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FUNCTIONAL HIERARCHY OF COMPUTER BASED MANAGEMENT SYSTEMS

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PREFACE

This paper has been prepared within the framework of IIASA's Management and Technology Research Area's activity on the research task of automated management systems. The material presented here is based partly on international experiences which were studied within the framework of IIASA's Integrated Industrial Systems Project and later as part of the Management and Technology Area.

The main purpose of this paper is to identify the activities of computer based management systems (CMS) and the environment in which they operate. The discussions (e.g., functional hierarchy for different managerial levels, hardware architecture, evaluation efficiency, etc.) show us the development and results from using the system, and also the problems connected with CMS implementation.

ABSTRACT

Computer based management systems (CMS) are characterized by a number of attributes: functional structure, data basis, technical tools, as well as the organization and implementation of design and efficiency. Each system operates in a particular environment: managerial levels, socio-economic systems, industrial sectors. This paper discusses the functional hierarchy of CMS for different managerial levels (e.g., technological unit or process, individual plant-enterprise, corporation sector, region, nation, international grouping), as well as the evaluation of the data base, the hardware architecture, and efficiency. Most of these problems are considered with respect to plan-oriented and market-oriented economies.

FUNCTIONAL HIERARCHY OF COMPUTER

BASED MANAGEMENT SYSTEMS

INTRODUCTION

The multilevel and multilayer hierarchical approach to CMS is implemented for the study and evaluation of different management and organizational problems [1]. This approach was used in the Integrated Industrial Systems Project control study in the steel industry at IIASA [2]. The different aspects of a hierarchical approach (for example, a planning hierarchy) in integrated control systems and the managerial-control levels were studied there.

This paper will discuss the functional hierarchy of CMS that could be implemented for different managerial levels, starting from CMS for technological unit control up to CMS for national planning and management levels.

Information processing plays an important part in various areas of society. In developed countries today the labor force employed in information occupations is greater than the labor force employed in industrial occupations (see Figure 1;[3]). Computer Based Management Systems provide one possibility of reducing the information problem.

To study CMS we must first describe the following three characteristics of the particular system we are working with:

- functional structure of CMS;
- data base of CMS necessary for decision preparations.
- technical tools--mathematical models, and algorithm soft ware, hardware structure, computers, periphery etc.

Two other very important characteristics of the CMS are

- design organization, implementation, and development of CMS;
- evaluation of CMS efficiency (economic, social, etc.).

CMS operate in a concrete environment: at a specific management level, in a specific industrial service or non-economic sector, in societies with different socio-economic systems. Let us present some examples of the environment.

At a specific management level, CMS can operate:

- technological unit of process;
- individual plant-enterprise (we define an enterprise as an integrated group of individual plants that make a concrete product);
- corporation;
- sector (e.g., industrial sector);
- region (territory);
- nation;
- international grouping.

CMS can operate simultaneously at one or several control-management levels.

In a specific industrial sector [4], for example, CMS can operate processes that are

- continuous (paper, steel, cement, chemicals);
- standard (household appliances, radio-electronic components);
- semi-standard (automobiles, machine tools, power transformers);
- job-shop (steam turbines, space vehicles, large motors).

CMS can operate not only in industrial sectors but also in social (service) sectors (education, health, etc.) and in non-economic sectors.

The functioning of CMS in particular operations depends in turn on the socio-economic system, and this can be

- plan oriented;
- market oriented;
- mixed.

These attributes lend themselves to several different approaches when studying the problems of CMS. Studies could be organized as comparisons, state-of-the art surveys, or as mathematical modeling methods, etc.

To summerize these attributes of CMS, let us create a "Space of Attributes" that characterizes CMS itself as well as its environment (see Fig. 2).

Now let us discuss the functional hierarchy of CMS from the technological unit control level to the national level, CMS implementation in different socio-economic systems, and also some aspects of CMS development and evaluation.

TECHNOLOGICAL UNIT OR PROCESS CONTROL LEVEL

The complexity of modern technology, the complex criteria to be optimized and measurement difficulties all make control tasks at the technological unit level very difficult. These difficulties very often do not allow for classical feedback systems. The open computer system, which is working in the dialogue regime, is used in this level. Function analysis at this level can be made from the hierarchical approach viewpoint [5].

Let us take steel production process as an example. We should mention that the steel industry was one of the first industrial sectors in which computers were implemented in the 1950's. The main goal of steel production processing in basic oxygen furnaces is to organize the process control (oxygen value, addition, blast tuyere height, etc.) in order to bring several process parameters simultaneously to a desired point, thus optimizing several criteria (time, cost, etc.) Additional resources are necessary without this optimization.

The control and management of these production processes are based on computer systems that include two subsystems, i.e. dynamic and static. Each computer subsystem can operate independently or as a part of an integrated CMS. The dynamic system is a closed feedback system that presents the possibility of controlling process variables. The static system is a more widely distributed system. The main function of these systems is to prepare decision making alternatives for the operator. On the basis of the results obtained from this system it is recommended that the operator control the processes manually.

Fig. 3 shows the results of implementing static and dynamic computer systems in comparison to the results of the operator's work. With the operator manual process control about 50% of the amount of steel smelted has a permissable carbon value. With the implementation of static computer systems this percentage is increased to approximately 70% and with dynamic computer systems to about 90%.

INDIVIDUAL PLANT-ENTERPRISE AND CORPORATION CONTROL LEVELS

These two management levels carry out the following functions:

- production control (complex operational processes and procedures, provide real time information to meet departmental needs for disposition purposes, etc);

- planning on different time scales (short-, medium-, long-term strategy, etc);

- technical/scientific and economic specialized tasks, etc.

These functions are considered together with process control systems as an integrated control system. The concept of design implementation and evaluation for the individual plant-enterprise level is developed very well. There are numerous examples of these functions that are in operation in various industrial enterprises.

The management level structure is implemented for multilevel (three or four levels) concepts. In Fig. 4 the August Thissen Hutte Steel M.B.H. (FRG) three-level CMS development concept is shown.

If we consider the functional structure of CMS in various socio-economic system environment, we will discover more similarities than differences. CMS's that are implemented in both plan-oriented and market-oriented systems carry out process control, scheduling, planning, etc., but there are disparities in system functionings.

Let us consider as an example the planning function in plan- and market-oriented systems. This function could be presented as shown in Fig. 5. There are disparities in the planning procedure at the entire plant level, and examples of these can be found in Fig. 6. There is a direct customer-production connection in market-oriented systems (Order Type A). This order type is possible, but not typical, in a plan-oriented system. A sophisticated example is shown in Fig. 6 where the customer sends an order to his Ministry X, which in turn sends the order to the State Planning Committee or another administrative authority that summarizes the orders from various sectors, enters them, and presents the plan to Ministry Y, which should produce a concrete product (Order Type B). There are a number of other possibilities, i.e. the order does not necessarily have to go through a State Ministry, but could also go through a regional or local planning authority.

Other particular features are considered in Fig. 7. For both the plan-oriented and market-oriented systems a typical feature is the increase in uncertainty as planning intervals are increased. But this uncertainty increases more rapidly in the market-oriented systems; it is a larger field of change. Another feature that can be seen in Fig. 7 is the loading of capacity. For the plan-oriented economic systems the 100% loading of capacity is more typical; for market-oriented systems the loading can fluctuate within broad limits.

It is necessary to discuss very briefly another aspect of CMS, namely hardware hierarchy. There are different approaches to the build up of hardware architecture.

Fig. 8 illustrates the "ideal hardware structure" which conforms to the CMS functional structure. The term "ideal" is a voluntary term, of course. The hardware structure depends a lot on real factors: production and management structure of enterprises, financial position, implementation time scale, etc., because there are numerous hardware structures in enterprises.

Concluding this section, it is necessary to stress that these levels are practically the highest levels planned for and are more or less independent in market-oriented countries the enterprise level and the corresponding CMS could be a subsystem of a sector, either a regional or a national CMS.

SECTOR CONTROL LEVEL

Sectors represent general economy units in the planned-economy countries. The sector's management development concept and corresponding CMS is one of the more important tasks of a plan-oriented country. There are a number of good examples of sector CMS (SCMS) in the CSSR (steel and heavy industry, mechanical engineering, mining and coal, agriculture), in Poland (coal and automobile industries), in the USSR (instrument and steel industries). Let us consider the functional structure of SCMS that has been developed in the USSR.

The following are main objectives of SCMS [6]: Optimal management sectors (planning development, allocation, etc.) on the basis of economics, mathematics, and administrative methods, as well as computer implementation. These objectives are achieved by means of information collection, transmission, and processing of design on sector levels and transmission of this design to individual plants, enterprises, and institutions, as well as local regional authorities.

All subsystems, that are included in SCMS, can be grouped as follows:

- planning (operating and perspectives);
- sectors development management;
- material-technical supply;
- planning and control of work;
- payment and labor force;
- research and information.

The following typical subsystems are included in SCMS:

- prospective development and location of sectors;
- techno-economic planning and analysis;
- operating control;
- material-technical supply;
- data compilation management;
- sales management;
- finance;
- bookkeeping and accounting;
- planning and analyzing the labor force and wages;
- planning and accounting for labor force and principal personnel.

Part of this subsystem is typical for corporate CMS [7]. Let us consider some subsystem functions in more detail.

<u>Prospective Development and Location of Sectors</u>.

The main function of the subsystem is to supply the optimal sectoral development version based on long-term (15 years), middle-term (5 years), and short-term (1 year) plans. There are differences in planning horizons, i.e. if in a one year plan there is only one design, the middle- or long-term plans (5 or 15 years) should have several alternatives and include maximal and minimal indices.

In this subsystem the following problems should be solved:

- calculating prospective demand (including export) in sector production;
- calculating different versions of development and allocation in sector enterprises and plants, analyzing these versions and choosing design;
- recommending development for improving the economy and technique of production sectors.

The sector's information flow is shown in Fig. 9 in a simplified form. The information connecting the prospective development and location PDALP and other subsystems are shown in Table 1.

<u>Operating Control Subsystems</u>.

The main objectives of this subsystem are real time operating and management of sectors, enterprises and individual plants. There is a constant flow of information from sector

Table 1.

Subsystem	Input to PDALP	Output to PDALP
Techno-economic planning and analysis of economics	Analysis of production-economic results of sector	Prospective demand of sector production Investment cost Out-of-action unit costs Allocation and specialization of sectors' enterprises
Operating control	Capital construction plan fulfilment	Capital construction plan
Material-technical supply	Material resources demand	Plans for research, design work and capital construction
Compiling	Compiling units demand Connecting customer-producer	
Finance	Finance task (benefit value, deductions)	General funds for putting into operation
Planning and analyzing labor and wages	Number of personnel Wages Monthly wages Productivity per employee	
Planning and accounting labor force and principal personnel	Number of workers and engineering personnel	New enterprises location plan

enterprises and individual plants to and from the Ministry (see Fig. 10). There are two possibilities for this information flow:

- the large scale enterprises send information directly to the main sector's computer, or,
- middle-scale, small enterprises or individual plants send the information to the regional computer center.

The regional computer center's task is a preliminary processing and sending of information to the main sector's computer center. The regional computer center is not only responsible for fulfilling operating management tasks, but also processing information for local authorities or governments, who choose the designs.

It is necessary to give some characteristics of the information that is gathered and processed in SCMS. The frequency of transmitting information from enterprises to the sector "CMS Instrument", that has been developed and accepted for Ministry of Instrument Making, is

- product sales (daily);
- product shipment (every 5 days);
- export product shipment (every 5 days);
- production and supply of the most important products (every 10 days);
- capital construction's value (monthly);
- expecting benefit (monthly);
- need of materials for a given month (monthly);
- need of materials for next month (monthly);
- number of employees, etc. (monthly).

The whole value of the sector's information is gathered and processed in the main sector's computer center. This information can be quantitively characterized as shown (in millions symbols) [6] in Table 2.

SCMS, some characteristics of which have already been given, is one of the different hierarchical levels of the national CMS. This is developed in a number of countries with plan-oriented economies. This function is considered below using the National CMS of the USSR as an example.

Table 2

Volume of processed information (yearly)	250-750
Input information (during year)	100-300
Peak volume of processed information (daily)	4-20
Peak volume of input information (daily)	1-2
Conventional-constant information in main computer center	200-550
Total volume output information	350-450
Peak volume of output information	2-3
Peak number of computer operations (daily)	10^9-2.10^9

NATIONAL CMS (NCMS)

The development of the general concept of National CMS was started in the USSR several years ago [8]. Several versions of CMS were developed, one of which uses a four level concept, shown in Fig. 11 [6].

The first level of the NCMS includes information systems of all the state's committees and ministries. The 75-80 CMS for all-union ministry and the 15-17 CMS for all-union organizations, state committees, Gosplan, etc. are being planned through to 1980. Some CMS for the ministry and state committees have already been started. The function of the SCMS has been mentioned above. One of the computer centers at this level (i.e., Gosplan) should play the role of head computer center in the NCMS. Another possibility is to organize special computer centers to carry out these functions.

The second level of the NCMS is included in the CMS of the various republics. At present the development of CMS has been started in the 15 republics of the USSR.

The third level of NCMS is a regional CMS (RCMS) whose main functions are

- to gather and process the information from all enterprises and other organizations in the region; in this sense RCMS plays a major role as a collective computer center;

- to secure the linkage between the lowest level of SCMS and the second NCMS level of the various republics;

- to be able to take over for the highest level computer.

The 200 RCMS will be planned through to 1990. The number is determined by the administrative units in the USSR, of which there are 143. The last 57 RCMS left will become plans for more industrialized regions of the USSR.

The functional structure of NCMS reflects the combination of sectors and regional management principals. The planning of sector development, which was made on the basis of intersectoral input-output models took into consideration the interests of both sectors and regions.

In the operating phase, part of the information (fulfilling the most important orders, exports, etc.) is sent directly to or through the RCMS to a corresponding ministry. Another part of the information, which for example characterizes social infrastructure, is sent to the regional and republic CMS's and helps the authorities to arrive at a decision.

The organizational structure of CMS in the USSR is based on three state systems:

- state computer network;
- standard state communication system;
- standard state data transmission system.

For the time being the state computer network is based on the "Rjad" system that was developed by the CMEA countries. Fourth generation computers should probably be employed for the NCMS. A second system secures communications between computers, and a third system performs two functions: data collection multiplexing and information transmission to other managerial levels.

The development of a NCMS demands the solution of a large number of different problems. For example, the information that is circulated in the production sphere of the USSR is estimated at the value of 2×10^{13} bits/year. It is necessary to implement a modern information communication network that has the possibility of increasing the speed of information transmission to 48,000 bits/sec or more, which is beyond the standard telephone speed of 4,800 bits/sec or telegraph's 200 bits/sec.

Fig. 12 shows the hierarchy of computer systems in the USSR and the development of these systems. At the moment there are about 3,000 computer centers in the USSR. During the last five years (1970-1975) 700 computer based systems for technological unit or process level and 1,800 CMS's for the enterprise level were put into operation. Twenty-six CMS's for all state committees and ministries and 57 for the republics are partly in operation and should be completed within the next five years. The 22 large regional computer centers will be organized in the five year period also. The number of regional computer centers should be 200 by 1990. Fifteen CMS's at the republic level are partly in operation and should be ready by 1980. Most of these systems should be integrated in the NCMS which should be ready about 1990.

SOME QUESTIONS OF IMPLEMENTATION AND EVALUATION OF EFFICIENCY

The organization of CMS implementation, particularly the integrating of various managerial level demands and systems considerations, contains many factors. There is much experience in design and implementation of CMS for technological unit control and plant and enterprise management, but there is less experience in design and implementation of CMS for sector, regional, and national levels. Integrating CMS for the various managerial levels is a most difficult problem.

Speaking about the design and implementation of CMS it is necessary to stress that the time factor in CMS concept development depends very much on experiences in the field (Fig. 13). In our example 32 firms are considered that belong to the continuous and semi-standard industrial sector processes and are shown. The 20 enterprises that started to develop the CMS concept before 1970 required an average of 4.1 years until "fully operational," but the 12 enterprises that started after 1970 have required only 1.75 years. Of course, the concept "fully operational" is a voluntary term. It is often reasonable to consider CMS as a developing system that is adapted to the special conditions of the enterprises and improved and changed.

Another important aspect of CMS is the evaluation of its efficiency. It is necessary to understand this term in a broad sense. The efficiency of CMS should be evaluated from the social as well as the economic side, particularly with regard to-top level management: corporate, sectoral, national. For these levels it is very difficult, even impossible, to find the quantitive economic indicies.

The general advantages of CMS implementation are well known [7]:

- more timely information;
- creates a facility to carry out managerial functions;
- improved decision making;
- more effective use of manpower and facilities;
- prompt communication;
- very little need to recreate data;
- elimination of peak period volume reports;
- prompt correction of out-of-control conditions (management by exception).

Considering the different levels of hierarchical structure, it is possible to unite them in two spheres: production and management (see Fig. 14).

Evaluation of economic efficiency is based on cost-benefit analysis and includes first of all the cost of CMS itself. CMS implementation gives some direct benefit in the production sphere: increased productivity, conservation of resources, etc. For example, the implementation of CMS in one steel company in Japan produced the following results:

- 30% reduction of employees and reduced planning and scheduling and technical departments;

- 10% increase in slab surplus with improvement of planning accuracy;

- 20% shortening of order lead time;

- 30% improvement of yield (by precalculation of the optimal sizes for ingots and slabs);

- uniformity of quality and decrease accuracy and reduction of the management cycle.

In a modern steelworks equipped with an integrated control system (in Japan), for example the annual productivity per employee is approximately 750 tons of steel. In steelworks that do not have such a system the productivity per employee is 300 tons (Europe).

The estimating of economic efficiency for the managerial sphere is most difficult. For example, in the USSR alone there are several different methods of calculation. The general point is that of the economic benefit of CMS's implementation at different levels should be found in the production sphere.

Table 3 shows some results of the evaluation of economic efficiency, some data concerning computer implementation in the USSR, and some techno-economic results [6,9]. For the last five year period, in the 700 CBMS's that are in operation at the process-control level, the average period to recover cost was three years. For 1,800 CMS's that are operating at the individual plant-enterprise level the average cost of the one system decreased during the five year period from 0.70-0.90 to 0.35-0.40 million rubles. The expenditure period covered was 2.0-2.5 years. The average cost of SCMS was reduced from 1.8 to 1.2 million rubles. The main reasons for the decrease in cost include the standardization of software and hardware, greater experience, etc.

Table 3. Economic efficiency of SCMS (millions of rubles).

SCMS	Cost of the Systems	Benefit in Year.
"Instrument" (10 subsystems)	5.90	12.00
Electrical engineering industry (4 subsystems)	1.55	0.22
Road building industrial engineering (4 subsystems)	1.80	2.60

The total cost of computer facilities is shown in the first line of Table 4. The cost of NCMS itself is estimated at about 5-7 billion rubles. This evaluation is based on the cost of up-to-date technology. This is the reason these costs should be considered as tentative.

An attempt to estimate the efficiency of CMS implementation for the whole country was made. The total benefit for the five year period (1971-1975) is estimated at about 1.8 billion rubles [9].

Fig. 15 presents some qualitative characteristics of the managerial heirarchical structure. The concept of development and implementation of CMS is made in both plan-oriented and market-oriented countries. In plan-oriented countries more attention is paid to the highest level of hierarchy: sector, region, nation. When considering the hierarchical structure from the lowest level upward, we can see that the capacity of some attributes increases, e.g. the time intervals necessary for planning and decision making, model aggregation, part of special tasks, etc. On the other hand it is possible to see a reduction in other functions: direct control functions that characterize technological units or process level and the real time implementation. This qualitative characteristic of CMS can aid in a better understanding of the hierarchical structure of CMS.

Table 4. Some characteristics of computer implementation in the USSR

		1971	1975	1990
National	Cost of system millions of rubles	880 (Total)	2,400 (Total)	$5\text{-}7{:}10^3$ (NCMS)
Sector	Number of CMS		83	
	Average cost of 1 System (in millions of rubles)	1.8	1.2	
Individual Plant-Enterprise	Number of CMS		1,800	
	Average cost of 1 System in millions of rubles).	0.7-0.9	0.35-0	
	Recovery of expenditure period in years	2.0-2.5		
Automated Technological unit control	Number of CMS		700	
	recovery of expenditure period in years	3,0		

CONCLUSION

Study of the functional hierarchy and the different attributes of CMS shows the tendencies in the development and results from using the system, and also the problems. The approach that is implemented by the CMS concept of development is reflected in the environment in which CMS is operating: managerial levels, socio-economic systems, industrial sectors, etc. In both plan-oriented and market-oriented countries the general CMS concept for the technological unit or process-individual plant-enterprise levels has developed. In plan-oriented countries this concept is also developed for sectoral, regional and national levels.

One of the important attributes is efficiency of CMS implementation. Evaluation of efficiency should be made in social and economic fields. Some CMS implementation data, based on cost-benefit analysis in production and managerial spheres, show the economic advantages of CMS application.

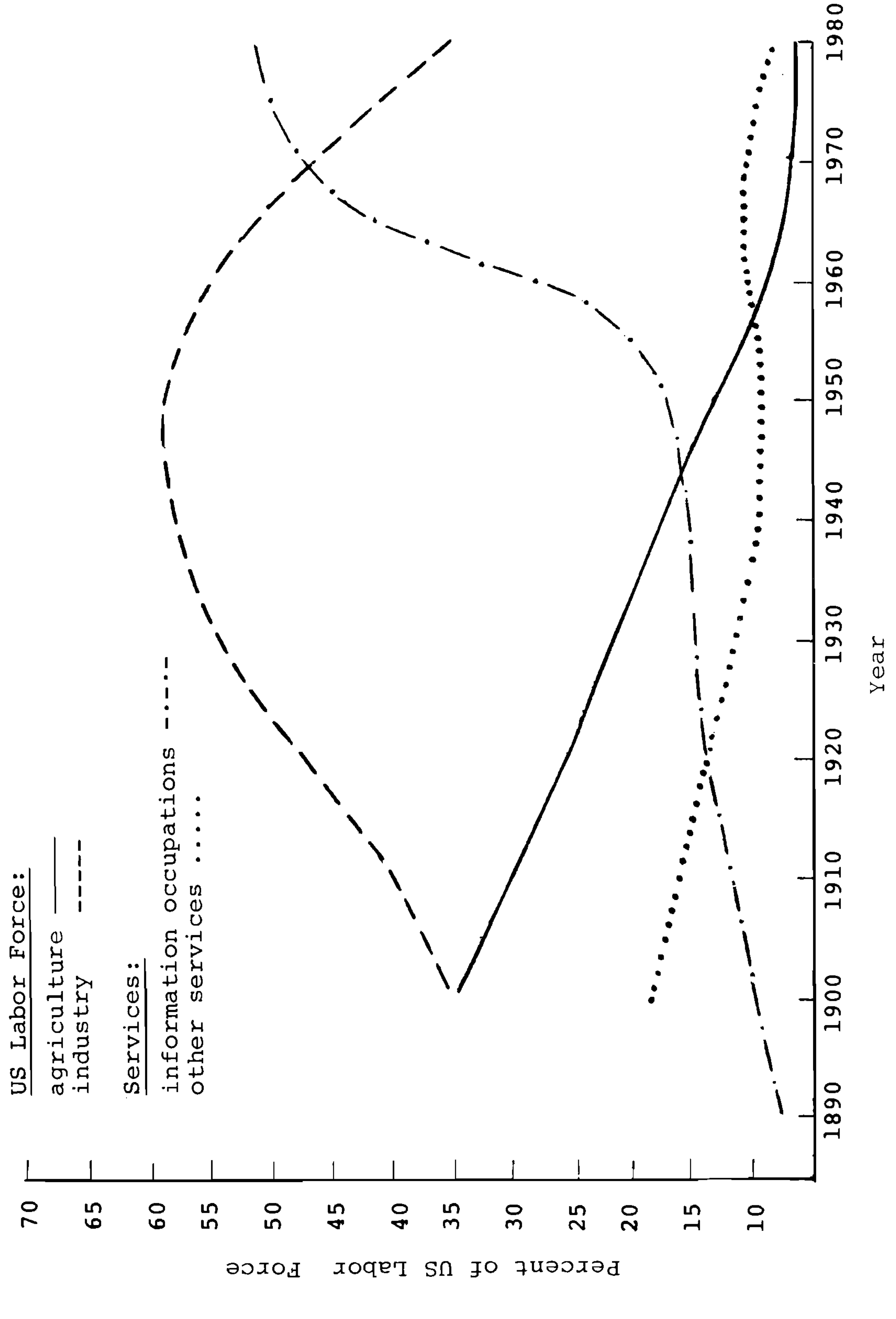

US Labor Force:
agriculture ——
industry - - - -
Services:
information occupations -·-·-
other services ·····
Percent of US Labor Force
70
65
60
55
50
45
40
35
30
25
20
15
10
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
Year

Figure 1

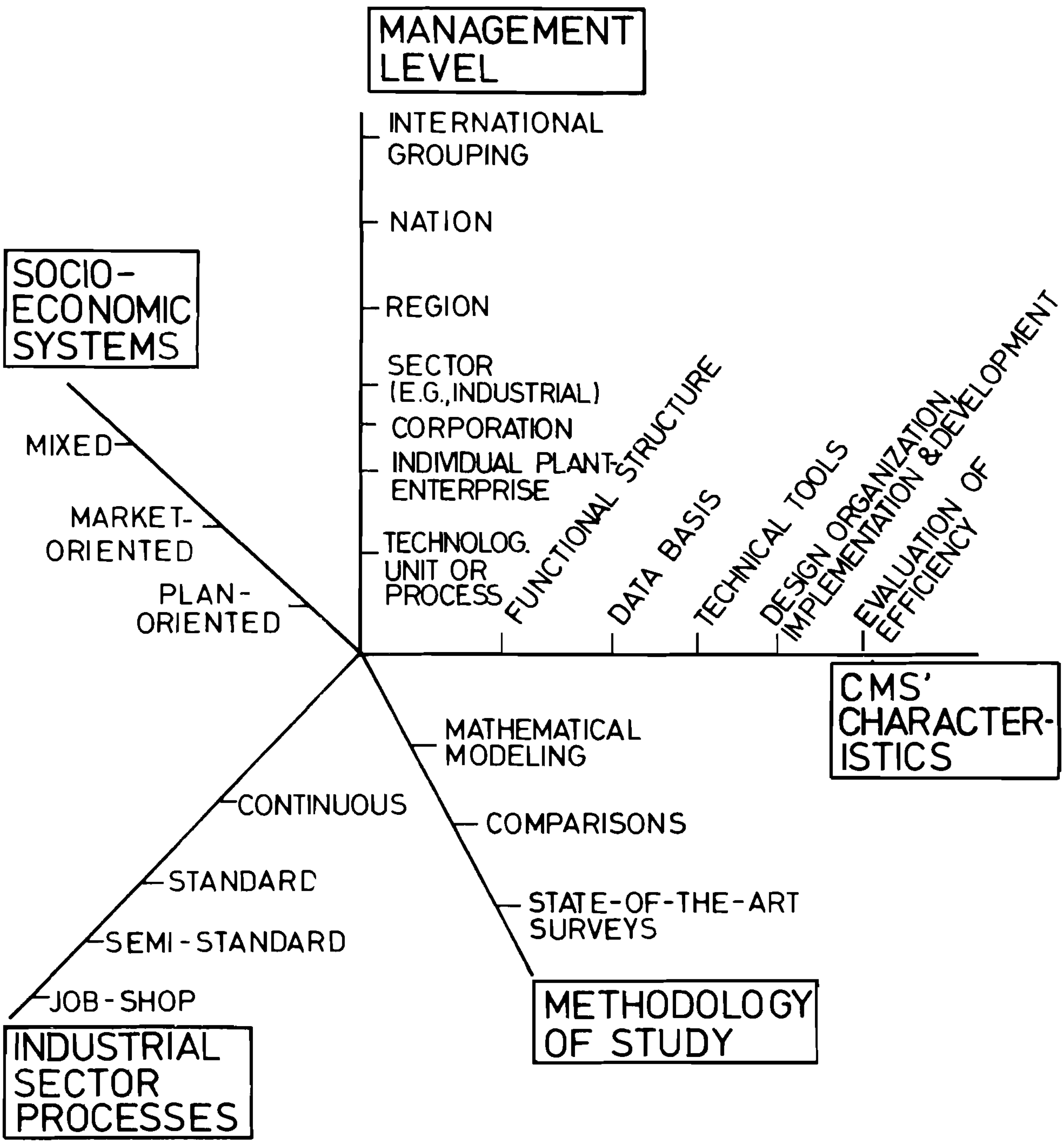


FIGURE 2

SPACE OF ATTRIBUTES FOR CMS

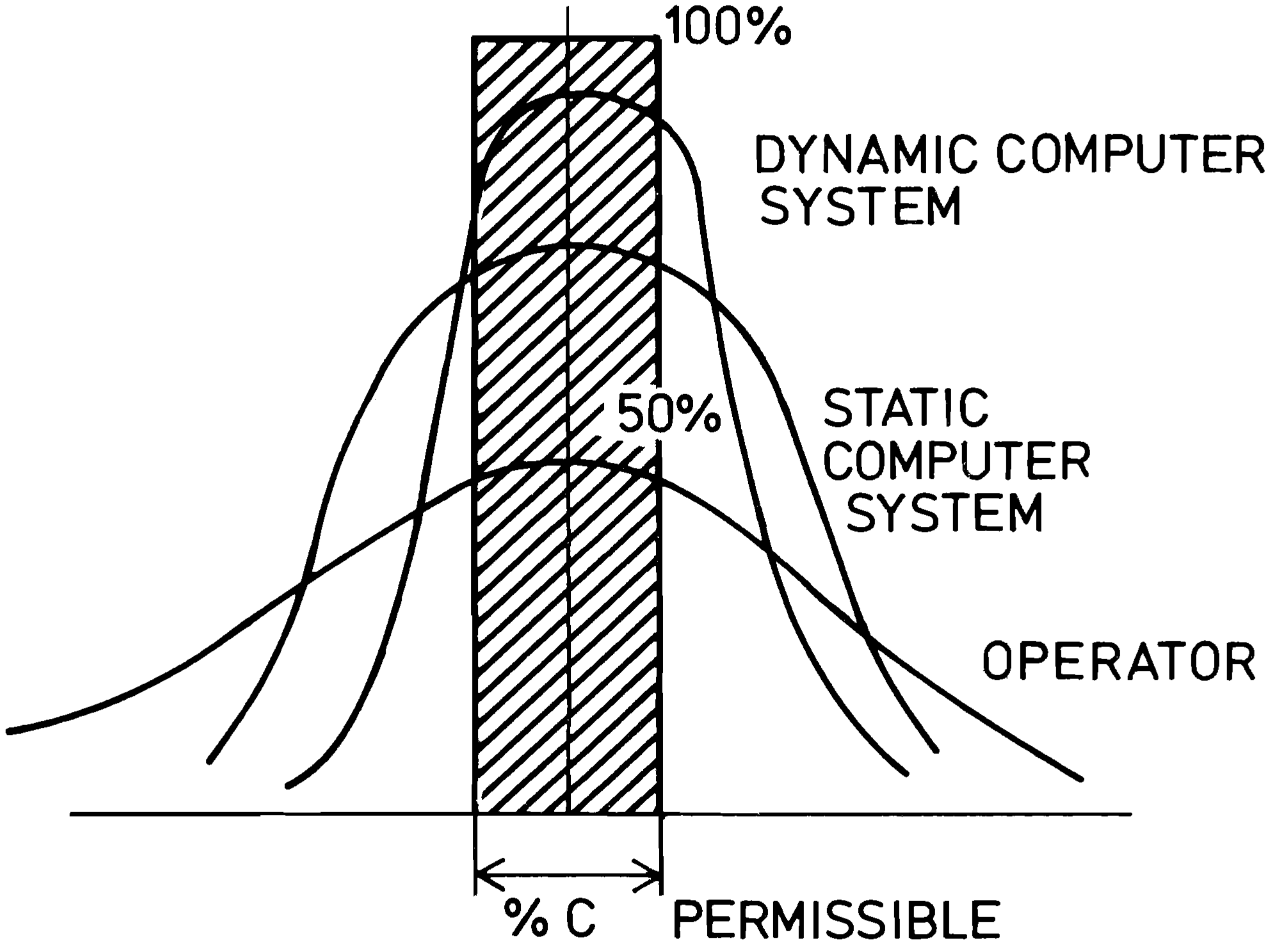

100%
DYNAMIC COMPUTER SYSTEM
50%
STATIC COMPUTER SYSTEM
OPERATOR
% C PERMISSIBLE

FIGURE 3.

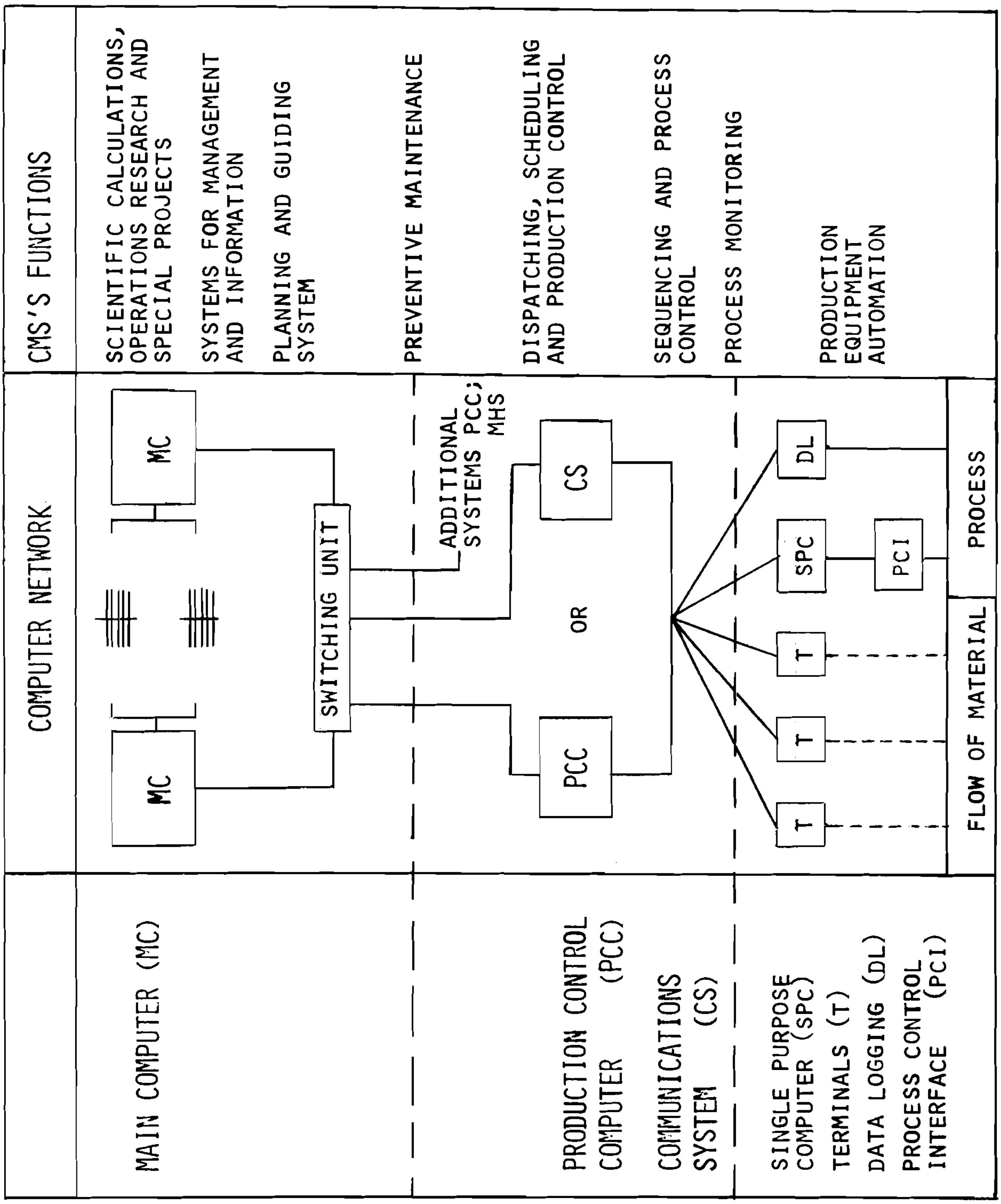

CMS'S FUNCTIONS
COMPUTER NETWORK
SCIENTIFIC CALCULATIONS, OPERATIONS RESEARCH AND SPECIAL PROJECTS
SYSTEMS FOR MANAGEMENT AND INFORMATION
PLANNING AND GUIDING SYSTEM
PREVENTIVE MAINTENANCE
DISPATCHING, SCHEDULING AND PRODUCTION CONTROL
SEQUENCING AND PROCESS CONTROL
PROCESS MONITORING
PRODUCTION EQUIPMENT AUTOMATION
MC
MC
SWITCHING UNIT
ADDITIONAL SYSTEMS PCC; MHS
CS
OR
PCC
DL
SPC
PCI
T
T
T
PROCESS
FLOW OF MATERIAL
MAIN COMPUTER (MC)
PRODUCTION CONTROL COMPUTER (PCC)
COMMUNICATIONS SYSTEM (CS)
SINGLE PURPOSE COMPUTER (SPC)
TERMINALS (T)
DATA LOGGING (DL)
PROCESS CONTROL INTERFACE (PCI)

Figure 4

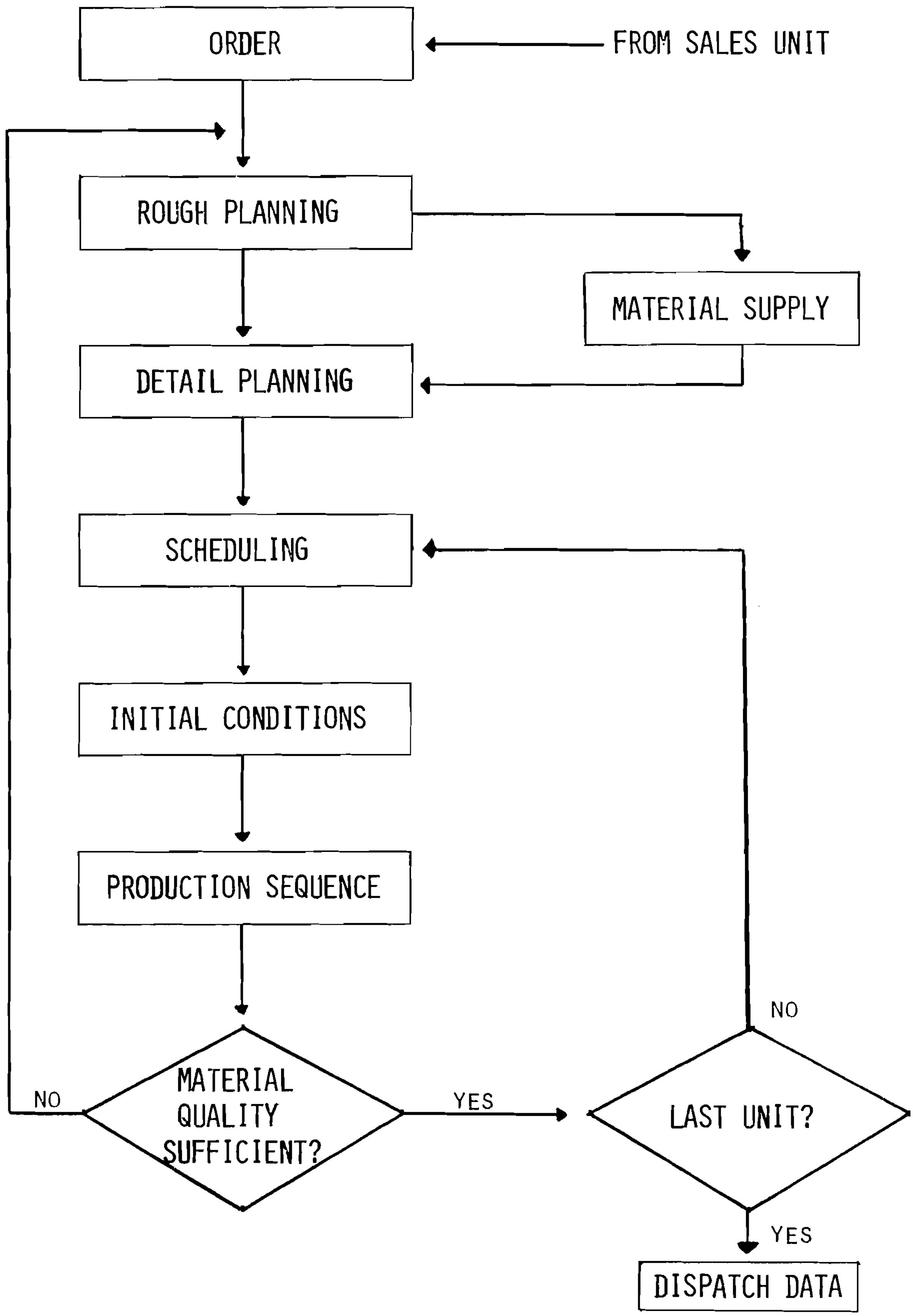


Figure 5. Planning Functions

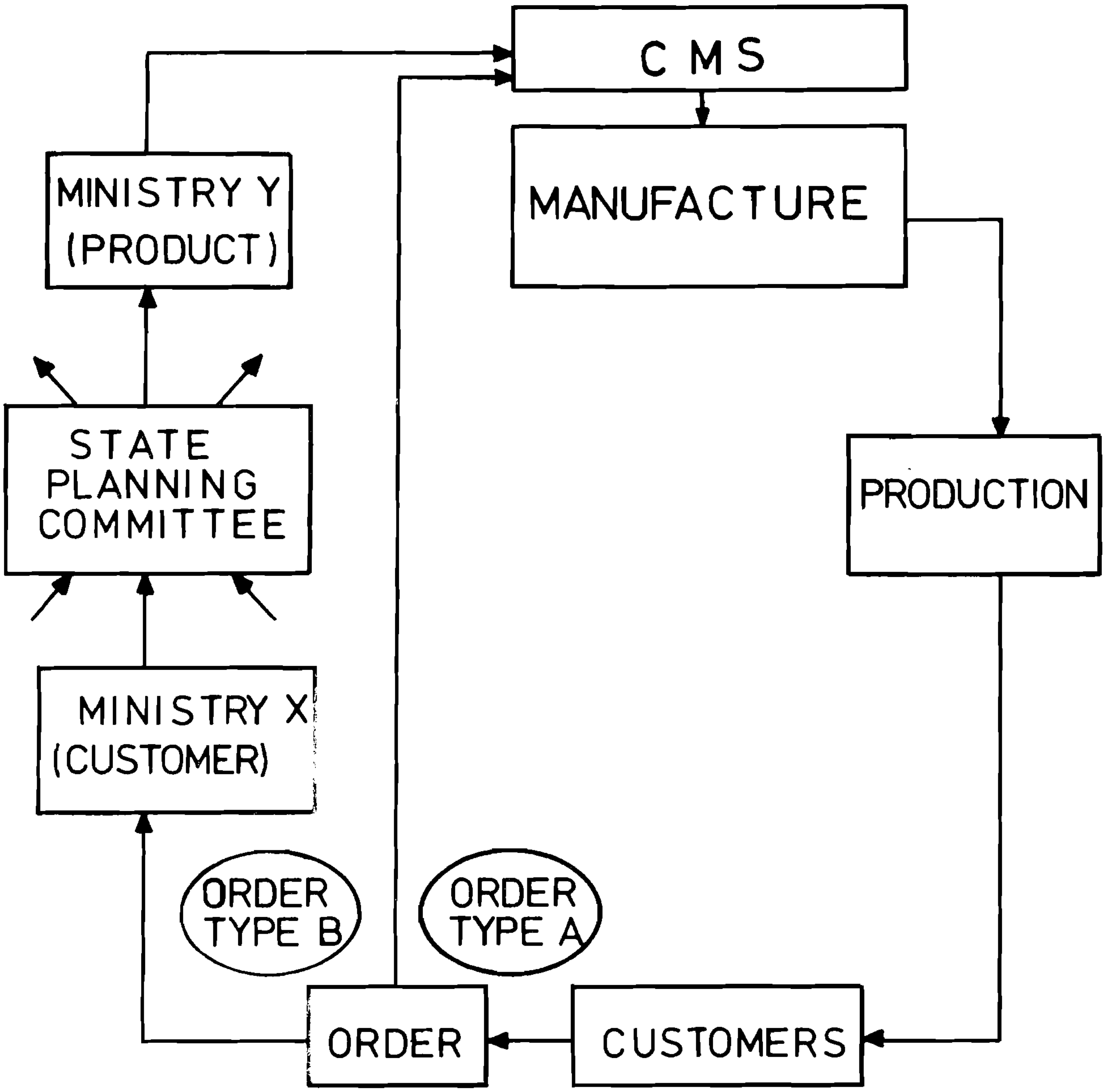

C M S
MANUFACTURE
MINISTRY Y
(PRODUCT)
STATE
PLANNING
COMMITTEE
PRODUCTION
MINISTRY X
(CUSTOMER)
ORDER
TYPE B
ORDER
TYPE A
ORDER
CUSTOMERS

FIGURE 6

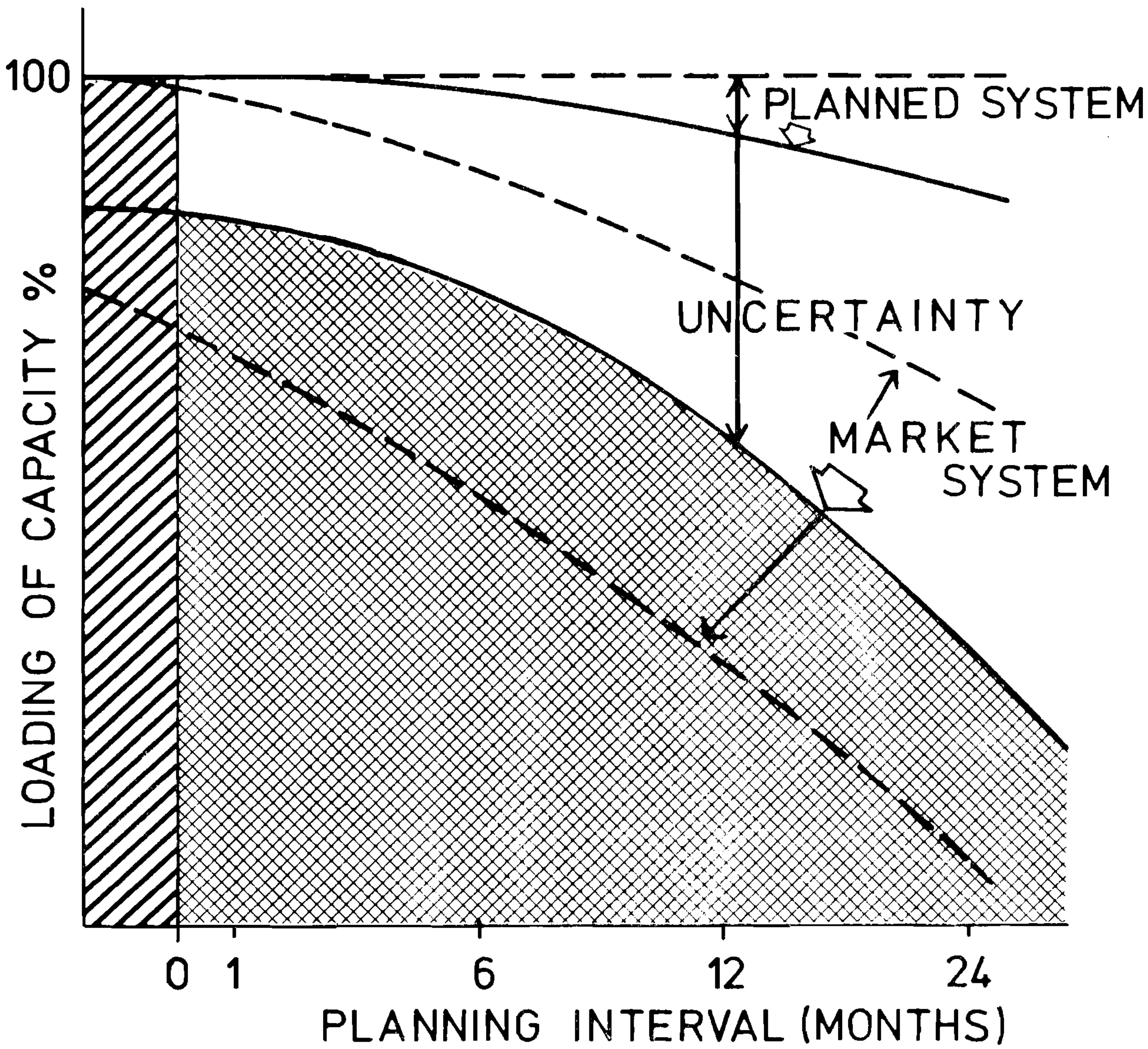
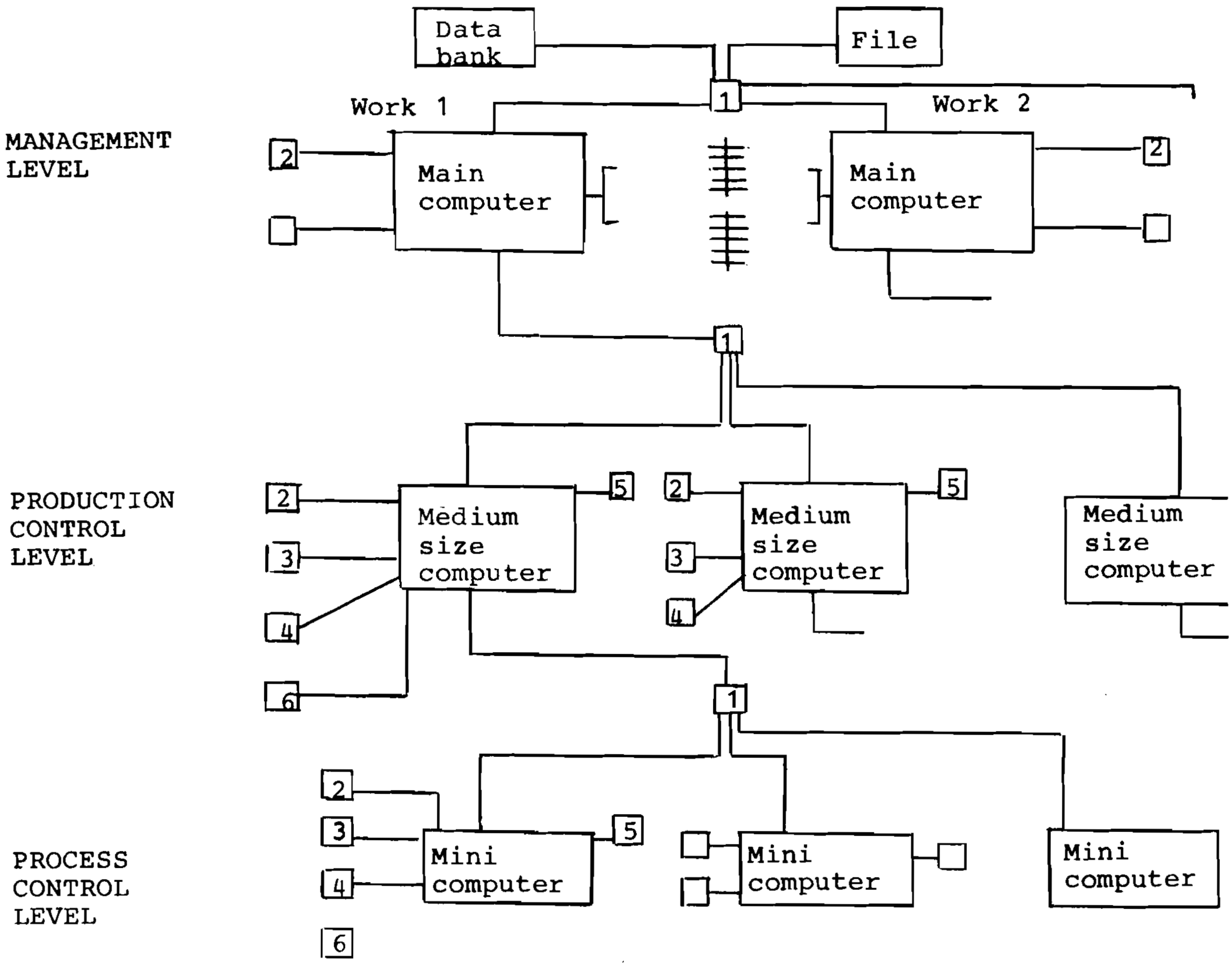

100
PLANNED SYSTEM
UNCERTAINTY
MARKET
SYSTEM
LOADING OF CAPACITY %
0
1
6
12
24
PLANNING INTERVAL (MONTHS)

FIGURE 7.



1 - Switching system

2 - Terminals

3 - Cards - and paperreader

4 - Specialized manual

5 - Input devices indicating panels

6 - Sensors

Figure 8 "Ideal" hardware structure

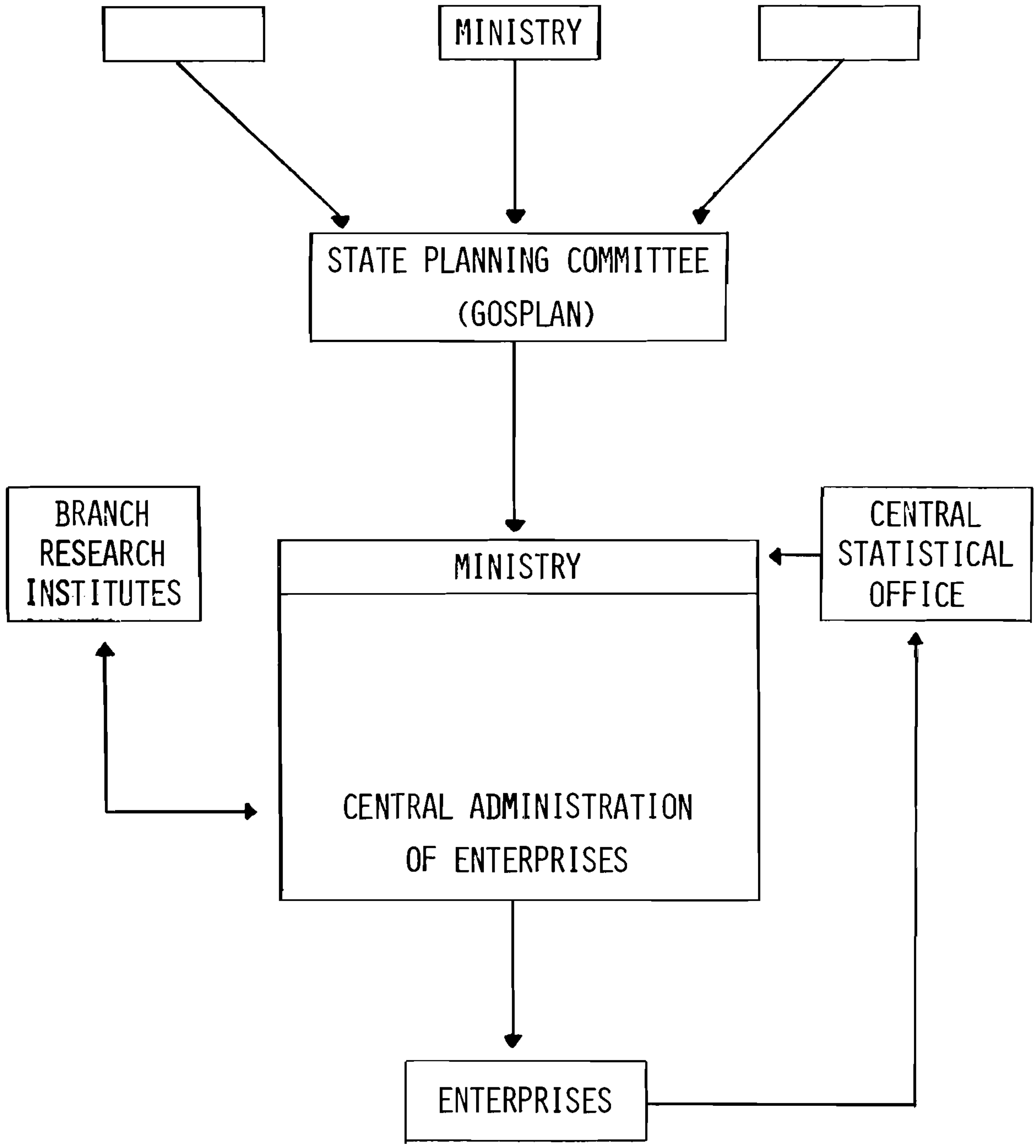


Figure 9 Planning of Perspective Sector Development

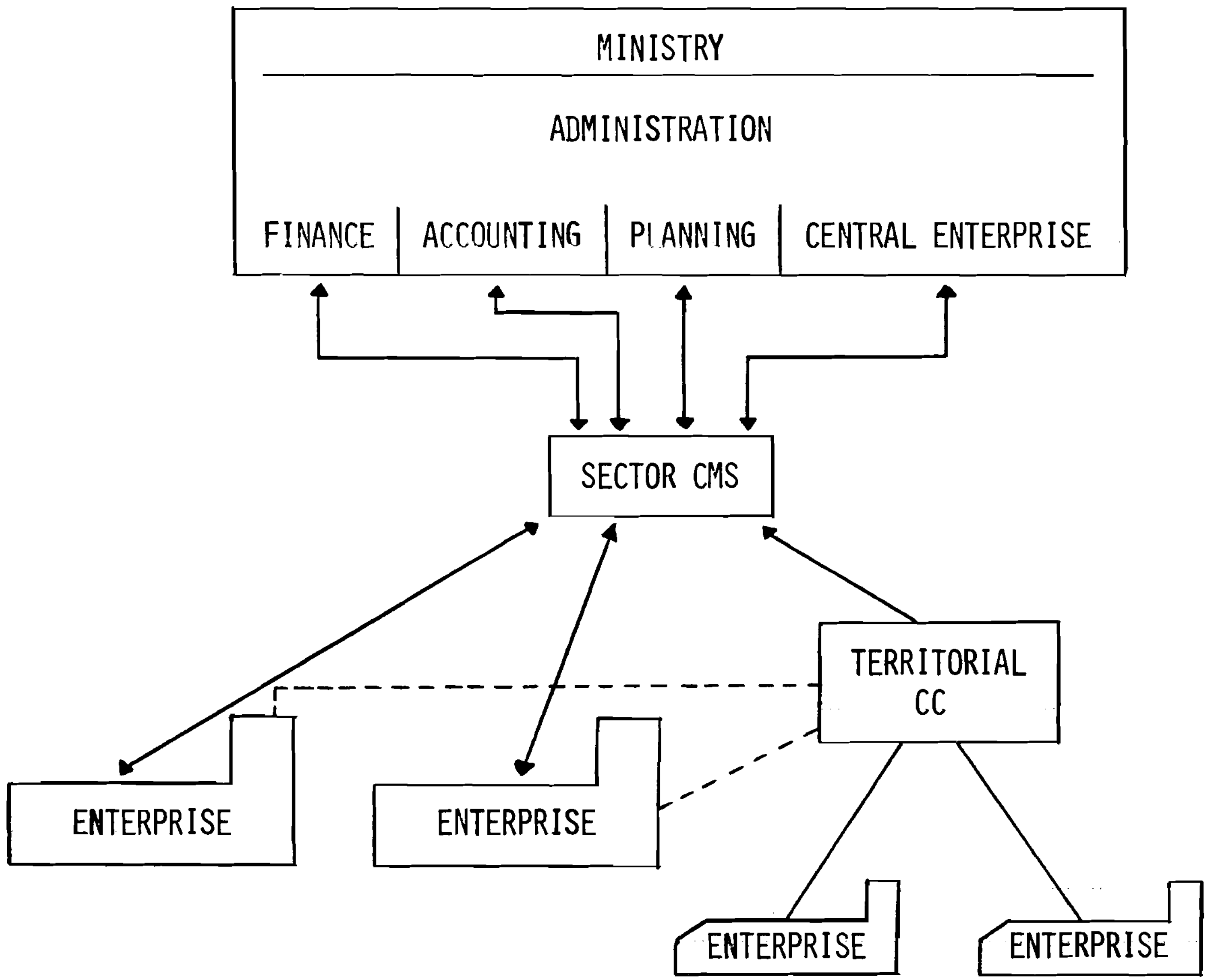

MINISTRY
ADMINISTRATION
FINANCE
ACCOUNTING
PLANNING
CENTRAL ENTERPRISE
SECTOR CMS
TERRITORIAL CC
ENTERPRISE
ENTERPRISE
ENTERPRISE
ENTERPRISE

Figure 10

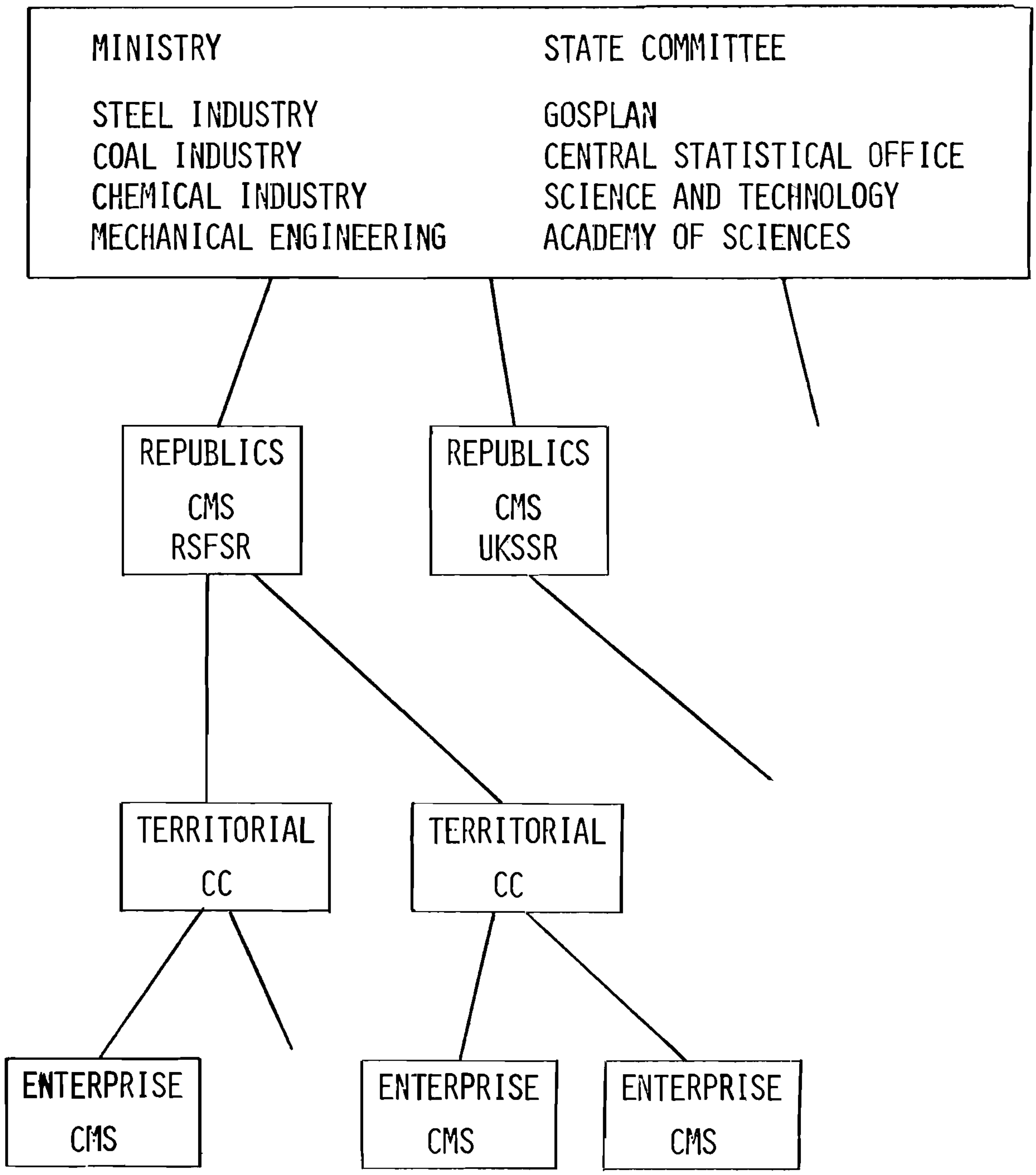

MINISTRY
STEEL INDUSTRY
COAL INDUSTRY
CHEMICAL INDUSTRY
MECHANICAL ENGINEERING
STATE COMMITTEE
GOSPLAN
CENTRAL STATISTICAL OFFICE
SCIENCE AND TECHNOLOGY
ACADEMY OF SCIENCES
REPUBLICS CMS RSFSR
REPUBLICS CMS UKSSR
TERRITORIAL CC
TERRITORIAL CC
ENTERPRISE CMS
ENTERPRISE CMS
ENTERPRISE CMS

Figure 11

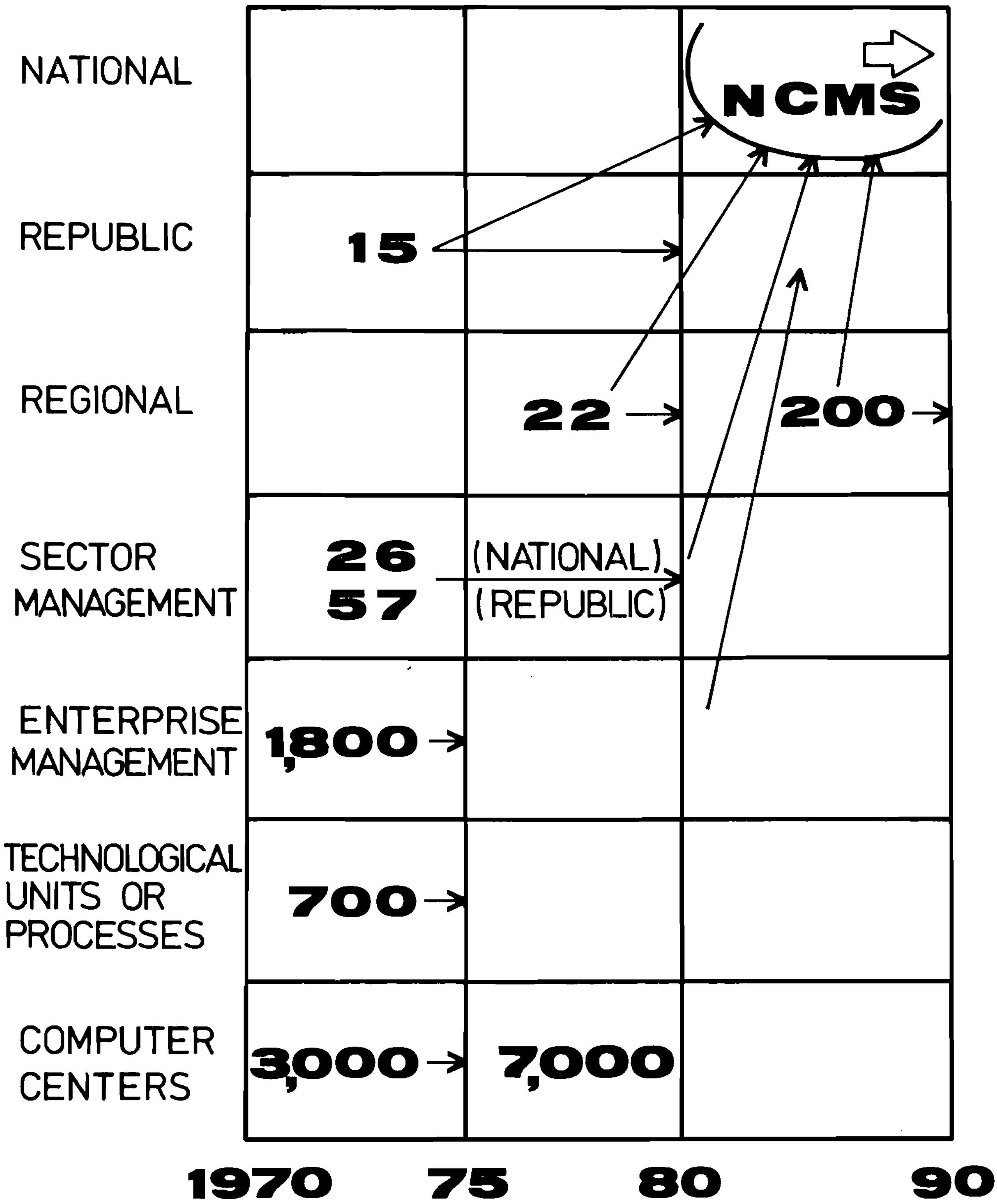

NATIONAL
NCMS
REPUBLIC
15
REGIONAL
22
200
SECTOR MANAGEMENT
26
57
(NATIONAL)
(REPUBLIC)
ENTERPRISE MANAGEMENT
1,800
TECHNOLOGICAL UNITS OR PROCESSES
700
COMPUTER CENTERS
3,000
7,000
1970
75
80
90

FIGURE 12

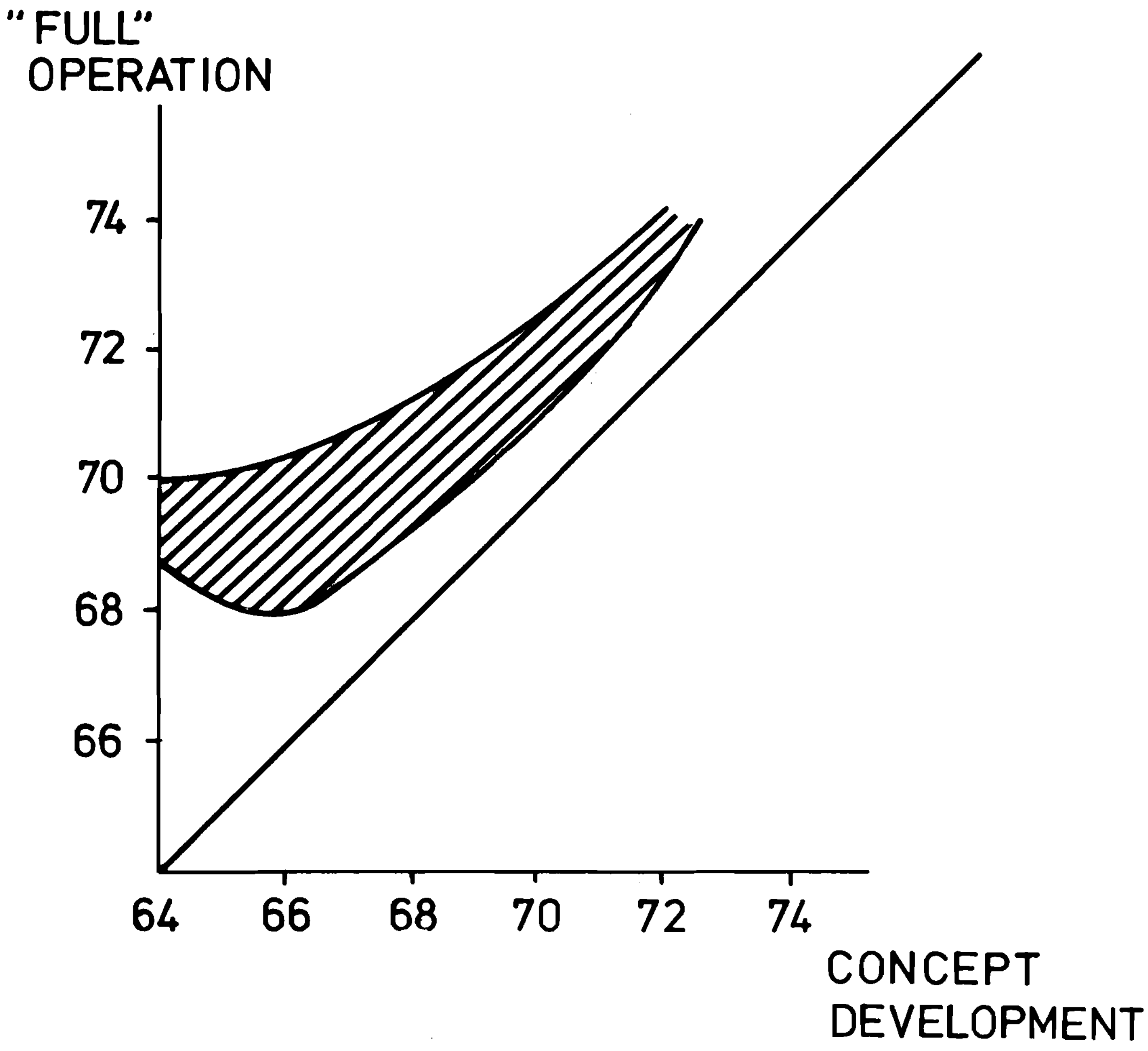

"FULL"
OPERATION
74
72
70
68
66
64
66
68
70
72
74
CONCEPT
DEVELOPMENT

FIGURE 13

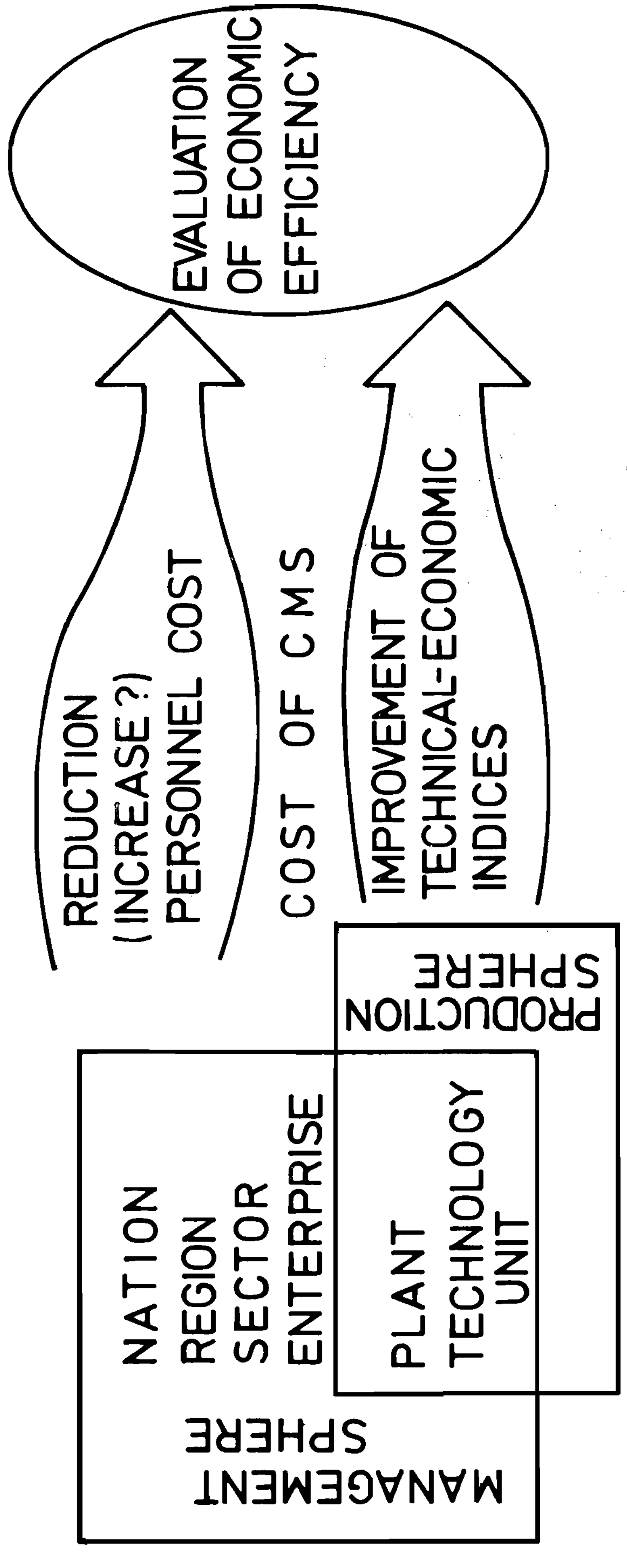

EVALUATION OF ECONOMIC EFFICIENCY
REDUCTION (INCREASE ?) PERSONNEL COST
COST OF CMS
IMPROVEMENT OF TECHNICAL-ECONOMIC INDICES
MANAGEMENT SPHERE
NATION
REGION
SECTOR
ENTERPRISE
PLANT
TECHNOLOGY
UNIT
PRODUCTION SPHERE

FIGURE 14

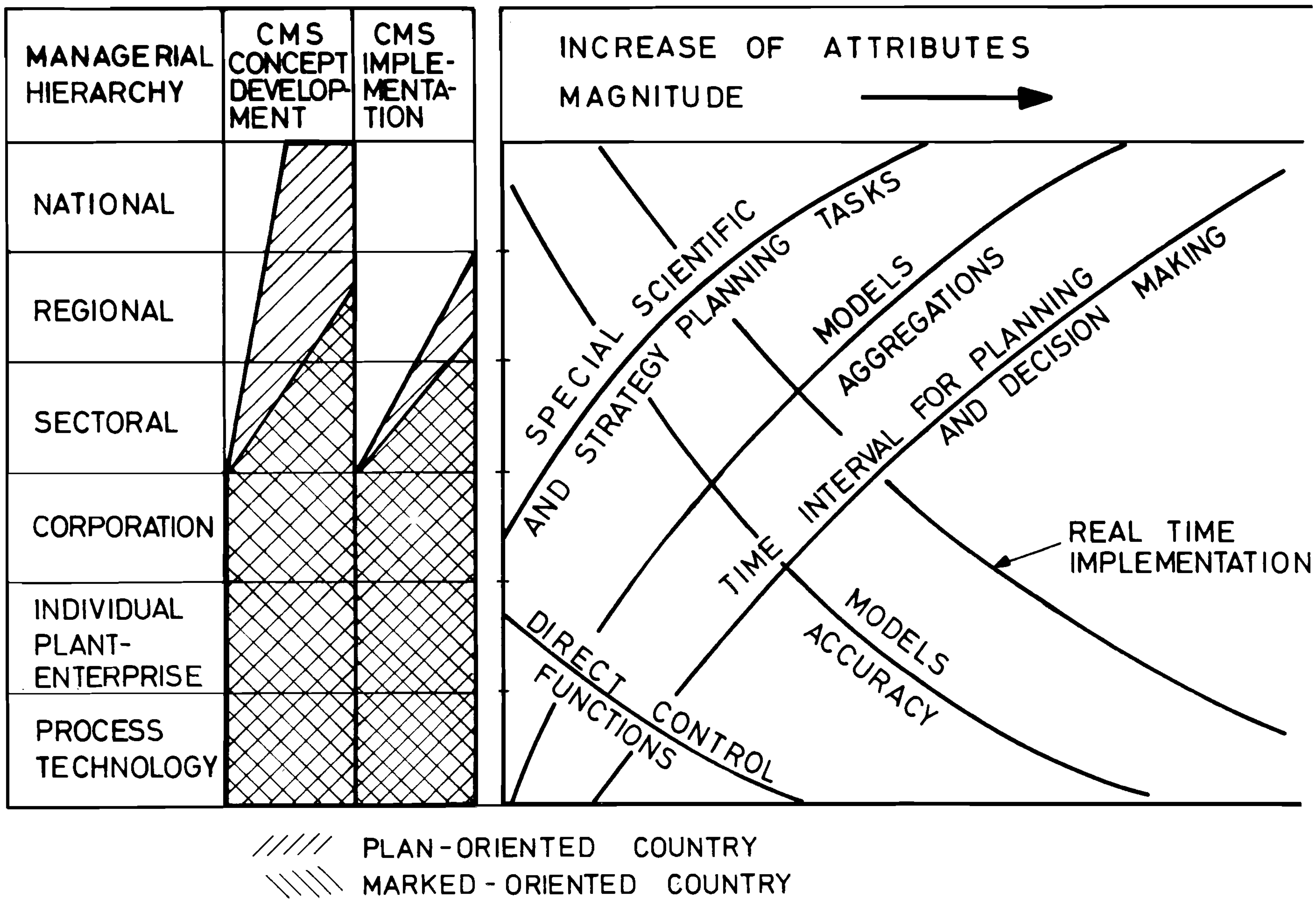

MANAGERIAL HIERARCHY
CMS CONCEPT DEVELOPMENT
CMS IMPLEMENTATION
NATIONAL
REGIONAL
SECTORAL
CORPORATION
INDIVIDUAL PLANT-ENTERPRISE
PROCESS TECHNOLOGY
INCREASE OF ATTRIBUTES MAGNITUDE
SPECIAL SCIENTIFIC
AND STRATEGY PLANNING TASKS
MODELS AGGREGATIONS
TIME INTERVAL FOR PLANNING AND DECISION MAKING
REAL TIME IMPLEMENTATION
MODELS ACCURACY
DIRECT CONTROL FUNCTIONS
PLAN-ORIENTED COUNTRY
MARKED-ORIENTED COUNTRY

FIGURE 15

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