SOME RESULTS OF THE STATE OF THE ART OF (PRODUCTION) PLANNING AND CONTROL IN THE AUSTRIAN MECHANICAL ENGINEERING AND CONSTRUCTION INDUSTRY AND SHORT REMARKS TO THE IIASA IIS PROJECT

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January 1975 WP-75-8

C O N T E N T S

1. Introduction

The initial phase of IIASA's IIS Project is to produce a "state-of-the-art" survey with the following objectives:

- determining the current status of planning, scheduling and control functions and their integration;
- identifying problem areas and limitations inherent in current practices; and
- identifying people and information sources useful in the further development of the project.

This report may be one stone in the mosaic of the initial phase of the IIS Project: After discussing general questions of the planning process, it shows the "state-of-the-art" for advanced industrial engineering companies and construction companies ("Mechanical Engineering resp. Discrete Manufacturing Systems") in Austria. Against this background the possibilities of small countries such as Austria making use of the latest developments in planning methods and information technology[1] are discussed finally.

2. The Elements of Corporate Planning, Main Tasks of Production Planning and Some Remarks on Different Types of Planning.

Figure 2.1 shows the elements of corporate planning. As the planning of production is especially considered within this survey, the figure also shows the main tasks of production planning.

The first step in the planning of production has to be the design of product(s). As the design process sometimes is confused with the planning process, the difference may be clarified by carefully questioning the objectives of the two activities. The main questions within a planning process are:

- what,
- how,
- where, and
- when,

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[1] Steiner, G. - Top-Management Planning, Moderne Industrie, Munich, 1971, p.605; "Information technology includes all methods to get, use and transmit the knowledge necessary for all the tasks to be done within company ...The difference between Information Technology and Inf. System is that the Information System includes men and their work too".

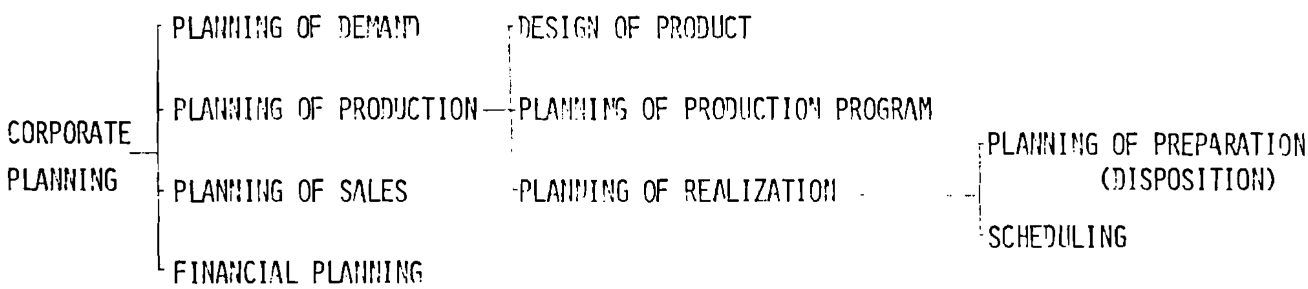

FIG. 2.1. PRODUCTION-PLANNING WITHIN THE CORPORATE PLANNING.

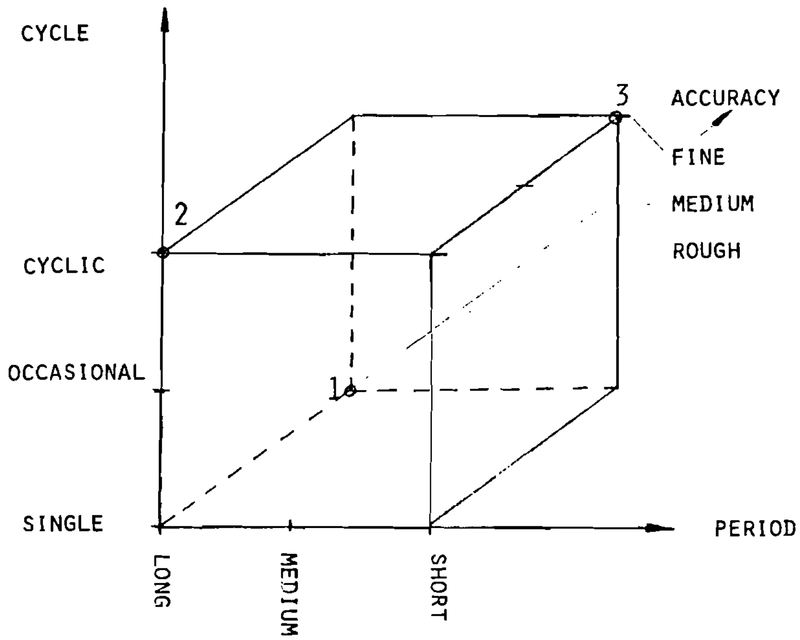

FIG. 2.2. TYPES OF PLANNING

while the most important question within the design process is the

- how. (The "what" and "where" are normally the input)
Thus the design process is primarily a technical (engineering) process.

The most important difference between the planning and the design processes seems to be that there is no time planning ("when") within the design process. Of course there is normally a time limit for designing, but this is a constraint imposed from outside. Now, let us analyze the planning process.

It seems that the following three criteria are important for considering the planning process:

1) Planning period,
2) Planning cycle, and
3) Accuracy of planning (level of detailing).

For each criterion it is common to further distinguish three ranges:

1) Planning period:
   a) Long
   b) Medium Range
   c) Short
2) Planning cycle:
   a) Single
   b) Occasional
   c) Cyclic
3) Accuracy of planning:
   a) Rough
   b) Medium
   c) Fine

Figure 2.2. shows the different types of planning combining the three criteria and their ranges. For instance, the most

important so-called "strategic planning" to be done by the top management will be occasional, long range and rough planning. Though it would be possible to give an example for each type of planning, three types are of the twenty-four signified as points 1, 2 and 3 in Figure 2.2, and they are discussed as they seem to be very important for industrial system planning.

Type 1 (point 1) means long range, single, fine planning
Type 2 (point 2) means long range, cyclic and rough planning
Type 3 (point 3) means short range, cyclic and fine planning

Type 1 will be used especially for planning of new industrial plants, working on the aspects of

- location
- traffic
- personnel
- infrastructure
- environmental factors, and
- planning of the design process.

Type 2 will be used for existing industrial plants, for example, to develop a production-program plan for a certain period such as one year.

Type 3 will be used for existing industrial plants, and it is most important where production scheduling and control (daily, weekly or longer) is to be done.

3. The General Working Sequence for Orders (and Quotations) within Industrial Systems of the"Discrete Manufacturing Type"

3.1 The Special Importance of Production Planning and Scheduling for the Discrete Manufacturing Branch

In considering the different production technologies, we can distinguish three groups:[2]

1) Energy
2) Processing (continuous production, e.g. chemistry), and
3) Discrete manufacturing (job shop).

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2 W. Simon, Produktionsverbesserungen mit NC-Machinen und Computern C. Hanser, Münich, 1969, p.566.

The most important planning for the energy production seems to be the long range planning for and design of power plants.There are normally no short-range scheduling problems for production, and at least only long range contracts for delivery of fuel (not ncessary for water power plants). The processing branch primarily has to plan the production demands for rough material (short, medium and long range planning). There are no needs for detailed production scheduling as the steps of production are fixed by the production equipment.

In the "discrete manufacturing" industry, the indivudual path through the workshop has to be planned for each of some thousand of parts which when assembled will form one finished product. Normally there are several different products being produced simultaneously on the same production facilities. In addition to the planning of the "how" and "where" for each part, the most important planning is the time planning (scheduling), the "when" because normally nearly all parts have to be ready before starting the end assembly. The step from planning for one product to planning the production for all parts for several different products is very complex.

Regarding the great number of different parts for one product, whereby several operations have to be done for each part on different machine tools, the possibilities for deviations from the plans in the manufacturing industry are higher than in the energy and processing industries. Therefore there is a need for a more frequent set ups resulting in a shorter cycle time for the scheduling in the manufacturing industry. The difficulties in the long range planning in this branch depend upon the portion of customer-specified orders in all product orders.

3.2 The Technical Documentation of Products and the Main Tasks of Production Planning

To point out the state of the art for planning, scheduling and control functions, it is necessary to consider the general working sequence for orders and quotations. Figure 3.1 shows this sequence.

Generally for the production of each new product, three important technical documents have to be worked out:

1. The Drawings have to be worked out by the design department (together with R & D). The drawings show the parts for the product, and the geometrical data for each component. Normally, a so-called "construction parts list" is also worked out.

2. The Parts Lists have to be worked out by the production planning department, starting from the drawings and the construction parts list. Production planning works out the so called requirement parts lists which show the needs for raw materials, auxiliary parts, etc. for every piece of the product.

3. The Working Plans have to be worked out by the production planning department for each product. Production planning has to work out a detailed description of the manufacturing process for each component, using the drawings and parts lists. The resulting document is the so-called "working plan" (Arbeitsplan), showing all the technological operations and the needs for manufacturing time for each operation on each capacity unit the part has to pass through. The document is then used as the base for production scheduling.

These three technical documents, the drawing, part lists and working plans, have to be worked out once for each product.

The work of the R & D and the design departments for a certain order depends on the portion of customer specification on the ordered product. This influence is shown in Figure 3.1. There is no work in the R & D and the design department on orders for standard products, for spare parts, or for repetition orders of special products. If there is no change in the technology of manufacturing for these orders, they may be directly scheduled by the "production scheduling and control department".

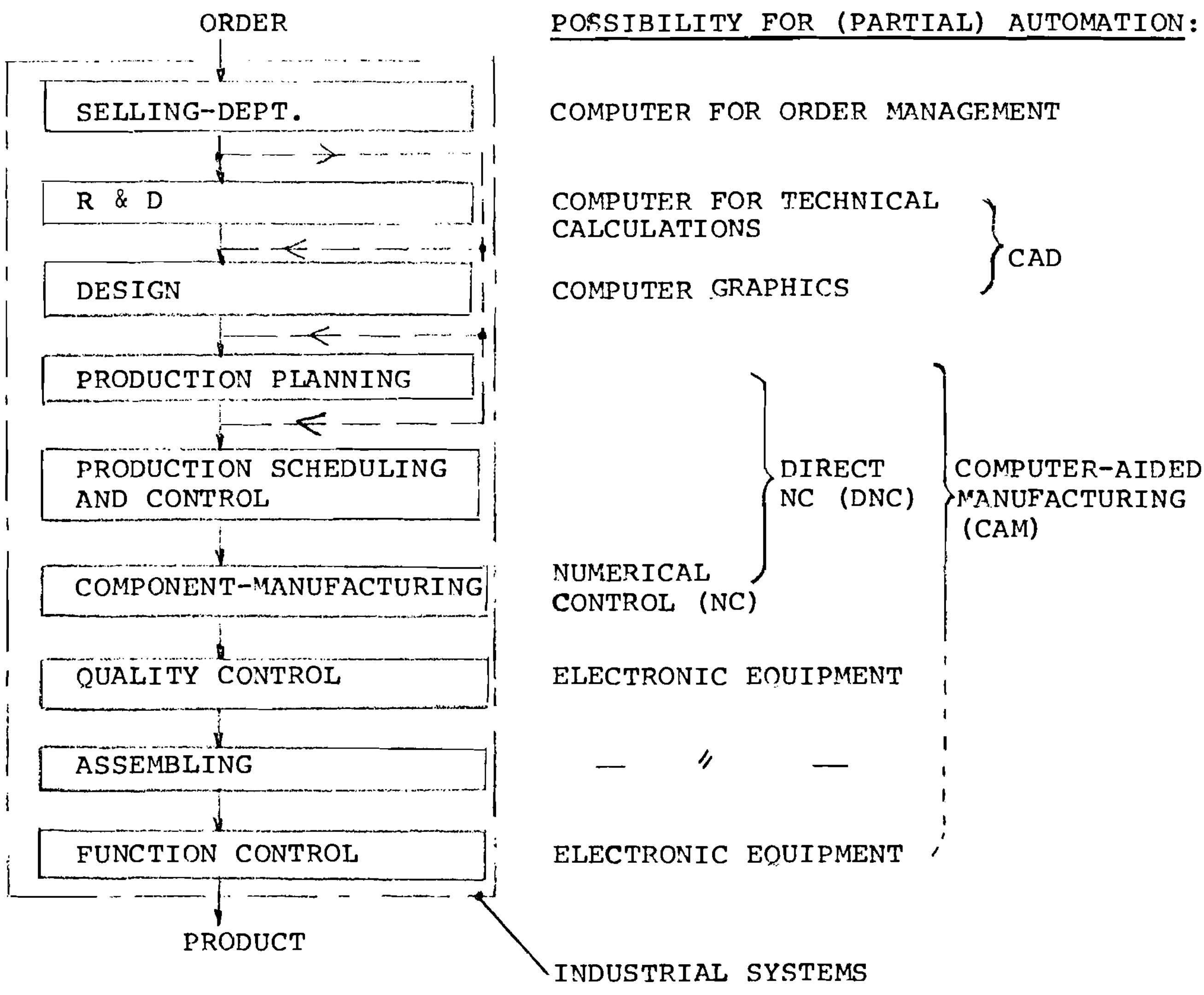


FIG. 3.1. WORKING SEQUENCE FOR ORDERS.

In any case the management of these technical documents is most important, on the one hand, for scheduling, and, on the other hand, for planning new similar parts. The ability to retrieve these documents for use indispensable for the planning process. Generally, the use of computers is possible here, and it is important therefore to have a suitable numbering system to identify the parts, capacity units and working plans.

The following summarize the main tasks of the produciton planning department:

a) The working out of parts lists showing the needs for material;

b) The working out of working plans showing the time needs for manufacturing;

c) The working out of the NC program for parts to be manufactured on numerically controlled machine tools; and

d) The managing of the technical documentation.

3.3 The Main Tasks of the Production Scheduling and Control Department

While the production planning department organizes planning for one piece of a certain product (principally not related to special orders), the scheduling and control department has to handle the orders and to consider the number of pieces to be manufactured. The three technical documents mentioned above, are the basis for scheduling, especially the working plan drawn up by the production planning department. The following main tasks have to be done:

a) requirement planning for material,
b) inventory control,
c) capacity planning,
d) shop floor control (including the working out of the "working papers" for the shop floor and the "data acquisition").

Principally the use of computers (and programs) seems to be possible for all these tasks, but there are a number of partly unknown organizational prerequisites to be worked out before computers can be used in this field.

At the end of this chapter it should be noted that a detailed description of all tasks done in production planning and in production scheduling and control are given -in the report worked out at the "Arbeitswissenschaftliches Institut" of the Technical University, Vienna as a research project for the Austrian engineering and construction industry in 1973. The report by Wojda, Schmiderer, Meingast, Hübner, is titled "Systematik der Arbeitsvorbereitung bei unterschiedlichen Automatisierungsstufen in der Einzel--und Serienfertigung" ("Systematic of Production Planning and Control Considering Different Levels of Automation in the Single and Small Series Part Manufacturing") published in Vienna, by the Fachverband der Maschinen--u. Stahlbau-Industrie Österreich, in 1973.

4. The Position of the Mechanical Engineering and Construction Industry within the Whole of Industry in Austria[3]

4.1 General Remarks

From a total of about 672,000 employees in Austrian industry, 75,000 or about 11%, are working in the mechanical engineering and construction companies branch. While the number of employees in this branch increased within the past ten years by 8.6% (corresponding to the average for the whole of industry), the production output increased by more than the corresponding average for the whold of industry:

- Nominal increase (measured in sales, including price increase through inflation) within the past 10 years: 150% (average: 130%);
- Real increase (measured in quantity) within the past ten years: 49% (average 15%).

3 Information in this section is from the Bundeskammer der gewerblichen Wirtschaft (Department for Statistics and Documentation, Vienna) and the Österr. Statistisches Zentralamt, Vienna.

Altogether in Austria there are about 700 mechanical engineering and construction companies in which

60.1%	have	less than 50	employees
18.4%	have	51 - 100	"
11.7%	"	101 - 250	"
4.9%	"	251 - 500	"
3.3%	"	501 -1000	"
1.6%	"	more than 1000	"

4.2 Some Remarks on Selected Companies

The selection of about fourteen highly developed companies is based on a previous knowledge of this section of industry. In March 1974 this author finished a study on "Present Developments in the Use of Numerically Controlled Machine Tools in Austria", in which the use of computers for programming NC machines was considered. This study is attached as Annex I.

Figure 4.1 shows the selected companies and their products. It is the interesting to note some international connections of some companies: Voith is a "daughter" of the Voith concern in the FRG and the Swiss Schindler concern owns about 50% of the shares from Wertheim. Hörbiger, Plasser and Theurer, Steyr and Vöest keep plants in foreign countries.
For an international comparison on technological know how there are two companies in the first row:

GFM developped the world's first numerically controlled forge. More than 10% of all employees are working in the field of R & D and design. More than a third of about 100 machine tools are numerically controlled, including an NC tracing machine.

Plasser & Theurer holds about 75 % of the world market for railway track construction and maintenance machines.

Name and Address	Contacted Person(s)	Products
Engel K.G. 4311 Schwertberg	Ing. J.Hahnl, Dr. Schwarz	Pressure die-casting machines
Epple-Buxbaum, 4600- Wels, Buxbaumstr. 2	Ing. Rossmann, Dr. Edlinger	Agricultural machinery E.G. combine harvester
GFM - 4400 Steyr	Dipl.Ing. Gumbsch	Forges, crankshaft- milling machines
Heid, 2000 Stockerau	Dr.-Ing. Meingast	Lathes
Hörbiger, 1110 Wien Braunhubergasse 23	Prokurist Ing. Haja	Valves
Krause & Co. 1020 Wien Engerthstr. 151	Dir.-Ing. Valenta Betr. Leiter	High precision mult-bit drilling machines for car engine production
MFA, Reichsstr. 66 8045 Graz	Dipl.-Ing.Faissner	1. Hydraulic machinery (water turbines, pumps) 2. General plant and equipment 3. Papermaking machinery 4. Steel structures 5. Castings to customers drawings
Plasser & Theurer Hafenstr. 61 4020 Linz	Dipl.-Ing. Pichler	Machines for railway track-construction and maintenance
Reformwerke Wels 4600 Wels	Dir.Dipl.-Ing. Schauffler	Agricultural machines
Steyr-Daimler-Puch AG Werk Steyr 4400 Steyr	Dipl.-Ing.Mungenast	Motocars -lorries, tractors
Einsenwerke Sulzau- Werfen, Konkordiahütte 5450 Werfen	Ing. Wurzer Dir. Ziegler	Rolls for steel and paper mills
Voest-Alpine Zeltweg 8740 Zeltweg	Dipl.-Ing. Pfandl	Tunnelling machines, steel structures railway points
J.M Voith AG, 3100 St. Pölten, Passauerstr. 40	Dipl.-Ing. Probst	Hydraulic machines, papermaking machinery, match-making equipment, gear boxes
Wertheim 1100 Wien Wienerbergstr. 21-23	Prok.Dipl.-Ing. Hlawatsch	Lifts, Escalators

Fig. 4.1. THE SELECTED AUSTRIAN COMPANIES AND THEIR PRODUCTS

It is one of the few Austrian "multinationals", keeping plants in the FRG, Australia, Great Britain, Canada, Spain, Japan, South Africa and the U.S.A.

Next, three companies were selected for the following reasons:

Vöest-Alpine, Zeltweg is using a Modular Program for capacity planning (CLASS, IBM);

Eisenwerke Sulzau, Werfen is using programs developed in-house for scheduling and control; and

Krause, Vienna has a functional system using a medium-size computer.

Several facts are nearly common for this branch:

- High flexibility against customer's specification for products:
- 57% of all scheduled orders for component manufacturing are based directly on customer's orders (only 43% are produced for stock)
- 73% of all scheduled orders for assembling are based directly on customer's order
- Nearly all companies are working in two shifts
- All companies export 50% - 90% of their products
- There are no long range contracts with customers.

5. The State of the Art in the Selected Companies

5.1 The general Structure of the Planning Process

Stage No.	Planning-Cycle (approximately)		Objective	Time Horizon
1.	1 year	Long Range Planning	New Products, Improvements (R & D)	5 years (or more)
2.	3 months	Medium Range Planning	Production Program Planning	1 - 1½ years
3.	1 month	Short Range Planning	Production Planning and Course Scheduling	1 - 3 months
4.	1 week	Scheduling	Workshop Scheduling	1 - 2 weeks

Figure 5.1.: The structure of the planning process.

Stage 1

As more than 50% of all orders are based on customer's specifications, the long range planning cannot consider a long range production program. The main objectives are the development of new products, improvements on current products and planning of production facilities.

Stage 2

The objective of medium range planning is to establish a production program, based both on orders, and on quotations. Normally in this stage of planning the products to be manufactured are the objects of planning.

Stage 3

The short range planning includes requirement planning for material, tools etc. and capacity planning, considering the various parts (components) to be manufactured.

Stage 4

Within this last stage of planning the schedule has to be made for each operation to be done on each part on a certain capacity unit.

Figure 5.1 also shows the cycle of planning for these four stages.

5.2 Computer Applications

Figure 5.2 shows the fields (departments) of the selected companies, where computers and other equipment are used. For each company, the current status, and the status planned in a concrete manner is shown.

The figure shows that all except one selected companies are using computers for commercial tasks and numerically controlled machine tools for component manufacturing. (As shown in the NC-Study (Annex 1 most use computers for NC-programming). The use of computers in the field of R & D and Design is only for technical calculations; there is no use of computer graphics by the selected companies.

COMPANY	Status	SELLING	R & D	DESIGN	PRODUCTION PLANNING	PRODUCTION SCHEDULING AND CONTROL	COMPONENT MANUFACTURING	QUALITY CONTROL	ASSEMBLING	FUNCTION CONTROL	COMPUTER IN USE FOR COMMERCIAL TASKS
ENGEL	STATUS PLANNED	3		4	1	2					YES
	STATUS NOW					C	A				
EPPLE	Planned				1	2					NO
	Now						A				
GFM	Planned			2	1	2					YES
	Now						A	A			
HEID	Planned				2	1					YES
	Now			C			A				
HÖRBIGER	Planned				1	2					YES
	Now										
KRAUSE	Planned										YES
	Now			C			A	A			
MFA	Planned					1					YES
	Now			C		C	A	A			
PLASSER & THEURER	Planned				1	2					YES
	Now			C			A				
REFORM-WERKE	Planned				1	2	A				YES
	Now				C						
STEYR-WERKE	Planned					1					YES
	Now			C	C	C	A				
SULZAU	Planned	3			2	1					YES
	Now			C	C	C		A			
VOEST-ALPINE	Planned					1					YES
	Now			C		C	A				
VOITH	Planned				2	1					YES
	Now			C		C	A				
WERTHEIM	Planned				1	2					YES
	Now						A				

NOTES:

C... COMPUTER APPLICATION

A... AUTOMATION BY USING NUMERICAL CONTROL OR OTHER ELECTRONIC EQUIPMENTS

THE NUMBERS FOR THE "STATUS PLANNED" ARE INDICATING THE PRIORITIES FOR COMPUTER APPLICATION

Fig. 5.2. COMPUTER APPLICATION IN SELECTED MECHANICAL ENGINEERING-AND CONSTRUCTION COMPANIES IN AUSTRIA

Most companies have planned the applications of computers for production planning and scheduling. Though there are some companies which make use of computers for certain tasks of production scheduling, some of these companies are planning now to use the computer for production planning, as there are important steps analyzing the different products to obtain exact data for scheduling.

For the use of computers there seem to be the possibilities shown in Figure 5.3:

Computer-use
- small and medium size computer(s) (in house)
- teleprocessing
- large computer (in house)
- combination

Fig. 5.3 Possibilities of computer use

The selected companies use computers or are planning to use them in the following manner

4	companies:	large computer (in house)
4	" :	medium size computer (in house)
1	" :	large and medium size computer (in house)
2	" :	some medium size computers (in house)

Two companies are using one computer system together.

It is remarkable that there is not much use of teleprocessing in Austria: only a few companies are using TELE-APT for NC programming on IBM-computers.
Unlike, other countries, in Austria "Service Offices" selling Computing facilities do not exist. The following are possible

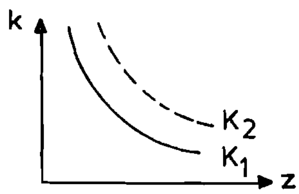
reasons for this:

- no highly developed data transmission network
- high costs for data transmission (and teleprocessing)
- the interest in having in-house computer experience.

In the field of component manufacturing there are no concrete plans to introduce direct numerically controlled systems: there is a concencus that this may be a further step after finishing the implementation of computer systems in the field of (production) planning and control.
Another concensus was found in the opinion, that such a DNC System will be of interest only if there are more than at least 10 (ten) NC machine tools.

There is only one company planning the use of computer for order entrance managing. One of the criteria to use computers in this field is the number of orders z.
Each company has a certain production capacity K (f.i. 20,000 hours a month), which can be used for z orders each requiring the capacity k:

$K = z.k$



$K_2 > K_1$.

If z is small (10 - 30 f.i), the order management can be done easily without a computer. Normally in this case the required capacity for working on one order is large. The use of computers for production planning and scheduling depends on the number of different parts of a product which is representive for the overall data to be handled within the planning process. It may be of interest to note some ranges of these data to be handled in the selected companies:

- number of orders: 15 ÷ more than some thousand / year
- number of parts per product: up to 100,000 (paper machinery)
- number of new operations to be planned (for new parts): up to 500 per day
- number of operations to be scheduled: up to 4000 per day
- number of capacity units to be controlled (with and without machining equipement): up to 500.

5.3. Unsolved Problems

5.3.1. Unsolved problems considering critical scope of function

STAHLE[4] writes that each system has a "critical scope of function" responsible for the success or failure of the whole system. As more than 50% of all products have to be manufactured according to customer spezifications, the main problem for planning and scheduling is that all the technical documents (drawings, part lists, work plans) are ready at right time to allow:

- the ordering of raw materials
- the capacity planning
- the ordering or manufacturing of special manufacturing devices for clamping, cutting etc. (most companies have their own small departments for design and manufacturing of these devices).

Corresponding to this, as a "critical scope of function" it was pointed out that :

- the R & D/design department from 5 companies
- the production planning and scheduling department from 4 companies.
- the special problem of disposition for raw materials from 3 companies.

The fact that the R & D/design department is in most cases the "critical scope" has at least three reasons since department

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4 STAHLE, W, Organisation und Führung sozio-technischer Systeme, Enke, 1972.

has to work out:

- detailed specifications for all parts on ordered products
- widely detailed specifications on inquires as the base to work out quotations
- developing and improving from products.

The first two tasks normally have to be done within a very limited time. Additionally it has to be considered, that between 8% and 25% of all quotations will become orders, but the design and raw planning of production has to be done for all quotations as a base for price calculation and planning the possible date for delivery. Regarding this, some companies keep their own sub-groups in R & D Design and production planning departments to work only on quotations. There are some discussions in which way this work can be charged to the company asking for the quotation, as is ususal in architectural firms for instance.

As it was pointed out in chapter 3, the working sequence for orders and quotatons starts with R & D design and normally finishes with assembling and function control. On the other hand, at the moment a scheduling is made only for the component manufacturing. So it is an open and unsolved problem to develop an overall planning and scheduling system including R & D/design and assembling. But first basic research has to be done for methods to get objective time needs for work in R & D/desing and assembling (as there are methods for manufacturing, for instance the synthetic method MTM, developed in U.S.A.).

5.3.2. Criteria to find the optimal possibilities of computer use

Though there are some computer applications for some tasks of production planning and scheduling, objective criteria do not exist for finding the best way of using medium or large computers, or a combination of the two or teleprocessing. The various possibilities lead to unsolved problems which require research-work:

a) Finding the optimal possibility to the question of integration using computer leads. As I feel this is a very important field of research, especially since the IIS Project uses this concept in its title, I am giving some notes on it in chapter 7. Basic research should be done to find methods to analize the requirements for information for the various tasks.

b) Depending on the different posibilities of computer use there are various organizational prerequisitions to be fulfilled, especially for computer applications in the more technical field.
As these prerequisities are generally unknown, this will be a very important field for research.

c) Considering the high part of customer specified orders in this branche there is a further question which of all data have to be stored on computer storage. The storage of all data, may be in a central "data bank" will not be an economic and optimal solution. As the storage of data for a part only used once will not be recommended, a further problem is how to use this data within a computer aided scheduling system.

5.3.3. Other problems

There are on the one side a lot of single-problems as

- Data-Aquisition for Production Control
- Updating the technical documentation
- Numbering System
- Possibilities for formalization to establish working plans
- Effectiv use of methods like function-analysis, worth-analysis, manufacturing of part-families.

On the other side there are more general problems such as

- human (social) motivation for organizational improvements
- social aspects on implementing new methods of planning maybe using computers
- quantitative methods for cost-efficiency analysis on computer applications.

6. Conclusions

Is it possible for the industry of a small country such as Austria to make use of latest developments in planning methods and information technology? To answer this question, different aspects have to be considered for a certain country:

- the general level of industry (especially for final production)
- the financial possibilities
- the existence of a computer and automation industry
- the level of education
- social aspects
- others.

The situation for Austria seems to be the following.

- the general level of Industry seems to be on the average of the industrialized countries
- the financial possibilities seem to be very limited compared with other industrialized countries
- there is no Austrian computer industry, very poor software development and only a small (process) automation industry.

But it olso seems, that in Austria there is

- a high level of education
- a relatively good connection between industrial management and trade unions.

Generally it seems to be possible for Austrian Industry to make use of planning methods and computer systems developed in other countries.
But the optimal use of such methods and systems requires research about

- criteria for system selection
- the technical and organizational prerequisites
- the steps for implementation
- the steps for optimization.

Research on these problems is being carried on by the author of this IIASA Report who leads a university research project on

> "The Optimal Mangement of Production regarding the latest Developments in Information Technology".

This project is supported by the Austrian association for the mechanical engineering and construction industry and by the "Forschungsförderungsfond der gewerblichen Wirtschaft". (Research Fund) both located in Vienna.
The ANNEX 2 presents the main objectives of this project over a two year period.

7. Some Notes on the Concepts "Integration" within Industrial Systems and Short Remarks on the IIS Project

7.1. Notes on the Concept "Integration"

The concept "integration" used in connection with the concept "automated data processing", usually means data processing using large computers including a "databank." But there are some questions. What will be integrated in this matter: data, departments, tasks, men or something else? Can "integration" within an organization only come about through the use of large computers, coupled with an enormous effort to establish a central "databank"? From where do the needs for any "integration" come, and are there significant limits to the integration? To answer these questions, let us first have a look at some authors to find out the meaning of "integration."

F. Kast and J. Rosenzweig Organization and Management:

> A systems Approach; New York, McGrow Hill p.187
>
> "Integration is defined as the process of achieving unity of effort among the various subsystems in the accomplishment of the organization's task.

..... It is important to recognize the interaction between the need to specialize activities and the requirements for integration. The more differentiation of differentiation of activities and specialization of labour, the more difficult the problems of coordination".

W. Staehle Organization and Management of Social-Technical Systems (Original in German: Organisation und Führung Sozio-technischer Systems).
Enke, p. 122, 125

Integration
- socio-economic (to reach goal identifiaction)
- factual economic
  - actual technical (machines)
  - factual and problem orientation
  - problematic technical

"The need to integrate depends upon the degree in which the related processes, communication channels and function terminations, especially those which are necessary to reach a mutual higher goal are interrupted or disturbed through differentiation".

"Integration - respective decision about choice and application of an integrating mechanism is the function of two components:

a) logical fact component: degree of differentiation (division of work)

> b) political component: measurement of the striving for synergisumus of the entire system: the entire system is larger (or at least differs from) the sum of sub-system."

D. Bedworth Industrial Systems: Planning, Analysis, Control New York: Ronald Press Company, p.433.

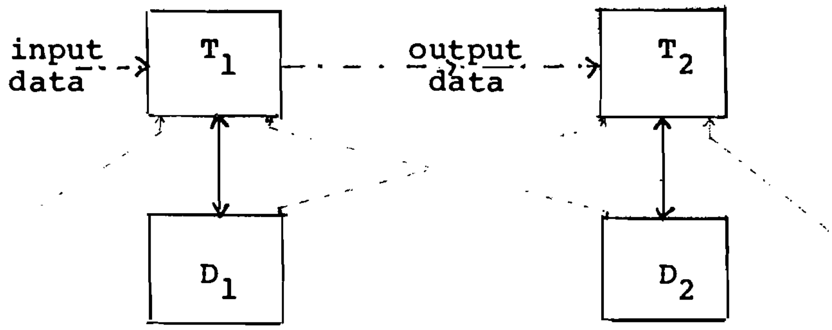
> "A management information system integrates equipment, people and procedures in such a way as to deliver analysis-supporting and analytical information pertinent to management systems".

A prime characteristic of industiral systems is the division or differentiation of work which includes interruptions of the whole process. The more the division of labour, the greater the need for integration by organizational methods. It seems that the objects to be integrated again primarily have to be the tasks to be done and this integration will be considered in the following proposal ("factual economic integration"). The objectives for this integration may be thought to be the optimal solution of individual tasks, but because of interactions the overall company objectives must be optimized.

7.2 Proposal for a Model of Integration

It seems important to distinguish two types of integration[5] for the various tasks to be solved within any organisation.

a) Integration by interaction and personally feedback

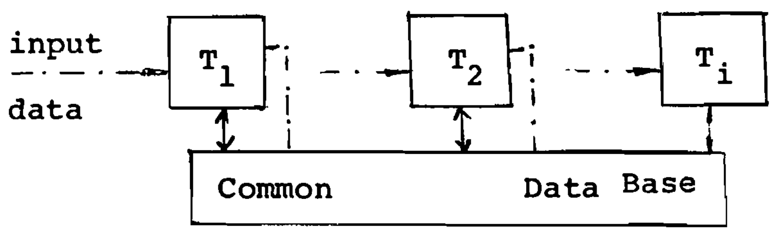


T_i .... task

D_i .... basic data used to solve T_i

The basic data are separately prepared and stored for each task normally in a conventional manner, using a card index, or something similar. The tasks are linked together in a sequential mode. Normally, a certain organisation structure is necessary to also integrate the people.

b) Integration Using Common Data Base



T_i ... task

5 H. Hübner, "Systematik der Vefahren der Datenerfassung und Beurteilungs-Kriterien für deren Einsatz bei spezieller Berücksichtigung eines Automatisierungsgrades", Thesis, Techn, Univ. Vienna, 73

The common data for various tasks considered together are stored only once and stored in such a manner that they can be utilized independently by each person involved in one of the tasks. Though theis type of integration generally need not lead to storage in connection with computers, often this will be the best solution. But this does not denote the use of a large central databank: it is possible to integrate only the tasks, for example, of one department using small or medium size computers.

Using this type of integration, the tasks are linked together by the data, so that men may work more independently of each other, and the organization becomes important primarily to organize the data. Generally, I feel the question is not "integration type a) or b)," but rather "what is the optimal combination?"

The draft of INTEGRATION Model shown in figure 7.1 may be the basis for finding the answer: The model combines the two types of integration, named above, showing that a certain level of integration for a defined group of tasks may be arrived at by a combination of the two types.

It seems to be useful to define a scale for the level of integration (comparable to the level of automation). This would be basic to working out the model in a quantitative manner.

Now the two types of integration shall be explaines in an example using numerical controlled manufacturing.

a) The tasks to be done:

- T_1 ... establishing the program for the part to be manufactured on a numerically controlled (NC) machine tool, the so called "NC programing"
- T_2 ... the manufacturing process itself on the NC machine tool.

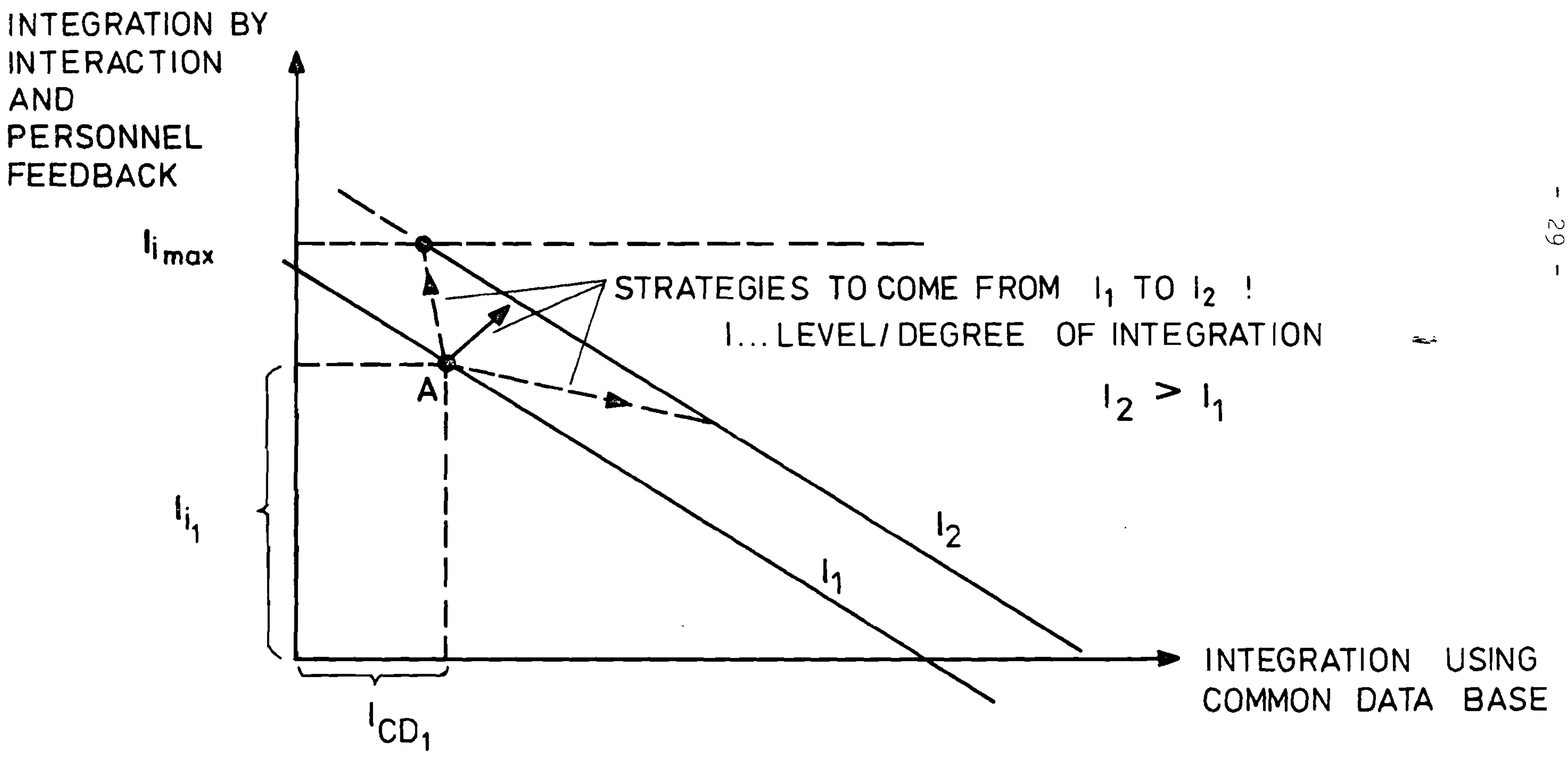


FIGURE 7.1 MODEL OF INTEGRATION (DRAFT)

b) The basic data:

D_1 ... data about machine tools, tools, technological data for different materials

D_2 ... data of machine tool and workshop

c) The input data:
For T_1: geometrical data and material of the part to be manufactured.

For T_2: Detailed description of manufacturing process for the part to be manufactured.

Usually these two tasks are done using integration by interaction personally feedback.

The NC program is established with or without use of a computer on the input data and the basic data. Then the NC program data are brought on a data carrier, usually a punched tape. This tape is next brought to the man on the NC machine tool and he starts the manufacturing.

To integrate these two tasks by using a common data base (type 2 of integration), it is necessary to use a computer. The NC program has to be stored in the external storage of a computer. The NC machine tool is connected to the computer in such a manner that the data for the manufacturing process can be transmitted directly to the NC machine tool. The man has to assure only that tools and materials for the part are on the machine at the right time. A system working in this manner, a so-called Direct Numerically Control System (DNC System) is shown in Figure 7.2.

CRT - Cathode Ray Tube

PTR - Punched Tape Reader

PTP - Punched Tape Printer

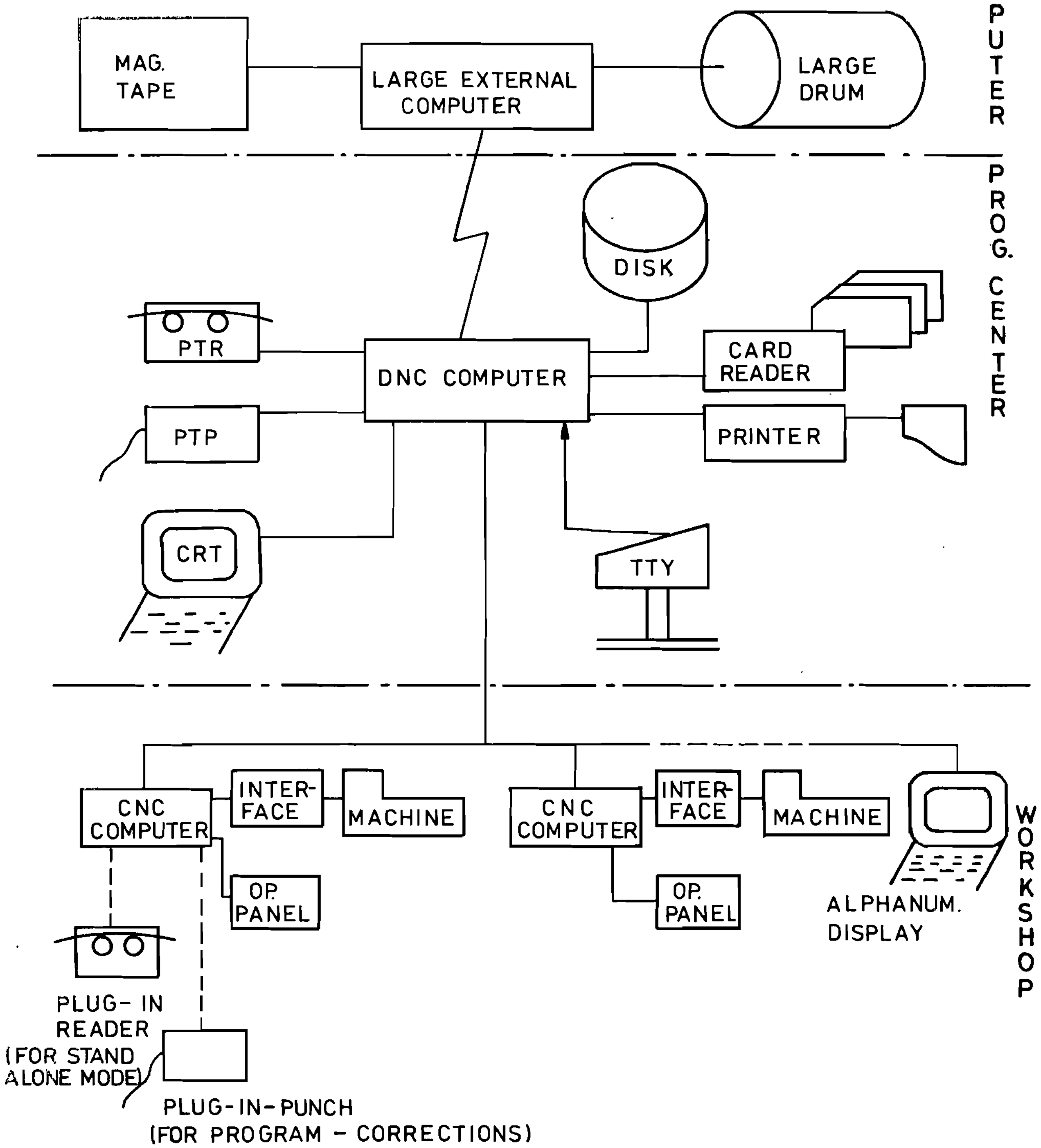


FIGURE 7.2: HARDWARE CONFIGURATION OF A FULL D N C - SYSTEM.

(DIRECT NUMERICAL CONTROL)

7.3. Short remarks to the IIS Project

As it was pointed out in the latest long range plan on the IIS project investigations shall be made to develop "more generally applicable methodology and techniques for the integration of data processing in production management and control system". It seems that the ideas about a model of integration pointed out above may be a base for such investigations. The most important aspect of integration is how the data are used in planning,-control-and decision making processes.

In the IIASA Working paper "Computer aided techniques as a tool for the integration of industrial processes" (WP-74-39, August 1974) the authors (Werler K, Zander H) express their meaning about the importance of the concept for integration, too (page 12):

> "Integration in industrial systems requires a unified way of thinking and unified techniques and technologies in computer application (languages, data structures, data banks). In this connection it would be of interest to distinguish the kinds and steps of integration and the factors by which the bounds of useful integration are determined."

Generally such a common integration model should be viewed as an instrument which could clear up the following questions:

- possibilities of integration
- integration of tasks for subsystems through use of the small or medium size computers
- limits of integration through a common data base in the building up of a central data bank
- definition of "level of integration" as a quantitative size which will make comparisions possible
- strategies toward arriving at a higher level of integration.

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{13} Cheliustkin, A; Lefkowitz, I; Hatvany, J; Kelley, D — Project proposals (goals, objectives) for Integrated Industrial Systems Project for 1974, 1975.

ANNEX 1

Present Developments in the Use of Numerically Controlled Machine Tools in Austria

Study by

Heinz Hübner

Vienna, March 1974

Summary

The data of 86 representative Austrian enterprises were collected in the course of this study (cf. annex 2)

Since 1964 NC-machines have been increasingly used in Austria (cf. fig. 12), so that a total of 280 NC-machines will be employed in the surveyed enterprises by the end of December 1974. They are subdivided in figures 3a, 3b, 4a, 4b and 5 according to their employment in industrial regions and industrial groups, in figures 8, 9 and 10 according to machining processes and control methods.

It can also be seen from the study that 36 of the interviewed enterprises will not be using NC-machines until the end of December 1974.

With regard to NC-programming it can be noted that more than 50 per cent of all enterprises using NC-machines intend to introduce automation by means of automated data processing equipment.

Annex 3 (at the end of the study) shows a list of all interviewed enterprises and the NC-machinery they use; enterprises intending to introduce automation of NC-programming are specially marked.

It must be pointed out in this connection that Voest-Alpine is at present the only enterprise in Austria with automated NC-programming for which the universal programming language EXAPT is used.

Finally the enterprises with more than 10 NC-machines are ranged; GFM, Steyr, is in the lead with 33 NC-machines, even if several plants of one combine are taken together.

CONTENTS

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1. Introduction and Definition

Numerically controlled processing machines (NC-machines) are machines which process directly numbers and figures. Nearly all information is fed by figures (path-, switching function).

NC-machines can be classified from various points of view; according to the objective of this study the following criteria were applied in the subdivision:

a) According to the production process for which the processing machine is suited we differentiate the following groups:
   - drilling and milling machines (drilling machines, milling machines and machines for drilling and simpler kinds of milling)
   - drilling and milling tools (horizontal and vertical drilling and milling tools, automatic drilling machines)
   - turning machines (spindle-, vertical turning machines)
   - processing centres
   - other (e. g. flame cutting machine, nipple machine, punching-, pipe bending machine, errosion machine)

This subdivision seems suitable with regard to existing NC-programming languages; it has to be pointed out, however, that all classifications are problematical , as according to a US analysis there are about 140 (!) different kinds of processing machines.

b) According to numerical control
   - (point to point- and) linear path controls: no functional connection between the motions in the individual coordinates.

   - continuous path controls: functional connection between the movements in the coordinates, (depending on interpolation we differentiate between linear, circular and parabolic connections)

c) According to information input

According to the definition of numerical control there are various forms of information input; the different kinds of input media are presented in annex 1. The magnetic tape has not been included in this list, although it could be principally used, since opinions differ as to its suitability in the rather rough workshops.

With respect to possible automation of NC-programming by means of problem-oriented programming languages the study includes only such NC-machines as can be fed by punched tape.

2. Data on Interviewed Enterprises

2.1 Subdivision into Industrial Groups.

The following subdivision, e.g. common with IBM, has been used for this study, although in a limited sense :

Group 1: electrical engineering industry, electronics

Group 2: constructional engineering and assembly (machine-building)

Group 3: vehicles

Group 4: shipbuilding

Group 5: rubber

Group 6: raw materials (metal)

Group 7: other (i.a. precision mechanics, glass making, fittings, valves, tools).

As group 2 expectedly comprises the bulk of NC-machines, it is further divided into:

2: constructional engineering and assembly	2.1	machine tool construction
	2.2	other constructional engineering (gear units, pumps, compressors, agricultural machines, internal combustion engines, etc.)
	2.3	steel construction (lift, etc.)

2.2 Subdivision of the Austrian Territory into Industrial Regions

There are 4 regions:

- Vienna and Lower Austria
- Graz area, Styria
- Linz and Steyr areas, Upper Austria
- Remaining federal provinces

In this classification the individual parts of one combine are treated separately.

2. 3 Number of Surveyed Enterprises Subdivided into Industrial and Regional Groups

Industrial Regions	Interviewed Enterprises absolute	Interviewed Enterprises in percent
Vienna, Lower Austria	37 enterprises	43 %
Graz, Styria	15 enterprises	17 %
Linz, Steyr, U. A.	18 enterprises	21 %
Remaining provinces	16 enterprises	19 %
Total	86 enterprises	100 %

Fig. 1: Subdivision of interviewed enterprises into industrial regions

Industrial group	Interviewed Enterprises absolute	Interviewed Enterprises in per cent
1	5	6
2	51	59
3	4	5
4	2	2
5	2	2
6	7	8
7	15	18
Total	86	100

Fig. 2: Subdivision of interviewed enterprises into industrial groups

Results of the Survey (Interpretation and Analysis)

The data of the above mentioned enterprises were collected on the basis of a questionnaire (cf. annex 2),
The following results were obtained:

3. 1 Results regarding the Use of NC-Machines

All figures include planned and already made purchases of NC-machines; thus this study represents the situation of the current calender year until the end of 1974

3. 1. 1 Total Number of NC-Machines, Subdivision into Industrial Regions and Industrial Groups

The representative 86 enterprises will employ a total of

280 NC-MACHINES by the END OF DECEMBER 1974

which are distributed over the four industrial regions as follows:

	Number of NC-machines	
Industrial region	absolute	in percent
Vienna, L. A.	105	37, 5
Graz, Styria	44	16, 0
Linz, Steyr, U. A.	109	39, 0
Remaining provinces	22	7, 5
Total	280	100, 0

Fig. 3a: Subdivision of NC-machines into industrial regions
Fig. 3b: is a graphic representation of this distribution

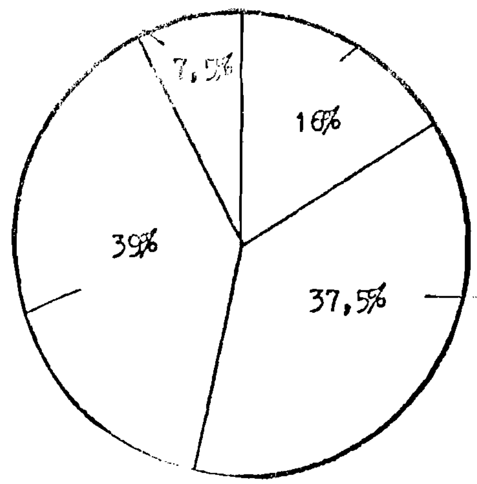


Fig. 3 b: Percental distribution of NC-machines over Austrian industrial regions

Figs. 4a, 4b and 5 show the distribution of NC-machines over the individual industrial groups.

Ind. group / Ind. region	1	2					3	4	5	6	7
		2.1	2.2	2.2 a. 2.3	2.3	2.1 a. 2.2 a. 2.3					
Vienna, L. A.	18	23	11	15	11	1	13	-	1	-	12
Graz, Styria	6	2	-	11	4	-	1	-	-	15	5
Linz, Steyr, U. A.	5	33	41	2	1	9	15	3	-	-	-
Remaining prov.	-	-	-	13	-	-	-	-	-	-	-
Total	29	58	52	41	16	10	29	3	1	15	26
In percent	10,4	63, 2					10,4	1, 1	0,4	5,5	9, 0

Fig. 4a: Distribution of NC-machines over industrial groups (absolute and in percent.)

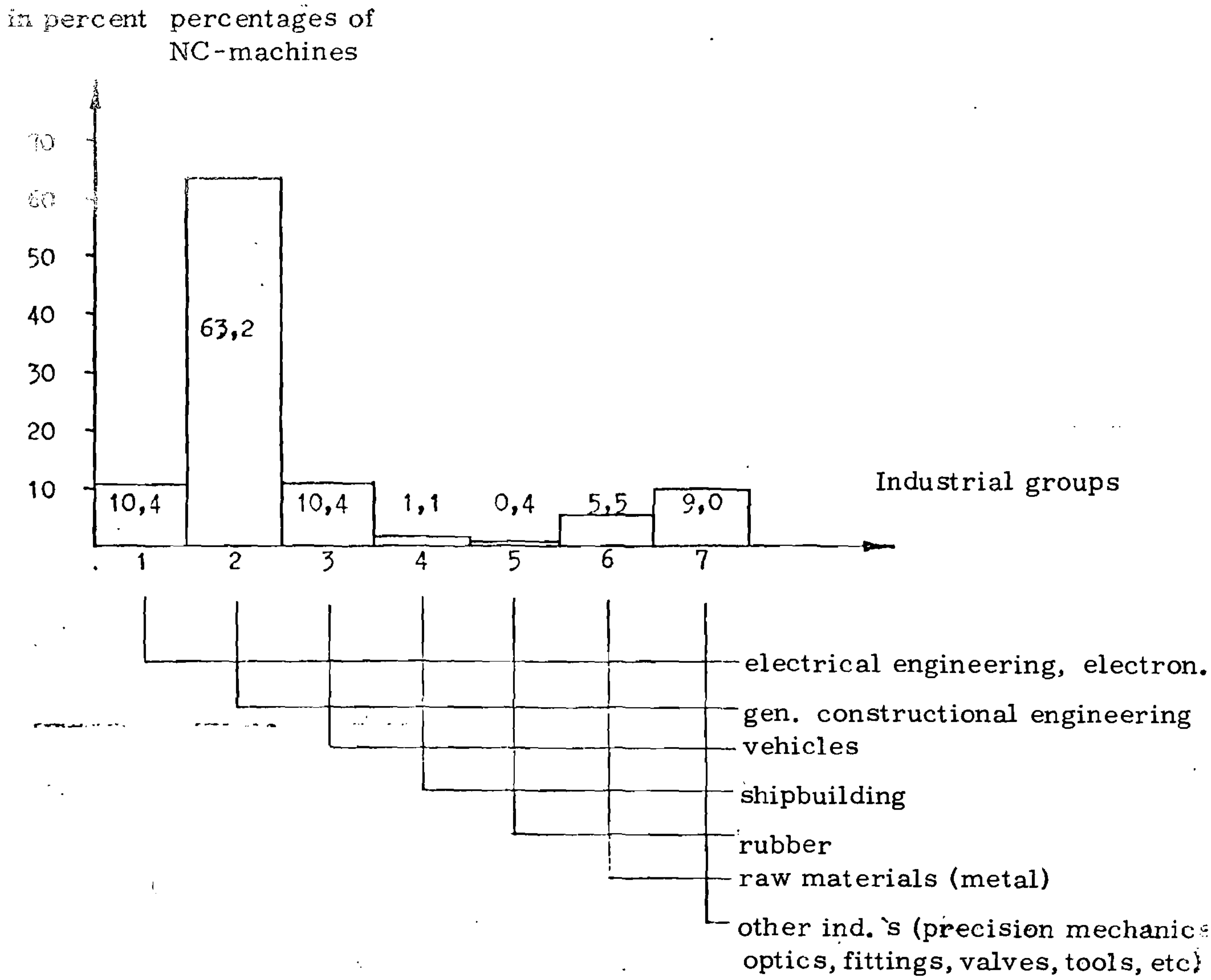


Fig. 4b: percental distribution of NC-machines (chart)

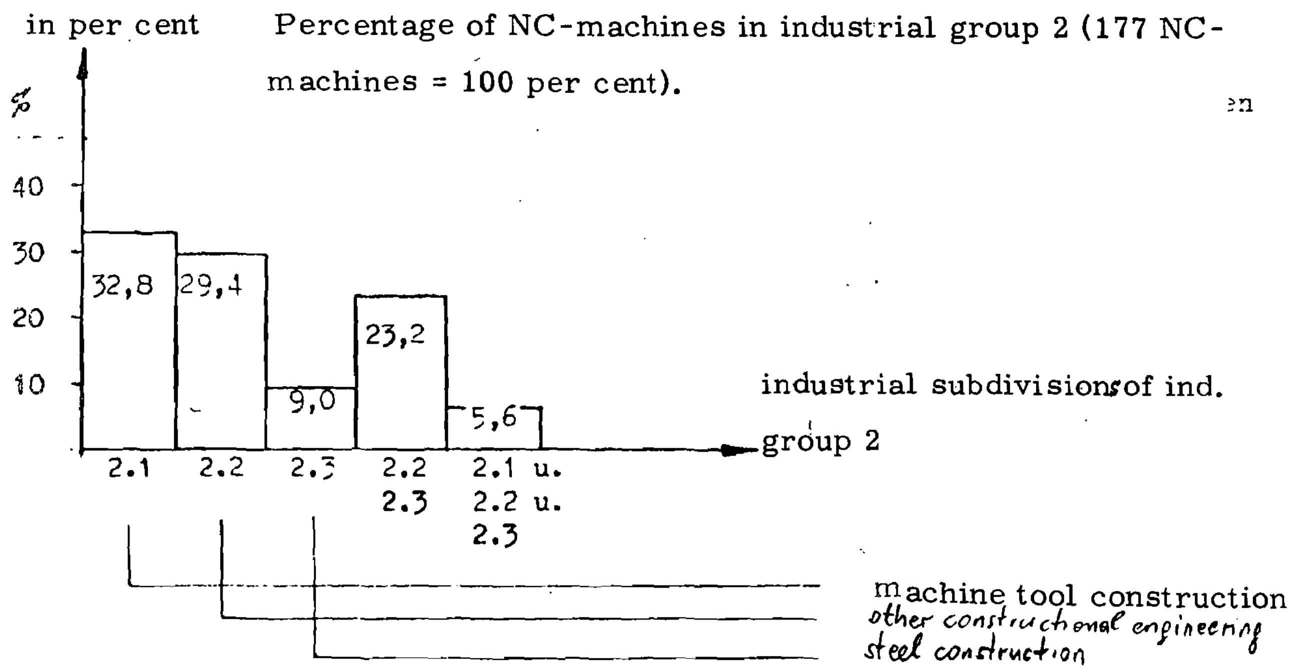


Fig. 5: Percental distribution of NC-machines of ind. group 2 (gen. constructional engineering) over

36 of a total of 86 interviewed enterprises will not possess NC-machines by December 31st 1974, (that is about 40 per cent) and are distributed according to fig. 6:

Ind. region	Interviewed enterprises without NC-machines absolute	in per cent with regard to ind. regions
Vienna, L. A.	15 (of 37)	40
Graz, Styria	3 (of 15)	20
Linz, Steyr, U. A.	7 (of 18)	39
Remaining provinces	11 (of 16)	69
Total	36	

Fig. 6: Distribution of enterprises without NC-machines over industrial regions

Enterprises without NC-machines are distributed over the individual industrial groups as follows:

Industrial group	Interviewed enterprises without NC-machines absolute	in percent with regard to industrial group
1 (electical engineering, electronics)	1 (of 5)	20
2 (gen. constructional en.)	19 (of 51)	37
3 (vehicles)	1 (of 4)	25
4 (shipbuilding)	1 (of 2)	50
5 (rubber)	1 (of 2)	50
6 (raw materials/metal)	4 (of 7)	57
7 (other)	9 (of 15)	60
Total	36	

Fig. 7: Distribution of enterprises without NC-machines over industrial groups.

The following reasons were given for the non-employment of NC-machines:

- scepticism vis-a-vis highly automated machinery
- reluctance to implement the necessary organisational measures
- simple parts spectrum, no complicated geometry
- no repeated single-part production
- series production and predominance of research technique

3.1.2 Division into Manufacturing Processes and Kinds of Numerical Control

Fig's. 8, 9 and 10 show above-mentioned subdivision.

manufacturing proc. and control / region	DRILLING-, MILLING M. point./linearp.	DRILLING-, MILLING M. cont. path c.	DRILLING-MILLING T. linear	DRILLING-MILLING T. contin.	TURNING M. linear	TURNING M. cont.	PROCESS. Centres 1)	Other M. 2)
Vienna, L. A.	24	2	10	6	3	38	9	11
Graz, Styria	10	1	3	3	1	19	4	2
Linz, Steyr U. A.	22	3	16	4	2	31	18	5
Remaining Provinces	4	-	6	1	-	7	7	8
Total/absolute	60	6	35	14	6	95	38	26
/in per cent	21,4	2,2	12,5	5,0	2,2	33,9	13,5	9,3
	23,6		17,5		36,1		13,5	9,3

Fig. 8: Distribution of sum total of NC-machines over manufacturing processes and kinds of control.

1) approximately 2/3 with linear path control

2) approximately 2/3 with continuous path control

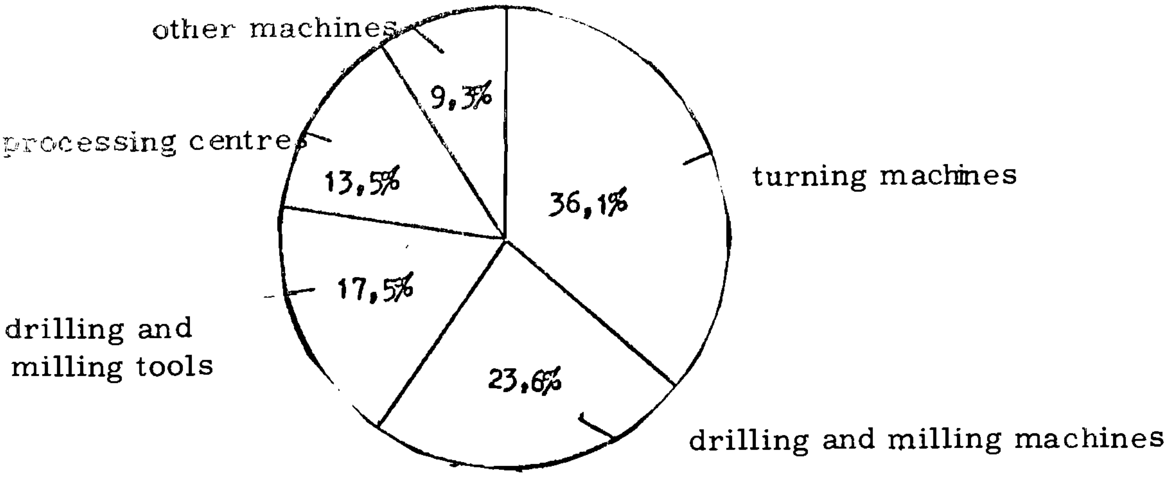


Fig. 9 shows the share of NC- machines in manufacturing processes

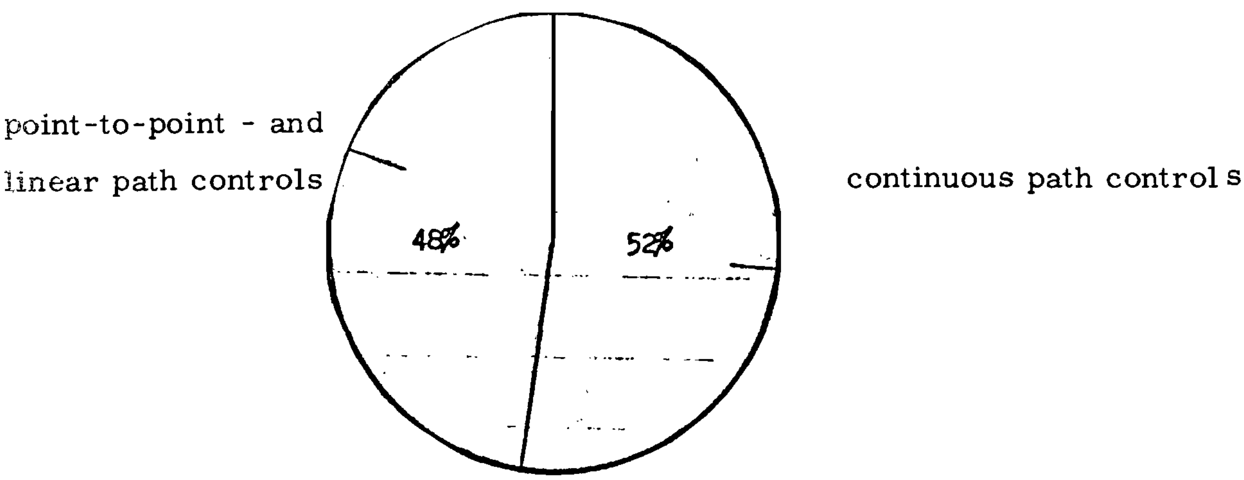


Fig. 10 shows the kinds of control in NC-machines.

3.1.3 Purchases of NC-Machines Planned and Made, Respectively, by December 31 st, 1974.

As already mentioned, above mentioned data include all purchases up to the end of 1974.

A total of 61 NC-machines is distributed over the industrial regions as follows (cf. fig. 11)

Ind. region	purchase of NC-machines by Dec. 31, 1974
Vienna, L. A.	19
Graz, Styria	17
Linz, Styria, U. A.	19
Remaining provinces	6
Total	61

Fig. 11 shows how the purchases of NC-machines up to the end of 1974 are distributed over the industrial regions.

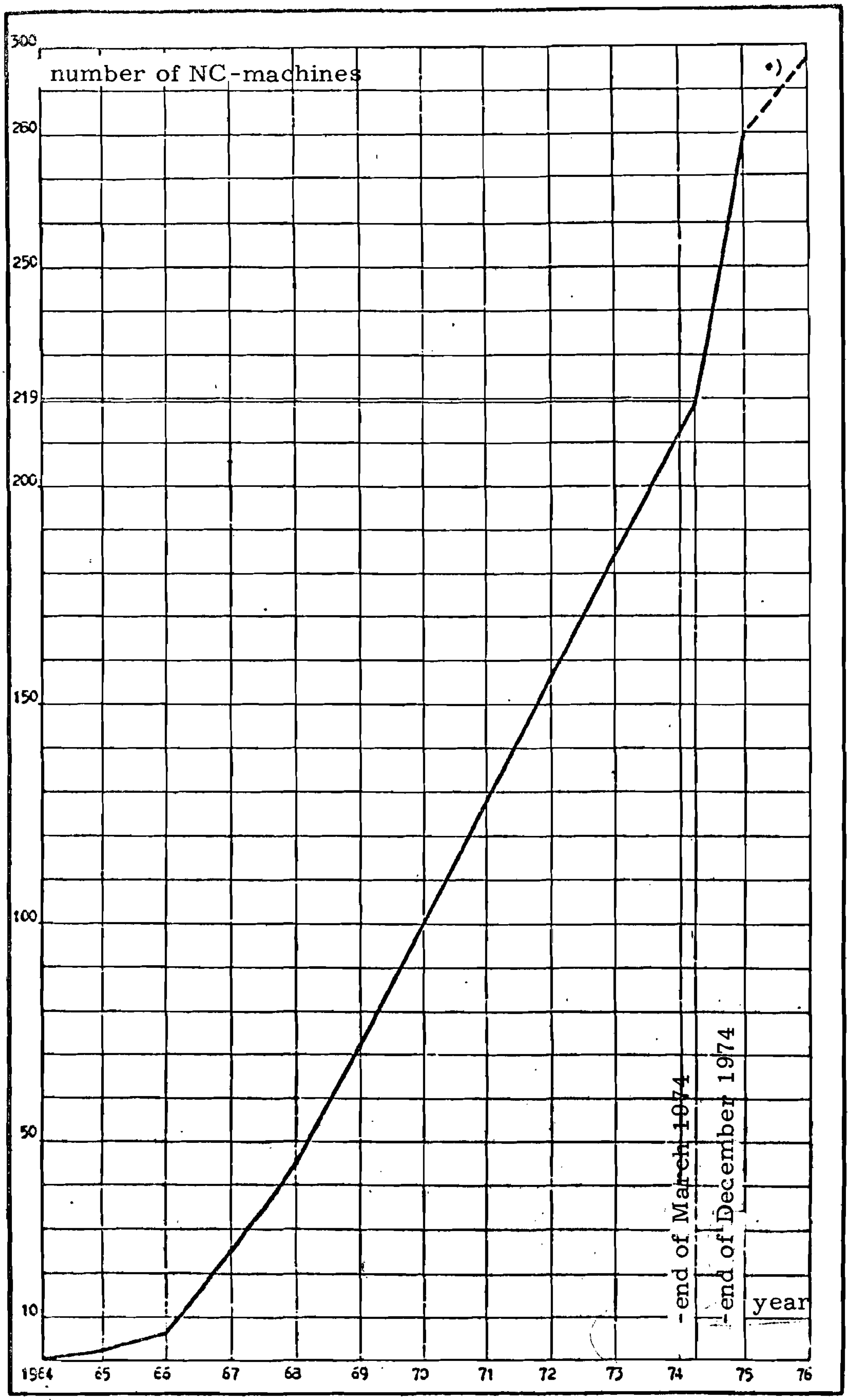
3.1.4 Trend of and Necessity for Medium- and Long-Term Purchases of NC-Machines

The following judgements were passed by the interviewed enterprises:

29 enterprises: positive
6 enterprises: saturated, no further purchases planned
27 enterprises: sceptical, not yet ready to buy
8 enterprises: NC-machines not suited for the particular enterprise
remaining enterprises: no medium term planning

It is interesting to note that nearly 60 per cent of the sceptical enterprises employ only one or none machine . This scepticism may therefore easily give way to a more positive attitude.

Fig. 12: Development of NC-machine employment in Austria



*) already in the stage of concrete planning (2 - 5 years)

On the basis of quantitative information from enterprises which judge the development positively and make medium- and long-term plans (there is an important connection!) we know that the purchase of about 50 NC-machines has been definitely planned for the next 2 (to 5) years for all mentioned manufacturing processes, but also for other machines, such as nipple-, flame cutting- and punching machines.

Fig. 12 shows the development of NC-machine employment in Austria also with regard to definite medium-term planning.

3.1.5 Long-Term Assessment of CNC- and DNC-Systems

This question was answered satisfactorily by only 7 enterprises which already use several NC-machines (5 - 33). The following statements were made:

a) positive:

- satisfactory for the control of very capital-intensive enterprises (1 enterprise)
- justified if more than 10 machines are used (2 enterprises)
- DNC useful for better organisation and in particular for more effective production planning (1 enterprise)+

b) negative:

- sceptical because of sudden unexpected incidents during production (1 enterprise)
- at present not of interest, no burning question (1 enterprise)
- too risky, standstill of all machines in case of computer breakdown
- CNC prevents the shift of responsibility to production planning effected by NC-technology (DNC supports it)+

3.2 Results of NC-Programming

NC-programming means setting up an information carrier carrying all information necessary for the control of the automatic job flow. This is principally the computation of the geometric characteristics (description of the relative movements of part and tool), and of the technological data (cutting speed, thrust, etc.)

The effort involved in the computation of these data depends above all on the complicity of the part and the number of manufacturing processes and plants; accordingly it was sought already at a very early stage to use automatic data processing equipment (EDP) for this purpose, especially for complicated parts.

We must differentiate between different NC-programming methods (cf. fig. 13)*

<table>
<tr><td colspan="4">NC- Programming Technique</td></tr>
<tr><td colspan="2">without NC-programming language</td><td colspan="2">with NC-programming language</td></tr>
<tr><td></td><td></td><td>specific programmg. language or symbols</td><td>universal pr. language</td></tr>
<tr><td>desk calculators or commonly used calculator for special geometrical problems</td><td>programming stands (with small computer)</td><td>from small computers onwards</td><td>with large computers</td></tr>
<tr><td>Manual programming</td><td colspan="2">semi-automated programming</td><td>automated programming</td></tr>
</table>

Fig. 13: System of programming for NC-machines.

+) WOJDA, F./Hübner, H.: The Optimal Tool File Independent of Machine Types. Report of the Arbeitswissenschaftliches Institut (o. Prof. N. Thumb) of the Technische Hochschule Vienna, sponsored by the association of the machine and steel construction industry; Vienna, January 1971

3.2.1 Present Programming Methods

Of the enterprises with at least one NC-machine at the end of 1974

- 33 use manual programming : M
- 15 use semi-automated programming : SA
- 2 use automated programming : A

The two enterprises with automated programming belong to the Voest-Alpine combine and use the universal programming language EXAPT.

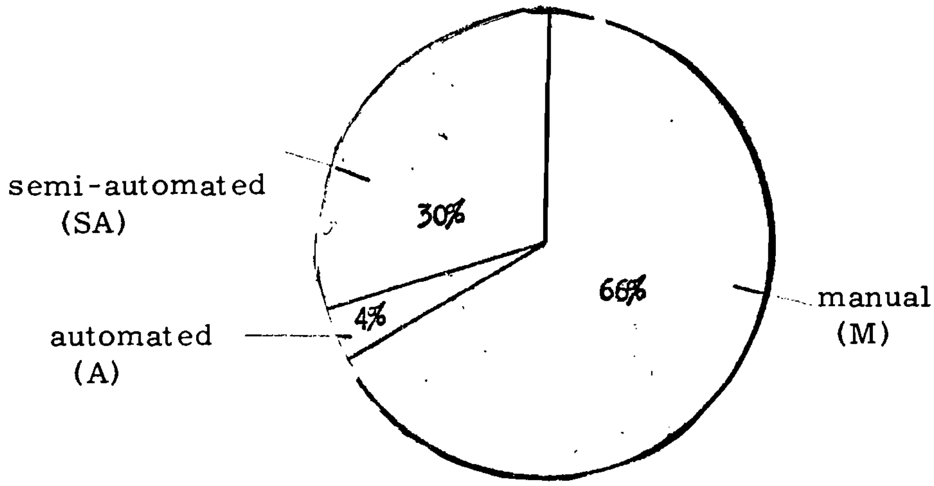


Fig. 14: Percentages of presently used programming methods.

The 15 enterprises with semi-automated programming use a total of 126 NC-machines (thus 30 per cent of the enterprises using NC-machines possess 45 per cent of all NC-machines employed), that is one enterprise has an average of 8,4 NC-machines.

3.2.2 Number of NC-Machines Operated by One Programmer

We determined the number of NC-machines to be operated by one programmer, as it seemed highly significant for our purposes. All enterprises concerned use their NC-machines <u>in double shifts:</u>

- manual programming : 1,9 NC-machines operated by one programmer
- semi-automated programming: 1,85 NC-machines
- automated programming: at present 4 NC-machines operated by one progr.

These figures are partly surprising, since one would expect the number of NC-machines to be larger with semi-automated programming than with manual programming.

The result shows the problems involved in a quantitative analysis of the automation of NC-programming, as with regard to the programming effort one has to differentiate between

- the effort for the initial programming of NC-machines and
- the effort needed for current NC-programming

The programming effort is generally lower in case of a relatively simple geometry of the part. The effort for current NC-programming depends largely on the share of repeated single-part production.

Above mentioned figures are only of value in showing that the question of automated NC-programming has to be treated with special regard to the particular production processes of the enterprise concerned and that initial and current NC-programming have to be strictly differentiated.

3.2.3 Number of New Programmes per Period

Again one has to differentiate between initial and current NC-programming; only 20 per cent of all enterprises were able to quote respective figures as well as figures concerning the average record number per programme. One enterprise quoted

200 programmes per year for a machine to be nawly purchased, if it is operated in 2 1/2 shifts(2 shifts and overtime).

The following figures were cited for current programming; all machines were operated in double shifts.

5 programmes /week
10 programmes /week

30 programmes/month
85 programmes/month
30 programmes/year
200 programmes/year
200 programmes/year (2 1/2 shifts)

There is agreement that, if concretely planned, a continuous programming schedule could be set up for initial and current programming.

3.2.4 Average Record Number per Programme

Only 7 enterprises were able to quote respective figures which varied between 10 to 1000 records per programme (20 + 400, 70 + 150, 10 + 1000, 20 + 400, 150 + 500, 70 + 120).

Therefore the number of programming records to be made per period seems to be of value for this survey with regard to initial as well as current programming.

3.2.5 Planned Further Automation of NC-Programming

27 of the interviewed enterprises with NC-machines plan further automation of NC-programming, namely
- 20 enterprises presently programming manually
- 7 enterprises presently programming on a semi-automated basis

3.2.6 Kind of Planned Further Automation

Above mentioned enterprises will analyse the following alternatives of further automation:

Abbreviations: MDP...... medium data processing
DTP....... data teleprocessing
OEDP...... EDP in the firm's possession

a) enterprises programming on a manual basis:

MDP	6 enterprises

MDP or DTP	: 3 enterprises
MDP or OEDP	: 2 enterprises
DTP	: 1 enterprise
DTP or OEDP	: 3 enterprises
OEDP	: 2 enterprises
not yet analysed	: 3 enterprises
	20 enterprises

b) enterprises programming on a semi-automated basis

DTP	: 3 enterprises
DTP or OEDP	: 2 enterprises
OEDP	: 2 enterprises
	7 enterprises

We see that at the moment about 12 enterprises are more or less concretely analysing, if a computer centre with teleprocessing may be effectively used for NC-programming.

Some enterprises presently analysing "MDP" or "OEDP" will also discuss whether "DTP" might be taken as an alternative. +)

Some doubts have been raised concerning the failure rate of data teleprocessing and a guarantee was called for.

In general no definite dates have been fixed for the introduction of more highly automated NC-programming methods; periods of 1 to 5 years were mentioned.

3.2.7 Assessment of Computer-Aided Calculation of Technological Data

This question was naturally answered only by enterprises with several years of NC-experience which programme partly on a semi-automated basis. The following answers were given:

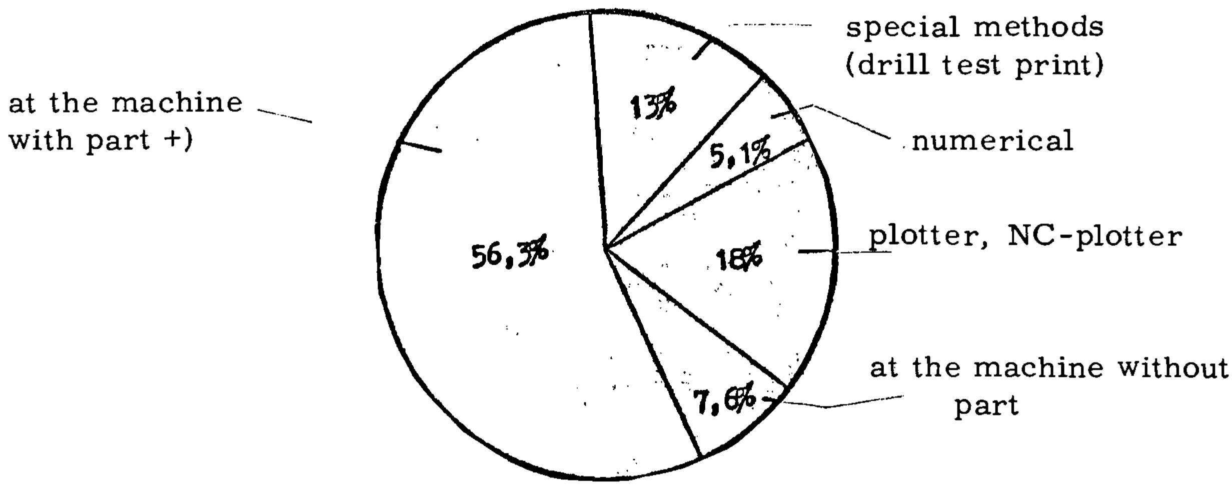
+) Annex 3 shows the respective enterprises

not important	5 enterprises
sceptical (high failure rate of OEDP, big organisational effort, varying material quality	7 enterprises
interesting if large number of NC-machines is used	2 enterprises
interesting for medium- and long-term planning	14 enterprises
necessary and useful	2 enterprises
	30 enterprises

Some enterprises pointed out that computer-aided calculation of technological data was also possible by means of medium data processing equipment.

3.2.8 Testing of NC-Programmes

The following methods are being used or planned:



+) i. a. in "unique record process" partly in the presence of the programmer

Fig. 15 shows the percentages of planned or already used tests for NC-programmes

3.2.9 Special Problems Encountered in NC-Technology

The fact that some enterprises have not encountered any particular problem when using NC-technology shows that the necessary organisational measures have already been taken and NC-technology has been fully integrated in the manufacturing process.

Some enterprises are concerned with special problems, such as follows:

- service (rapid changing of the electonic material used)	: 9 enterprises
- programming of machines controlled in 3 and 4 dimensions (rotary attachment)	: 2 enterprises
-wages for NC-personnel	: 2 enterprises
-organisational measures, in particular before introduction	: 9 enterprises

4. Final Remarks

It can be seen from this study that Austria's industry, in particular the group "general constructional engineering" makes full use of automation for single-part and series production by the use of NC-machines.

The enterprises with more than 10 NC-machines are ranged as follows:

1st :	GFM, Steyr	33 NC-machines
2nd:	Plasser, Linz	25 NC-machines
3rd:	Steyr, Steyr plant	15 NC-machines
4th:	Engel, Schwertberg	14 NC-machines
	together with Elin, Wien	14 NC-machines
5th:	Steyr, Vienna plant	13 NC-machines
6th:	Heid, Stockerau	10 NC-machines
	together with	
	Voest-Alpine, Zeltweg	10 NC-machines

GFM, Steyr has been in the lead since at least 1969.

According to the firm's statement more than 30 per cent of all machinery are NC-machines, this share will rise to about 40 per cent until 1979, and will amount to about 50 per cent in 1984.

Even when taking all branches of one combine together, GFM remains in the leading position, with Steyr-Werke being second with 29 NC-machines.

This combine also plans a considerable expansion of its NC-machinery. Voest-Alpine is third with a total of 24 NC-machines(in 6 plants).

It is remarkable that at present the Voest-Alpine combine is the one and only enterprise in Austria that programmes on an automated basis using the universal programming language EXAPT.

ANNEX I

	characteristics / data input media	decade switch	cross bar switch	data module	punched card	punched paper tape
1	techn. principle of data input	binarily coded switches	electr. line via diode plug	binarily coded plugs	punching, mechanically or optically sensed	punching, mechanically or optically sensed
2	data presentation	parallel	parallel	parallel	parallel	serial (serial-parallel transcriber necessary)
3	programming	sign by sign	bit by bit	sign by sign	bit by bit	sign by sign
4	is programming, locally and temporally independent of control possible	no preparation of pattern possible	no preparation of mask possible	no, if memory folio is used	yes	yes
5	programming/ is programme change of control possible	yes very simple	yes, very simple	difficult pulling of plug necessary	hardly	no
6	have non-used signs to be allowed for	not specially	no	yes because of soiling (e. g. "zero plug")	no	no
7	suited for repeated use as long-term store	no	no	yes	yes	yes
8	managableness as long-term store	----	----	rather unhandy	handy	handy as compact
9	effort for wiring	big	average	big	little	little
10	may assembly be separated from control	yes	yes	not recommendable	not recommendable	not recommendable, no
11	specially suited for the input of	small to medium-sized volumes of data	small volumes of data	small to medium-sized volumes of data	small to medium-sized volumes of data	medium-sized and large of volumes of data
12	main responsibility for the job flow	part production	part production	part production and preparation (PP)	mainly production planning (PP)	production planning (PP)

Comparison of various data input media for NC-machines.

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Questionnaire for NC-Study /Austria

A. NC-Machines

1) Total number of NC-machines
2) Distribution - production processes
   - type of control
3) Planned/already made purchases of further NC-machines in 1974
4) Trend of or necessity for medium- and long-term purchases of NC-machines (as exactly as possible for the next 2 to 5 years)
5) Long-term assessment of DNC- and CNC-systems.

B. NC-Programming

1) Presently used programming methods
2) Number of programmers
3) Number of new programmes per period (timing, use of NC-machines in single or double shifts)
4) Average record number per programme
5) Will semi-automated programming be introduced?
6) if yes - when ?
   - by means of firm-owned small computers
   - by firm-owned EDP
   - data teleprocessing via terminal
7) The value of computer-aided calculation of technological data
8) How are programmes tested, (presently/in future)
   - by plotter
   - at the machines (model)
   - other possibilities
9) special problems

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Industrial region Industrial group	Vienna area Lower Austria		Graz area Styria		Linz and Steyr areas		Remaining provinces	
1	Elin, Wien BBC, Wiener Neudorf Siemens, Wien	14 4 Ø	Elin, Weiz	6	Sprecher und Schuh, Linz	5		
2.1	Heid, Stockerau Krauss, Wien Zuckermann, Wien König und Bauer, Mödling	10 8 Ø 5	EVG-AVI, Graz	2	GFM, Steyr und Werk Ampflwang Dr.Linsinger, Steyrmühl	33 Ø	Maier und Co., Hallein	Ø
2.2	Haas, Wien Vogel, Stockerau Friedmann, Wien Garvens, Wien Leobersdorfer Maschinenfabrik	9 Ø 1 Ø 1			Engel, Schwertberg Plasser, Linz Dr.Fehrer, Linz Ochsner, Linz Rotax, Gunskirchen Eisenbeiss, Enns	14 25 Ø Ø Ø 2		
2.2 u. 2.3	Wagner Biro, Wien Alfa-Laval, Wien Stabeg, Wien Voith, St.Pölten Schoeller-Bleckmann, Ternitz Worthington, Wien Warchalowski, Wien	1 5 Ø 7 Ø 2 Ø	Wagner Biro, Graz MFA, Graz MAG, Graz Schöller-Bleckmann, Mürzzuschlag	4 5 Ø 2	Pöttinger, Grieskirchen Epple-Buchsbaum, Wels	Ø 2	Liebherr Austria, Bischofshofen Zimmer, Kufstein Zimmer, Klagenfurt Jenbacher Werke Haslinger, Kärnten	Ø 3 Ø 9 1
2.3	SGP, Wien 11 SGP, Wien 22 Hütte Krems Wertheim, Wien Freissler-Otis, Wien Sowitsch, Wien	7 1 2 1 Ø Ø	SGP, Graz Vogel und Noot, Wartberg VÖEST-Alpine, Liezen	2 Ø 2	IFE, Waidhofen/Ybbs	1		
2.1, 2.2 u. 2.3	Wiener Brückenbau (VÖEST-Alpine)	1	VÖEST-Alpine, Donawitz	Ø	VÖEST-Alpine, Linz Reformwerke Bauer, Wels	8 1		
3	Steyr Werke, Wien Gräf und Stift, Wien (ÖAF)	13 Ø	Steyr-Puch, Graz	1	Steyr Werke, Steyr und Oberösterreich	15		
4	Schiffswerft Korneuburg	Ø			Schiffswerft Linz	3		
5	Semperit, Traiskirchen Semperit, Wimpassing	1 Ø						
6	VMW, Amstetten und Berndorf	Ø	Böhler, Kapfenberg VÖEST-Alpine, Zeltweg Binder, Gleisdorf	3 10 2	VMW, Ranshofen	Ø	Eisenwerke, Sulzau Plansseewerke, Reutte	Ø Ø
7	Hörbiger, Wien Hübner-Vamag, Wien Swarovski, Wien Manner, Wien Eumig, Wien und Niederösterreich	5 2 Ø Ø 5	Böhler, Deuchendorf	5	Miba, Laakirchen	Ø	Friedmann und Maier, Hallein Tyrolit, Schwaz Schmiedl, Hall i.T. Simmer, Kufstein Voere, Kufstein Stubaier Werkzeugindustrie Tiroler Röhrenwerke, Hall i.T. Swarovski, Absam und Wattens	1 Ø Ø Ø Ø Ø Ø 8

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ANNEX 2

Objectives of the Research Project

"The Optimal Management of Production regarding the latest Developments in Information Technology"

a) Detailed system analysis for the sectors of an enterprise which comprise the "points of intersection" of the information flow (information - "a non-physical flow element") and of the "material sphere" (physical elements of the "system enterprise").

b) Analysis of inter dependencies (retroactive effects) of problems to be solved, particularly with a view to automated information processing.

c) Investigation into the applicability of terms/concepts and values/magnitudes in automated control technology in the description of informational relations of tasks, as far as this seems practicable.

d) Integration possibilities in solving problems.

e) Analysis and systematization of automation options and description of necessary "services" (EDP, programs) "auxiliary means."

f) Analysis of these options by means of facilities of programs without large storage requirements with a view of a later integration, specifically with regard to small and medium size enterprises, but also with a view to the use of these facilities as a possible first stage of integration of medium and large scale enterprises.

g) Investigation into a relation between integration and automation.

h) Investigation into a (quantative) relation between the number of ways of communication and the organizational stage of an enterprise.

i) Effects of automation and integration on the static and dynamic part of organization

j) Establishment of organizational prerequisites for the integration and automation of tasks and problems.

k) Derivation of an action plan for the execution of a step wise integration and automation.

The goals (results) of this research project can be described as follows:

1) Provision of facilities which allow for the (quantitative) description (evaluation) of the sectors of an enterprise mentioned above with respect to:-
    - the stage of automation
    - the type and stage of integration
    - the stage of organization.

2) Description and systematization of the stages of automation, integration and organization of a varying degree of feasibility.

3) Description and systematization of the necessary organizational prerequisites for the realization of stages.

4) Description of an action plan for the stepwise realization of given higher stages of organization, automation and integration.