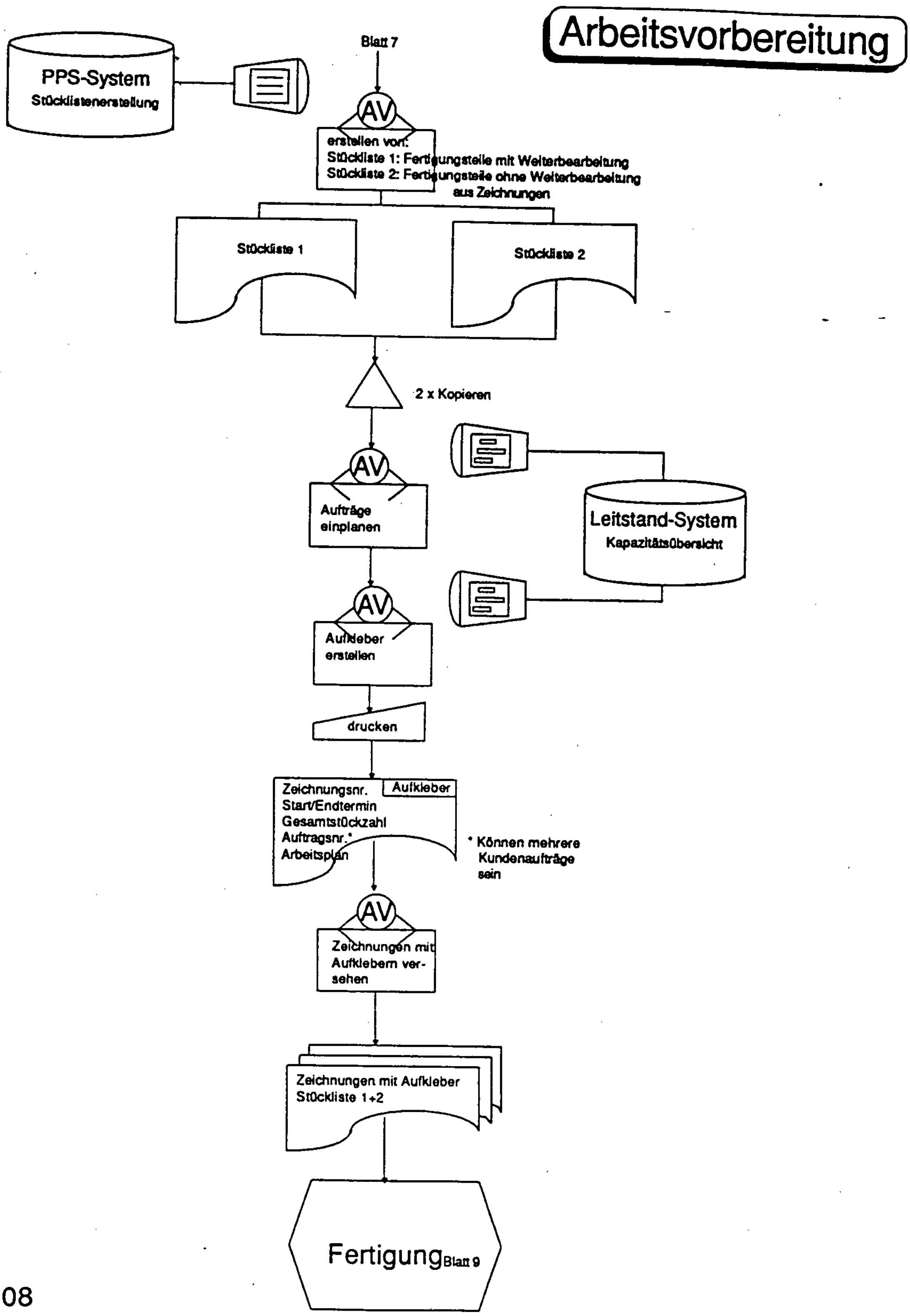
Blatt 05



Arbeitsvorbereitung
PPS-System
Stücklistenerstellung
Blatt 5
Auftragsbestätigung
Baugruppenübersichtsplan
AV
Baugruppen/
Einzelteil-
auflösung
Ablage
Bauübersichtspläne
Auftragsbestätigung
Blatt 8
Standard-
teil?
N
J
Standardteil
ändern?
J
N
Standardeinzel-
teilzeichnungen
Auftragsbestätigung
Standardeinzelteilzeichnungen
CAD-System
CAD-System
K
Konstruktion:
Zusatzausführung
Sonderausführung
K
prüfen, ob
Zeichnung
aktuell ist
drucken
Einzelteilzeichnungen
Einzelteilzeichnungen
geänderte Standardzeichnung
neue Sonderausf.zeichnung
Übergabe der
Geometriedaren
Änderung des
NC-Programm
Blatt 9
Blatt 7
Blatt 06

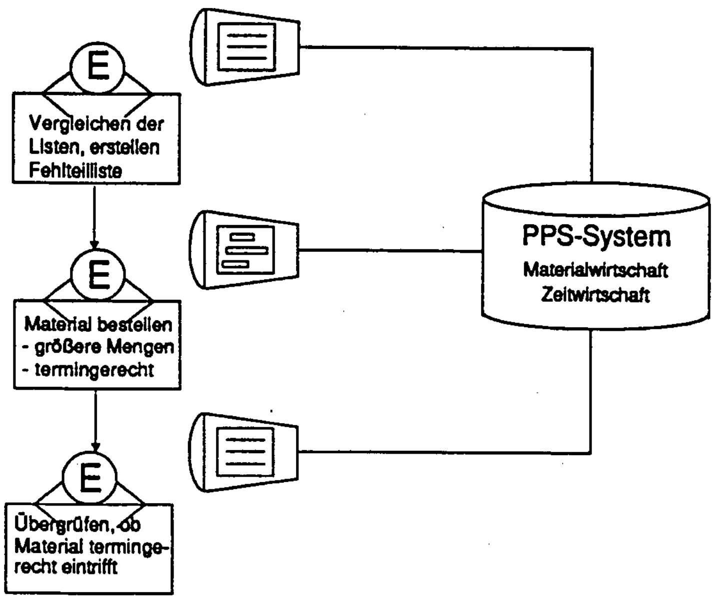

Arbeitsvorbereitung
Blatt 6
Eilteile Sonderteile?
N
J
Eilteile Sonderteile?
N
J
Leitstand-System
Auftragslose bilden
AV
Kundenaufträge sofort zu einem Los zusammenfassen
AV
Kundenaufträge v. 14 Tg. zu einem Los zusammenfassen
Leitstand-System
Auftragslose bilden
AV
Überprüfen, ob Rohmaterial + Teile vorhanden sind.
PPS-System
Materialwirtschaft
Sind Teile im Magazin vorhanden?
N
J
AV
Bestellauslösung für Kaufteile + Rohmaterial
AV
Teile auftragsbezogen reservieren
AV
Eigenfertigungsaufträge auslösen
PPS-System
Materialwirtschaft
PPS-System
Materialwirtschaft
AV
Fremd - bearbeitung auslösen

Blatt 07


Arbeitsvorbereitung
PPS-System
Stücklistenerstellung
Blatt 7
AV
erstellen von:
Stückliste 1: Fertigungsteile mit Weiterbearbeitung
Stückliste 2: Fertigungsteile ohne Weiterbearbeitung
aus Zeichnungen
Stückliste 1
Stückliste 2
2 x Kopieren
AV
Aufträge einplanen
Leitstand-System
Kapazitätsübersicht
AV
Aufkleber erstellen
drucken
Aufkleber
Zeichnungsnr.
Start/Endtermin
Gesamtstückzahl
Auftragsnr.*
Arbeitsplan
* Können mehrere Kundenaufträge sein
AV
Zeichnungen mit Aufklebern versehen
Zeichnungen mit Aufkleber
Stückliste 1+2
Fertigung Blatt 9

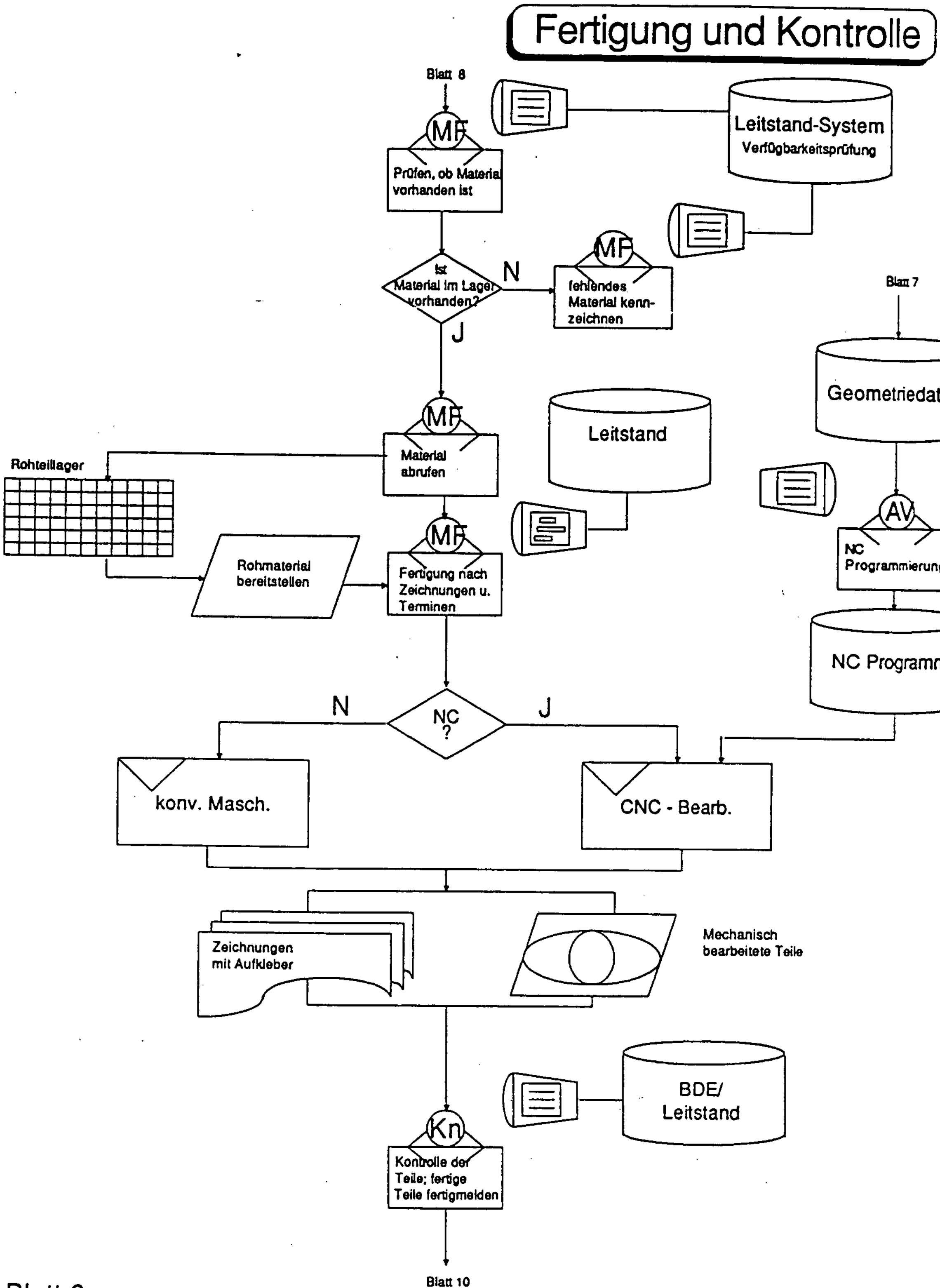
Blatt 08

Einkauf
täglich

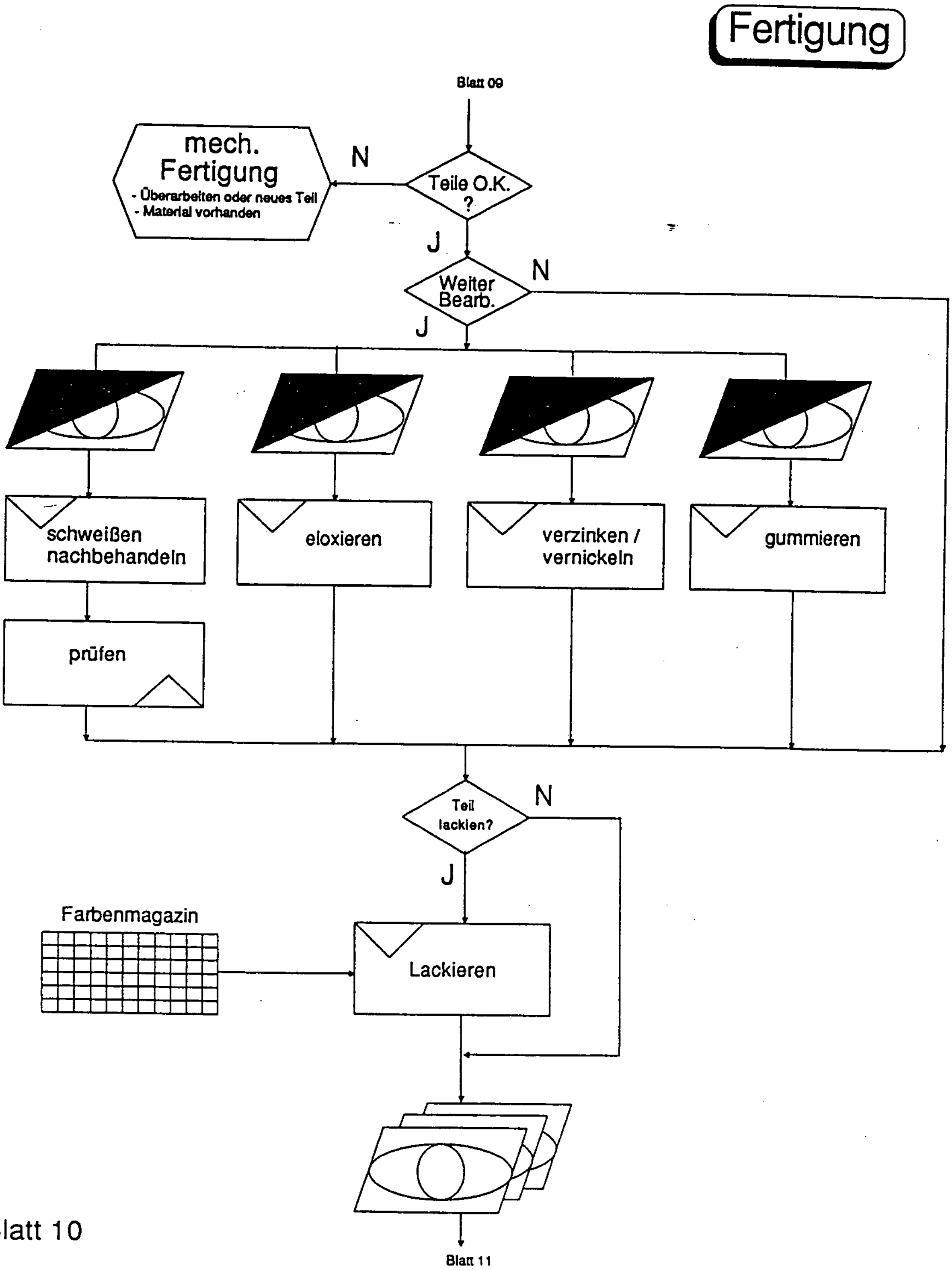


E
Vergleichen der Listen, erstellen Fehlteilliste
E
Material bestellen
- größere Mengen
- termingerecht
E
Übergrüfen, ob Material terminge-recht eintrifft
PPS-System
Materialwirtschaft
Zeitwirtschaft

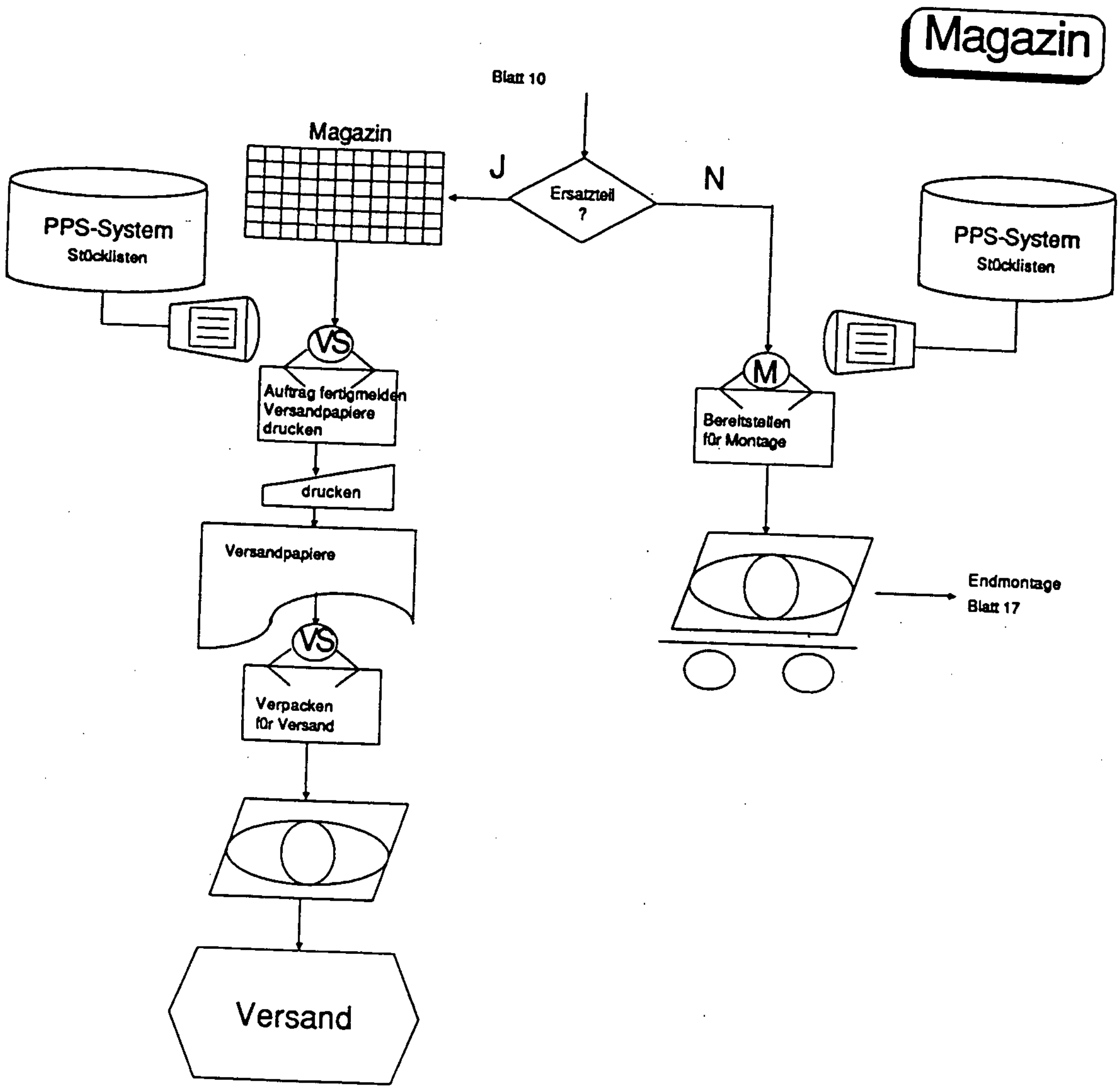
Blatt 13


Fertigung und Kontrolle
Blatt 8
MF
Prüfen, ob Material vorhanden ist
Leitstand-System
Verfügbarkeitsprüfung
Ist Material im Lager vorhanden?
N
J
MF
fehlendes Material kenn-zeichnen
Blatt 7
Geometriedaten
MF
Material abrufen
Leitstand
Rohteillager
AV
NC Programmierung
MF
Rohmaterial bereitstellen
Fertigung nach Zeichnungen u. Terminen
NC Programm
N
NC ?
J
konv. Masch.
CNC - Bearb.
Zeichnungen mit Aufkleber
Mechanisch bearbeitete Teile
BDE/ Leitstand
Kn
Kontrolle der Teile; fertige Teile fertigmelden
Blatt 10

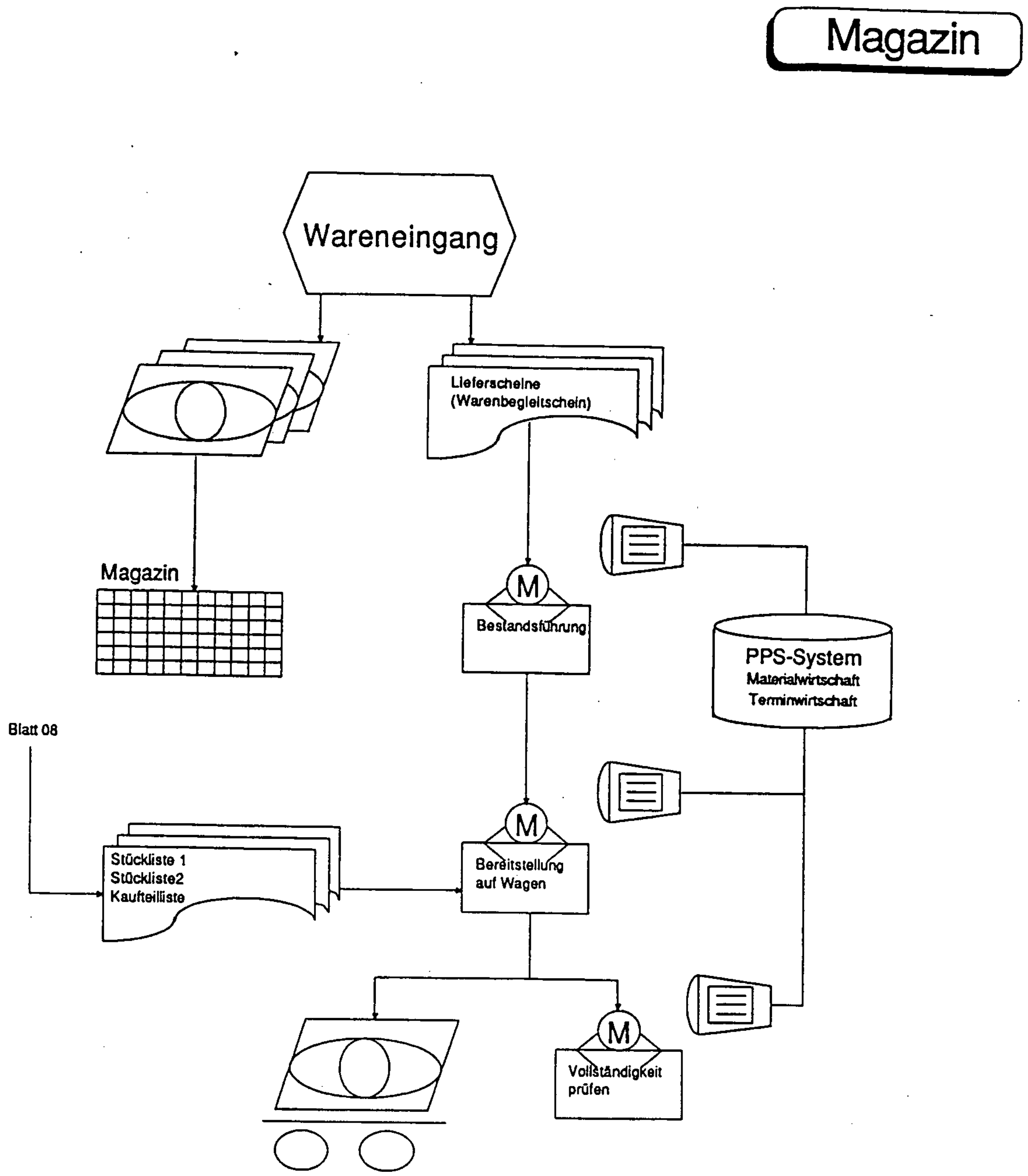
Blatt 9


Fertigung
Blatt 09
mech. Fertigung
- Überarbeiten oder neues Teil
- Material vorhanden
N
Teile O.K. ?
J
Weiter Bearb.
N
J
schweißen nachbehandeln
eloxieren
verzinken / vernickeln
gummieren
prüfen
Teil lackien?
N
J
Farbenmagazin
Lackieren
Blatt 11

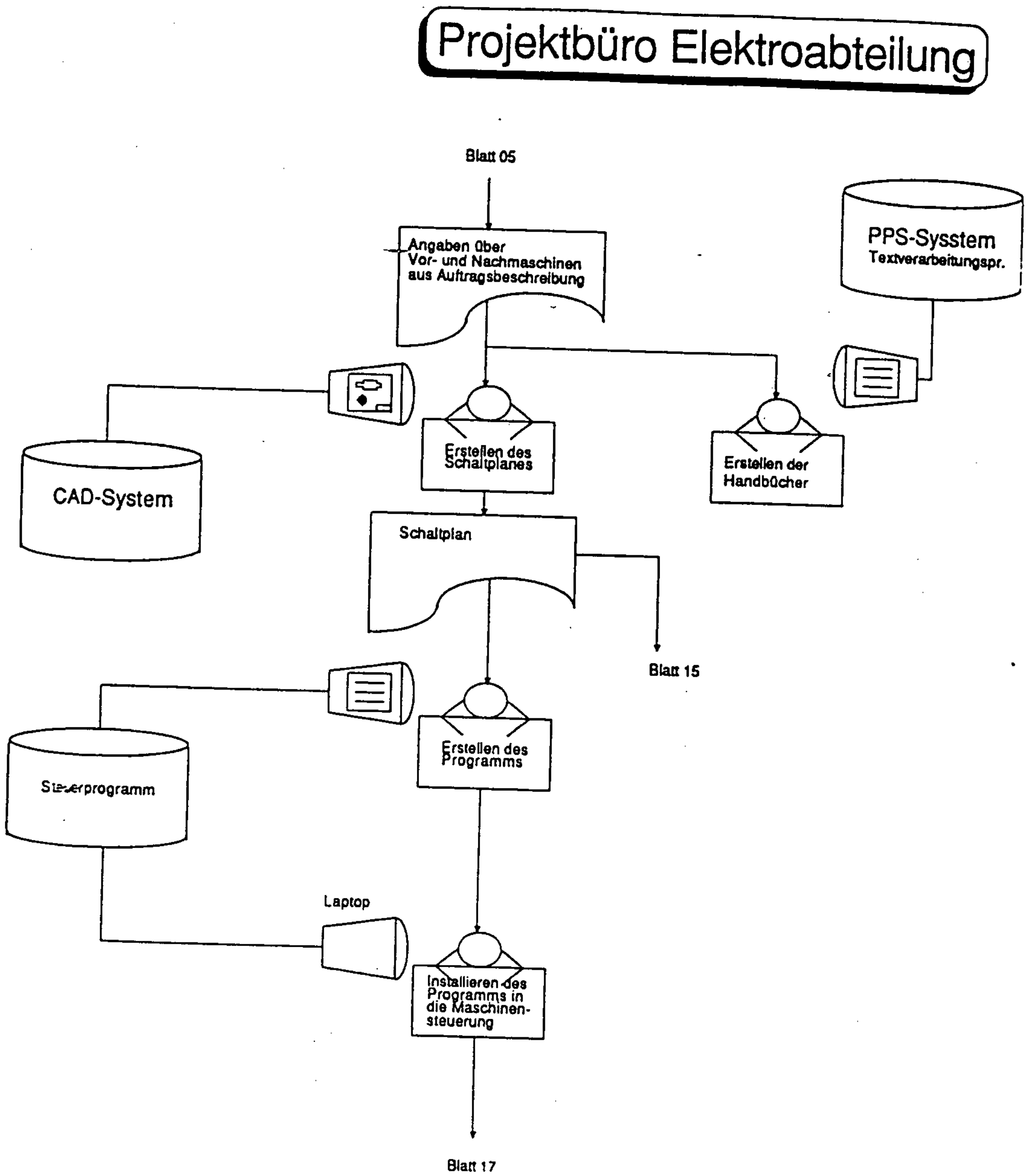
Blatt 10


Magazin
Blatt 10
Magazin
J
Ersatzteil
?
N
PPS-System
Stücklisten
PPS-System
Stücklisten
VS
Auftrag fertigmelden
Versandpapiere
drucken
M
Bereitstellen
für Montage
drucken
Versandpapiere
Endmontage
Blatt 17
VS
Verpacken
für Versand
Versand

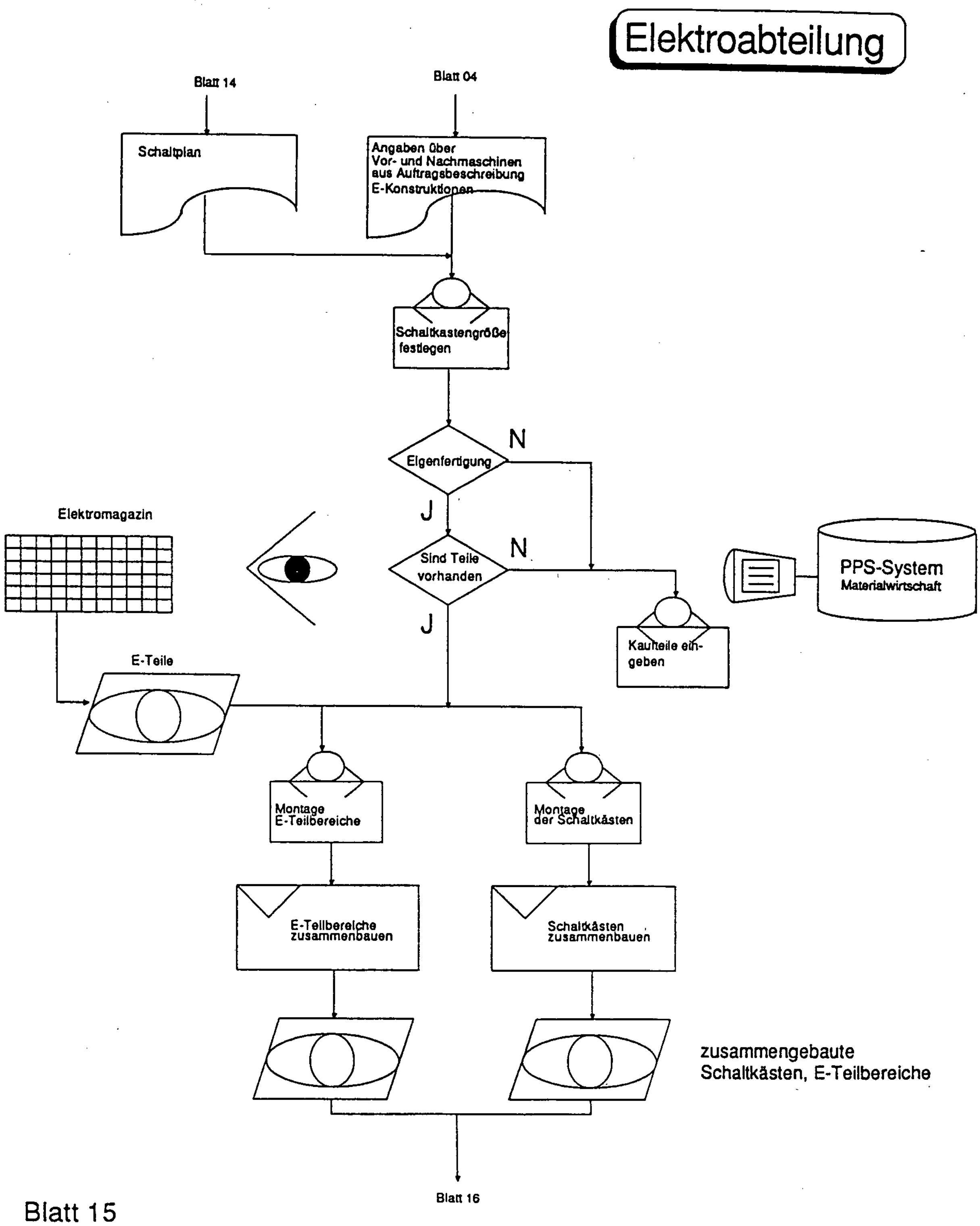
Blatt 11


Magazin
Wareneingang
Lieferscheine
(Warenbegleitschein)
Magazin
M
Bestandsführung
PPS-System
Materialwirtschaft
Terminwirtschaft
Blatt 08
M
Stückliste 1
Stückliste2
Kaufteilliste
Bereitstellung
auf Wagen
M
Vollständigkeit
prüfen

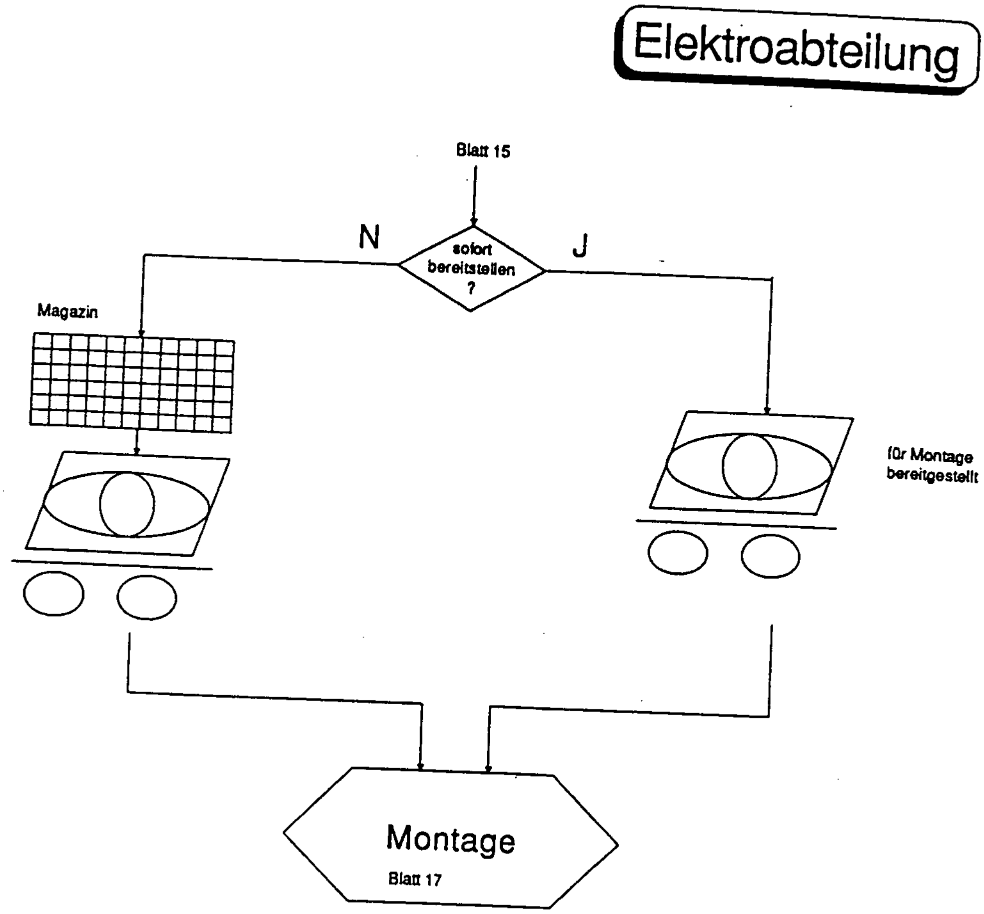
Blatt 12


Projektbüro Elektroabteilung
Blatt 05
Angaben über Vor- und Nachmaschinen aus Auftragsbeschreibung
PPS-Sysstem
Textverarbeitungspr.
CAD-System
Erstellen des Schaltplanes
Erstellen der Handbücher
Schaltplan
Blatt 15
Erstellen des Programms
Laptop
Installieren des Programms in die Maschinensteuerung
Blatt 17

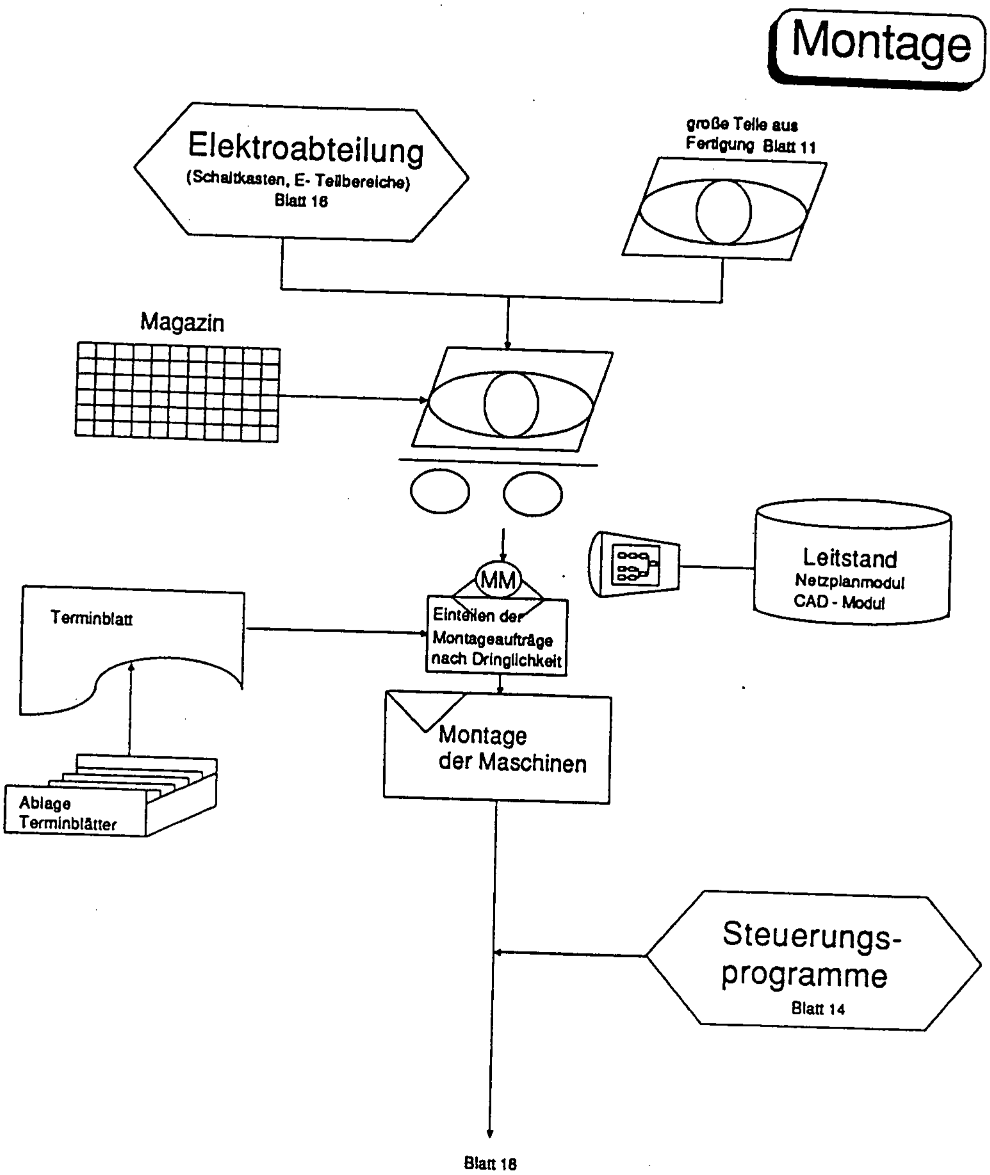
Blatt 14


Elektroabteilung
Blatt 14
Blatt 04
Schaltplan
Angaben über Vor- und Nachmaschinen aus Auftragsbeschreibung E-Konstruktionen
Schaltkastengröße festlegen
Eigenfertigung
N
J
Elektromagazin
Sind Teile vorhanden
N
J
PPS-System
Materialwirtschaft
Kaufteile ein-geben
E-Teile
Montage E-Teilbereiche
Montage der Schaltkästen
E-Teilbereiche zusammenbauen
Schaltkästen zusammenbauen
zusammengebaute Schaltkästen, E-Teilbereiche
Blatt 16

Blatt 15

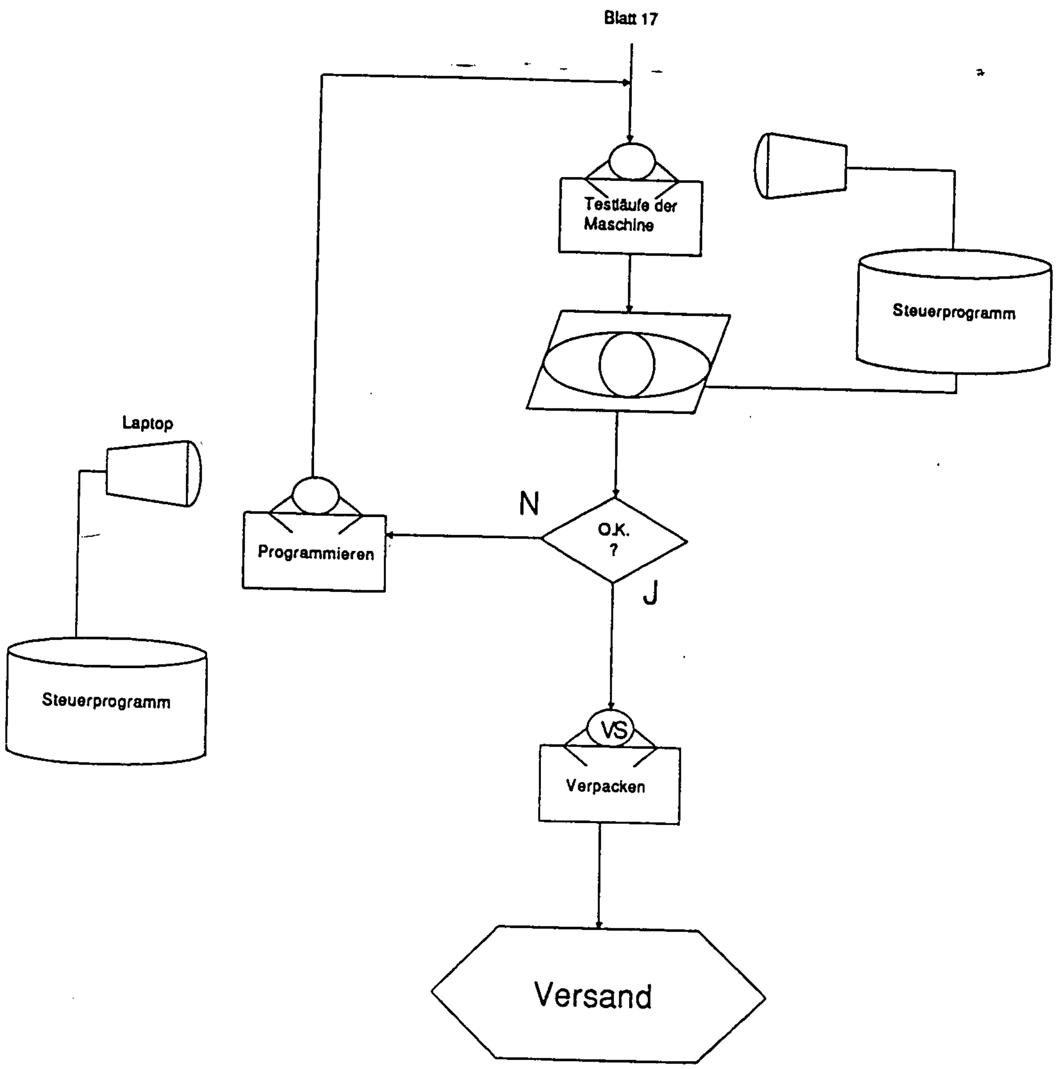

Elektroabteilung
Blatt 15
N
J
sofort bereitstellen ?
Magazin
für Montage bereitgestellt
Montage
Blatt 17

Blatt 16


Montage
Elektroabteilung
(Schaltkasten, E- Teilbereiche)
Blatt 16
große Teile aus
Fertigung Blatt 11
Magazin
MM
Leitstand
Netzplanmodul
CAD - Modul
Terminblatt
Einteilen der
Montageaufträge
nach Dringlichkeit
Montage
der Maschinen
Ablage
Terminblätter
Steuerungs-
programme
Blatt 14
Blatt 18

Blatt 17

Montage und Versand

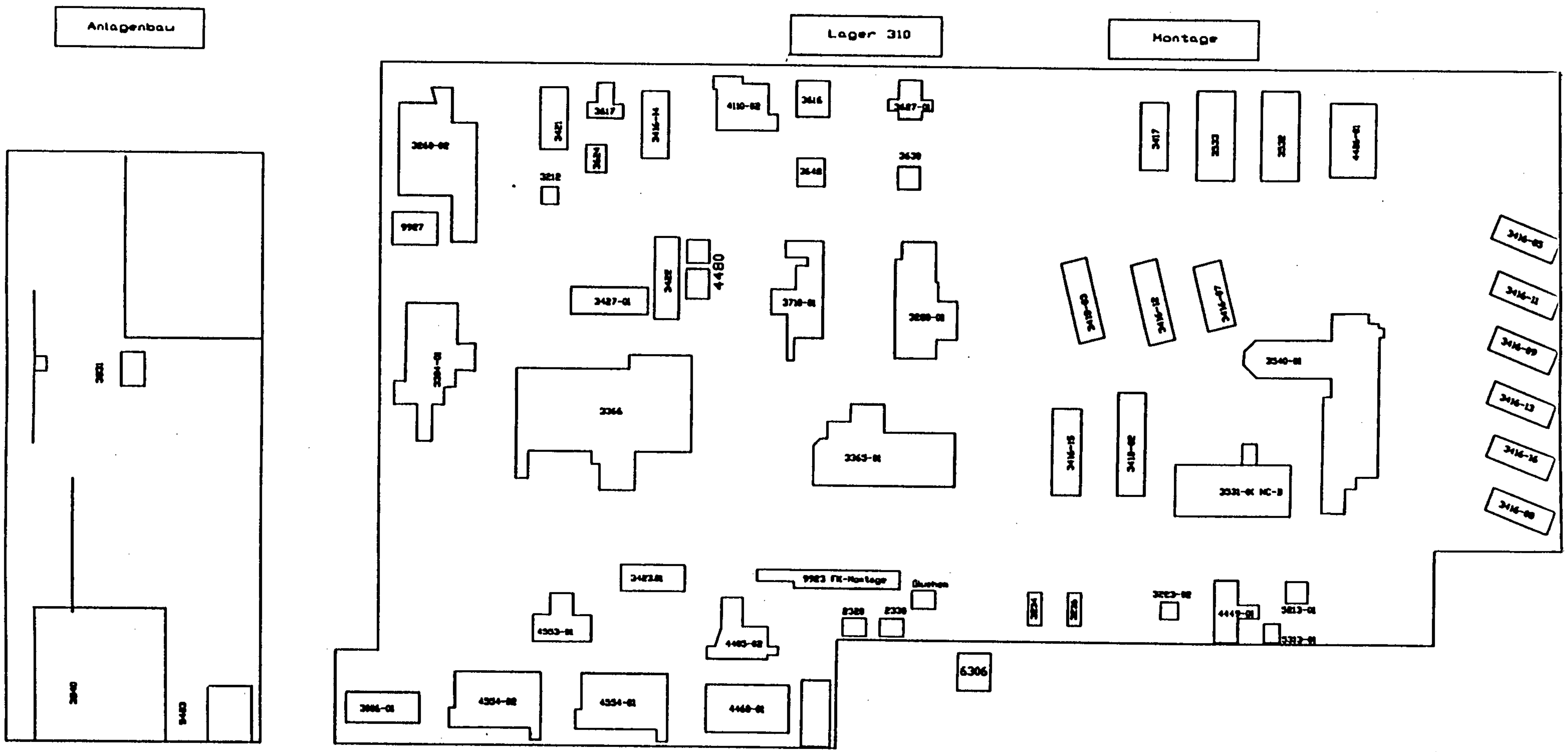


Blatt 18

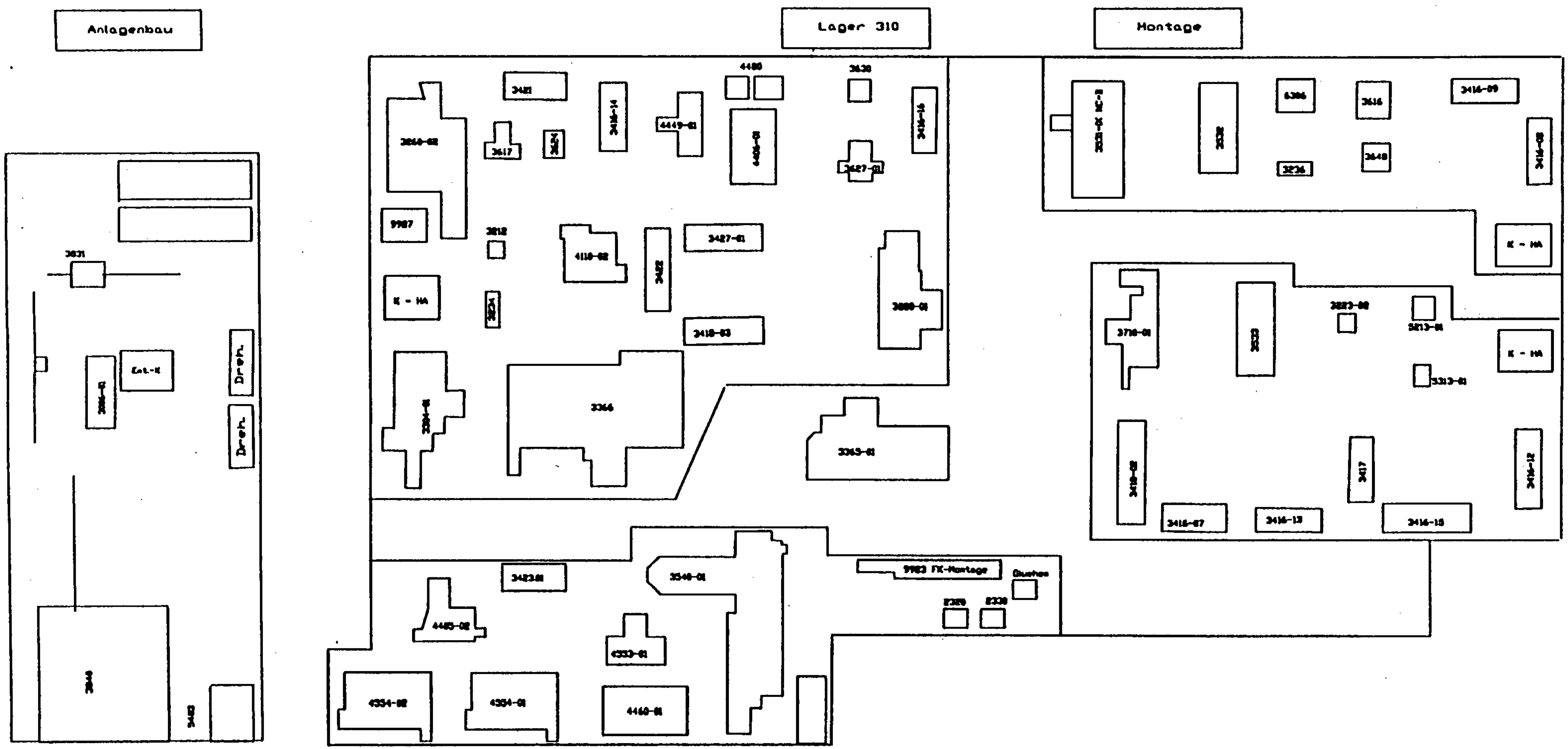
APPENDIX 6

LAYOUT ALTERNATIVES (KUHLMANN, MAßOW, PEREIRA KLEN AND VÖGE, 1991)

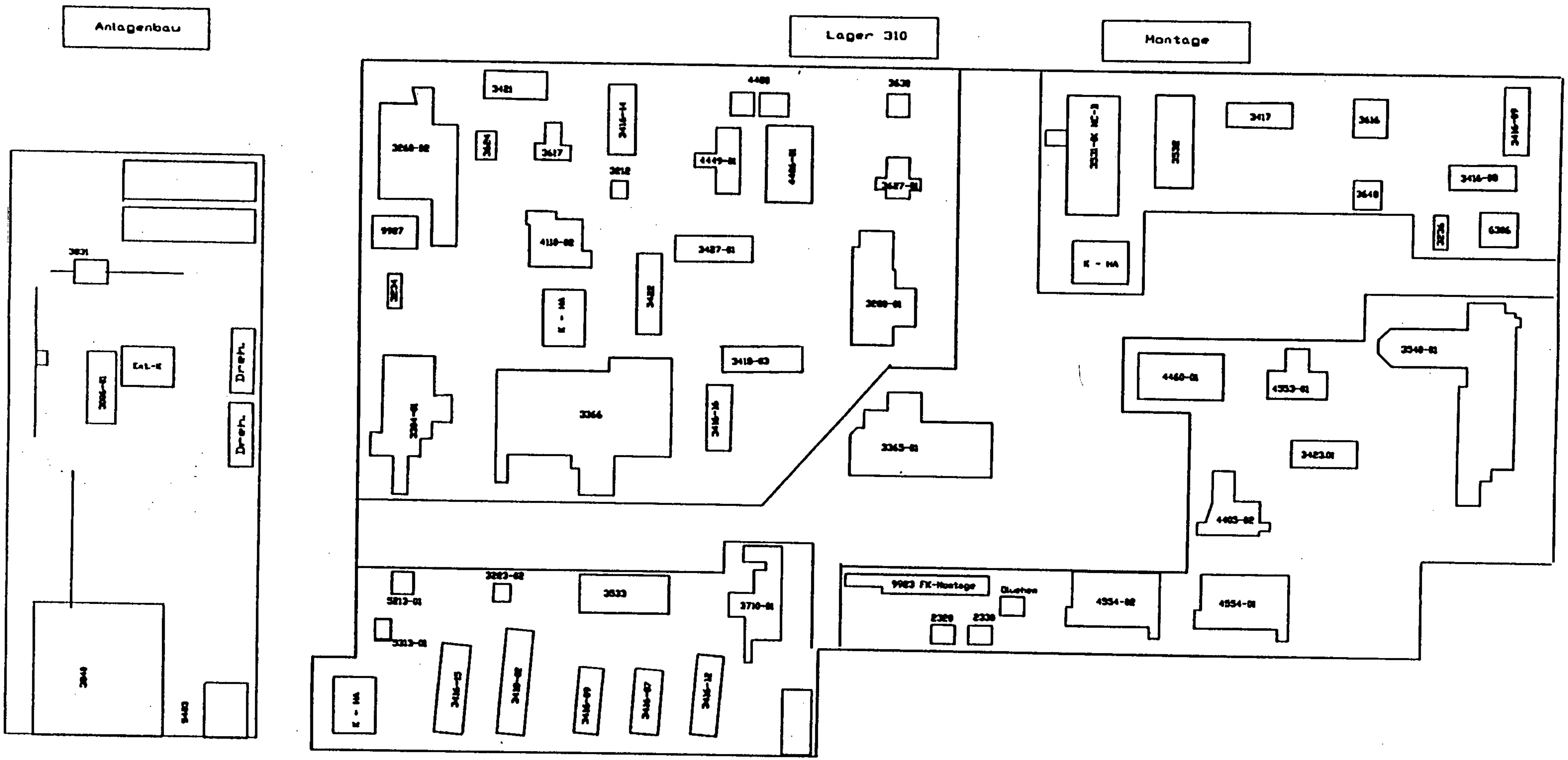
ORIGINAL LAYOUT



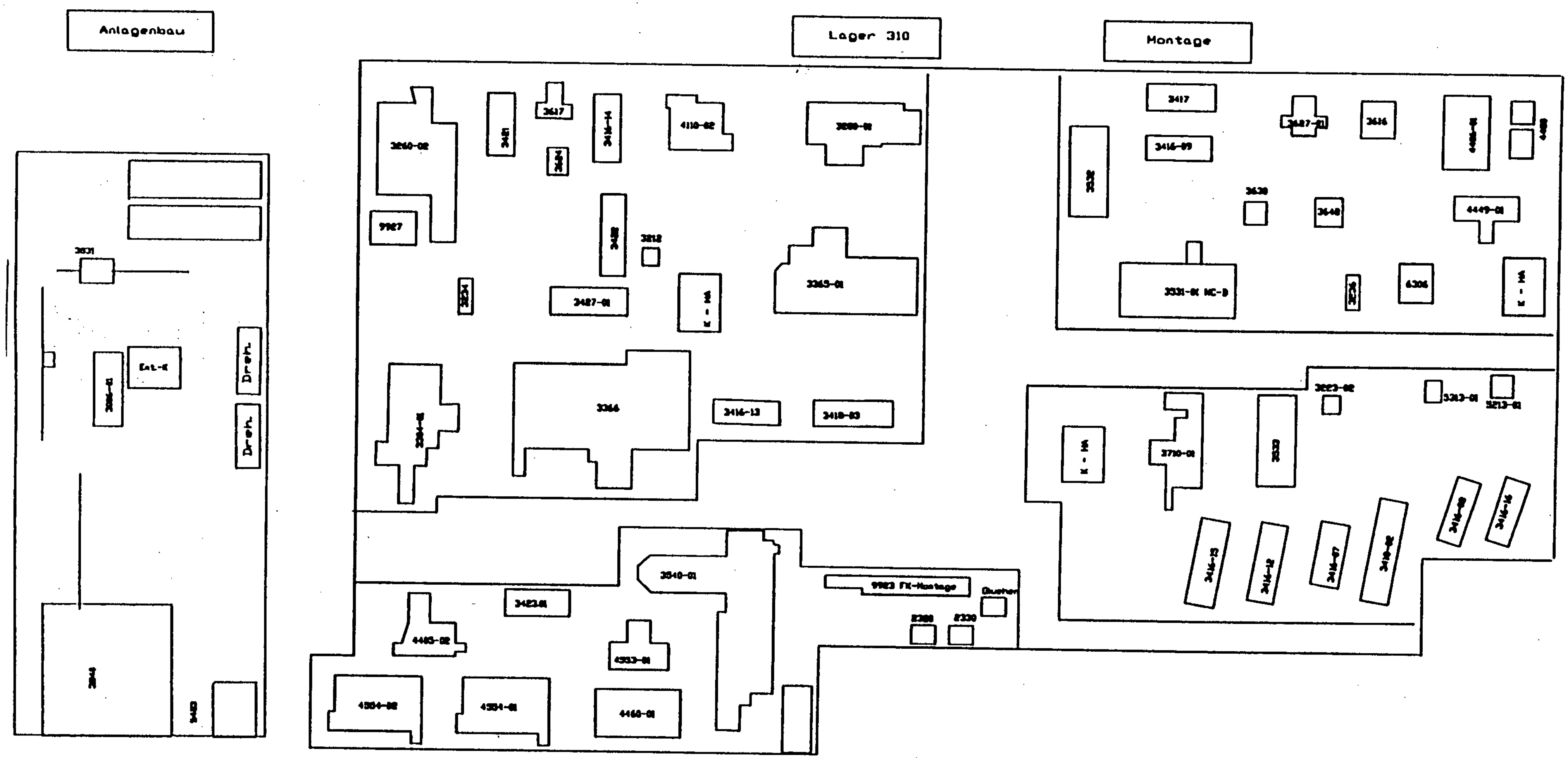
ALTERNATIVE 1



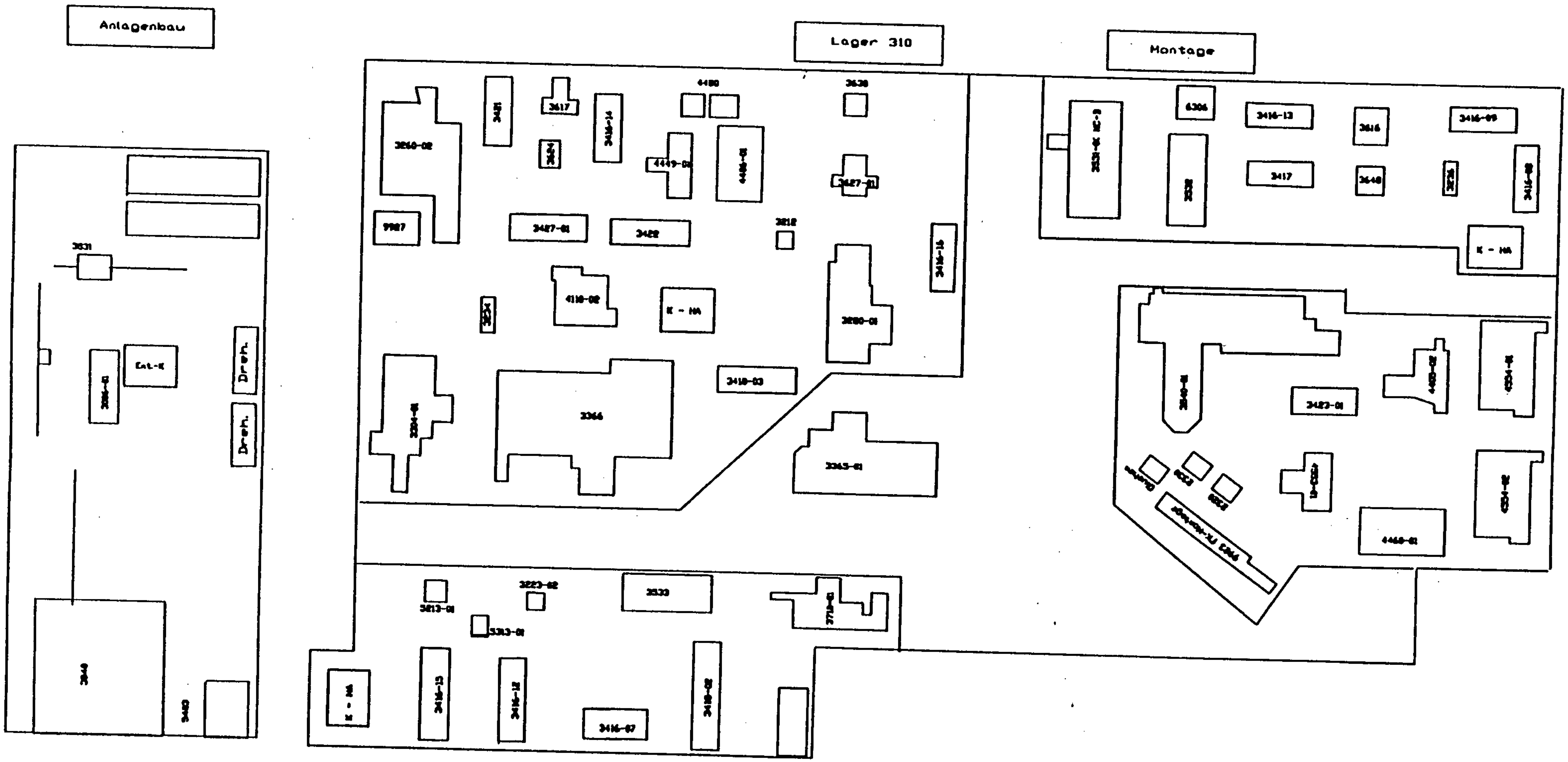
ALTERNATIVE 2



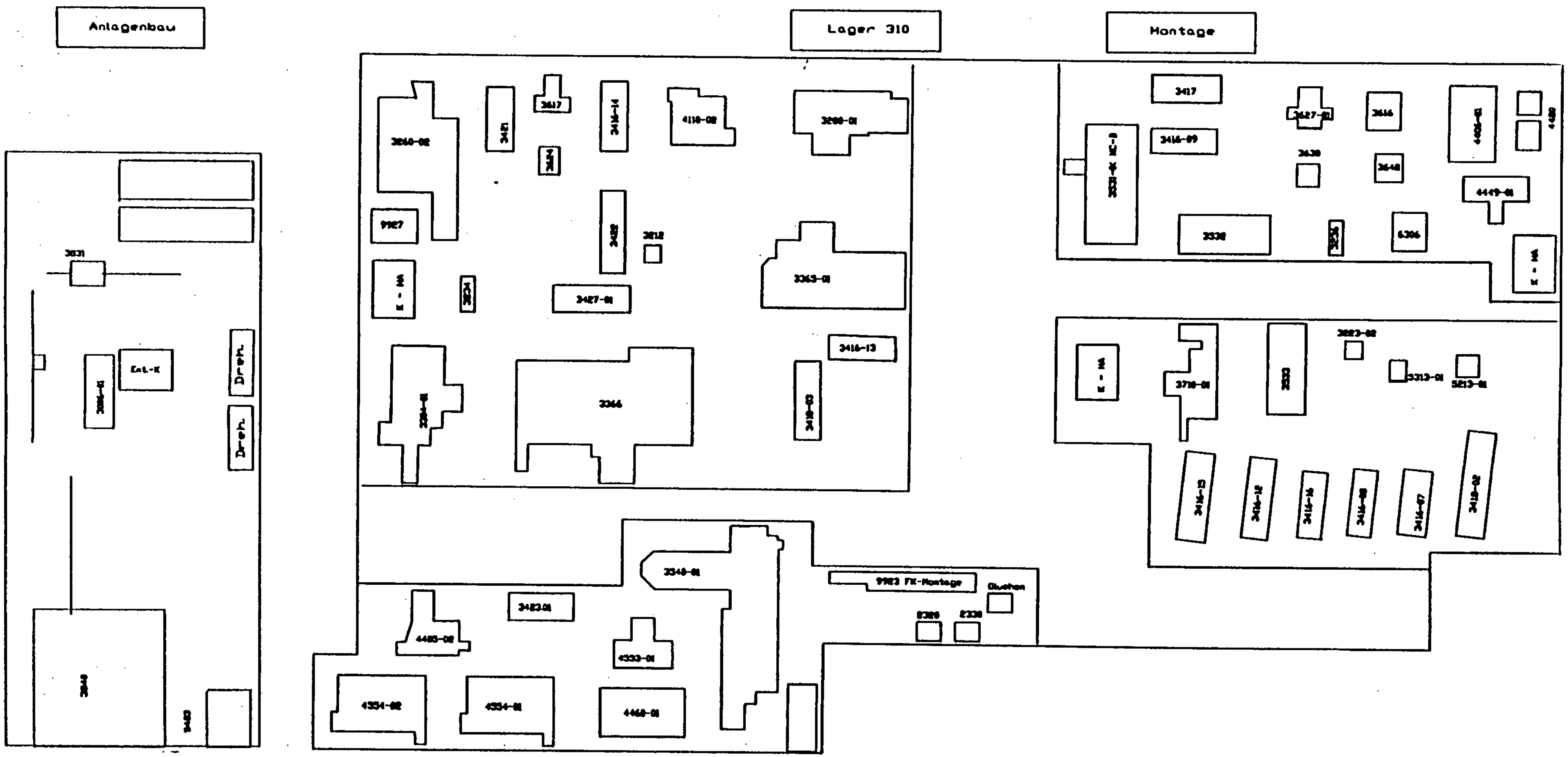
ALTERNATIVE 3



ALTERNATIVE 4



ALTERNATIVE 5



APPENDIX 7

INTERCELL FLOW: NUMBER OF CELLS VISITED BY AN ORDER

(KUHLMANN, MAßOW, PEREIRA KLEN AND VÖGE, 1991)

Teilenummer	Stückzahl	Insel 1	Insel 2	Insel 3	Insel 4	Insel 5	Montage	Anlagenbau	Auswärts	Kooperationszahl
111 300 140	180					1				1
123 170 000	408	1								1
128 110 180	176					1				1
128 110 200	160					1				1
128 120 001	724	1								1
128 200 120	184					1				1
128 205 000	184	1								1
128 206 020	253					1				1
128 400 130	190	1								1
128 400 140	178			1						1
128 400 151	363	1								1
128 510 060	411					1				1
128 520 030	207					1				1
128 600 090	161					1				1
128 600 110	95					1				1
128 641 050	27					1				1
128 641 060	40					1				1
128 641 080	27					1				1
111 540 120	250					1				1
114 420 570	250	1								1
121 420 271	250			1						1
123 170 040	250	1								1
126 552 000	250	1								1
855 320 002	500			1						1
855 320 010	250					1				1
SK 3 139 100 040	1000	1								1
SK 3 139 100 280	250					1				1
SK 3 139 111 010	250					1				1
SK 3 139 140 000	250	1								1
SK 3 139 140 020	250			1						1
SK 3 139 200 270	250			1						1
SK 3 139 200 280	250	1								1
SK 3 139 200 310	250	1								1
SK 3 139 200 680	250			1						1
SK 3 139 230 020	250	1								1
SK 3 139 230 050	250			1						1
SK 3 139 245 000	250	1								1
SK 3 139 246 000	250	1								1
SK 3 139 247 000	250	1								1
SK 3 139 248 000	250	1								1
SK 3 139 301 060	250			1						1
SK 3 139 301 100	250			1						1
SK 3 139 302 090	250					1				1
SK 3 139 310 020	250	1								1
SK 3 139 310 080	250					1				1
SK 3 139 310 100	250					1				1
SK 3 139 350 020	250	1								1
SK 3 139 350 030	250	1								1
SK 3 139 360 050	250					1				1
SK 3 139 360 060	250	1								1
SK 3 139 360 080	250					1				1
SK 3 139 361 000	250	1								1
SK 3 139 362 000	250	1								1
SK 3 139 362 020	250					1				1
SK 3 139 410 120	500	1								1
SK 3 139 410 540	250					1				1
SK 3 139 411 010	250	1								1
SK 3 139 411 040	250					1				1
SK 3 139 411 070	250			1						1
SK 3 139 411 080	250			1						1
SK 3 139 412 020	500			1						1
SK 3 139 440 190	250					1				1

Teilenummer	Stückzahl	Insel 1	Insel 2	Insel 3	Insel 4	Insel 5	Montage	Anlagenbau	Auswärts	Kooperationszahl
SK 3 139 440 200	250					1				1
SK 3 139 500 510	1000					1				1
SK 3 139 530 000	250					1				1
SK 3 139 641 100	500					1				1
SK 3 139 641 120	250					1				1
SK 3 139 641 130	250					1				1
SK 3 139 641 140	500					1				1
SK 3 139 680 000	250	1								1
SK 3 139 750 070	250					1				1
SK 3 139 750 170	250					1				1
SK 3 139 750 210	250					1				1
SK 3 140 840 001	250	1								1
Gesamtstückzahl	20718									
Gesamtanzahl	74									
114 420 180	1286		2			1				2
123 170 030	654			2		1				2
123 170 110	673		2			1				2
123 170 170	651			2		1				2
123 171 000	685			1			2			2
126 871 601	389			2				1		2
128 110 150	167			2		1				2
128 110 160	174		2			1				2
128 110 220	197			2		1				2
128 112 000	201			2		1				2
128 116 020	355		2			1				2
128 120 030	680			2		1				2
128 161 071	1108			2		1				2
128 200 090	193	2					1			2
128 200 130	280		2			1				2
128 202 000	186			2		1				2
128 205 010	180			2		1				2
128 210 020	209			2		1				2
128 210 050	201			2		1				2
128 211 020	216		2			1				2
128 400 040	188	1					2			2
128 400 050	184			1			2			2
128 400 060	172		1	2						2
128 400 110	196			2		1				2
128 400 120	180			2		1				2
128 500 590	181			2		1				2
128 510 050	412			2		1				2
128 510 100	543		2			1				2
128 520 020	201		2			1				2
128 520 050	202					1		2		2
128 541 010	248		2			1				2
128 911 020	180					1			2	2
854 210 050	314		2			1				2
889 300 070	530		2			1				2
121 420 012	250			2		1				2
121 420 110	500		2			1				2
121 420 201	250			2		1				2
855 300 060	250			2		1				2
855 310 073	250					1		2		2
855 310 140	250	2				1				2
855 310 160	250					1		2		2
855 310 200	250			2		1				2
855 310 280	250					1		2		2
855 510 050	250		2			1				2
857 310 130	250		2			1				2
857 420 000	250			2				1		2
SK 3 139 111 000	1000							1	2	2
SK 3 139 111 020	250					1			2	2

Teilenummer	Stückzahl	Insel 1	Insel 2	Insel 3	Insel 4	Insel 5	Montage	Anlagenbau	Auswärts	Kooperationszahl
SK 3 139 115 000	250					1		2		2
SK 3 139 180 030	1500			2		1				2
SK 3 139 180 070	1500		2			1				2
SK 3 139 180 110	500	1							2	2
SK 3 139 180 170	500	2				1				2
SK 3 139 180 230	500			2		1				2
SK 3 139 180 240	500			2		1				2
SK 3 139 182 020	500			2		1				2
SK 3 139 182 040	1000		2			1				2
SK 3 139 191 020	500			2		1				2
SK 3 139 200 030	250	1					2			2
SK 3 139 200 110	250		2			1				2
SK 3 139 200 200	250						1	2		2
SK 3 139 200 390	250			1			2			2
SK 3 139 200 560	250						2	1		2
SK 3 139 200 600	250			2		1				2
SK 3 139 200 610	250		2			1				2
SK 3 139 200 650	250			2		1				2
SK 3 139 200 950	500		2			1				2
SK 3 139 210 000	250	1					2			2
SK 3 139 230 010	250			2		1				2
SK 3 139 240 000	250	1					2			2
SK 3 139 280 030	250		2			1				2
SK 3 139 301 070	250			2		1				2
SK 3 139 301 080	250							1	2	2
SK 3 139 302 080	250		2			1				2
SK 3 139 302 110	500	2				1				2
SK 3 139 303 030	250			2		1				2
SK 3 139 303 040	250	2				1				2
SK 3 139 310 040	250					1			2	2
SK 3 139 310 050	250					1			2	2
SK 3 139 310 060	500			2		1				2
SK 3 139 310 130	500			2		1				2
SK 3 139 350 040	250			2		1				2
SK 3 139 360 040	250					1			2	2
SK 3 139 362 010	250	2				1				2
SK 3 139 410 330	250		2			1				2
SK 3 139 411 030	250	2						1		2
SK 3 139 411 100	250			2		1				2
SK 3 139 412 000	250			2		1				2
SK 3 139 412 010	250			2		1				2
SK 3 139 413 000	250			2		1				2
SK 3 139 500 040	250			2		1				2
SK 3 139 520 070	500			2		1				2
SK 3 139 600 610	250		2			1				2
SK 3 139 600 620	250		2			1				2
SK 3 139 610 000	250					1	2			2
SK 3 139 610 430	500		2			1				2
SK 3 139 611 000	250	2				1				2
SK 3 139 612 080	250			2		1				2
SK 3 139 613 020	250			2		1				2
SK 3 139 641 150	250		2			1				2
SK 3 139 642 000	250			2				1		2
SK 3 139 750 030	250	2				1				2
SK 3 139 750 050	250			2		1				2
SK 3 139 750 090	250		2			1				2
SK 3 139 750 110	250		2			1				2
SK 3 139 751 000	500			2		1				2
SK 3 140 810 401	1000		2			1				2
Gehäuse	1585	2				1				2
Gesamtstückzahl	40501									
Gesamtanzahl	108									

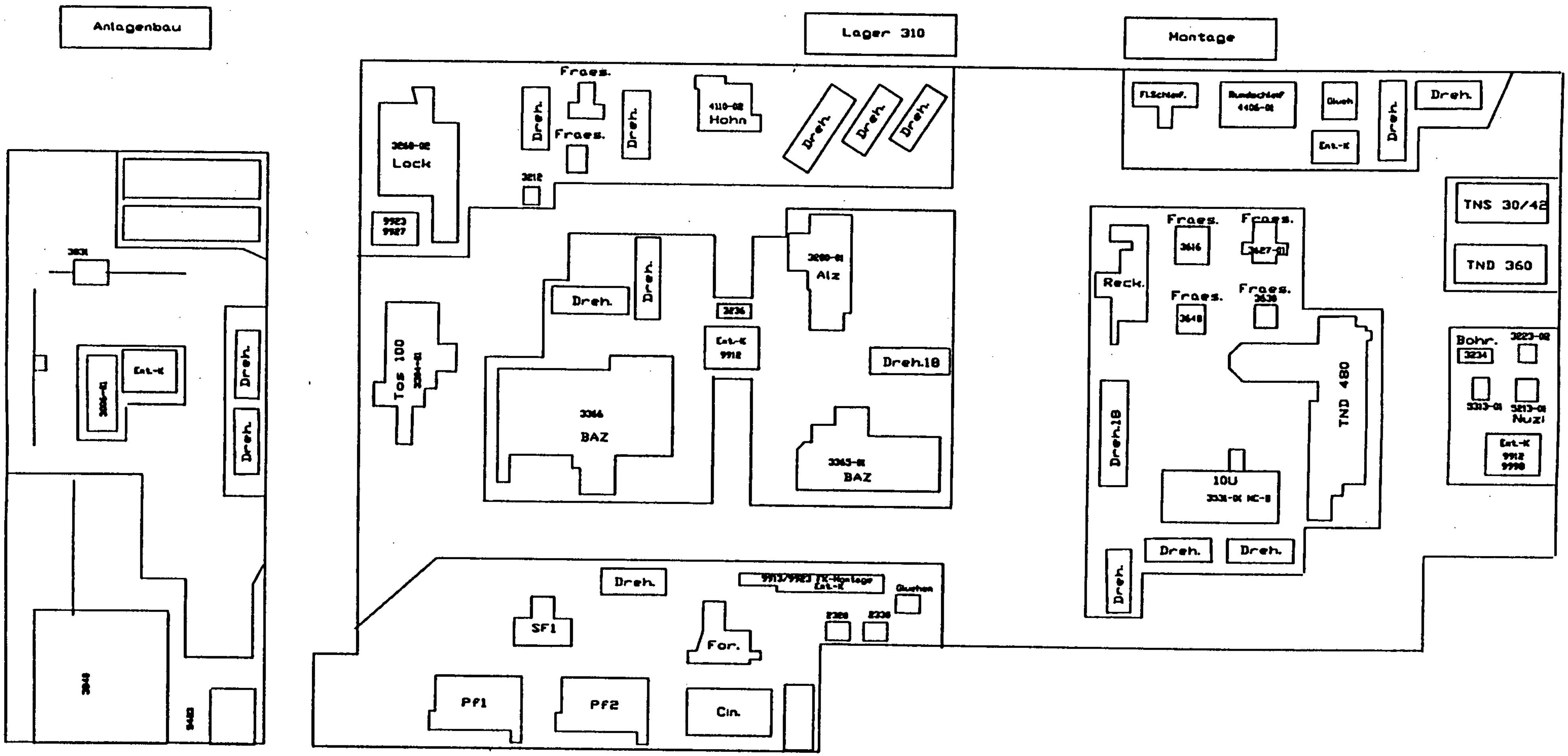
Teilenummer	Stückzahl	Insel 1	Insel 2	Insel 3	Insel 4	Insel 5	Montage	Anlagenbau	Auswärts	Kooperationszahl
111 220 030	2041	3				1			2	3
111 220 050	1911		2	3		1				3
111 220 060	659		3			1			2	3
111 220 291	587		2	3		1				3
114 420 131	262		2	3		1				3
114 420 132	263		2	3		1				3
114 420 170	1347		2	3		1				3
128 000 000	154	2					1 / 3			3
128 100 130	189			2		1			3	3
128 100 150	193			2		1	3			3
128 130 000	30					2		1 / 3		3
128 140 010	372		2	3		1				3
128 200 080	197		2	3		1				3
128 200 140	209		3	2		1				3
128 420 220	193			2		1			3	3
128 420 400	192		2	3		1				3
128 500 130	198		2	3		1				3
128 510 070	538		2	3		1				3
128 510 080	431			2		1	3			3
128 511 000	422		2	3		1				3
128 520 000	181			2		1			3	3
128 600 050	186			2		1	3			3
128 621 020	104		2	3		1				3
822 221 051			2	3		1				3
846 200 020	379		2			1	3			3
128 302 033	250					1	3	2		3
853 420 030	250	2		3			1			3
855 300 061	250		2	3		1				3
855 310 090	250			2		1		3		3
855 310 100	250			2		1		3		3
857 420 020	250		3	2		1				3
SK 3 139 141 000	250					2		1 / 3		3
SK 3 139 151 000	250						2	1	3	3
SK 3 139 161 000	250						2	1	3	3
SK 3 139 171 000	250						2	1	3	3
SK 3 139 180 120	500	2				1			3	3
SK 3 139 190 200	1000		2	3		1				3
SK 3 139 191 050	500			2		1 / 3				3
SK 3 139 240 040	250		2			1 / 3				3
SK 3 139 303 000	250	2				1			3	3
SK 3 139 303 020	250	3	2			1				3
SK 3 139 304 000	250					1	3		2	3
SK 3 139 361 020	250		2			1	3			3
SK 3 139 410 110	250		2			1			3	3
SK 3 139 410 160	500	3	2			1				3
SK 3 139 410 280	250		3	2		1				3
SK 3 139 411 000	250	2				1	3			3
SK 3 139 421 030	250	2						1	3	3
SK 3 139 430 010	250			2		1			3	3
SK 3 139 441 000	250	3					1		2	3
SK 3 139 500 500	250	2					3	1		3
SK 3 139 600 460	250	2	3			1				3
SK 3 139 610 090	250		3	2		1				3
SK 3 139 610 110	500		2	3		1				3
SK 3 139 614 000	250			2		1	3			3
SK 3 139 641 070	250	3		2			1			3
SK 3 139 650 010	250	2	3			1				3
SK 3 139 660 010	250	2	3			1				3
SK 3 139 680 120	250	2					3	1		3
SK 3 139 691 000	250					2		1 / 3		3
SK 3 139 692 000	250					2		1 / 3		3
SK 3 139 750 130	250			2		1			3	3
SK 3 170 830 201	250	2				1			3	3

APPENDIX 8

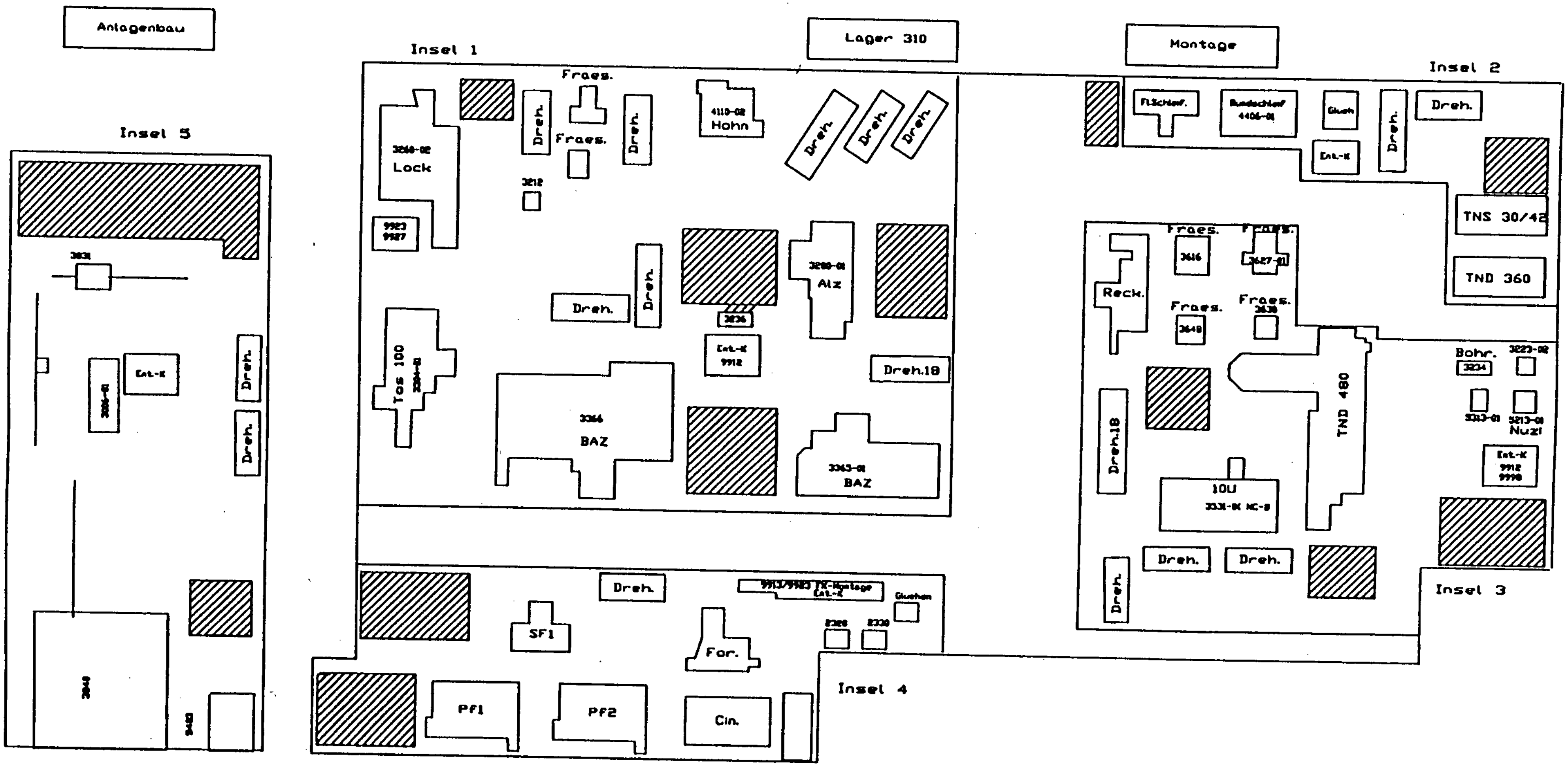
„SHOULD-BE“ LAYOUT: TRANSPORT PATHS, INTERMEDIATE STORAGE POSSIBILITIES AND RESOURCES SHARING CONSIDERATIONS

(KUHLMANN, MAßOW, PEREIRA KLEN AND VÖGE, 1991)

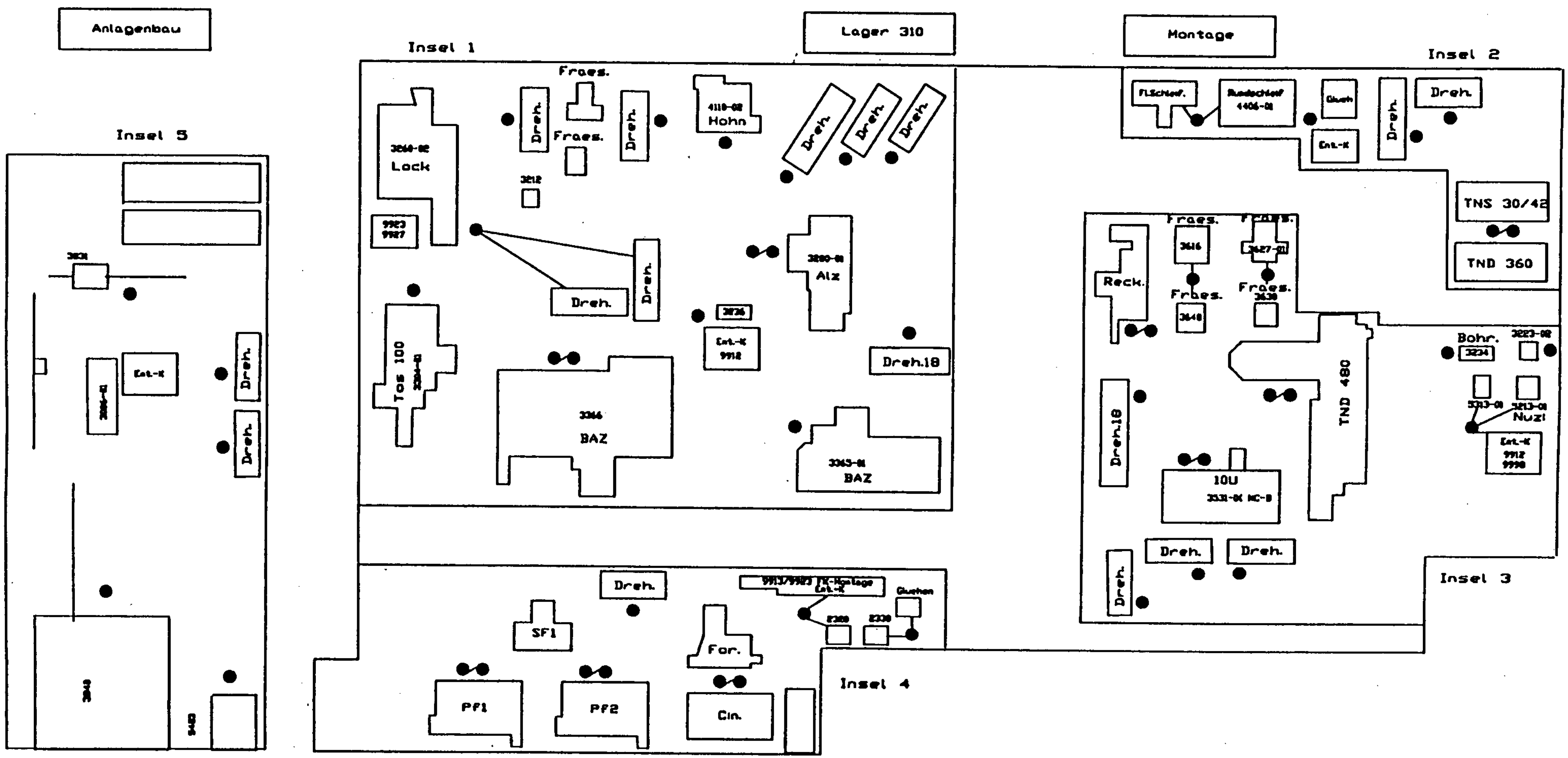
TRANSPORT PATHS



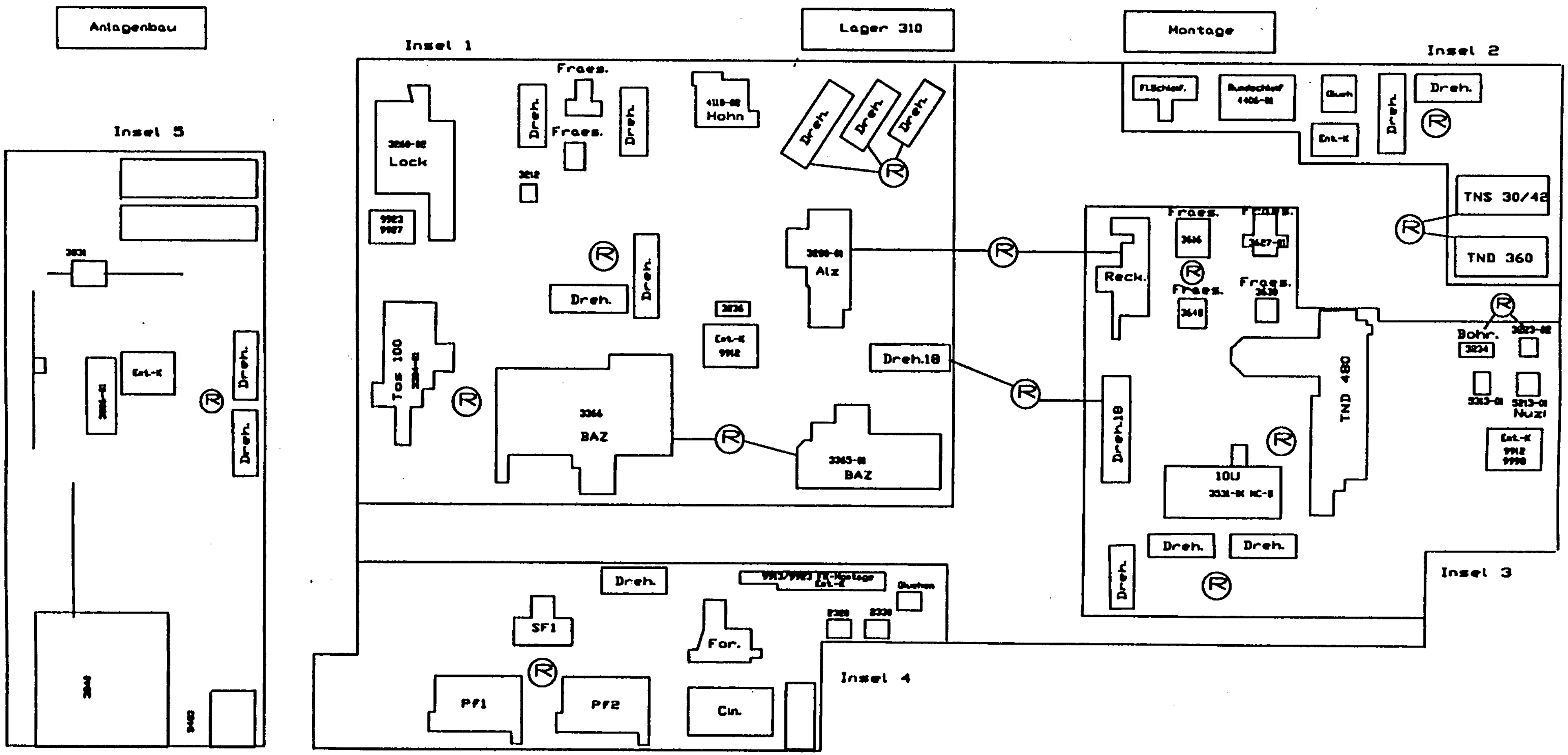
INTERMEDIATE STORAGE POSSIBILITIES



RESOURCE SHARING - WORKERS



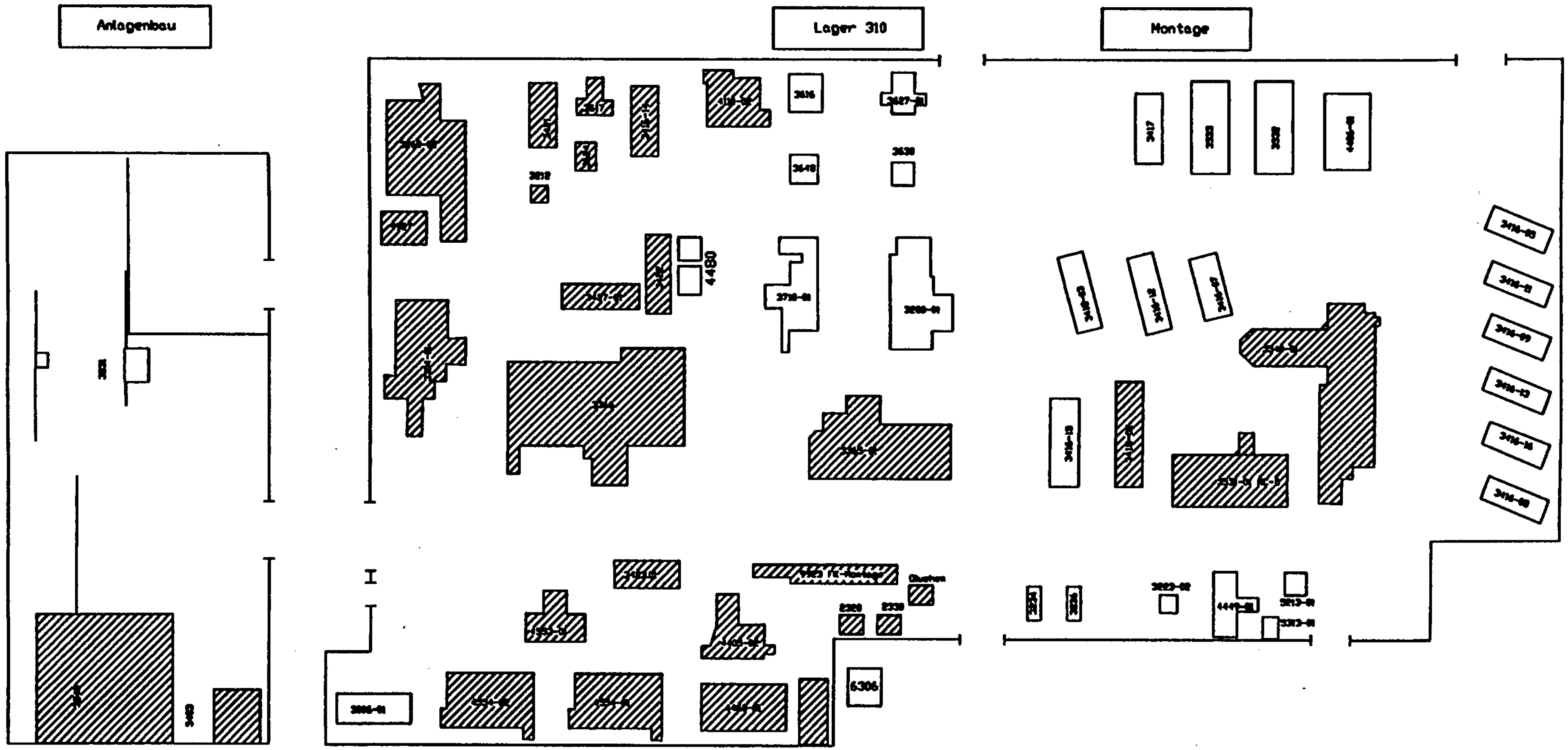
RESOURCE SHARING - EQUIPMENT



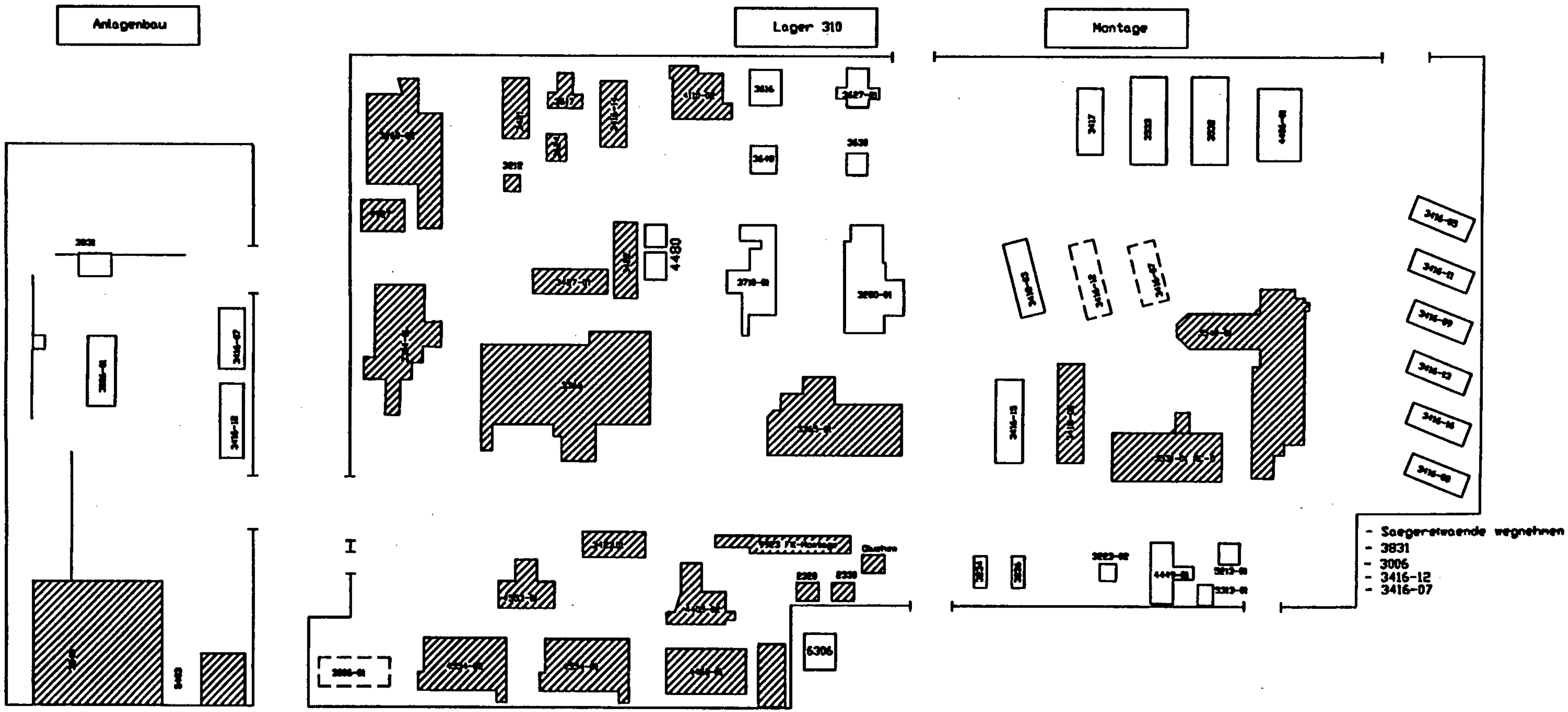
APPENDIX 9

SEQUENCE OF SHOP FLOOR LAYOUT MODIFICATIONS (STUDY BY THE AUTHOR)

ORIGINAL LAYOUT

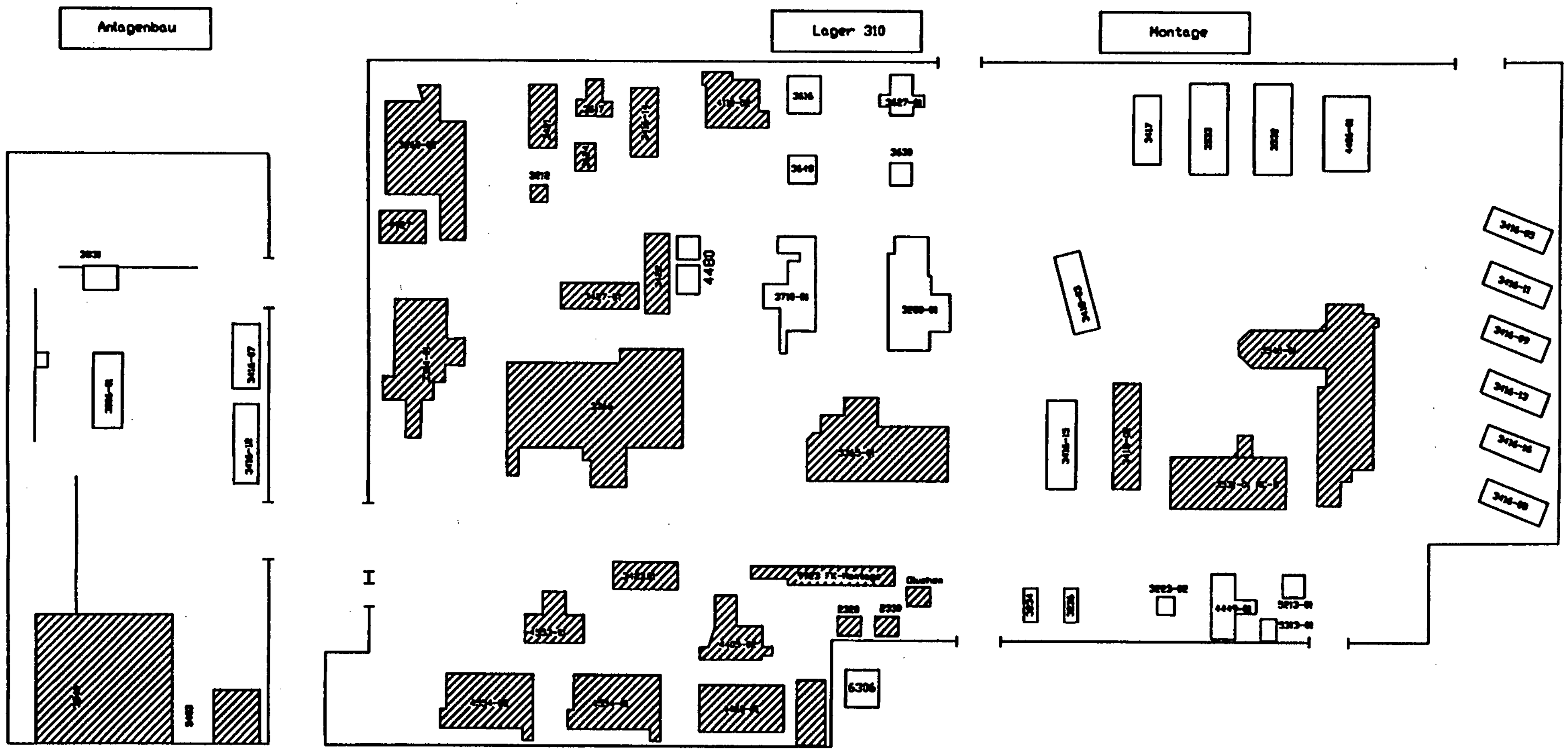


STEP 1

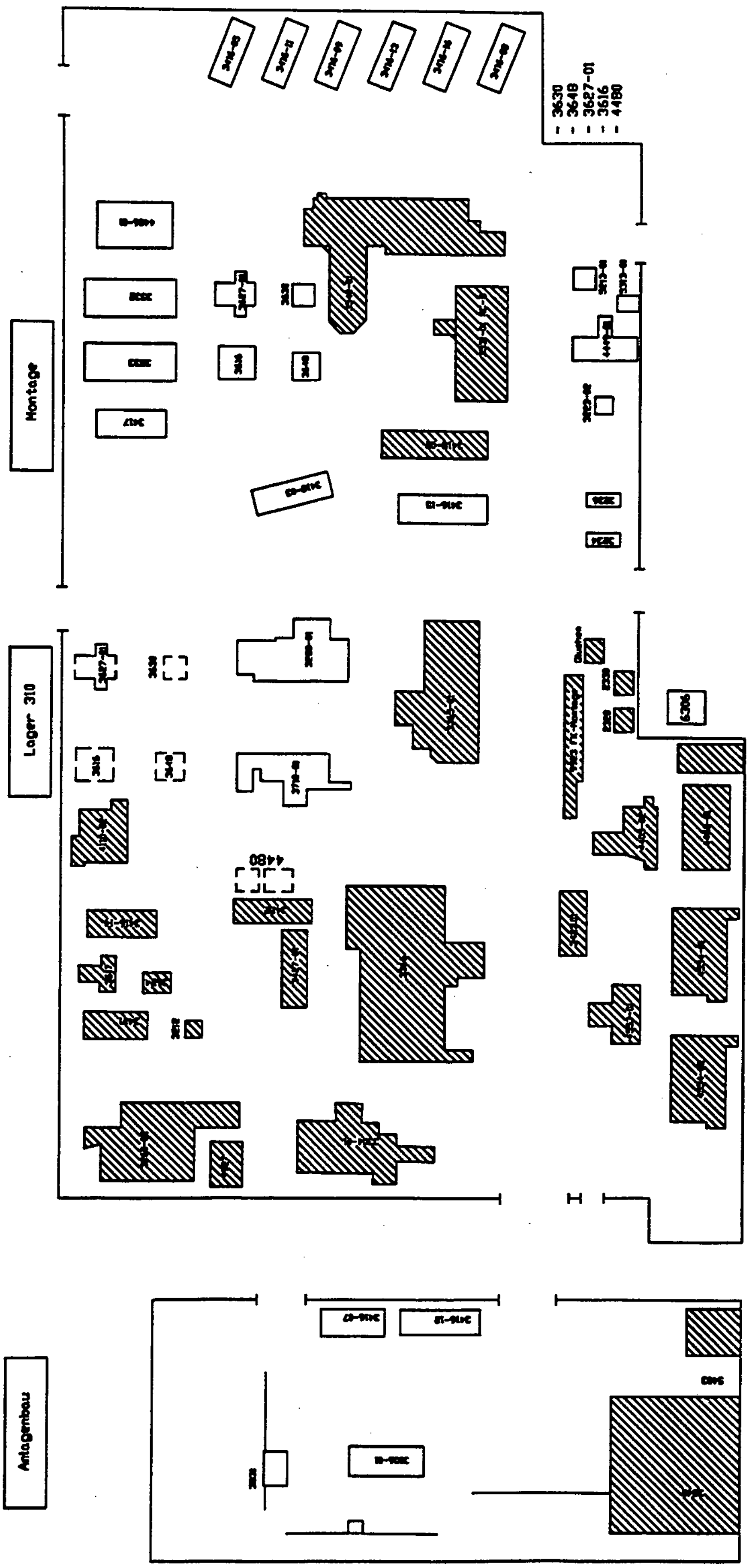


Anlagenbau
Lager 310
Montage
4480
6306
- Saegerelwaende wegnehmen
- 3831
- 3006
- 3416-12
- 3416-07

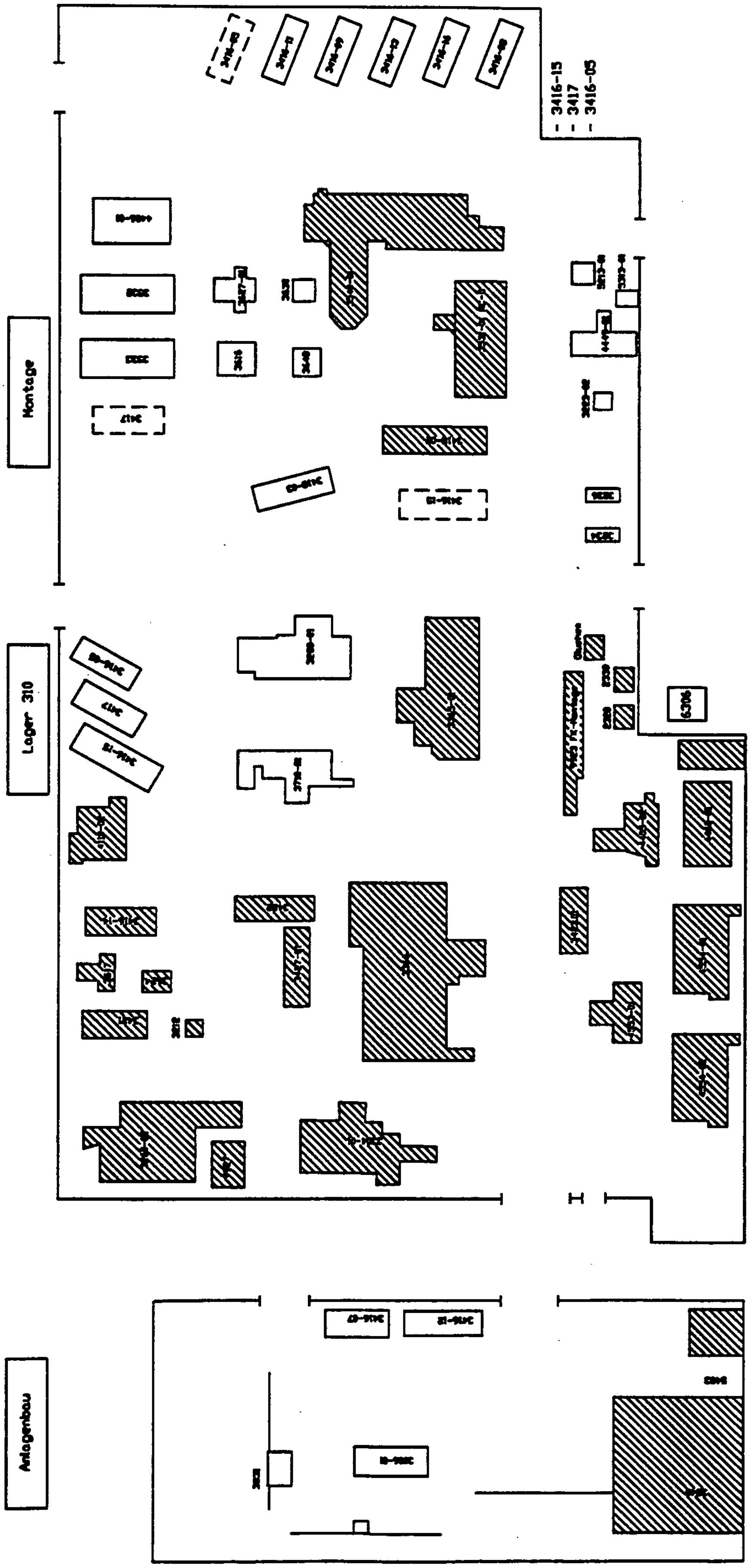
INTERMEDIATE RESULT



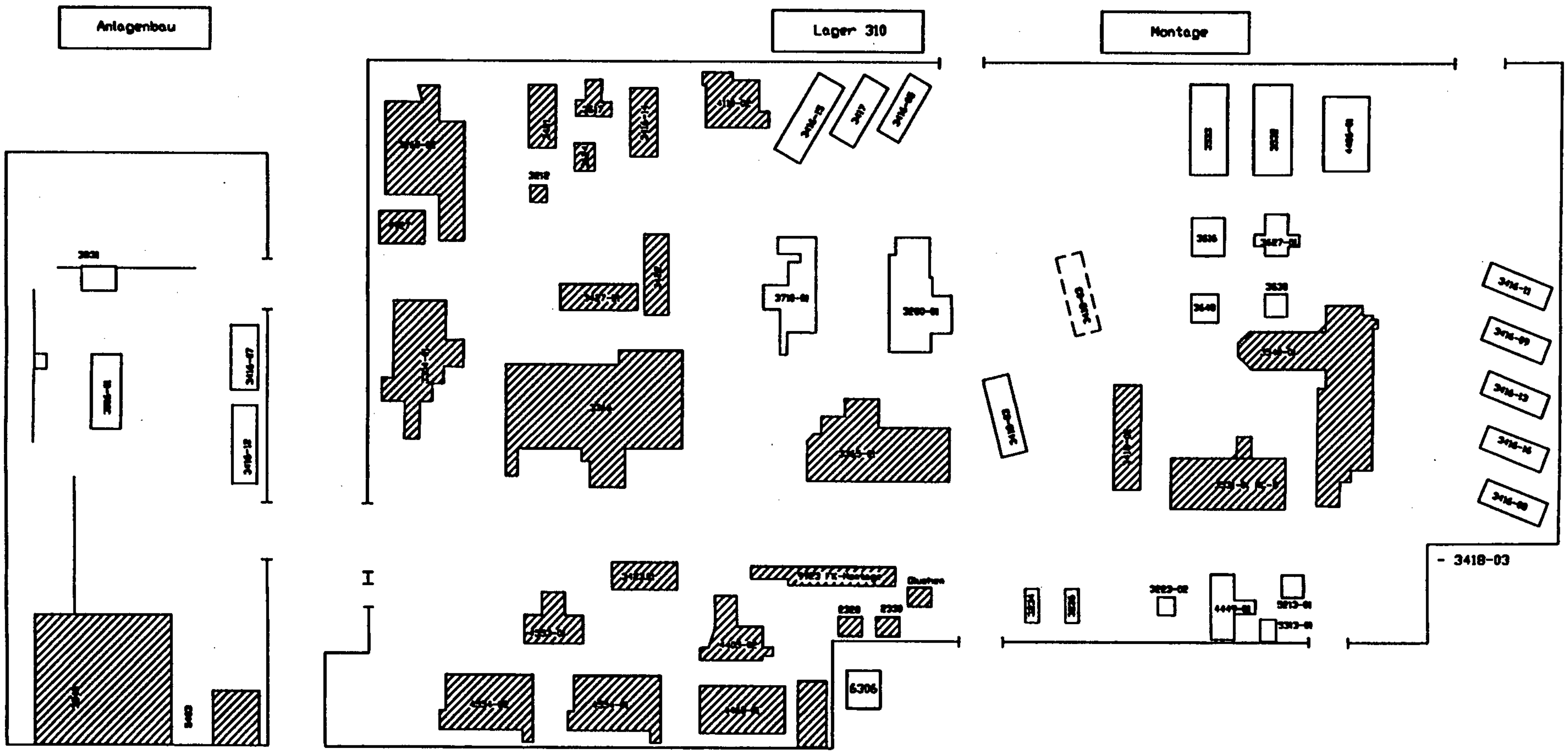
STEP 2


Montage
Lager 310
Anlagenbau
3630
3648
3627-01
3616
4480
4480

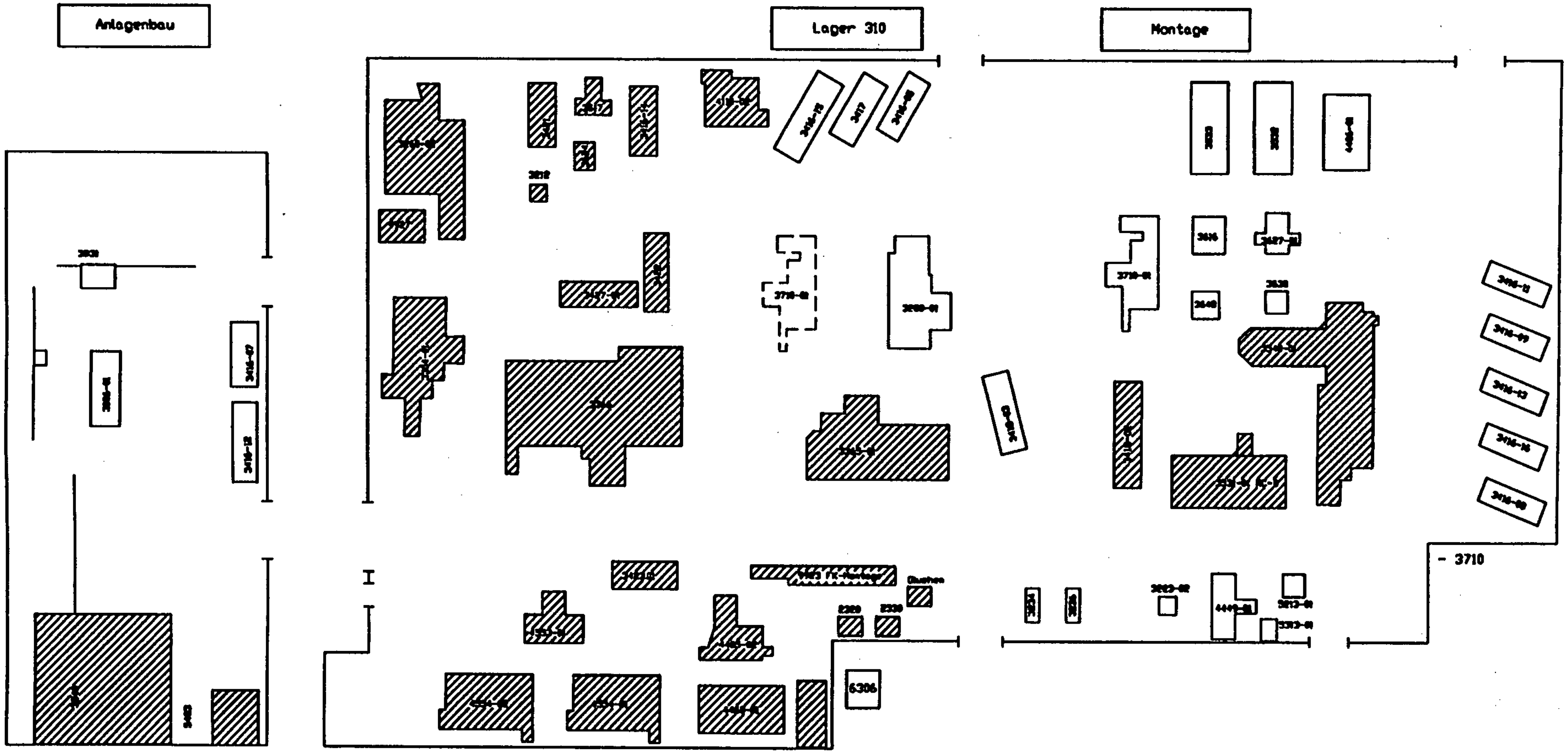
STEP 3



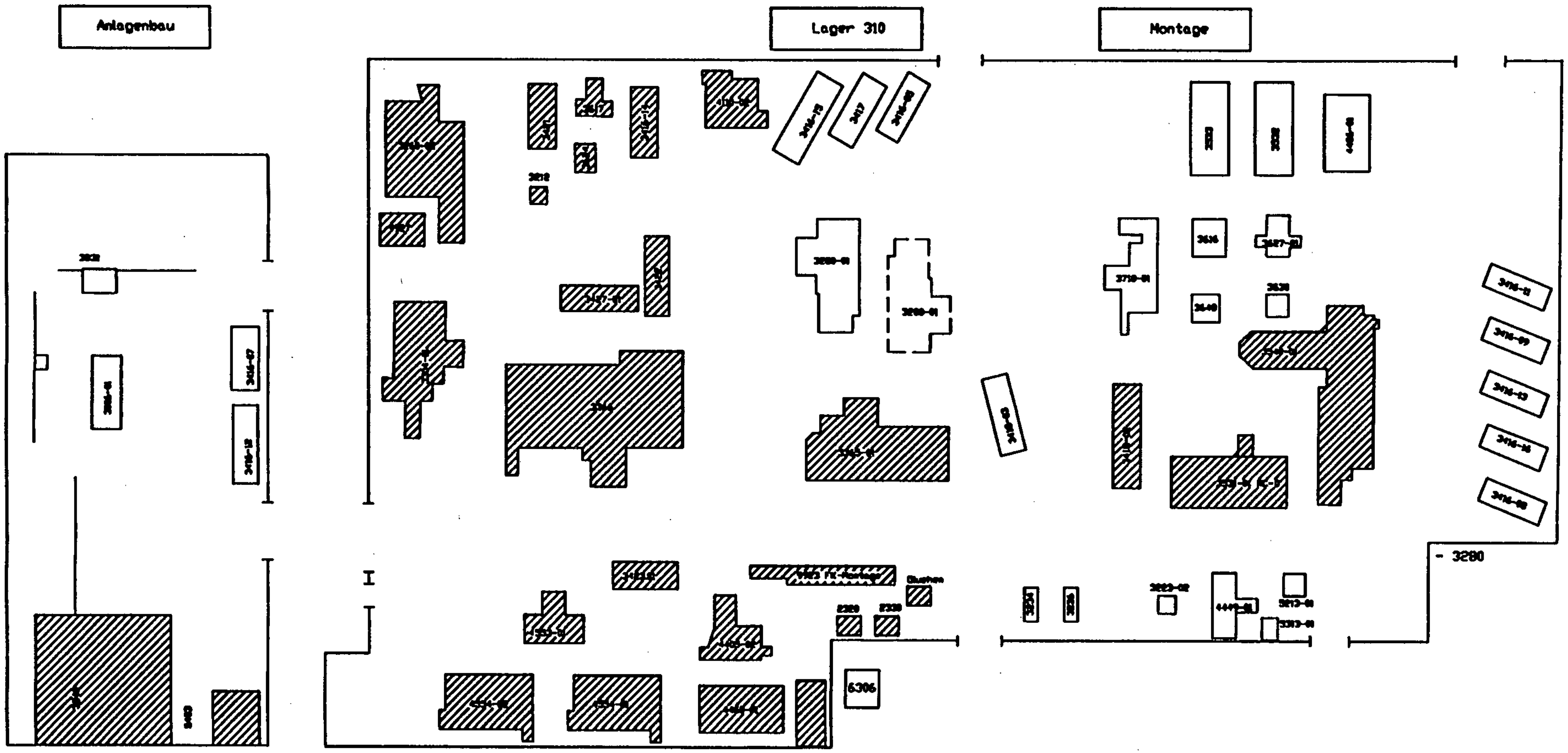
STEP 3.1



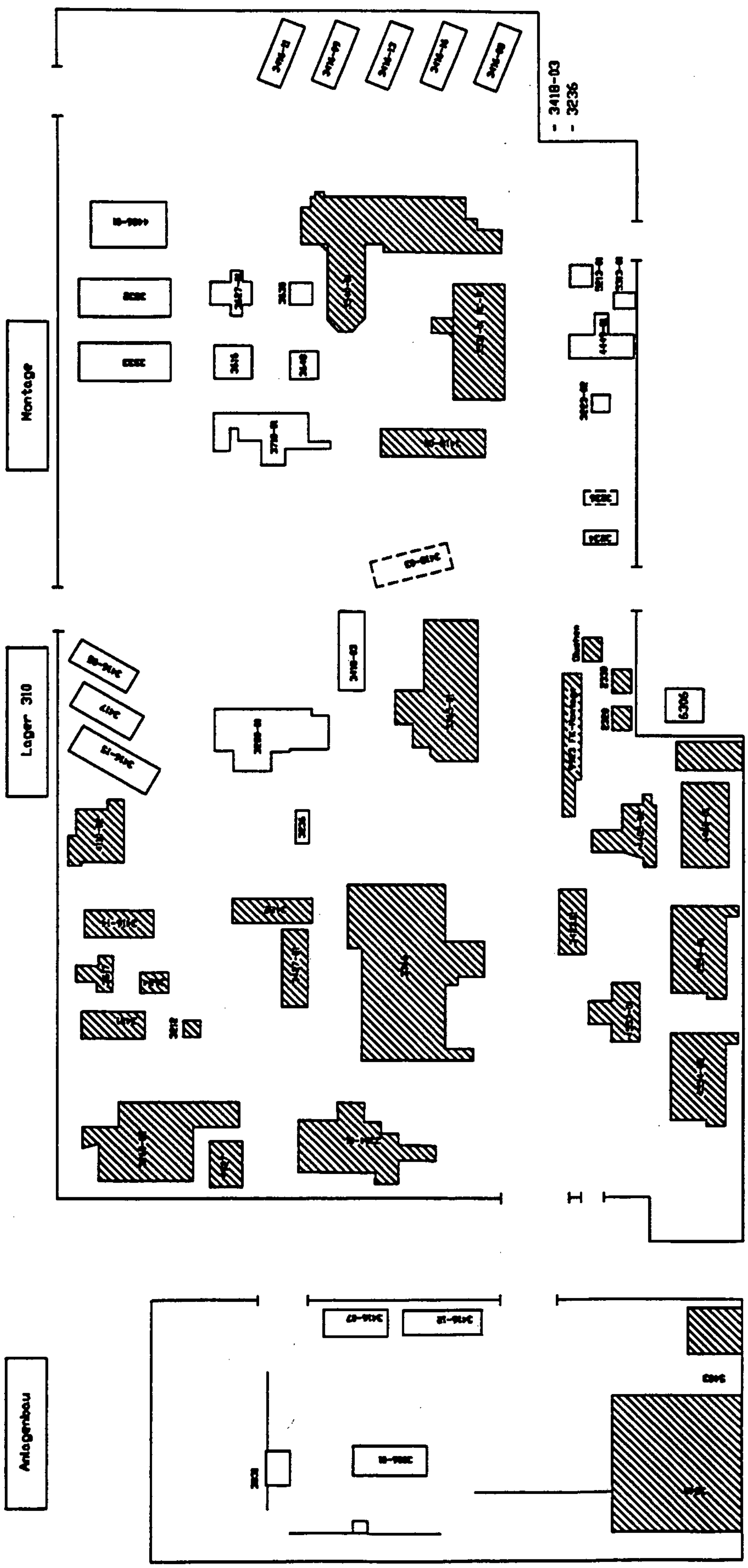
STEP 3.2



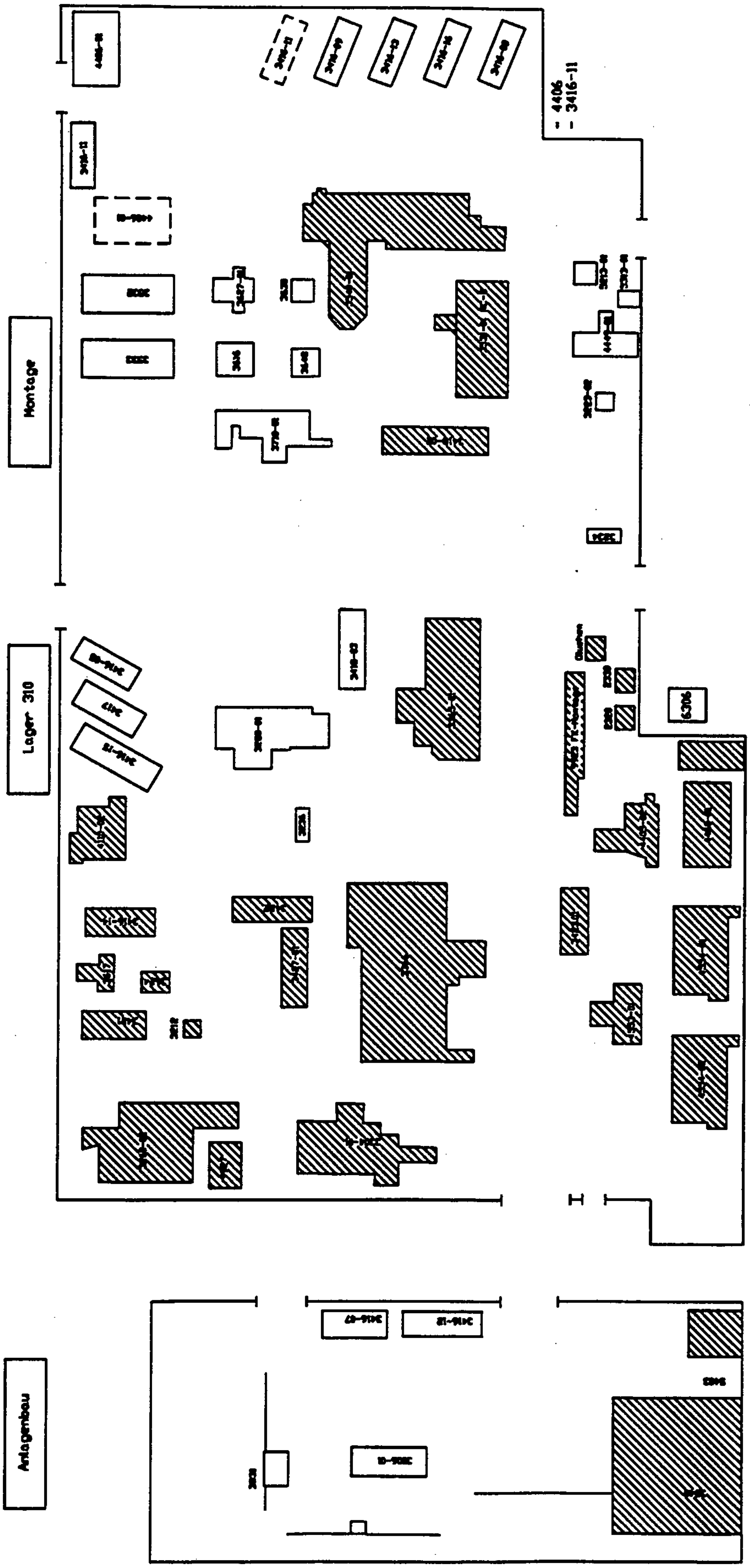
STEP 3.3



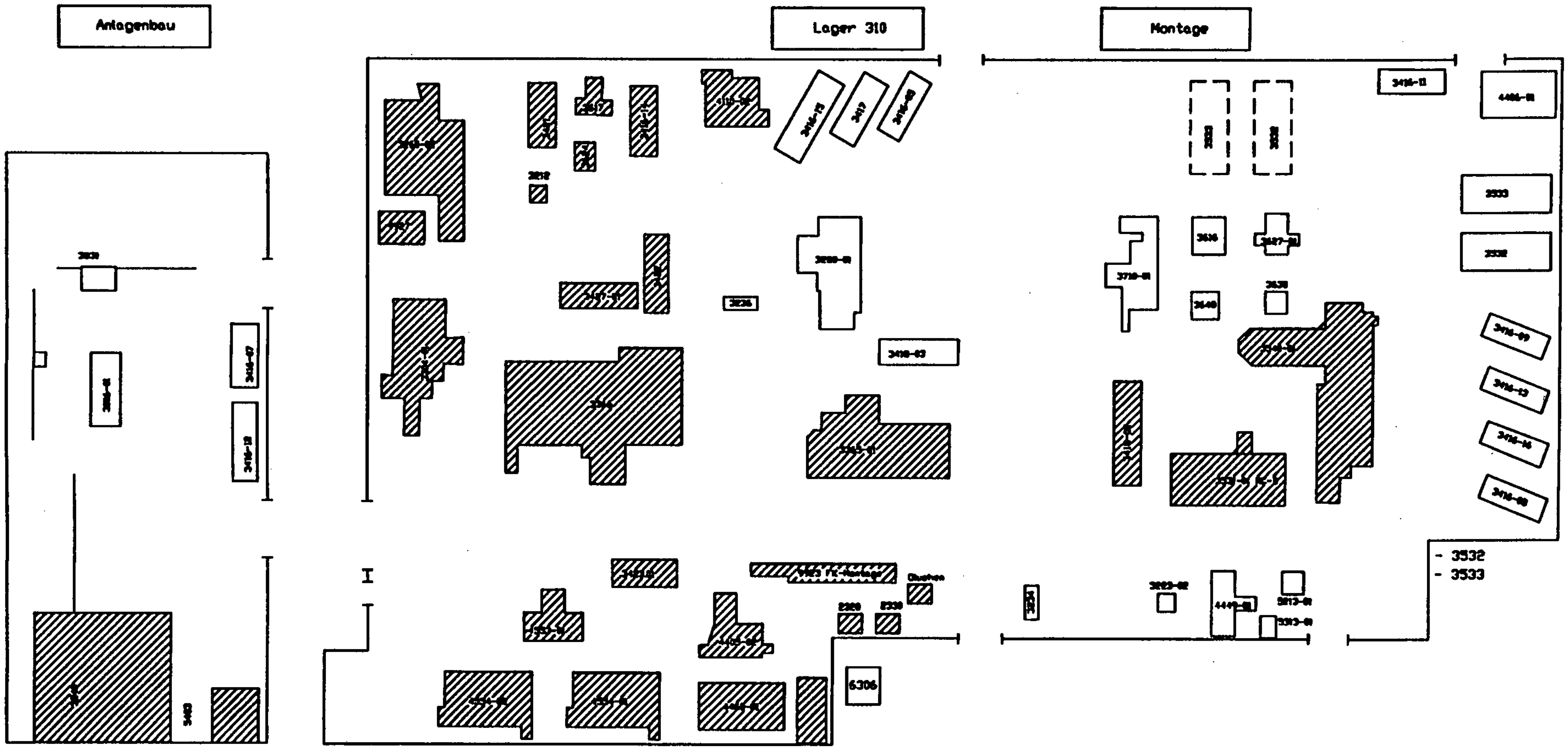
STEP 3.4



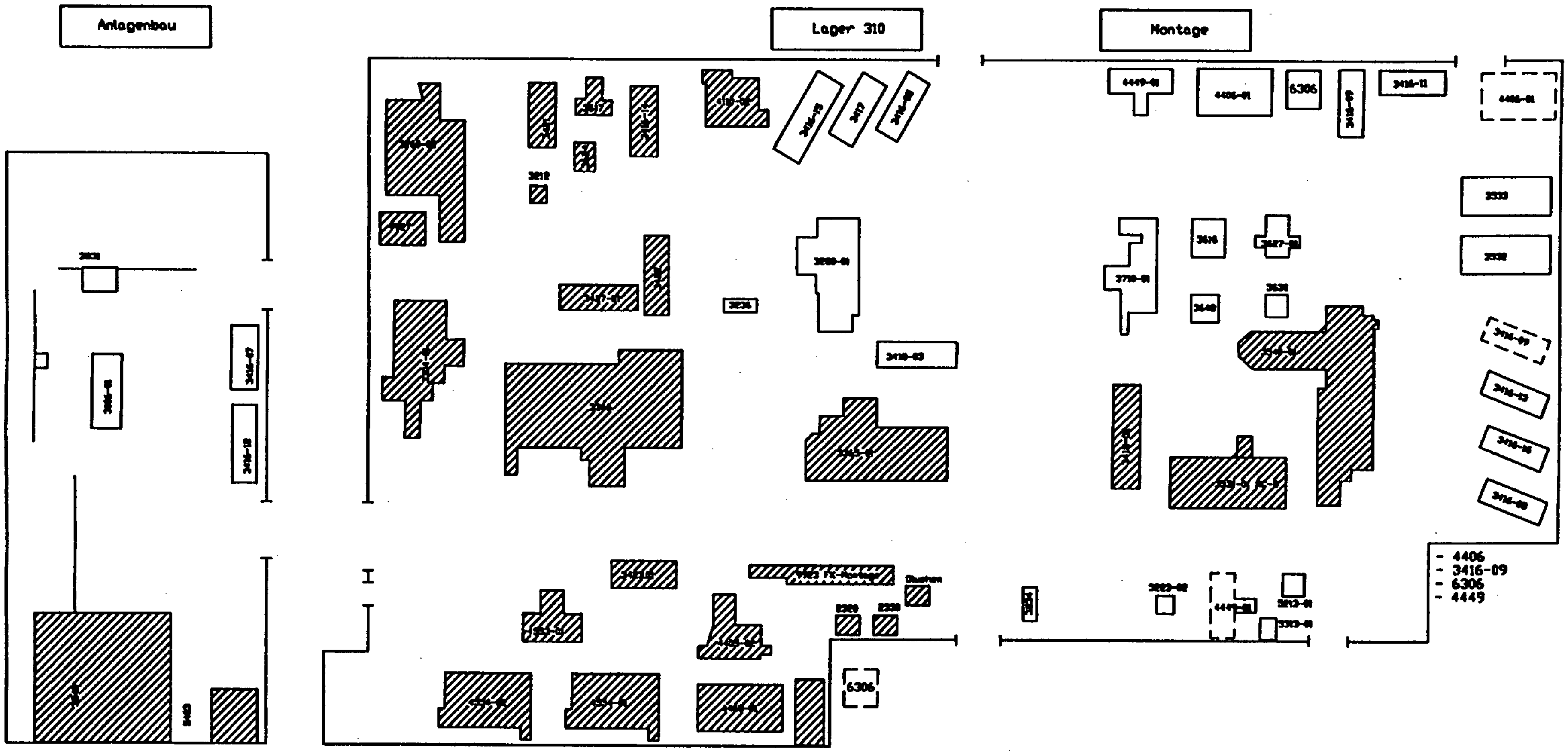
STEP 4



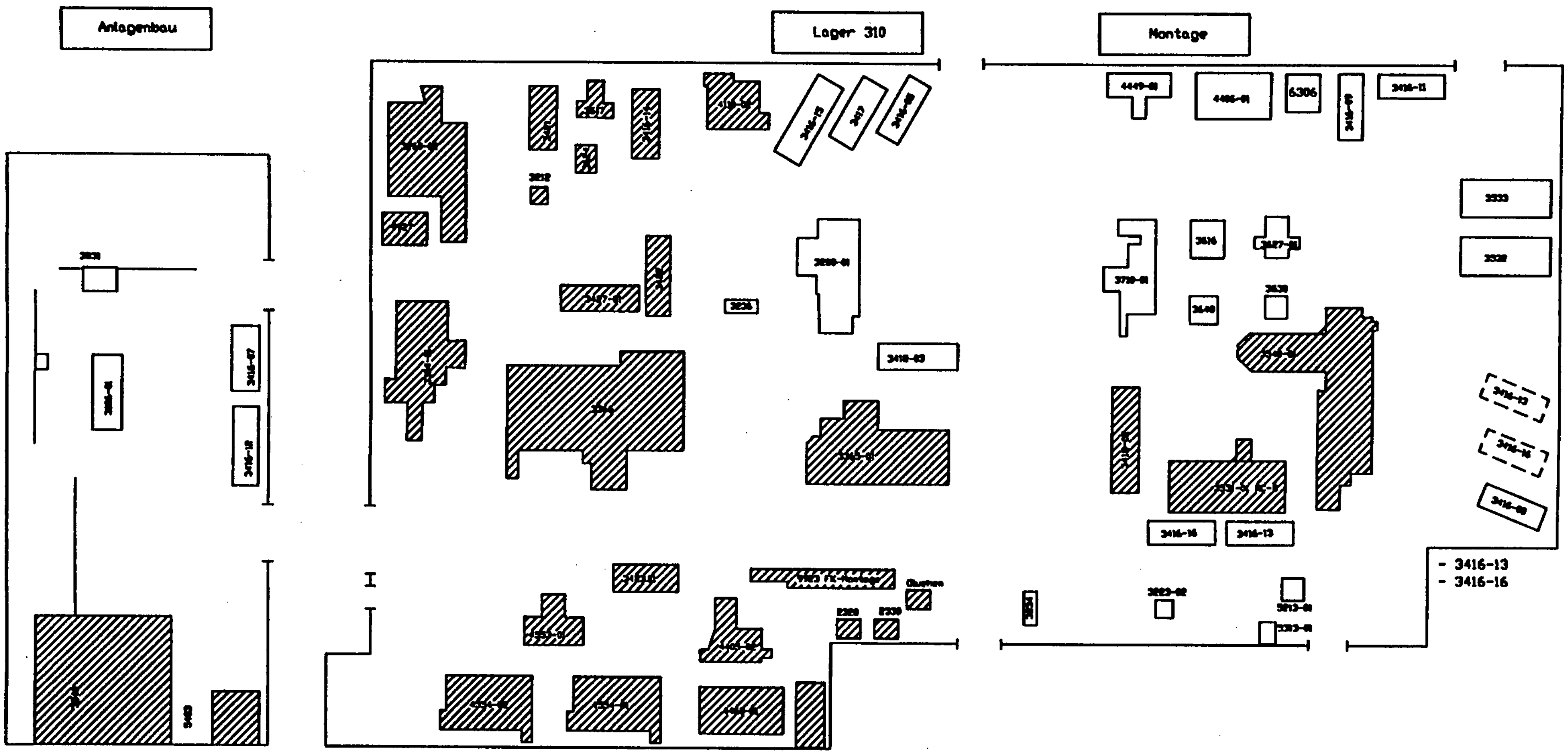
STEP 4.1



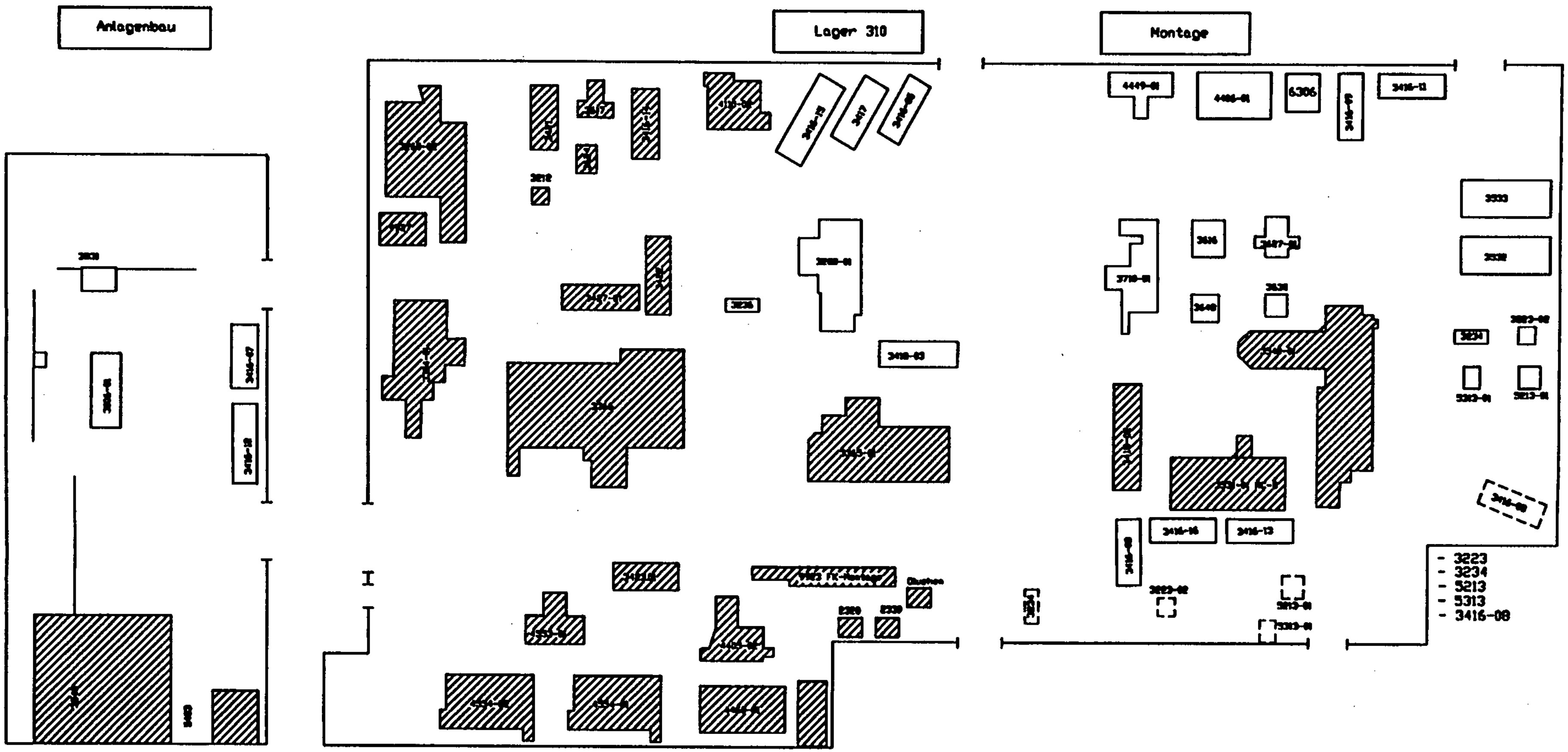
STEP 4.2


Anlagenbau
Lager 310
Montage
6306
6306
- 4406
- 3416-09
- 6306
- 4449

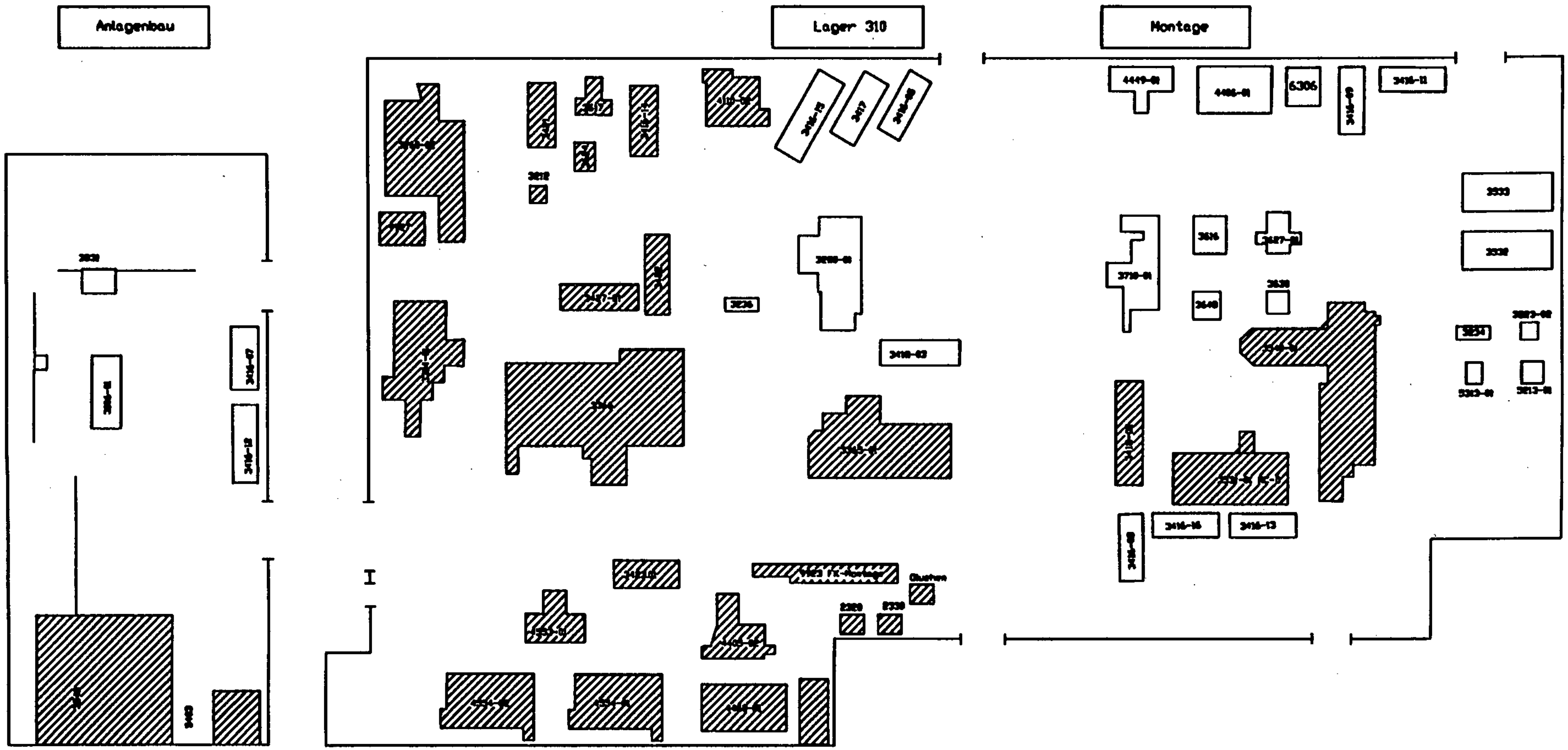
STEP 5


Anlagenbau
Lager 310
Montage
6306
3416-13
3416-16
3416-13
3416-16

STEP 5.1


Anlagenbau
Lager 310
Montage
6306
- 3223
- 3234
- 5213
- 5313
- 3416-08

SHOULD-BE LAYOUT



Maschinentyp	Gewicht (kg)	Bodenaufnahme	Lasthaken	Abmessungen (mm)
3006 Ablängen				
3223 Bohrmaschine				
3234 Bohrmaschine	3360			3500X2500X2900
3236 Bohrmaschine				
3280 Bohrwerk				
3416-12 konventionelle Dreh.				
3416-07 konventionelle Dreh.				
3416-15 konventionelle Dreh.				
3416-05 konventionelle Dreh.				
3416-11 konventionelle Dreh.				
3416-09 konventionelle Dreh.				
3416-13 konventionelle Dreh.				
3416-16 konventionelle Dreh.				
3416-08 konventionelle Dreh.				
3417 Drehmaschine				
3418-03 Drehmaschine				
3532 CNC Drehmaschine	3500			3270X2005X1800
3533 CNC Drehmaschine				
3616 Fräsmaschine				
3627 Fräsmaschine	2500			1900X1900X1740
3630 Fräsmaschine	1200			850X650X1900
3648 Fräsmaschine				
3710 Bohrwerk				
3831 Säge				
4406 Schleifmaschine	4100			4450X1900X2000
4449 Schleifmaschine				
4480 Schleifmaschine				
5213 Nutenziehmaschine				
5313 Nutenziehmaschine				
6306 Glühofen				

APPENDIX 10

SHOP FLOOR MONITORING AND CONTROL SYSTEMS ANALYSIS

(BULLINGER AND HIRSCH, 1994, P. 73-84)

The pre-selection of the systems available in the German market in 1992 led to nine SMC systems, which were analysed regarding not only their functionalities but also the software conception, the possibilities of implementation, the innovation aspects and the development perspectives.

Resource Organization	Order Processing Input Data	Detailed Planning of Orders	Controlling of Orders	Monitoring and Evaluation of Orders	Management of Orders	Material Management	Statistical Control and Evaluation
Number of resources to be managed ◒	Order-specific information ●	Automatic/ event oriented/ interactive ◒	Order the manufacture ●	Order specific information ●	Feedback (PPC/ data collector) ●	Availability control ◍	Statistical programs interface ◐
Kind of management: - status - availability - reservation ◒	Capacity specific information ●	Strategy for the sequence formation ◐	Print of job papers ◒	Manufacturing specific information ◒	Order specific data ●	Order specific reservation ◐	Evaluation of data amount ◐
Control/ provision/ transport ◐	Date information ●	Methods event-oriented (forward/ backward) ●	Control of order progress ●	Resource-specific information ◐	Neutral order data (standard data) ●	Inventory accounting ○	Arrangement and checking of units ○
Determination of resource bottleneck ○	Arrangement and modification of orders ●	Reversion of interactive allocations ◐	Rescheduling; unexpected events management ●	Evaluation of alternative allocations ○	Working papers (bill of material, process plan) ◒	Transport control ○	Analysis under specific questions ○

● Complete ◒ Extensive ◐ Partial ◍ In preparation ○ Not done

Table 1. AHP-Leitstand

Resource Organization	Order Processing Input Data	Detailed Planning of Orders	Controlling of Orders	Monitoring and Evaluation of Orders	Management of Orders	Material Management	Statistical Control and Evaluation
Number of resources to be managed ●	Order-specific information ◒	Automatic/ event oriented/ interactive ●	Order the manufacture ◒	Order specific information ●	Feedback (PPC/ data collector) ◒	Availability control ◒	Statistical programs interface ◐
Kind of management: - status - availability - reservation ●	Capacity specific information ●	Strategy for the sequence formation ◐	Print of job papers ○	Manufacturing specific information ●	Order specific data ◒	Order specific reservation ◒	Evaluation of data amount ◐
Control/ provision/ transport ◒	Date information ●	Methods event-oriented (forward/ backward) ●	Control of order progress ●	Resource-specific information ●	Neutral order data (standard data) ●	Inventory accounting ◐	Arrangement and checking of units ◍
Determination of resource bottleneck ●	Arrangement and modification of orders ◐	Reversion of interactive allocations ○	Rescheduling; unexpected events management ◒	Evaluation of alternative allocations ○	Working papers (bill of material, process plan) ◐	Transport control ○	Analysis under specific questions ◍

● Complete ◒ Extensive ◐ Partial ◍ In preparation ○ Not done

Table 2. AMS-Leitstand

Resource Organization	Order Processing Input Data	Detailed Planning of Orders	Controlling of Orders	Monitoring and Evaluation of Orders	Management of Orders	Material Management	Statistical Control and Evaluation
Number of resources to be managed ●	Order-specific information ●	Automatic/ event oriented/ interactive ◒	Order the manufacture ●	Order specific information ●	Feedback (PPC/ data collector) ◒	Availa-bility control ●	Statistical programs interface ◔
Kind of management: - status - availability - reservation ●	Capacity specific information ●	Strategy for the sequence formation ●	Print of job papers ◒	Manufac-turing specific information ◒	Order specific data ●	Order specific reservation ●	Evaluation of data amount ◒
Control/ provision/ transport ◒	Date information ●	Methods event-oriented (forward/ backward) ●	Control of order progress ●	Resource-specific information ●	Neutral order data (standard data) ◒	Inventory accounting ●	Arrange-ment and checking of units ◒
Determi-nation of resource bottleneck ●	Arrange-ment and modification of orders ◒	Reversion of interactive allocations ◒	Resche-duling; unexpected events management ●	Evaluation of alternative allocations ○	Working papers (bill of material, process plan) ◒	Transport control ◔	Analysis under specific questions ◒

● Complete ◒ Extensive ◔ Partial ◍ In preparation ○ Not done

Table 3. Factory-Tower-Leitstand

Resource Organization	Order Processing Input Data	Detailed Planning of Orders	Controlling of Orders	Monitoring and Evaluation of Orders	Management of Orders	Material Management	Statistical Control and Evaluation
Number of resources to be managed ◔	Order-specific information ◒	Automatic/ event oriented/ interactive ◒	Order the manufacture ●	Order specific information ●	Feedback (PPC/ data collector) ◒	Availa-bility control ◔	Statistical programs interface ◔
Kind of management: - status - availability - reservation ◔	Capacity specific information ●	Strategy for the sequence formation ●	Print of job papers ●	Manufac-turing specific information ◒	Order specific data ◒	Order specific reservation ◍	Evaluation of data amount ●
Control/ provision/ transport ◔	Date information ◒	Methods event-oriented (forward/ backward) ●	Control of order progress ●	Resource-specific information ◔	Neutral order data (standard data) ●	Inventory accounting ◍	Arrange-ment and checking of units ●
Determi-nation of resource bottleneck ◒	Arrange-ment and modification of orders ◔	Reversion of interactive allocations ●	Resche-duling; unexpected events management ◒	Evaluation of alternative allocations ○	Working papers (bill of material, process plan) ◒	Transport control ○	Analysis under specific questions ●

● Complete ◒ Extensive ◔ Partial ◍ In preparation ○ Not done

Table 4. FI-2-Leitstand

Resource Organization	Order Processing Input Data	Detailed Planning of Orders	Controlling of Orders	Monitoring and Evaluation of Orders	Management of Orders	Material Management	Statistical Control and Evaluation
Number of resources to be managed (Partial)	Order-specific information (Complete)	Automatic/ event oriented/ interactive (Extensive)	Order the manufacture (Partial)	Order specific information (Complete)	Feedback (PPC/ data collector) (Extensive)	Availa-bility control (Not done)	Statistical programs interface (Complete)
Kind of management: - status - availability - reservation (Not done)	Capacity specific information (Complete)	Strategy for the sequence formation (Partial)	Print of job papers (Not done)	Manufac-turing specific information (Extensive)	Order specific data (Complete)	Order specific reservation (Not done)	Evaluation of data amount (Extensive)
Control/ provision/ transport (Not done)	Date information (Complete)	Methods event-oriented (forward/ backward) (Complete)	Control of order progress (Extensive)	Resource-specific information (Complete)	Neutral order data (standard data) (Complete)	Inventory accounting (Not done)	Arrange-ment and checking of units (Extensive)
Determi-nation of resource bottleneck (Partial)	Arrange-ment and modification of orders (Extensive)	Reversion of interactive allocations (Not done)	Resche-duling; unexpected events management (Partial)	Evaluation of alternative allocations (Extensive)	Working papers (bill of material, process plan) (Extensive)	Transport control (Not done)	Analysis under specific questions (Complete)

● Complete ◓ Extensive ◐ Partial ◎ In preparation ○ Not done

Table 5. PIUSS-O-Leitstand

Resource Organization	Order Processing Input Data	Detailed Planning of Orders	Controlling of Orders	Monitoring and Evaluation of Orders	Management of Orders	Material Management	Statistical Control and Evaluation
Number of resources to be managed (Extensive)	Order-specific information (Complete)	Automatic/ event oriented/ interactive (Extensive)	Order the manufacture (Complete)	Order specific information (Complete)	Feedback (PPC/ data collector) (Complete)	Availa-bility control (Complete)	Statistical programs interface (Extensive)
Kind of management: - status - availability - reservation (Extensive)	Capacity specific information (Complete)	Strategy for the sequence formation (Complete)	Print of job papers (Complete)	Manufac-turing specific information (Complete)	Order specific data (Complete)	Order specific reservation (Complete)	Evaluation of data amount (Extensive)
Control/ provision/ transport (Extensive)	Date information (Complete)	Methods event-oriented (forward/ backward) (Complete)	Control of order progress (Complete)	Resource-specific information (Extensive)	Neutral order data (standard data) (Complete)	Inventory accounting (Complete)	Arrange-ment and checking of units (Extensive)
Determi-nation of resource bottleneck (Extensive)	Arrange-ment and modification of orders (Complete)	Reversion of interactive allocations (Extensive)	Resche-duling; unexpected events management (Complete)	Evaluation of alternative allocations (Not done)	Working papers (bill of material, process plan) (Complete)	Transport control (Not done)	Analysis under specific questions (Extensive)

● Complete ◓ Extensive ◐ Partial ◎ In preparation ○ Not done

Table 6. DASS-Leitstand

Resource Organization	Order Processing Input Data	Detailed Planning of Orders	Controlling of Orders	Monitoring and Evaluation of Orders	Management of Orders	Material Management	Statistical Control and Evaluation
Number of resources to be managed (Partial)	Order-specific information (Complete)	Automatic/ event oriented/ interactive (Extensive)	Order the manufacture (Complete)	Order specific information (Complete)	Feedback (PPC/ data collector) (Complete)	Availability control (In preparation)	Statistical programs interface (Partial)
Kind of management: - status - availability - reservation (In preparation)	Capacity specific information (Complete)	Strategy for the sequence formation (Complete)	Print of job papers (Extensive)	Manufacturing specific information (Complete)	Order specific data (Complete)	Order specific reservation (In preparation)	Evaluation of data amount (Partial)
Control/ provision/ transport (Partial)	Date information (Complete)	Methods event-oriented (forward/ backward) (Complete)	Control of order progress (Complete)	Resource-specific information (Extensive)	Neutral order data (standard data) (Partial)	Inventory accounting (In preparation)	Arrangement and checking of units (Partial)
Determination of resource bottleneck (Extensive)	Arrangement and modification of orders (Extensive)	Reversion of interactive allocations (Partial)	Rescheduling; unexpected events management (Extensive)	Evaluation of alternative allocations (Partial)	Working papers (bill of material, process plan) (Partial)	Transport control (Not done)	Analysis under specific questions (Not done)

● Complete ◒ Extensive ◐ Partial ◌ In preparation ○ Not done

Table 7. STRATO-Leitstand

Resource Organization	Order Processing Input Data	Detailed Planning of Orders	Controlling of Orders	Monitoring and Evaluation of Orders	Management of Orders	Material Management	Statistical Control and Evaluation
Number of resources to be managed (Partial)	Order-specific information (Complete)	Automatic/ event oriented/ interactive (Extensive)	Order the manufacture (Complete)	Order specific information (Complete)	Feedback (PPC/ data collector) (Complete)	Availability control (Partial)	Statistical programs interface (Extensive)
Kind of management: - status - availability - reservation (Partial)	Capacity specific information (Complete)	Strategy for the sequence formation (Partial)	Print of job papers (Complete)	Manufacturing specific information (Complete)	Order specific data (Complete)	Order specific reservation (Partial)	Evaluation of data amount (Extensive)
Control/ provision/ transport (Partial)	Date information (Complete)	Methods event-oriented (forward/ backward) (Extensive)	Control of order progress (Extensive)	Resource-specific information (Complete)	Neutral order data (standard data) (Complete)	Inventory accounting (Partial)	Arrangement and checking of units (Not done)
Determination of resource bottleneck (Extensive)	Arrangement and modification of orders (Complete)	Reversion of interactive allocations (Extensive)	Rescheduling; unexpected events management (Extensive)	Evaluation of alternative allocations (Partial)	Working papers (bill of material, process plan) (Complete)	Transport control (Not done)	Analysis under specific questions (Not done)

● Complete ◒ Extensive ◐ Partial ◌ In preparation ○ Not done

Table 8. PRO/LS-Leitstand

Resource Organization	Order Processing Input Data	Detailed Planning of Orders	Controlling of Orders	Monitoring and Evaluation of Orders	Management of Orders	Material Management	Statistical Control and Evaluation
Number of resources to be managed ●	Order-specific information ●	Automatic/ event oriented/ interactive ◓	Order the manufacture ●	Order specific information ●	Feedback (PPC/ data collector) ●	Availa-bility control ●	Statistical programs interface ◓
Kind of management: - status - availability - reservation ◓	Capacity specific information ●	Strategy for the sequence formation ●	Print of job papers ●	Manufac-turing specific information ●	Order specific data ●	Order specific reservation ●	Evaluation of data amount ◓
Control/ provision/ transport ◓	Date information ●	Methods event-oriented (forward/ backward) ●	Control of order progress ●	Resource-specific information ◓	Neutral order data (standard data) ●	Inventory accounting ●	Arrange-ment and checking of units ◓
Determi-nation of resource bottleneck ●	Arrange-ment and modification of orders ●	Reversion of interactive allocations ●	Resche-duling; unexpected events management ●	Evaluation of alternative allocations ●	Working papers (bill of material, process plan) ●	Transport control ○	Analysis under specific questions ◓

● Complete ◓ Extensive ◔ Partial ◌ In preparation ○ Not done

Table 9. OPS-Leitstand

APPENDIX 11

EVALUATION MATRIX (BULLINGER AND HIRSCH, 1994, P. 86)

As an outline of the 'future-users' involvement, an evaluation matrix was developed based on their own experiences in testing three SMC systems at the CIM Application Laboratory at BIBA.

Information evaluation of:	Manual planning chart	1. SMC-System	3. SMC-System	2. SMC-System
Checkup of resource availability	○	○	◔	◐
Communication with PPC level	○	◕	◕	●
Planning of urgent orders	○	●	◔	●
Process plan modification	○	◕	◔	●
Planning of orders	◐	◕	◕	◕
Simulation of order sequence	◔	◔	◕	◕
Evaluation and selection of alternative simulation strategies	○	○	◕	○
Distribution and allocation of orders	◔	●	●	●
Rescheduling order sequence	◔	◕	◔	◕
Reaction of unexpected events	◔	◐	◐	◕
Control of order progress	◐	◕	◕	◕
Feedback from the shop floor	◔	◕	◕	◕
Standard data modifications	○	●	◕	●
Checkup of material availability	○	○	◔	○
Evaluation of shop floor status	○	◐	◕	◐

Not done ○ Good ◕
Insufficient ◔ Complete ●
Partial ◐

BIBLIOGRAPHIC REFERENCES

AHLERS, R.; LUTZ-KUNISCH, B. et al. *The DIMUN Project - Experiences with Multimedia Communication in "One-of-a-kind" Manufacturing.* In: Proceedings of the International Working Conference on New Approaches Towards 'One-of-a-Kind' Production, Germany, 1991.

ALTER, S.L. *Decision Support and Expert Systems: Current Practice and Continuing Challenges.* Addison-Wesley, 1980.

ARGYRIS, C. *Single-Loop and Double Loop in Research Decision Making.* Administrative Science Quarterly, September 1976.

____. *Double Loop Learning in Organizations.* Harvard Business Review, September-October 1977.

____. *Overcoming Organizational Defenses.* Allyn and Bacon, 1990.

____. *Teaching Smart People How to Learn.* Harvard Business Review, May-June, 1991.

____. *On Organizational Learning.* Blackwell, 1993.

____. *Good Communication that Blocks Learning.* Harvard Business Review, July-August, 1994.

ARGYRIS, C; SCHON, D.A. *Theory in Practice - Increasing Professional Effectiveness.* Jossey-Bass Publishers, 1974.

____. *Organizational Learning: A Theory of Action Perspective.* Addison-Wesley Publishing Company, 1978.

ARVINDH, B.; IRANI, S.A. *Cell Formation: the need for an integrated solution of the subproblems.* In: Int. J. Prod. Res., V.32, N.5, P.1197-1218, 1994.

BABBAGE, C. *On the Economy of Machinery and Manufactures.* 4. edition, New York, 1963.

BARTELS, R. *Partizipation als Voraussetzung für die partizipative CIM-Einführung.* In: Krallmann & Scholz-Reiter (Hrsg.), Partizipative CIM-Einführung - Einsatz von Planungsgruppen zur Gestaltung einer CIM-Struktur, R.Oldenbourg Verlag München, Wien, 1993.

BECK, M. *Learning Organizations - How to create them.* Industrial & Commercial Training, 21 n°3, Spring, 1992.

BEIER, H.H. *Die Entwicklung der Leitstände.* In: Fertigungsleittechnik, Carl Hanser Verlag, München, Wien 1991.

BOONSTRA, F.K.; VAN LANGEN, P.H.G. *Dynamic Project Scheduling in a 'One-of-a-Kind' Production Environment.* In: ROCOCO - Real Time and Control of Construction Site Manufacturing, Results and Achievements - Final Public Project Report, 1992.

BOUGON, M.G. *Congregate Cognitive Map: A Unified Dynamic Theory of Organization and Strategy.* Journal of Management Studies, 29:3 May, 1992.

BOWERS, D. *Systems of Organization.* Ann Arbor: University of Michigan Press, 1976.

BRENNAN, L. *The Formation of Structures, Roles and Interactions within Agile Manufacturing Systems.* In: Advances in Agile Manufacturing - Integrating Technology, Organization and People, IOS Press, 1994.

BUCHELE, Robert. *The Management of Business and Public Organizations.* McGraw-Hill Book Company, 1977.

BULLINGER, H.-J.; HIRSCH, B.E. *Leitstände für die Werkstattsteuerung (Erfahrungen, Konzepte und Realisierungsbeispiele).* Forschungsberichtsreihe „Arbeit und Technik“, Bonn, 1994.

BULLINGER, H.-J. *Personalentwicklung und -qualifikation.* Springer-Verlag, Verlag TÜV Rheinlan, 1992.

BURBIDGE, J.L. *Group Technology (GT): Where do we go from here?* In: Proceedings of the IFIP TC5/WG5.7 Fifth International Conference on Advances in Production Management Systems, Athens, Greece, 1993.

BURGOYNE, J. *Creating a Learning Organization.* RSA Journal, 1992.

CALDWELL, B.J.; CARTER, M.A. *The return of the mentor: Strategies for workplace learning.* The Falmer Press, 1993.

CAMARINHA-MATOS, L.M.; AFSARMANESH, H. *Balanced Automation Systems - Architectures and Design Methods.* In: Introduction - Towards Balanced Automation. Proceedings of the IEEE/ECLA/IFIP International conference on architectures and design methods for balanced automation systems, Chapman & Hall, Brazil, 1995.

CHANDLER JR., A.D.; DALMS, H. *Managerial Hierarchies: Comparative Perspectives on the Rise of the Modern Industrial Enterprise.* 198?

CHEN, C.-Y.; IRANI, S.A. *Cluster first-sequence last heuristics for generating block diagonal forms for a machine-part matrix.* In: Int. J. Prod. Res., V.31, N.11, P.2623-2647, 1993.

COLLINGRIDGE, D. *The Management of Scale.* Routledge, London and New York, 1992.

COPLEY, F.B. *Frederic W. Taylor: Father of Scientific Management.* Vol.I, P.5, New York: Harper & Brothers, 1923.

CROM, S.; PEREIRA KLEN, A.A. et al. *Management Challenges in Globally Distributed Production Environments: Necessities and Strategies for Reorienting Production Management Methods.* Reflections of a study group (Steve Crom, Bernd Hamacher, Marita Sinnigen, Alexandra Pereira Klen, Bernd Hirsch), unpublished, Intern BIBA paper (draft), March 7, 1994.

CYERT, R.M.; MARCH, J. *A Behavioural Theory of the Firm.* Blackwell, Second Edition 1992 (first edition 1963).

DAFT, R.L.; WEICK, K.E. *Toward a Model of Organizations as Interpretation Systems.* Academy of Management Review, Vol.2, 1984.

DEAL, T.E.; KENNEDY, A.A. *Corporate Culture.* Reading, Mass.: Addison-Wesley, 1982.

DEEP, S. *Human Relations in Management.* Collier Macmillan Publishers, London, 1978.

DESSLER, G. *Organization and Management - A Contingency Approach.* Prentice-Hall, Inc, 1976.

DIXON, N.M. *A Theoretical Framework for Organizational Learning.* Unpublished, 1993 (to be published in Organizational Learning (Working Title) McGraw-Hill).

____. *The Organizational Learning Cycle: How we can learn collectively.* McGraw-Hill, 1994.

DOUMEINGTS, G.; DUCQ, Y.; CLAVE, F.; MALHENE, N. *From CIM to Global Manufacturing.* In: Proceedings of CAPE'95 - Computer Applications in Production Engineering, Chapman & Hall, 1995.

DROLET, J.; MONTREUIL, B.; MOODIE, C. *Decision Architecture for Scheduling Virtual Cellular Manufacturing Systems.* IFAC-CIRP-IFIP-IFORS - International Workshop on Decisional Structures in Automated Manufacturing, Genova, Italy, September, 1989.

DUNCAN, R.; WEISS, A. *Organizational Learning: Implications for Organizational Design.* In: Barry M. Staw, Research in Organizational Behaviour, AiJAI Press INC, Vol. 1, 1979.

DUTTON, H. *Princípios de Organização - aplicado às atividades industriais e comerciais.* Editora Atlas S.A., fifth edition, 1965.

DYER, W. *Team Building: Issues and Alternatives.* Addison-Wesley, 1977.

EDEN, C. *On the Nature of Cognitive Maps.* Journal of Management Studies, 29:3 May, 1992.

ESPRIT Project 1217 (1199). *Human-Centred CIM Systems.* Concluding Report, March 1990.

ESSER, M.; PEREIRA KLEN, A.A.; VÖGE, M. *Ist Ablaufdarstellungen & Schwachstellenanalyse.* Unpublished Intern Project Report (Meurer Firm), April, 1992a.

____. *Sollkonzept zur Unternehmensorganisation.* Unpublished Intern Project Report (Meurer Firm), July, 1992b.

EVERSHEIM, W.; MÜLLER, S.;. HEUSER, T. *"Schlanke" Informationsflüsse schaffen.* VDI-Z 134, Nr.11, November, 1992.

FAYOL, H. *General and Industrial Management.* London, Sir Isaac Pitman and Sons, 1949.

FEIGENBAUM, E.A. *Information Processing and Memory.* In: Donald Norman: Models of Human Memory, New York, Academic Press, 1970.

FERSTL, O.; MANNMEUSEL, T. *Dezentrale Produktionlenkung.* In: Cim Management, P. 26-32, March 1995.

FIOL, C.M.; LYLES, M.A. *Organizational Learning.* Academy of Management Review, October 1985.

FLAMME. *SPRINT RA237 BIS.* Final Report, May 1994.

FREITAS, D.R. *Um Ambiente para Ensaio de Tecnologia de Grupo.* Dissertation (M.Sc.), CPGCC, Porto Alegre, 1992.

FRIEß, P.M.; KÖSTER, U. *Leitlinien für die Integrative Gestaltung von Technik, Organisation und Personal.* Unpublished Intern Report - Projekt Procim, 1995.

GAITHER, N.; FRAZIER, G.V.; WIE, J.C. *From Job-Shops to Manufacturing Cells.* Production and Inventory Management Journal, p.33-37, 1990.

GARRAT, B. *Learning to Lead: Developing your organization and yourself.* Fontana, 1991.

GARVIN, D.A. *Building a Learning Organization.* Harvard Business Review, July-August 1993.

GILLIS, J. *Human Factors Collaborative Research Within Manufacturing, Department of Trade & Industry.* Technology Programmes & Services Division, London, 1994.

GOLDMAN, S.; NAGEL, R.; PREISS, K. *Agile Competitors - Concorrência, Organizações Virtuais e Estratégias para Valorizar o Cliente.* Editora Érica Ltda, 1995.

GOLDRATT, E.M. *Mais que Sorte... Um Processo de Raciocínio.* São Paulo: Educator, 1994

GOLDRATT, E.M.; COX, J. *A Meta - Um Processo de Aprimoramento Contínuo.* São Paulo: Educator, 1993.

GOTTSCHALCH, H. *Mentale Modelle und Gestaltung von Werkstattsteuerungen.* Middle-Term Report of PLANLEIT Project, P.60-87, 1991.

GOULD, Lawrence. *1990s Mentoring is not the same old ego trip.* Managing Automation, April 1993.

GROOVER, M.P. *Automation, Production Systems and Computer Integrated Manufacturing.* Prentice Hall, New Jersey, 1980.

HABICH, M. *Handlungssynchronisation autonomer, dezentraler Dispositionszentren in flexiblen Fertigungsstrukturen - Ein Beitrag zur Integration dezentraler Leitstände in PPS - Systeme.* Dissertation, Bochum 1990.

HALL, D.T.; FUKAMI, C.V. *Organizational Design and Adult Learning.* In: Barry M. Staw, Research in Organizational Behaviour, AiJAI Press INC, Vol.1, 1979.

HAMACHER, B. *Human Resource Management at the Heart of One-of-a-kind Production.* In: Proceedings of the IFIP TC5/WG5.7 Working Conference on New Approaches towards "one-of-a-kind" production, edited by Hirsch, B.E. and Thoben, K.-D., Bremen, Germany, 1991.

HAMACHER, B.; PEREIRA KLEN, A.A.; HIRSCH, B.E. *Production Management Elements for the Learning Enterprise.* In: Proceedings of the IFIP WG5.7 - Working Conference on Evaluation of Production Management Methods, Gramado, Brazil, 1994.

HARHALAKIS, G.; NAGI, R.; PROTH, J.M. *An Efficient Heuristic in Manufacturing Cell Formation For Group Technology Application.* International Journal of Production Research, V.28, P.185-198, 1990.

HARS, A.; SCHEER, A.-W. *Entwicklungstendenzen von Leitständen.* In: Scheer, August Wilhelm (Hrsg.): Fertigungssteuerung - Expertwissen für die Praxis, Oldenbourg Verlag, München 1991.

____. *Stand und Entwicklungstendenzen von Leitständen.* In: Cim Management, March 1993.

HARVEY, R. *Group Technology: Revitalized by Computer Power.* Iron Age, p.61-72, May, 1983.

HEEG, F.J.; MEYER, R.; PEREIRA KLEN, A.A.; SPATZ, H.; VÖGE, M. *Fertigungsleitstände als kompetenzförderndes Werkzeug bei der Arbeit in Fertigungsinseln.* Workshop Leitsysteme für die Fabrik vom Morgen, Paderborn, Germany, March 1994.

HEYEL, C.; MENKUS, B. *Handbook of Management for the Growing Business.* Van Nostrand Reinhold Company, New York, 1986.

HIRSCH, B.E. *CIM in der Unikatfertigung und -montage.* Springer-Verlag, Verlag TÜV Rheinland, 1992.

HIRSCH, B.E.; KUHLMANN T. *Harmonization of Decentralized, Autonomous Production Areas.* Proceedings of IFAC 1992.

HIRSCH, B.E.; KUHLMANN, T.; MASOß, C. *Decentralized and Collaborative Production Management - A Prerequisite for Globally Distributed Manufacturing.* In: Proceedings of CAPE'95 - Computer Applications in Production Engineering, Chapman & Hall, 1995.

HOFF, H.; HAMMER, H.J.; SCHUMANN, P. *HIR Marktstudien, graphische und elektronische Leitstände.* Hoff Industrialisierung GmbH, Wiesbaden 1993.

HUBER, G.P. *Organizational Learning: The Contributing Processes and the Literature.* Organization Science, February 1991.

IRANI, S.A.; CAVALIER, T.M.; COHEN, P.H. *Virtual Manufacturing Cells: exploiting layout design and intercell flows for the machine sharing problem.* In: Int. J. Prod. Res., V.31, N.4, P. 791-810, 1993.

IRANI, S.A.; COHEN, P.H.; CAVALIER, T.M. *Design of Cellular Manufacturing Systems.* In: Transactions of the ASME, V.114, P.352-361, August 1992.

JELINEK, M. *Institutionalizing Innovation: A Study of Organizational Learning Systems.* Praeger Publishers, 1979.

KAST, F.E.; ROSENZWEIG *Organization and Management - a systems approach.* McGraw-Hill Book Company, 1970.

KATZENBACH, J.R.; SMITH, D. *The Discipline of Teams.* Harvard Business Review, March-April 1993a.

____. *The Wisdom of Teams.* Harvard Business School Press, 1993b.

KERN, G.M.; WIE, J.C. *The Cost of Eliminating Exceptional elements in Group Technology Cell Formation.* International Journal of Production Research, V.29, P.1535-1547, 1991.

KIDD, Paul. *Agile Manufacturing: Forging New Frontiers.* Addison-Wesley, 1994a.

____. *Agile Manufacturing: Key Issues.* In: Advances in Agile Manufacturing - Integrating Technology, Organization and People, IOS Press, 1994b.

KIEF, H.B. *NC/CNC Handbuch.* Carl Hanser Verlag München Wien 93/94.

KIM, D.H. *The Link Between Individual and Organizational Learning.* Sloan Management Review, Fall 1993.

KOTSCHENREUTHER, W. *Unterstützung der Störungsbewältigung in der Produktion durch verteilte wissenbasierte Systeme.* Dissertation - Universität Erlangen-Nürnberg, 1991.

KUHLMANN, T.; MASOW, C.; PEREIRA KLEN, A.A; VÖGE, M. *Verbesserung der Termintreue bei verkürzten Lieferzeiten durch Reduzierung der Auftragsdurchlaufzeiten.* Unpublished Intern final report (Vemag Firm), July 1991.

KUMAR, K.R.; VANELLI, A. *Strategic Subcontracting for Efficient Disaggregated Manufacturing.* International Journal of Production Research, V.20, P.117-133, 1987.

KUSIAK, A.; CHOW, W.S. *Efficient Solving of the Group Technology Problem.* Journal of Manufacturing Systems, V.6, P.117-1124, 1987.

LARDNER, J. *Integration and Information in an Automated Factory.* In: AUTOFACT Conference - Society of Manufacturing Engineers, Anaheim, CA, October, 1984.

LEVITT, B.; MARCH, J.G. *Organizational Learning.*American Review of Sociology, Vol. 14, 1988.

LORINI, F.J. *Tecnologia de Grupo e Organização da Manufatura.* Editora da UFSC, Florianópolis, 1993.

LORSCH, J.M.; LAWRENCE, P.R. *Organization and Environment: Managing Differentiation and Integration.* Harvard Uni. 1967.

LUEF, J. *Industrial Information searching (in Danish).* Unpublished Ph.D. Thesis, The Technical University of Denmark, 1990

LUHMANN, N. *Soziale Systeme.* Suhrkamp 1987.

MALONE, Robert. *Editor's Letter.* Managing Automation, January 1993.

____. *Editor's Letter.* Managing Automation, February 1994.

MARCH, J.; SIMON, H. *Organizations.* John Wiley & Sons 1966.

MARCH, J. *Decisions and Organizations.* Blackwell, 1989.

MARCH, J.; LAVE, C.A. *An Introduction to Models in the Social Sciences.* Harper & Row, publishers, 1974.

MARCH, J.; OLSEN, J.P. *Ambiguity and Choice in Organizations.* Universitets forlaget, Bergen 1976.

MARQUARDT, M.; REYNOLDS, A. *The Global Learning Organization: Gaining Competitive Advantage through Continuous Learning.* IRWIN, 1994.

MASON, R.M.; LYNN, L.H. *The Learning Organization in the U.S. and Japan.* Case Western Reserve University Cleveland, Ohio, USA, 1994.

MAßBERG, W. *Fertigungsinsel in CIM-Strukturen.* Springer-Verlag, Verlag TÜV Rheinland, 1992.

MATTHEW, J.L. *Selection and Evaluation of Advanced Manufacturing Technologies.* Springer Verlag Berlin, Heidelberg, 1990.

MAYO, E. *The Social Problems of and Industrial Civilization.* Boston: Graduate School of Business Administration, Harvard University, 1945.

MCAULEY, J. *Machine Grouping for Efficient Production.* Production Engineer, V.51, P.53-57, 1972.

MCGREGOR, D. *The Human Side of Enterprise.* McGraw-Hill, New York, 1960.

MCLEAN, C.R.; BLOOM, H.M.; HOPP, T.H. *The Virtual Manufacturing Cell.* IFAC - Information Control Problems in Manufacturing Technology, Maryland, USA, P.207-215, 1982.

MEREDITH, J.R. *The Strategic Advantages of the Factory of the Future.* California Management Review, V.29, N.3, P.27-41, 1987.

MEREDITH, J.R.; NALLAN, C.S. *Justifications Techniques for Advanced Manufacturing Technologies.* In: International Journal of Production Research, 24, 1034-1057, 1986.

MERTINS, K.; ALBRECHT, R.; EDELER, H. *Manufacturing Philosophy for the New European factory.* In: Proceedings of the IFIP TC5/WG5.7 Fifth International Conference on Advances in Production Management Systems, Athens, Greece, 1993.

MEYER, R.; SPATZ, H.; VÖGE, M. *Unterstützung bei der Konzeption und Realisierung einer autonomen Fertigungsinsel für Gleichstrommotoren.* Unpublished Second Middle-Term Project Report (LDW Firm), September 1994.

MINTZBERG, H. *The Structuring of Organizations: a synthesis of research.* Englewood Cliffs, N.J.: Prentice-Hall, 1979.

MOLIN, J. *Beyond Structure and Rationality.* Akademisk Folag, Copenhagen, 1987.

NAGEL, R.; DOVE, R. *21st Century Manufacturing Enterprise Strategy.* Iacocca Institute Report, Vol. 1, 1991.

NAGI, R.; HARHALAKIS, G.; PROTH, J.M. *Multiple Routings and Capacity Considerations in Group Technology Applications.* International Journal of Production Research, V.28, P.2243-2257, 1990.

NEERGAARD, Claus. *Creating a Learning Organization: A comprehensive framework.* Ph.D. Thesis, Department of Production, Aalborg University, Denmark, October, 1994.

NONAKA, I. *The Knowledge-Creating Company.* Harvard Business Review, November-December, 1991.

____. *A Dynamic Theory of Organization Knowledge Creation.* Organization Science, Vol.5, n° 1, February, 1994.

O'GRADY, P.J.; MENON, U. *A Concise Review of Flexible Manufacturing Systems and FMS Literature.* Computers in Industry 7, P.155-167, 1986.

PEDLER, M.; BURGOYNE, J.; BOYDELL, T. *Applying Self-development in Organizations.* Prentice-Hall, 1988.

____. *The Learning Company: A Strategy for Sustainable Development.* McGraw-Hill, 1991.

PEREIRA KLEN, A.A.; SPATZ, H.; VÖGE, M. *Unterstützung bei der Konzeption und Realisierung einer autonomen Fertigungsinsel für Gleichstrommotoren.* Unpublished First Middle-Term Project Report (LDW Firm), January 1994.

PEREIRA KLEN, A.A.; VÖGE, M. *Konzeption einer Fertigungsinsel mit dezentraler Leitstandunterstützung.* Unpublished Intern Project Report (DMR Firm), 1992.

PEREIRA KLEN, A.A.; VÖGE, M.; HIRSCH, B.E. *Experience with Implementation of a Shop Floor Monitoring and Control System in SMEs.* In: Proceedings of the 2nd International Conference on Computer Integrated Manufacturing, Vol. 2, Singapore, 1993a.

____. *New Approach for the Introduction of a Computer Aided Tool for Shop Floor Monitoring and Control in SMEs.* In: Proceedings of the IFIP TC5/WG5.7 Fifth International Conference on Advances in Production Management Systems, Athens, Greece, 1993b.

____. *European Experiences for Improving Production Efficiency in SMEs.* In: Proceedings of the IFIP WG5.7 - Working Conference on Evaluation of Production Management Methods, Gramado, Brazil, 1994.

PIKE, H. *Integrating the Buyer: Close to the Customer.* Computerworld, Oct 2, Vol. 23 (40), 1989.

QUINN, J.; GOOLD, M. *The Paradox of Strategic Control.* Strategic Management II, 1990.

RABELO, R.; CAMARINHA-MATOS, L.M. *Control and Dynamic Scheduling in Virtual Organization of Production Resources.* In: Proceedings of the IFIP WG5.7 - Working Conference on Evaluation of Production Management Methods, Gramado, Brazil, 1994.

RAJAGOPALAN, R.; BATRA, J.L. *Design of Cellular Production Systems: a graph-theoretic approach.* International Journal of Production Research, V.13, P.567-579, 1975.

RIIS, J. O. *Design of Management Systems: An Analytical Approach.* Akademisk Forlag, 1978.

____. *Gathering of Experience Cross Functionally (in Danish).* Department of Production, University of Aalborg, 1992.

RIIS, J.O.; FRICK, J. *Organizational Learning: A Neglected Dimension of Production Management Systems Design.* In: Proceeding of the APMS 90, Conference in Finland, Edited by Eero Elorante, North Holland, 1991.

RIIS. J.; NEERGAARD, C. *Creating the Learning Company: A New Manufacturing Challenge.* In: Proceedings of CAPE'95 - Computer Applications in Production Engineering, Chapman & Hall, 1995.

SACKMANN, S.A. *Cultural Knowledge in Organizations: Exploring the Collective Mind.* Sage, 1991.

SAVAGE, C.M. *Fifth Generation Management: integrating enterprises through human networking*. Digital Equipment Corporation, 1990.

SCHEEL, J. *Erfolgsfaktor Ablauforganisation - Systematische Gestaltung, Auswahl und Bewertung von Fertigungsleitsystemen.* Verlag Industrielle Organisation Zürich, Verlag TÜV Rheinland, 1990.

SCHEIN, E.H. *Organizational Culture.* American Psychologist, February, 1990.

SCHODERBECK, C.G.; SCHODERBECK, P.P.; KEFALAS, A.G. *Management Systems: Conceptual Considerations.* Plano, Tex.: Business Publications, 1980.

SEABRA LOPES, L.; CAMARINHA-MATOS, L.M. *Planning, Training and Learning in Supervision of Flexible Assembly Systems.* In: Proceedings of the IEEE/ECLA/IFIP International conference on architectures and design methods for balanced automation systems, Chapman & Hall, Brazil, 1995.

SEIFODDINI, H. *Duplication Process in Machine Cells Formation in Group Technology.* IIE Transactions, V.21, P.382-388, 1989.

SENGE, P.M. *The Fifth Discipline.* New York: Doubleday, 1990.

SHONK, J. *Team Based Organizations.* Business One Irwin, 1992.

SILVEIRA, G.J.C. *Uma Metodologia de Implementação da Manufatura Celular.* Dissertation (M.Sc.), UFRS, 1994.

SIMPSON, J.A.; HOCKEN, R.J.; ALBUS, J.S. *The Automated Manufacturing Research Facility of the National Bureau of Standards.* Journal of Manufacturing Systems, V.1(1), P.17-32, 1982.

SINGH, B.; REIN, G. *Role Interaction Nets (RINs): A Process Description Formalism.* MCC Technical Report, 1992.

SMITH, Adam. *An Inquiry into the Nature and Causes of the Wealth of Nations.* Penguin Classics, London, 1776.

SMMETT. *Technical and Organizational Spin-offs for SMEs from Flexible Machining Systems - A Vehicle to Develop a Technology Transfer Network for Mechanical Industry.* Final Report, 1991.

STATA, R. *Organizational Learning - The Key to Management Innovation.* Sloan Management Review, Spring 1989.

STEPHANOU, S.E.; SPIEGL, F. *The Manufacturing Challenge - From Concept to Production.* Competitive Manufacturing Series, New York, Van Nostrand Reinhold, 1992.

STRAUSS, G.; SAYLES, L.R. *Personnel - The Human Problems of Management.* Prentice-Hall International, Second edition, 1967.

SUNDARAN, R.M. *Cellular Manufacturing - Some Design Considerations.* In: Radharaman, R. (Ed.), Robotics and Factories of the Future'87, Springer Verlag, New York, 1987.

TAYLOR, F.W. *Principles of Scientific Management.* New York, Harper & Brothers, p. 128, 1911.

TÖNSHOFF, H.K.; GLÖCKNER, M. *Logische Fertigungsinseln - Ein alternatives Konzept für Einzel- und Kleinserienfertiger.* ZwF Zeitschriftt 89 (12), Carl Hanser Verlag, München, 1994.

TREWATHA, R.L.; NEWPORT, M.G. *Management.* Plano, Tex.: Business Publications, third edition, 1982.

TURBAN, E. *Decision Support and Expert Systems: Management Support Systems.* MacMillan, second edition, 1990.

VANDENBOSCH, B. *Executive Support Systems Impact viewed from a learning perspective.* Copenhagen University, 1994.

VIOLA, R.H. *Organizations in an Changing Society: Administration and Human Values.* Philadelphia: W.B. Saunders, 1977.

VÖGE, Markus. *Entwicklung und Erprobung einer partizipativen Vorgehenweise zur Einführung von rechnerunterstützten Werkzeugen für die Fertigung und Montage.* Dissertation, Bremen, 1995.

VOGT, J.; MURRELL, K. *Enpowerment in Organizations.* University Associates, 1990.

WALLACE, T.; DOUGHERTY. J.R. *APICS Dictionary.* 7th Edition, 1992.

WALSH, J.P.; UNGSON, G.R. *Organizational Memory.* Academy of Management Review, Vol.16, N.1, 1991.

WARNECKE, H.-J. *Die Fraktale Fabrik.* SpringerVerlag Berlin, 1992.

WEIGELT, M. *Dezentrale Produktionssteuerung mit Agente-Systemen.* Wiesbaden 1994.

WELLINS, R.; BYHAN, W.; DIXON, G. *Equipes Zapp na Prática.* Editora Campus, Rio de Janeiro, 1994.

WERSIG. G. *Organisations-Kommunikation.* FBO-Verlag, Baden-Baden, 1989.

WINNER, R.I. et al. *The Role of Concurrent Engineering in Weapons System Acquisition.* IDA Report R-338, Institute for Defense Analysis, Alexandria, Virginia, 1988.

WOMACK, J.P. et al. *The Machine that Changed the World.* MIT, 1990.