MANAGEMENT SIMULATION GAMES FOR EDUCATIONAL AND RESEARCH PURPOSES-- A COMPARATIVE STUDY OF GAMING IN THE SOCIALIST COUNTRIES

ISAK ASSA

February 1981
WP-81-18

INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
A-2361 Laxenburg, Austria

PREFACE

This research work has partly been initiated at IIASA seminars on Gaming (in August 1978 and October 1980) where great interest was shown in the state-of-the-art of the gaming activities in the socialist countries. The reported material covers a major part of the research in the area of gaming in Bulgaria, Czechoslovakia, the GDR, Hungary, Poland and the USSR. The basis for the analysis and the comparative studies are the proceedings from seven successive seminars on management simulation games held in Prague (1974), East Berlin (1975), Budapest (1976), Warsaw (1977), Sofia (1978), Tbilisi (1979) and Prague (1980).

In this working paper gaming is considered as a tool for applied systems analysis and special emphasis is given to the following areas:

- reasons for the management simulation game development;
- taxonomy and definitions;
- methodological problems in the design and implementation of management games;
- design of the simulation system of models in the game;
- multilevel management simulation games;
- applications and transfers of management games.

The goal of the paper is to disseminate gaming methods and results that have been obtained in the socialist countries when this approach was used for educational purposes, for teaching students and managers, and for research and operational purposes to test ideas and resolve situations in the decision making process.

Finally, we hope that fulfilment of this goal will contribute to bringing together the scientists working in this area by using IIASA's unique position in the ~~east~~-west scientific relationship.

CONTENTS

MANAGEMENT SIMULATION GAMES FOR EDUCATIONAL AND RESEARCH PURPOSES--A COMPARATIVE STUDY OF GAMING IN THE SOCIALIST COUNTRIES

Isak Assa

INTRODUCTION

During the last decade there has, together with the development of large and high speed computers, been a wide spread application of quantitative methods in the field of management. The expanding national socialist economies have become objects of extensive analysis carried out by scientists and practitioners. The problems which have arisen in the analyses have required immediate attention because they are connected with the task of the economic and social development as well as the necessity to improve methods of planning and management.

This need has given rise to a search for methods and tools which will provide new ways to analyse the problems in social sciences and economics. One of the new approaches is the management game approach to decision making. In the scientific literature this approach is very often referred to differently, according to the various already accepted terms such as "business games", "planning games", "simulation games", "interactive games", "operational games", etc.

The project - "Management Simulation Games" - reported on here started in 1974 as an essential part of the CMEA's* research plan. Scientists from six socialist countries gathered to work on the idea of developing a new tool for systems analysis in large socio-economic systems.

---

* CMEA, also known as COMECON, is the abbreviation for Committee for Mutual Economic Aid.

Many results concerning problems of taxonomy, design, application, transfer and implementation of the management simulation games for educational and research purposes were reported from seven annually held seminars during the period 1974-1980. The research work had its specific features in each particular country.

An overview is given in appendix 1. The scientists from the GDR have oriented their efforts towards the construction of educational games. The participants in the seminars from Humbolt University, Friedrich Schiller University in Jena, Wilhelm Pieck University in Rostock, Bergakademie in Freiberg etc., reported considerable experience in the application of gaming in their educational programs.

The scientists from the CSSR distinguished themselves in the methodological field by developing procedures for the design and computer programming of the games. In the last seminar the Institute for Management Studies reported a multilevel management game for planning purposes at corporational level.

The methodological problems in the field of gaming are also of interest for the scientists from Poland. The Institute for Scientific Organization and Management in Gdansk has achieved a great deal in the field of didactics and psychology in gaming. Games in accounting are being developed in Lodz University, in production planning on enterprise level in Warsaw University, and in the Institute for Organizational Studies and Training of Managerial Staff.

Bulgarian scientists set themselves to combine, through gaming, the search for more efficient methods in the decision making process with the development of active techniques (games) which together will facilitate the training of top managerial staff. In the Institute for Social Management in Sofia several games are being used for both educational and research purposes.

The distinguishing feature of the research work being carried out by the scientists in Hungary is the construction of many computer games in the Institute to the Ministry of Lahour in Budapest. In their papers, they have managed to discuss in great detail the methodological and implementation problems in the design of games using computers.

Practically all areas in gaming are covered by the publications of the scientists from the USSR. Nevertheless, the achievements in the mathematical theory of gaming can be mentioned here as a specific feature of the research work in the Institute for Management Sciences in Moscow, in the Novosibirsk Department of the Academy of Science etc. Considerable work in operational gaming is taking place in Moscow University and in the Leningrad Financial and Economic Institute.

The games reported on in the seminars were developed mainly for the field of economics. Some theoretical and practical work is also going on in the fields of military gaming, foreign trade, organizational behavior, human relations, politics, ecology etc. Such applications, however, were not covered by the seminars.

It should be pointed out here that many differences mainly concerning the methodological problems in gaming existed between the scientists at the beginning of the project. Some of these still exist, but in our opinion, they only contribute to a better understanding of the complex phenomena of the use of gaming in the systems analysis of complex socio-economic systems. The main questions which came under discussion were:

- What are the advantages and gains of using gaming in system analysis?
- Can we solve these problems by methods other than gaming?
- What is man's role in gaming?
- Does the game converge to an optimum solution?
- What kind of practical problems can be tackled successfully through gaming?

The reader will find answers to these questions in the following sections which are structured in the same manner as the areas mentioned in the preface.

REASONS FOR THE MANAGEMENT SIMULATION GAME DEVELOPMENT

Quantitative methods and large scale computers have become powerful tools in social and economic systems analysis. Their contemporary stage of development is basically characterized by models oriented to solve partial problems. These circumstances are due to the division of economic systems into practically independent subsystems which has given rise to monodisciplinary research and also resulted in the accumulation of considerable knowledge, methods and techniques. The disadvantages of the decomposition approach based on the separate treatment of the subsystems have shown up together with the continuous growth of system's complexity and became a real obstacle. On the other hand the systems under study are large and contain numerous elements linked together by complex relationships. These systems are not easily formalized both because they are stochastic in nature and because of the high degree of non-linearity and uncertainty which exists within them. In order to tackle these systems the quantitative methods applied in social sciences and economics have developed through four evolution stages in the socialist countries:

- statistical methods
- input/output analysis techniques
- optimization methods
- simulation techniques

The taxonomy of the applied quantitative methods in social sciences and economics is highly generalized, but in our opinion reflects the need of the scientists for methods which can take into account the "lack of knowledge", i.e., the uncertainty due to numerous factors which cannot be formalized and which to a large extent influence the final solution.

Among these factors are the intuition, the experience and the heuristic abilities of the decision maker. Management simulation games are able to combine the heuristic capabilities of man on one hand and the computing capabilities of the machine on the other. Therefore, this can be considered the <u>first</u> reason for the use of gaming in social sciences and economics.

The second reason is that a large gap still exists between management theory and managerial practice. Quite often, in literature, scientists and model builders discuss the lack of interest shown by managers whilst making decisions with the help of models. On the other hand scientists decline experimental opportunities if those require time consuming data collection or if the statistical and empirical information is considered as being inaccurate and insufficient. The present situation in management practice and theory can be characterized by a serious lack of communication between the decision makers (managers-practitioners) and the model builders. These circumstances are due to the following reasons:

a) Management practice requires the construction of simple and realistic models which are easy to cope with and to understand. Such models in the most general case do not exist.

b) The model building, the data collection, the model verification and implementation are interdependent activities. Most model builders and scientists in social management, think that the construction of an "elegant model" or the generation of a bright idea is the researcher's only domain.

c) The social and economic reality is far too complex for one man, to comprehend completely independent of his profession, training or knowledge. The management problem's solution require a team of specialists which can provide a framework for interdisciplinary communication and a better ground for the study of the complex phenomena.

Therefore the growing need for closer cooperation between scientists, and decision makers has given rise to the wide spread application of management simulation games.

This new technique conveys information to the manager about planning methods, forecasting, computers, management technology, etc., in the simplest and most easily understandable way. One of the main features of management games is that they satisfy the educational requirements in training managerial staff. They offer unique means of teaching the participants in the game to undertake appropriate action in the process of sequential decision making and to develop strategic abilities and positive managerial concepts and skills.

The advantages to train managers and build games are not only on the educational side. The participants can also be used as experts in games for research or operational purposes. Such games are in general very difficult and expensive. These games require realistic models to be built on empirical data. The rules must be constructed according to the existing economic mechanisms. Finally, the game must be played with players who are practitioners and have high managerial skills and a good understanding of the economic processes. The requirement to use games for research and operational purposes can best be met in a place where managers and scientists have the opportunity to work together. Therefore,

the teams of scientists working on management simulation games have consisted mainly of individuals from institutes involved in training managers from different sectors and management levels in the economy of a particular country.

The third reason stems from the following. Earlier the attitude was that problems in management can be solved by use of large optimization models. It is now widely recognized that the decision making process is more than just making a choice. It involves a set of interconnected activities, such as goal setting, gathering and processing the required information, definition of the problem, generation of alternatives for the different courses of action, estimation of their possible outcomes and finally the actual commitment to some course of action and its realization. These activities, sometimes called phases in the decision making process, are formed by different people, at different times and in different places.

The most efficient way to solve a complex management problem which forms a system of decisions is to divide it into decision stages. This approach introduces the concept of hierarchy and subdivides the decisions into a number of subdecisions sequentially in time. The subdecisions are closely related and form an oriented tree where the earlier decisions influence the later one. Each branch of the tree is a situation which has to be resolved and estimated.

The combination of the quantification approach and the introduction of the concept of hierarchy and tree structure into decision making resulted in a new method: situation analysis.

The idea is to identify the situations which are the key points in the decison making process and to facilitate their resolution by appropriate methods and techniques. The interaction of the resolved situations can be handled successfully by the management game structure with an efficient use of a sophisticated computer operation system.

Therefore, we consider, the third reason for extensive development of management games and their useful application in the field of social science and economics as being the introduction of situation analysis in management.

The fourth reason lies on the educational side of the management game application.

The gap between management theory and managerial practice is very often explained by the lack of interest of managers in the preparation and analysis of decisions with the help of mathematical models. The reasons are many and varied, ranging from little knowledge about what models, computers and new management approaches can do to the organizational deficiencies and psychological barriers. The rapid development of technology and growth of computer applications in management has made the decision makers regard it necessary to periodically obtain knowledge about planning methods, forecasting,

computer science, management technology etc. In order to convey to him this advanced knowledge a new educational technique was required.

The most important feature of a management game with an educational purpose is that it reflects the specific characteristics of the managerial staff. It offers a unique means of teaching managers (participants in the game) how to take appropriate action in the process of sequential decision making and to develop strategic abilities and positive management concepts.

TAXONOMY AND DEFINITIONS

Management games are used a. for educational purposes to teach students or managers how to operate a complex system, b. for practical applications (management purposes) to test alternatives and resolve situations in the decision making process and c. for research purposes to test theories, to analyse the behavior of large social and economic systems and explore the implications of some mechanisms.

Therefore, management simulation games can be divided into three main groups respectively according to the goal which is to be achieved:

a) educational games;
b) operational games;
c) research games.

The research undertaken on the existing management simulation games has shown that scientists use different classification criteria. For example, games are very often classified according to the area of use, economic games, military games, planning games, regional games, business games etc. By accepting different criteria we can generate several classifications which all have some useful theoretical applications.

A more important question is: What constitutes management simulation game? The answer is closely related to the basic principles of game theory.* Game theory is generally considered as a mathematical study of competitive and conflicting situations. That could mean that an element of conflict should always exist in gaming. In the socialist country, however, very few games, usually only those adopted from countries with market economies, contain this feature. The majority of the reported games in the seminars are interactive simulations of the decision making processes in large organizations, plants etc. The gaming structure of the man-machine interactive model plays a coordinational role and takes into account the interrelations between the decision makers (players) through their behavior and choices.

This broad understanding of the gaming approach in management gives rise to different terms--business games, interactive

---

* Morgenstern, O., and J. von Neumann. 1944. Theory of Games and Economic Behavior. Princeton University Press

games, simulation games, planning games, etc. The term "management simulation game" was established and widely accepted after Efimov and Komarov published their book on gaming.* This term, in our opinion, reflects the fact that every game is constructed on the basis of two elements:

a) a simulation system of models;
b) the game situation, a description of a real situation in managerial practice.

The former contains models (optimization, simulation, statistical etc) which facilitate the decision making process. The latter includes the players, the rules and the goals of the game.

Therefore, the problems in the theory of management simulation games are always discussed in close relation to simulation and optimization models and the decison making process. What is the major difference between simulation and gaming? The answer to this question will help to generate the definition of a "management simulation game".

Simulation means different things to different people. It is a technique of growing importance in many fields--both theoretical and applied.

Here we accept the definition given by Naylor# that "simulation is a numerical technique for conducting experiments on a digital computer which involves certain types of mathematical and logical models that describe the behavior of a social or economic system over extended periods of time".

Thus, simulation models and management games are both mathematical models which differ in purpose and mode of use. Simulation models are designed to simulate the functioning of the system and to generate a series of statistical results. The major disadvantage of simulation as a decision making tool is the "case study" process by which alternatives are evaluated. Using simulation each solution corresponds to the determination of the implications of a single proposed alternative or specified combination of them. In practice, this usually forces a substantial reduction in the number of alternatives but even under such conditions simulation can be expensive if adequate detail and scope are provided.

Several observations about simulation and optimization modeling approaches have shown that each suffers from important deficiencies. Simulation offers descriptive power and broad applicability but often requires extensive analysis. Optimization on the other hand offers analytical power but is weaker in descriptive accuracy

---

* Efimov, V., and V. Komarov. 1980. Introduction to Management Simulation Games. Izdatelstvo "Nauka", Moscow. (in Russian)

\# Naylor, T.H. 1971. Computer Simulation Experiment with Models of Economic Systems. John Wiley & Sons Inc.

and applicability. Thus the strength of one modeling approach complements the weakness of the other. Simulation and optimization are considered as complementary rather than alternative modeling approaches.

This suggests that management games are one possible avenue toward a combined use of simulation and optimization methods. This can be done through the construction of algorithms and routines which are going to control the procedure of sequential use of simulation and optimization methods and to guide the search for improved solutions.

In place of human intervention, rules for action are defined to achieve new systematic search procedures. The construction of this "hybrid" system is greatly facilitated by use of existing models for the solution of various economic and social problems which can be linked together with the management game structure.

Thus simulation models and management games are both mathematical models which differ in purpose and mode of use. We can hence proceed to the following definition:

"A management simulation game is an experimental model which simulates certain situations in the process of managing the system with man taking an active role in the different stages of the decision making process".

Management games are distinguished by the idea of play. That means the decisions of the different stages of the decision making tree are linked together through the game situation, where the scenarios, the roles and the rules are described. Management games in this sense can be viewed as a communication tool for use by the decison makers in a "management laboratory" environment, where they have the opportunity to use the achievements of other sciences such as mathematics, economics, computers, etc.

METHODOLOGICAL PROBLEMS IN DESIGN AND IMPLEMENTATION OF GAMES

The publications which appeared after the first work on game theory (J. von Neumann and O. Morgenstern 1944) dealt with the mathematical background of the theory, and practically nothing was reported to help answer the question of how the gaming approach can be applied to resolving problems in decision making. Today we talk about theory of management simulation games and numerous books and descriptions of games have been published in both eastern and western literature.

Serious attempts to develop the foundations of gaming theory have been made by the Soviet scientists V.Burkov* of the Institute for Control Sciences and Y.B. Germayer# of the Computer Center of the USSR Academy of Sciences.

---

* Burkov, V. 1977. Foundations of the Mathematical Theory of Active Systems. "Nauka", Moscow. (in Russian)

Germayer, Y.B. 1976. Games with non-conflicting interests. Moscow, "Nauka". (in Russian)

These two books have been widely used by scientists from the socialist countries as a methodological guide in the construction of the simulation system of models. They dealt mostly with the mathematical background of the gaming theory and with the problems of interaction between the different models used by the participants in the game.

A brief summary of the basic principles and concepts of their Interactive System Theory is given.

In this theory each participant in the game is considered as an interactive element with certain behavioral features. The interactive elements can be situated in different management levels which differ from each other with regard to the type of information processed in order to make a decision. Thus, the theory deals with multilevel management simulation games and applies the basic concepts of the Hierarchical System Theory.

In case of a two level management simulation game the interactive elements on the first level are called "control units" and these on second level "users". The "control unit" is the only element on the first level and it governs the behavior of the interactive elements on the second management level. It plays a coordinational role in order to achieve a higher pay-off of the system as a whole.

The game is designed on the basis of the existing interdependence between the decisions made by the interactive elements. Each decision maker (user or control unit) cannot make a decision without thinking what decisions the other decision makers will make. This interdependence is considered by Germayer as non-conflicting because it can be controlled and directed towards a situation from which the system as a whole can benefit. This is done through several interactions between the participants in the game.

The basic concepts of the interactive system theory are as follows:

- The control unit works with insufficient information about the characteristics of the second level interactive elements, (users).

- Each interactive element has its own objective function. This function may or may not be known by the control unit.

- Each interactive element knows the strategy and the abilities of the control unit to influence its behavior.

- Each interactive element can use this information in order to fulfill its goals.

- Each interactive element has the opportunity to optimize its actions according to its desired perspective development and interests.

- Each interactive element may or may not know the objective functions of the others.

Management games with similar structures are very appropriate for simulating the planning process in the Socialist economy. The situations which one can study by them are not conflicting and their hierarchical structure corresponds to the structure of the system where planning decisions are made.*

The structure of the planning procedure is an interactive one and is based on the dialogue between the elements in a multilevel management system. The clearest way to tackle the problem of realization of the dialogues between the corporations, the plants and the planning body is, in our opinion, the management game approach.

Some scientists working in the area of gaming believe that the scope of the application of management simulation games would be heavily limited if they are not applied to the strategic planning and testing of economic and social mechanisms. #

An other opinion is that games must be used to study the problems which arise in the functioning of large organizations (Efimov, Komarov, 1980).

The serious lack of methodology in gaming for operational purposes lead to different views about the structure, application, design and interpretation of games. A commonly held opinion is that the following procedure for building a game for operational purposes should be used. First, the object for research is chosen (enterprise, plant, organization etc) and a model for its behavior is developed. Second, the model is tested on real data and third, a game situation is constructed where the model is used for decision making.

In other words, emphasis has been laid on the construction of the simulation system of models and very little attention was

---

* Panov, O. 1978. Choice of the Type and the Characteristics of Management Games for Research and Training Purposes. Proceedings from the 5th International Seminar on Management Games for Research Purposes, Sofia. (in Russian)

Assa, I. 1978. Management Games in the Decision Making Process. Informatika 78, Bled, Yugoslavia.

paid to the design of the game situation (roles, scenarios and rules). However a considerable amount of work has been done on the latter by Efimov and Komarov. Using the example of a game built for an enterprise level they developed a procedure for the design of a gaming situation (Efimov, Komarov 1980).*

In this paper we shall limit ourselves to three approaches which can produce tentative structures of a gaming situation and we shall illustrate them with an appropriate examples.

The three approaches differ because they have different stratification of the management process.

The first approach is based on the stratification suggested by Mesarovic and Pestel# and adapted by Klabbers.† Large organizations are socio-economic systems which are goal directed and self-organized. They repond to the changing environment by conscientiously varying their structure in order to preserve their goals. They posess a large degree of uncertainty which is a consequence of a lack of knowledge about the system's elements and their relationships. In order to study the latter through gaming it is appropriate to disagregate the management process into three strata--norm stratum, decision making stratum and casual stratum. (See Figure 1.)

As an illustration of this approach for structuring the management process in a large organization the management game "Economic mechanism"‡ can be used. It was developed in the Institute for Social Management in Sofia for educational and research purposes. The goals of the game are:

- to convey knowledge about different economic instruments and to study their function in enterprise;
- to test different economic mechanisms at enterprise level.

---

* This is explained in more detail in a forthcoming CP by V. Marshev, "Gaming in the USSR", IIASA 1981.

\# Mesarovic, M.D. and E. Pestel. 1974. Multilevel Computer Model of World Development System. Proceedings of the Symposium, IIASA.

† Klabbers, J.H.G. 1975. Interactive Simulation on-line Interaction between Man and Machine for the Study and Management of Social Systems. 6th Annual Conference on IIASA, Milano

‡ Assa, I., Gevrenov, S., Kolarov, N. and S. Petrov. 1976 Management Game Production Enterprise Economic Mechanism. Seminar Proceedings, Budapest. (in Russian)

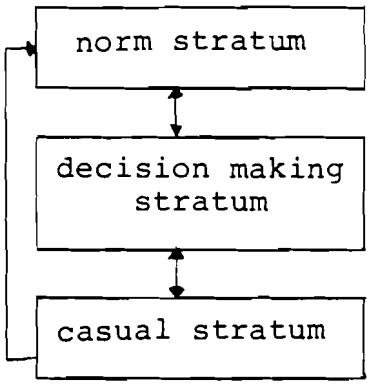


Figure 1: The casual stratum is related to that system of activities through which the dominant input/output processes are accomplished. The decision making stratum is related to the formation and implementation of goals, policies and strategies. The norm stratum is related to norms and values which govern the decision making process.

The enterprise in the game is represented by a simulation model (See Figure 2), based on a system of simultaneous equations. The equations are regressions estimated on statistical information gathered for the enterprise during a certain period of time. Sixteen economic instruments through which the decison maker (director, planner, chief of the production sector, etc) can influence the functioning of the enterprise serve as input to the simulation model. The outputs from the model are seven economic factors which give the state of the enterprise at each time period. They are:

- volume of production
- realization
- costs
- profit
- cost of labor
- capital stock
- manpower

The participants in the game have to achieve a required set of planning figures for these factors by varying the economic instruments according to the economic mechanism. Under the latter we understand rules, norms and laws for the relations between the different participants in the economic and social life.

The decision maker in the game acts according to the information which he receives from:

- the simulation model of the enterprise;
- the economic mechanism;
- the other decison makers;
- the decison support system;

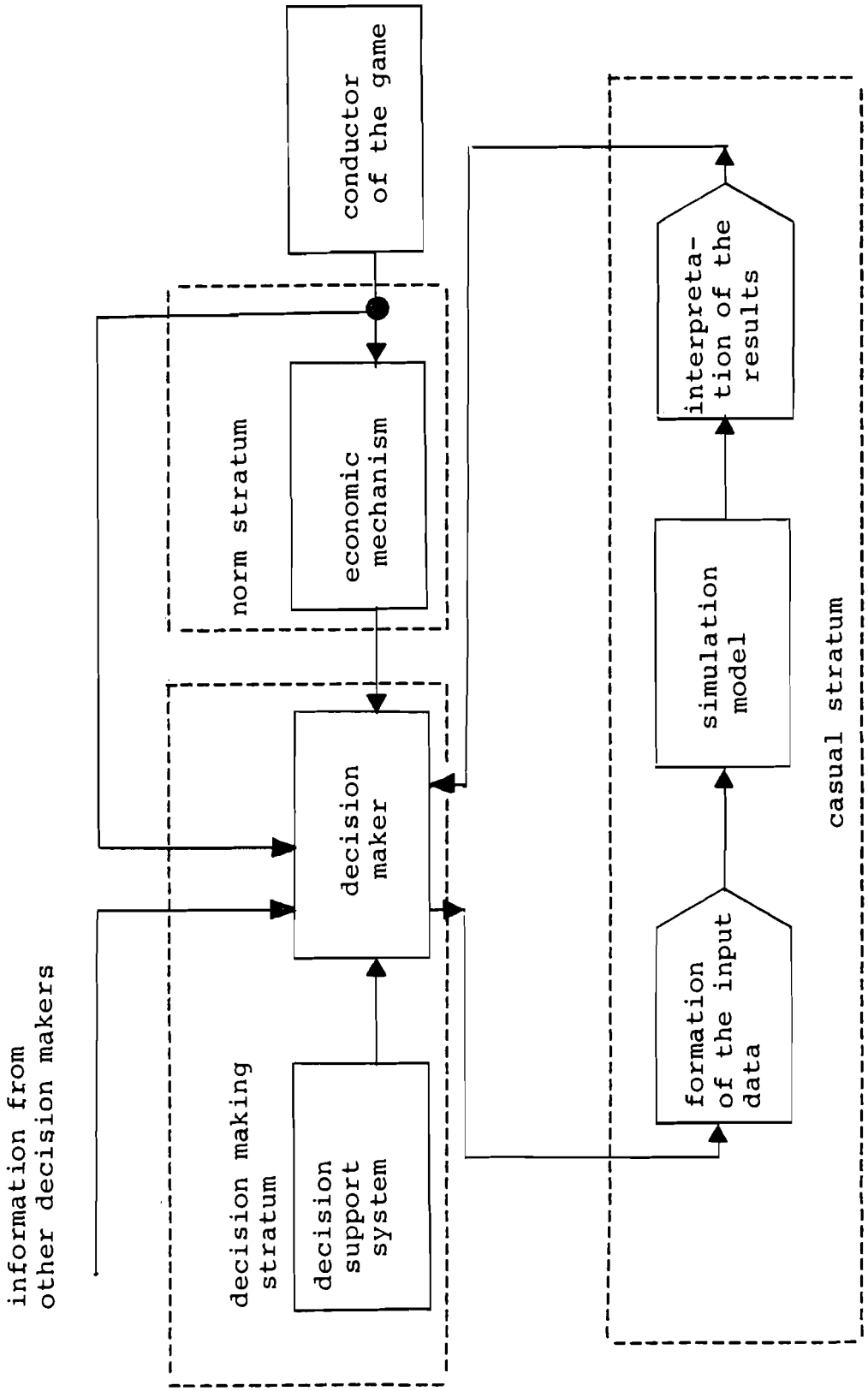


Figure 2: Management simulation game "Economic mechanism"

The decision support system contains additional models which, if the decision maker requires, can be run to obtain some forecasts, trends, general data etc.

The conductor of the game can change the economic mechanism and study the corresponding change in the behavior and the decisions. The advantages of studying the psychological interrelations between the different decision makers and the considerable knowledge which the participants obtain by using the computer cannot be neglected.

The second approach is concerned with the attempts of scientists to describe the management process as an information process decomposed into several interconnected phases which form the so called management cycle.* (See Figure 3.)

The management cycle illustrated in Figure 3 is formed by applying the "management by objectives" concept. The process of management is decomposed into several different phases expressing the main management functions. It is an aggregated cycle and can be adopted to the process of management in various levels of the economic system to enterprises, organizations and the economy as a whole.

In figure 3 several types of models are presented in order to illustrate their relationship to each particular phase.# The list is not complete but shows the stage reached in the development and in the application of the models. Combinations of statistical, optimization, and numerical methods as well as expert estimates are used to facilitate the decision making process in the phases of the cycle. The role of the management cycle here is to provide a general framework for the interdisciplinary research and link the models in one interactive procedure. It also introduces a concept of hierarchy.

A similar structure of the gaming situation has been used for the construction of the multilevel game "Management of an Industrial Production Organization"† in the Institute for Social Management in Prague.

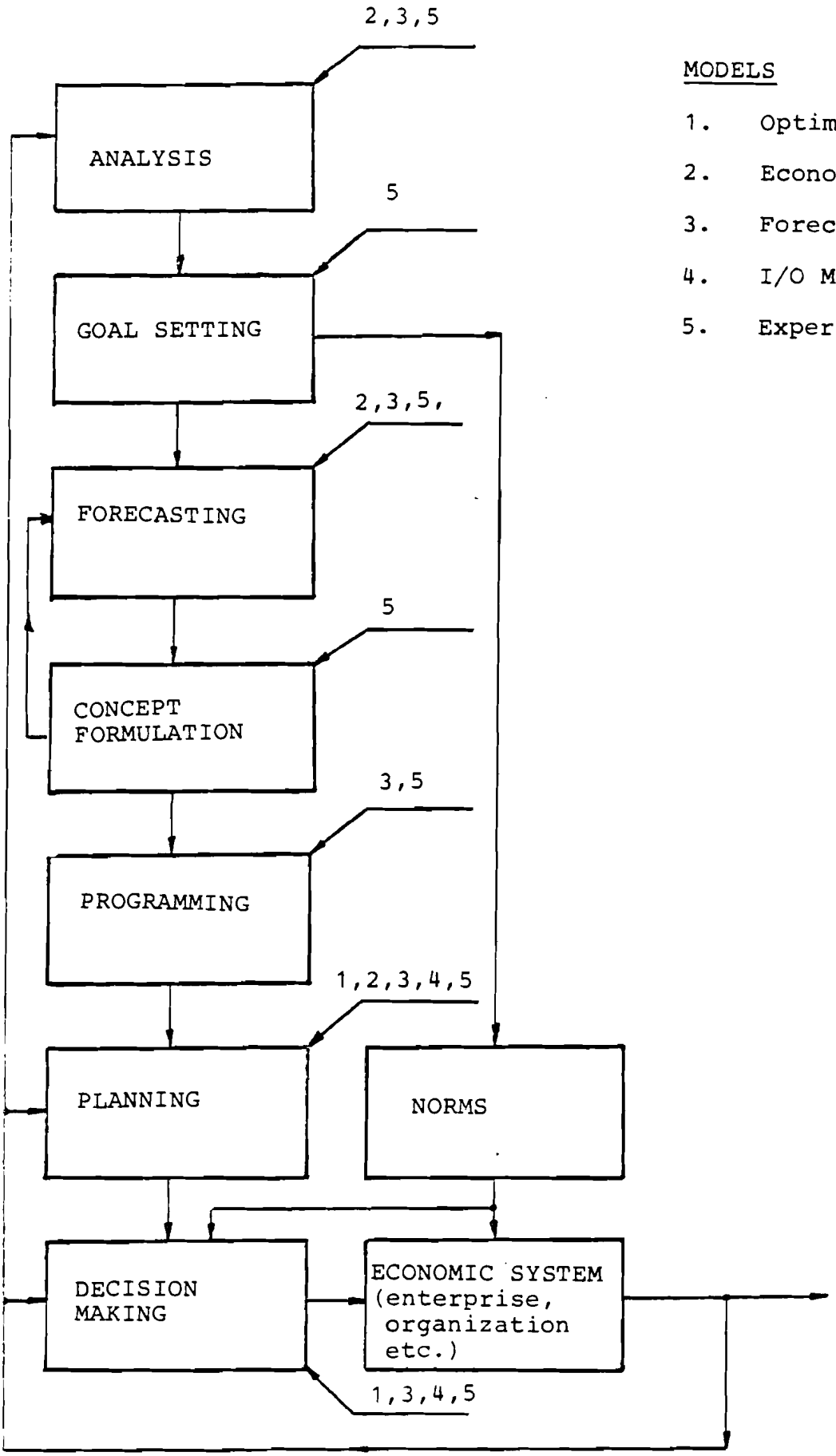
The game uses a complex dialogue procedure for the representation of the whole management process of a large organization. The organization consists of a central management level and three production enterprises. The goal of the game is to build the five year plan for the organization. Three different

---

* Nikolov, I. 1971. Cybernetics and Economics. Izdatelstvo "Nauka i Izkustvo", Sofia. (in Bulgarian)

\# Assa, I., and I Petrov. 1978. Cybernetic Approach to the Management of Economic Systems. Amsterdam VIII. Proceedings of the International Congress on Systems Research and Cybernetics (W.O.G.S.R.C.)

† Fotr, I. et al. 1980. Management of an Industrial Production Organization. Proceedings of the 7th International Seminar on Management Games, Xi. Prague. (in Russian)



MODELS

1. Optimization Models
2. Econometric Models
3. Forecasting Models
4. I/O Models
5. Expert Estimates

Figure 3: Management cycle and models used in each phase.

roles exist in the game: central managerial board of the organization, managerial boards for each production enterprise and conductor of the game which is playing the role of industrial ministry. Each gaming role is fulfilled by groups of managers. Each of them is responsible for different management functions. The participants in the game can make use of a sophisticated decision support system, i.e., a system of models which is designed to solve problems which can arise in the process of functioning in the organization. An information system for numerous economic parameters and instruments is adapted in order to facilitate the decision making in building the plan. The game is run on a WANG computer system using a large number of terminals. The mangement game is used in the Training Center of the Ministry of Industry in Prague.

The third approach which is used for the structuring of the game situation is closely related to the concepts of game theory and the Interactive system theory. (Germayer 1976, Burkov 1977.)

As an illustrative example we shall use the game "Mono-resource allocation planning", a result of the collaborative work of the Institute for Social Management and the Institute of Engineering Cybernetics in Sofia.* (see Figure 4.)

The planning resource allocation problem is structured as a two-level hierarchical system in which the first level is represented by the Central Unit (CU) and the second level by a number of users. The CU can influence the planning of the resource, i.e., the active behavior of the users, through the implementation of various economic instruments such as prices, penalty functions for unused resources or surpluses, premium functions, etc.

The conductor of the game is able to introduce some different laws or rules for the distribution of the resources and study the behavior of the CU and the users. Each user is characterized by demand and production functions. It has the opportunity to optimize its resource ordering policy according to the desirable development by using the models especially designed for that purpose. Each user may or may not know the demand and production functions of the others, depending on the rules introduced by the conductor of the game. In this way different scenarios can be generated in order to study a number of distribution mechanisms.

The game is designed on the basis of four algorithms which solve the following problems:

a) choice and estimation of the distribution rule used by the CU;

b) estimation of the value of the resource requirements;

---

* Assa, I. and I. Tzvetanov. 1979. Management Game, Mono-resource Allocation Planning. Institute for Social Management. Sofia. P.130. (in Bulgarian)

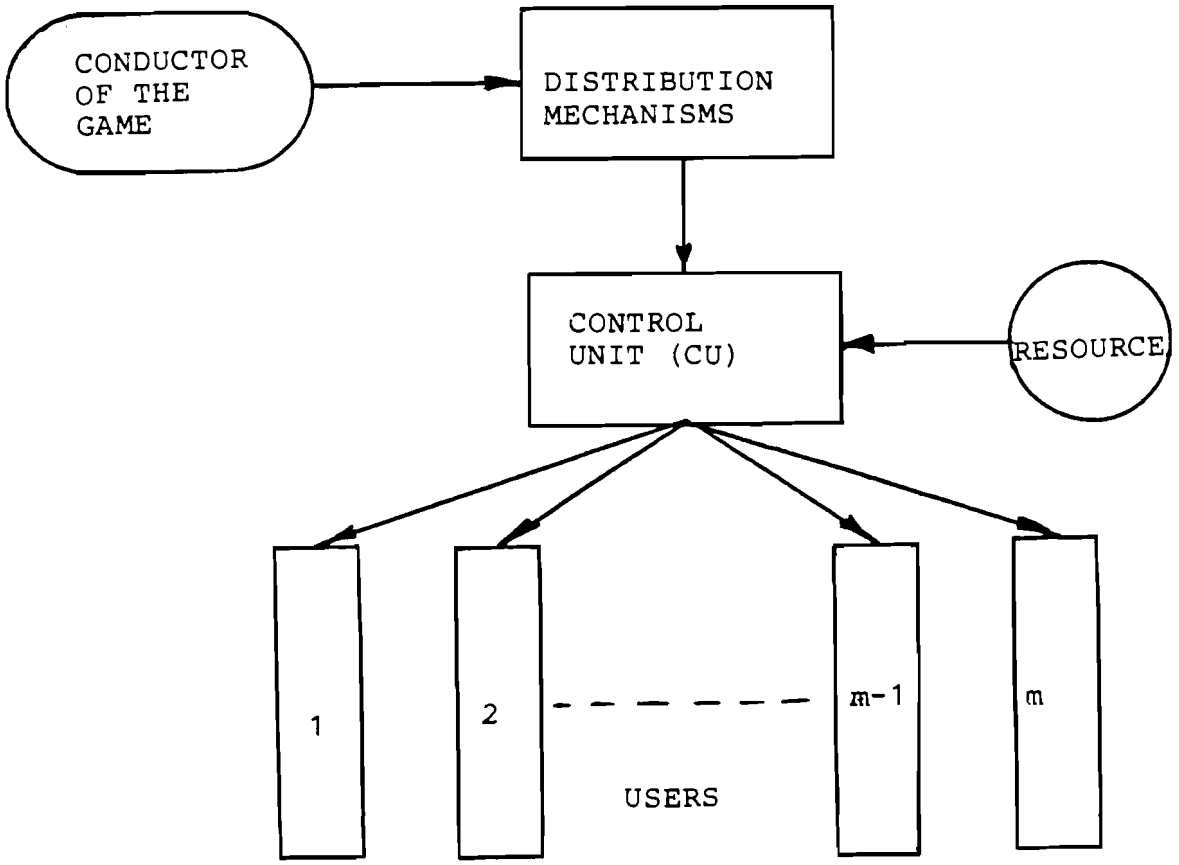


Figure 4: Management game for Resource Allocation Planning

c) estimation of the planned distribution of the resource by the CU;

d) estimation of the user's strategies in the game.

The algorithms are designed to solve problems with monotonous and step decreasing demand and production functions. The game is implemented on an ICL1904A computer using FORTRAN as a programming language. The programs are structured in a modular fashion.

By running the game both the concept of rational behavior and of the equilibrium point in the resource allocation are tested.*

The three illustrative examples given above are only part of the large number of games reported in the seminars. Analysing their structure and field of application the following conclusions are reached:

1. Management games consist of two main elements, a simulation system of models and a game situation.

2. Most of the games make use of the approaches discussed above as regards the construction of the game.

3. The games are interactive. Their general interaction scheme is shown schematically in figure 5.

4. Two main directions can be distinguished in the recent development of management games.

   The first is connected with the study of different mechanisms in large corporations based on simple interactive models. There is a widely held opinion that, with the help of small and simple models, new theorectical ideas and hypothesis can be tested. This refers in particular to different economic mechanisms and their impact on the economy, and different structures and their influence on the functioning and management of large organizations.

   The second direction is closely related to the actual functioning of different social and economic mechanisms in the economy. Here complex systems of models are required in order to provide a real framework for scientific and practical results. The latter is obtained through sophisticated models, programming techniques, and computer operating systems.

DESIGN OF THE SIMULATION SYSTEM OF MODELS IN THE GAME

There is a widely held opinion amongst scientists that only the presence of an interactive mode of communication in the model can classify it as a game. Many educational games reported in the seminars were, however, simply models which were designed to solve problems in different fields. The game situation in these games was simply a common work with the model by changing its input and interpreting the results.

Nevertheless this type of work in gaming has contributed to the fast development of models, programs and techniques which have been successfully applied in the building of new games.

---

* Nash, J. 1951. Non-Cooperative Games. Annals of Mathematics.

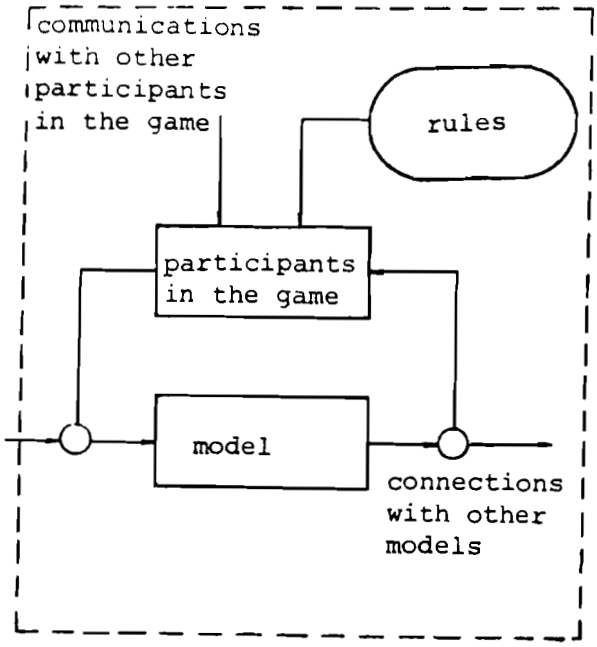


Figure 5: General Interaction Scheme

Some authors think that it is more convenient to start building a game by using existing models. However, one should bear in mind that they have to be connected by a game situation framework.

The computer structure of the system of simulation models is given in figure 6. The difference between the activities required for building a game situation and a system of simulation models is clearly defined.

Two major problems can be distinguished in the building of simulation system of models--the computer programming and the informational basis of the game. A dominant contribution in this field has been given by scientists from the CSSR, the GDR, and Bulgaria. * # † The efforts were directed towards the building of a standard type of programs with a modular structure making it usable for different games.

---

* Fotr, I. and S. Hajek. 1978. Tentative Programming Structure of a General Type Management Simulation Game. Proceedings of the 5th International Seminar, Sofia. (in Russian)

\# Vieviger, B. 1978. A Methodology for Development Simulation Models. Proceedings of the 5th International Seminar, Sofia. (in Russian)

† Assa, I., and S. Petrov. 1977: Programming and Information Problems in the Design of Management Games. Proceedings of the 4th International Seminar. (in Polish)

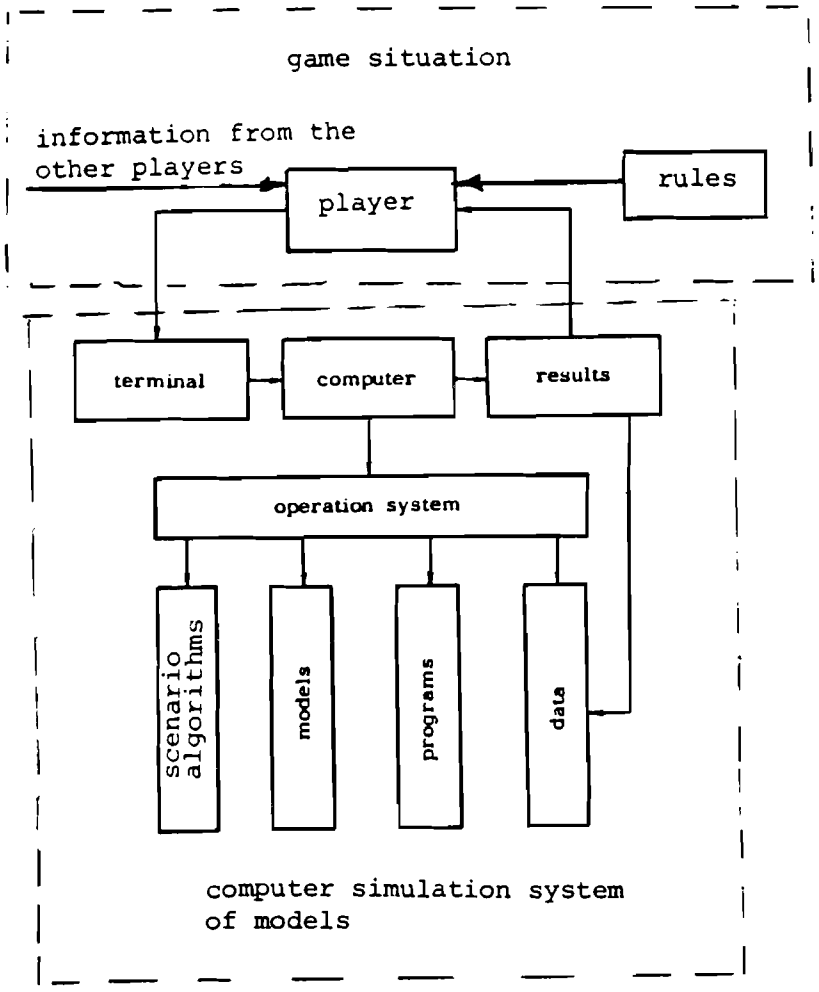


Figure 6: Management simulation Game Structure.

Their unified inputs and outputs enable the researchers to use them as modules in the game structure and to generate different scenario algorithms for the solution of certain game situations.

A bank of programs is gathered in the Institute for Social Management in Sofia (I. Assa, S. Petrov, 1977) and it consists of programs in FORTRAN IV for the following tasks.

- the solution of a large system of linear equations with imbedded topological and sparsity techniques for different types of matrices.
- continuous linear optimization problems with productive form of the inverse, reinversion subroutine, sparsity and topoligical techniques.
- the solution of large transportation problems using graph theory.
- statistical analysis (regression, correlation, factoral).

- the solution of non-linear systems of equations.

- the solution of integer 0-1 variable linear optimization problems.

- random number generation and filters for different probability distributions of the time series.

The reason behind the construction of such a bank of computer programs is to overcome the difficulties which often arise in connecting the models in an iterative procedure when standard computer programs with complex inputs and outputs are used.

There are two widely held opinions concerning the generation of the game's informational basis.

The first one emphasizes the model side. First of all an adequate model should be built for the description of the game situation and then appropriate information should be sought for its solution.

The second one takes into account that the information is scarce and inaccurate. Hence another group of scientists suggests that an appropriate model should be built on the basis of available information.

The optimum lies somewhere in between. If efficient methods and programs are developed for the processing of the available statistical information practically any kind of data for the games can be generated. Several reported games use Monte Carlo techniques, random number generators, filters for different probability distributions in order to enrich the existing data.

Summarizing the previous discussion the following common characteristics can be derived:

- All reported management simulation games are realized on computers;

- The computer language which is used most widely is FORTRAN IV. A very small number of games use PL1 and ASSEMBLER;

- The programming of games is generally performed without the use of standard computer programs which facilitates their transfer;

- The modular structure of the games facilities modification;

- Games use realistic statistical information.

MULTILEVEL MANAGEMENT SIMULATION GAMES

The necessity to develop multilevel management simulation games can be derived from the existing procedure of building the plan in socialist countries. Dialogues are taking place in the hierarchical structure of the management system either horizontally or vertically.

Vertical communications exist in the sectorial area between the planning authorities, ministries, enterprises and plants and in the regional area between the planning authorities, the region and the subregions.

Horizontal communications exist between the ministries, between the enterprises and between the regions and the sectorial ministries, enterprises and plants. (See Figure 7.)

This communications scheme (in figure 7) is highly aggregated and its purpose is to explain more clearly why multilevel management games are used for planning purposes.

This can be examplified by the multilevel game "KOMBINAT". This game is designed on the basis of two games, "Economic Mechanism" (IM-1) and management game BES-1. The latter was developed by scientists at the Humbolt University in Berlin, GDR.* The game covers the dialogue taking place between the ministry, the enterprises and the plants in the process of building the plan. The game situation is structured by applying the management cycle approach. BES-1 is a game on a plant level. It simulates the functioning of the plant at each quarter of the year during the whole planning horizon. The simulation model uses statistical data which reflects its "economic past". The game is oriented mainly towards education.

The connection of the game with IM-1 will open possibilities for research and operational use. The multilevel game IM-BES is still in the stage of development. The decision making process in the game is fulfilled in the form of discussions and consultations with the conductor of the game. The future work will be a collaborative venture between Bulgarian and German scientists. Similar to the CSSR game, "Enterprise", in this game it is also intended to build a system of models for decision making.

---

* Gernert, H., and M. Habedank. 1980. Multilevel Planning Game, "KOMBINAT". Proceedings of the 7th International Seminar on Management Games. Prague. (in Russian)

PA - Planning authorities
M - Ministry
E - Enterprise
P - Plant
R - Region
SR - Subregion

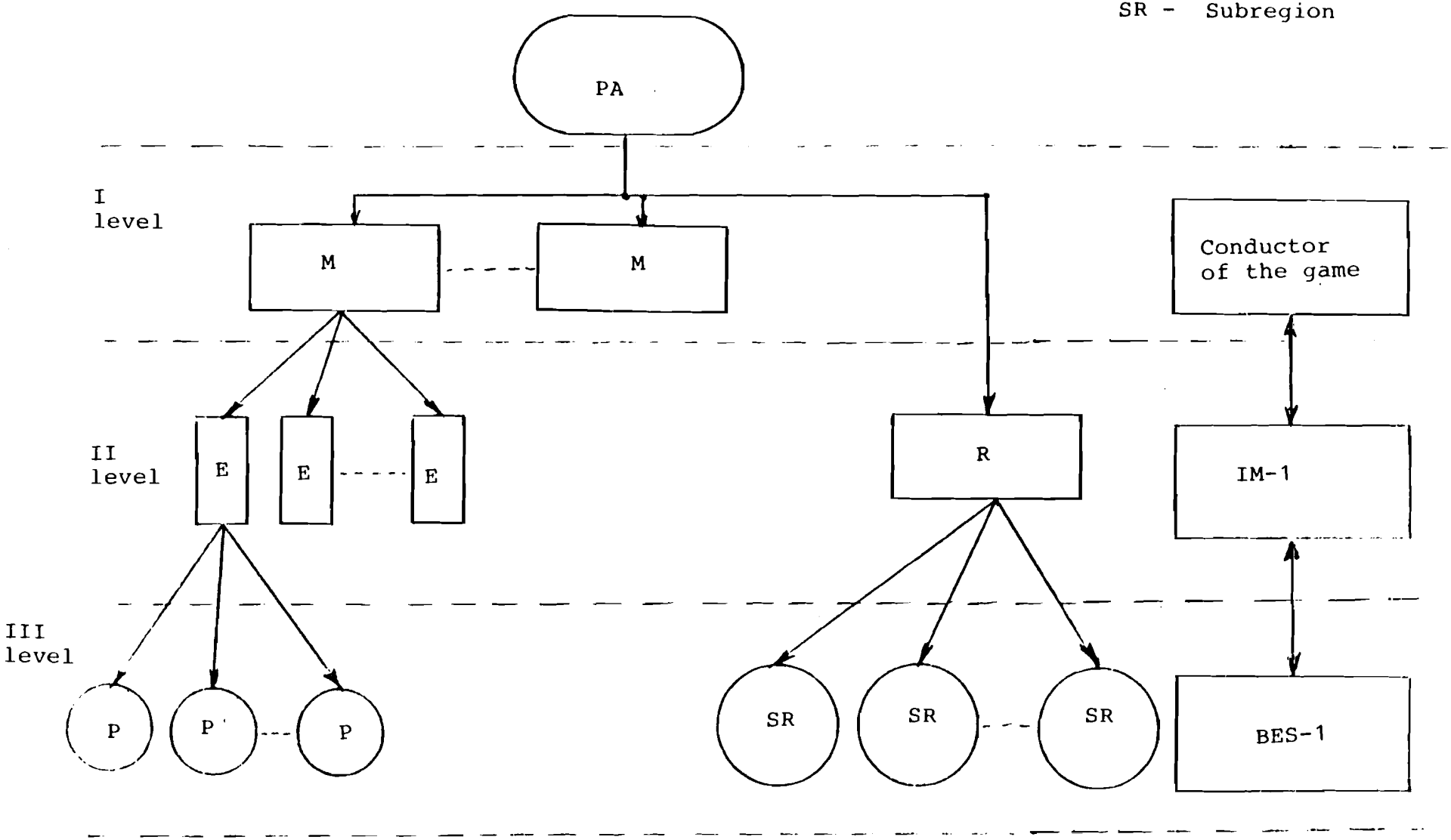


Figure 7: Communication Scheme

The system of models will be based on existing models and programs and it is going to be used for additional calculations by the players. The system is going to contain mainly the models shown in figure 8 where one possible connection between them is illustrated in the Silistra region in Bulgaria.

There are plans to construct a game with similar structure to that of the Silistra case study system of models. This game is intended to facilitate the dialogue in the strategic regional development process between the national and regional authorities.

APPLICATIONS OF MANAGEMENT GAMES

It is probably fair to say that the main area of applications of the management simulation games developed in socialist countries is in economics. (Games related to problems of humans relations, politics, ecology etc., were however, not reported in the seminars.)

For example, practically from each country *# games on inventory problems were reported. The management of the inventory process is a developed part of operations research. The gaming situation in these games is usually constructed by using a random generator and filters with specified probability distributions in order to simulate the processes of demand and supply in the warehouse. These games were used mainly for educational purposes.

Common for the research in gaming during the past five years is the development of large numbers of games based on the production process in the plant. The management game "Make a decision" designed by the scientists in the Institute to the Ministry of Labour in Budapest simulates the proudction process in a toy factory. †

The decision making process in a chemical production plant is modeled by the game IU-IV, developed by I. Fotr and S. Hajek from the Institute for Social Management in Prague.‡ BES-1 is as mentioned a game developed by H. Gernert from Humbolt University, East Berlin and also describes the production process and the relationship between the managers in a general type factory.

---

* Assa, I. and A. Kechayov, et al. 1978. Inventory Process Management. Proceedings of the 5th International Seminar on Managment Games in Sofia, X. (in Russian)

\# Dimitrova, I. and A. Marchev. 1978. Inventory. Proceedings of the 5th International Seminar on Management Games in Sofia, X. (in Russian)

† Doman, A. 1976. Make A Decision. Proceedings of the 3rd International Seminar on Management Games. Budapest. (In Russian)

‡ Fotr, I. and S. Hajek. 1976. Management Game, IU-IV. ISM, Sofia. (in Russian)

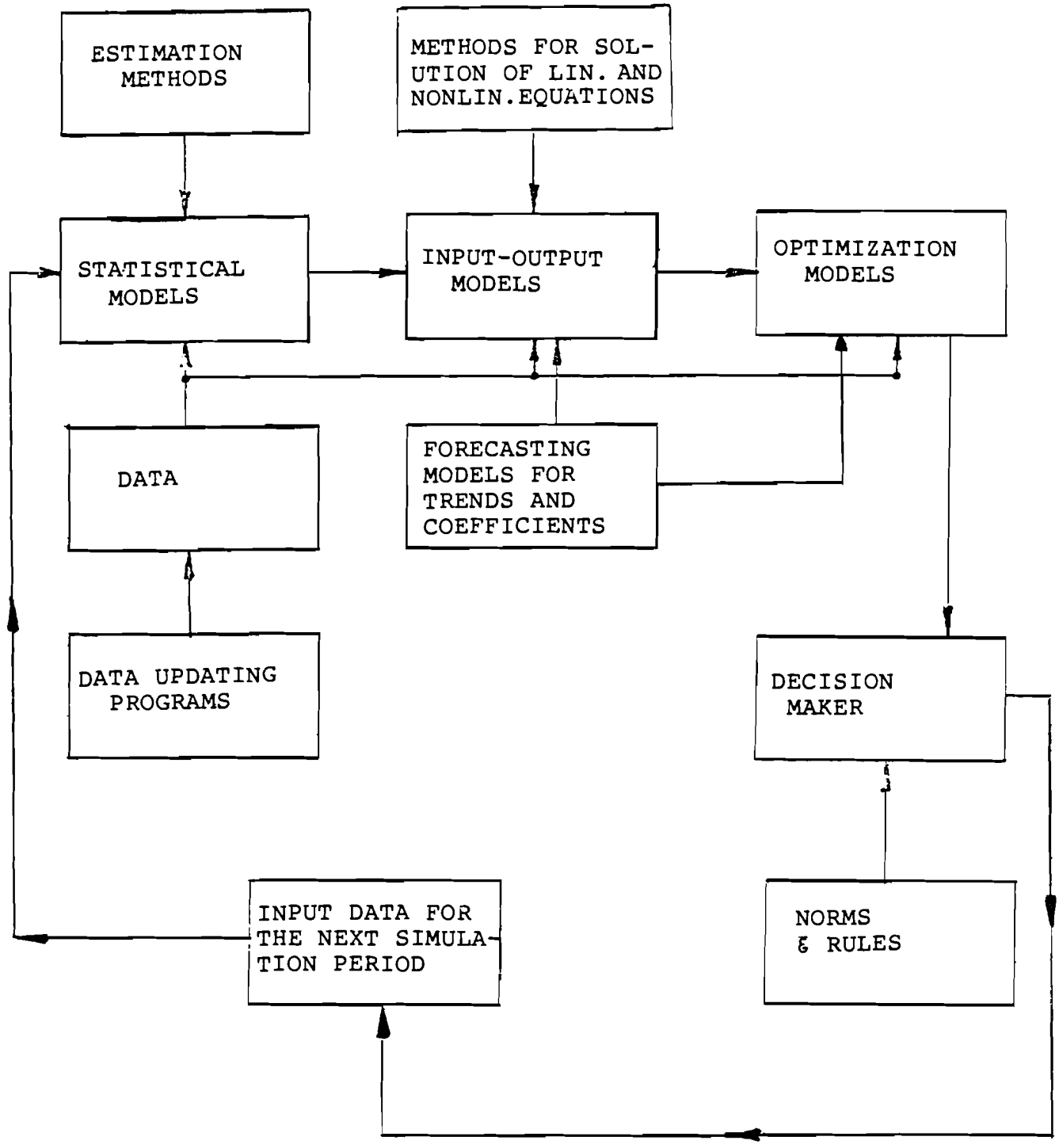


Figure 8: A Tentative Scheme for a System of Models

A number of games were reported on by the scientists from the Institute of Control Sciences, Moscow, which deal with the management process on plant level. These are the games "Project", "Plan", "Competition", "Maintenance", "Assignment", and "Stimuli of Production".[1]

The management game "Quality" analyses the factors which can influence the quality of production in the ship building industry. The game is reported by A. Stor, from Rostock, GDR.

"Red Weaver" is a game which is develped by V. Effimov and T. Djakubova[2] and studies the management and the production processes in a plant in the textile industry.

Several games were constructed and run in USSR in order to analyse the characteristics of a management information system (MIS) in large organization.[3] This idea was first given by R. Davis and B. Taylor[4] and it is widely used now for the efficiency assessment of MIS.

Management simulation games are considered by the scientists of the socialist countries working in the field of gaming as a powerful and active tool for educational purposes. According to answers to a questionaire ninety percent of them are convinced that the future use of gaming should be directed at educating students and managers.[5] Eighty percent of the

---

1 Burkov, V., Ivanovski, A., Nemzeva, A., and A. Shepkin 1978. Proceedings of the 5th International Seminar on Management Games. Sofia. (in Russian)

2 Djakubova, T. and V., Efimov. 1978. Management Game Red Weaver. Proceedings of the 5th International Seminar on Management Games. Sofia. (in Russian)

3 Efimov, V., and V. Komarov. 1978. Management Games used in the Development of MIS. Control Systems and Machines, No. 1. (in Russian)

4 Davis, R. and B. Taylor. 1975. Systems Design through Gaming. J. System Management, Volume 26.

5 Dobrinski, R. and I. Janeva. 1978. Management Games--today and tomorrow. Proceedings of the 5th International Seminar on Management Games. Sofia. (in Russian)

reported games in the seminars are educational. They are used in Humbolt University in GDR to teach students from the Department of Economics and Statistics, in the Institute for Social Management in Bulgaria to train top managerial staff in the application of quantitative methods and computers in social management, in the Institute for Training Managerial Staff in Poland in the field of economics, etc. (see appendix 1.)

From the reported applications several major conclusions can be drawn:

- The development of management games for educational purposes is done on the basis of simulation models and MIS.

- The construction of a game requires first the specification of those elements which could be useful in fulfilling the educational goals and second, the preparation of a scenario for a quasi-gaming situation with appropriate illustrative data. We consider that this approach is most commonly used for building games for educational purposes.

- The participants in the game get acquainted with the actual application of models in various sectors of the economy, and study how to act in different situations generated by concrete social and economic mechanisms.

- One can finally not neglect the advantages in studying the psychological interrelations between the different decision makers in the group and the considerable knowledge which the participants obtain by using the computer.

The researcher who designs an educational game must bear in mind two very important rules:

First, the educational game should reflect a real life situation and secondly, the didactic goals must be precisely and clearly formulated.

The didactic and psychological problems in the field of gaming are a major topic of the research activities in the institutes of Novosibirsk and Gdansk. The studies are oriented at describing the "specific features of managers personality", in the decision making process. The individuality of the manager is characterized by his knowledge, experience, intuition skills, attitude to the social and economic environment, habits

---

* Mironosezki, N.B. 1978. Active Educational Methods in the Training of Managerial Staff. Proceedings of the 5th International Seminar on Management Games, Sofia. (in Russian)

etc. The research in this particular field is done successfully by analysing the "history" of the game. Each management simulation game is considered to have its own history recorded when playing it with various participants different as regards to their education, profession, age and so on.

Valuable results have been obtained by scientists in Gdansk, Smolensk, Galendek, Repinski, on the basis of a sociological and statistical analysis of the history of a game which was run with more than 1500 participants--students, managers, scientists etc. * #

TRANSFER OF MANAGEMENT GAMES

The research reported on earlier has led to collaborative work among the scientists. The Hungarian game, "Make a Decision" has been transferred and implemented into the educational program in Freiberg University (GDR) and in the Institute for Social Management (Bulgaria). The game BES-1 designed at the Humbolt University (GDR) has been connected with the Bulgarian game "Economic Mechanism" designed by scientists from the Institute for Social Management. The result is as mentioned above a multilevel system which simulates the decision making process and the planning procedure in the chain - ministry - large enterprise - plant.

Some of the reported difficulties in the transfer of games can be summarized as follows:

1. Language difficulties;

2. The existing differences in the social and economic mechanisms;

3. The choice of appropriate institutional conditions (plant, enterprise, organization, etc) in each particular country where the game is transferred and adapted;

4. Gathering the necessary information.

5. The transfer of the models and the computer programs from one machine to another;

---

* Repinski, J. 1978. Use of Management Games in Educational Courses and Seminars. Proceedings of the 5th International Seminar on Managment Games, Sofia. (in Russian)

\# Wach, T. 1978. Participants Behavior in the Decision Making Process in theGame. Proceedings of the 5th International Seminar on Management Games, Sofia. (in Russian)

Scientists from the Budapest and Warsaw Universities have a great deal of experience in the transfer of games. In these two universities, the New York University Management Game designed by Myron Uretsky has been successfully transfered and implemented for the education of students and managers. The game is treated as an "Economic Laboratory".

A considerable amount of work has been done to change the economic instruments and the structure of the accounting procedures according to the existing economic system in the country.* Valuable results were obtained when the game was modified to take into account the new changes in the Hungarian economic mechanism. The three enterprises in the game were restructured according to the new conditions. Through this game managers are trained to use the new instruments and laws.

Scientists from GDR and Poland (M. Gernert and A. Metera) are working on the problem of building a computerized bank of management games. Reports show that the existing games in socialist countries are classified and stored in a computer in Warsaw. Considerable efforts were devoted to the game identification problem. Each game now is uniquely defined by a set of parameters which has been approved and accepted by all socialist countries. The existance of such a bank should hopefully stimulate further transfers of games and gaming ideas.

---

* MacWilliams, H., Mozes, L., and M. Uretsky. 1980. Transfer of Gaming Technology--A US-Hungarian Case. IIASA Seminar on Management Games.

Siebecke, R. editor. Die Experimentelle Methode in der Sozialistischen Betriebswirtschaftslehre. P.143, No 3/1, Okonomisches Labor Fridrich Schiller Universitaet, Jena.

CONCLUSIONS

The collaborative international work in the field of gaming among the CMEA's countries has led to successful results in the area of methodology, implementation, transfer and design of management simulation games. The experience is going to be published in the forthcoming international monograph on Gaming in the Institute for Social Management in Sofia.

The future of gaming is in the field of management of large organizations. Gaming must be considered as a tool of communication, as a language in the decision making process. The existing tendency to restrict management games application to education dangerously narrows their possible and useful implementation for operational and research purposes. In order to achieve implementation of gaming complex problems have to be solved. The management information process in large organizations has to be analysed and studied. Different and specific situations of the decision making process have to be generated. Scenarios for communication between the decision makers on different management levels and system of simulation models for the generated situations have to be designed. Algorithms and efficient techniques have to be used for the solution of the models.

The last seminar in Prague--3-7 November, 1980--discussed the problems of gaming in a new and different way. Two large and multilevel games were analysed on the basis of the problems of using such types of games for planning purposes in the socialist economies. The task will require an interdisciplinary team of specialists and international collaboration between the scientists in the CMEA countries.

We hope that the 1981 gaming seminar which will be held in IIASA will give rise to a more fruitful East-West collaboration in the field of gaming.

Appendix 1. The use of management simulation games in institutions represented at the CMEA gaming seminar.

Country/Institution	Field of Application	Participants in the gaming activities
BULGARIA		
Institute for Social Management - Sofia Karl Marx University of Economics - Sofia The Bulgarian Academy of Science	- inventory planning - industry planning - distribution of resources - site location - transportation - economic mechanism - global modeling - management information systems	students top managerial staff
ČSSR		
Institute for Social Management - Prague The CSSR Academy of Science Institute of Philosophy and Sociology Prague	- production planning in the enterprise level	students managers
GDR		
Humbolt University Berlin Bergakademie Freiberg Fr. Schiller University - Jena Technical Institute in Leuna - Merseburg Wilhelm Pieck University - Rostock Institute of Engineering - Zittau	- production planning in industrial enterprises - regional problems - international trade	students postgraduates managers
HUNGARY		
Research Institute to the Ministry of Labour - Budapest "Karl Marx" University in Budapest	- industrial planning - inventory problems - transportation	students managers
POLAND		
Warsaw University Lodz University Institute for organizational studies and training managerial staff - Warsaw Institute for Scientific Organization and Management - Gdansk	- accounting - planning on national and enterprise level - human relations	students managers
USSR		
Institute for Control Sciences - Moscow The USSR Academy of Science - Novosibirsk dept. International research Institute for Management Sciences, Moscow Moscow University	- planning - simulation of different economic mechanisms - inventory problems - transportation - allocation of resources - global modeling - management information systems - trade - regional studies	students postgraduates managers

REFERENCES

Assa, I., Gevrenov, S., Kolarov, N. and S. Petrov. 1976 Management Game Production Enterprise Economic Mechanism. Seminar Proceedings, Budapest. (in Russian)

Assa, I., and S. Petrov. 1977. Programming and Information Problems in the Design of Management Games. Proceedings of the 4th International Seminar. (in Polish)

Assa, I. and A. Kechayov, et al. 1978. Inventory Process Management. Proceedings of the 5th International Seminar on Managment Games in Sofia, X. (in Russian)

Assa, I. 1978. Management Games in the Decision Making Process. Informatika 78, Bled, Yugoslavia.

Assa, I., and I Petrov. 1978. Cybernetic Approach to the Management of Economic Systems. Amsterdam VIII. Proceedings of the International Congress on Systems Research and Cybernetics (W.O.G.S.R.C.)

Assa, I. and I. Tzvetanov. 1979. Management Game, Mono-resource Allocation Planning. Institute for Social Management. Sofia. P.130. (in Bulgarian)

Burkov, V. 1977. Foundations of the Mathematical Theory of Active Systems. "Nauka", Moscow. (in Russian)

Burkov, V., Ivanovski, A., Nemzeva, A., and A. Shepkin 1978. Proceedings of the 5th International Seminar on Management Games. Sofia. (in Russian)

Davis, R. and B. Taylor. 1975. Systems Design through Gaming. J. System Management, Volume 26.

Dimitrova, I. and A. Marchev. 1978. Inventory. Proceedings of the 5th International Seminar on Management Games in Sofia, X. (in Russian)

Dobrinski, R. and I. Janeva. 1978. Management Games--today and tomorrow. Proceedings of the 5th International Seminar on Management Games. Sofia. (in Russian)

Doman, A. 1976. Make A Decision. Proceedings of the 3rd International Seminar on Management Games. Budapest. (In Russian)

Djakubova, T. and V., Efimov. 1978. Management Game Red Weaver. Proceedings of the 5th International Seminar on Management Games. Sofia. (in Russian)

Efimov, V., and V. Komarov. 1978. Management Games used in the Development of MIS. Control Systems and Machines, No. 1. (in Russian)

Efimov, V., and V. Komarov. 1980. Introduction to Management Simulation Games. Izdatelstvo "Nauka", Moscow. (in Russian)

Fotr, I. and S. Hajek. 1976. Management Game, IU-IV. ISM, Sofia. (in Russian)

Fotr, I. and S. Hajek. 1978. Tentative Programming Structure of a General Type Management Simulation Game. Proceedings of the 5th International Seminar, Sofia. (in Russian)

Fotr, I. et al. 1980. Management of an Industrial Production Organization. Proceedings of the 7th International Seminar on Management Games, Xi. Prague. (in Russian)

Germayer, Y.B. 1976. Games with non-conflicting interests. Moscow, "Nauka". (in Russian)

Gernert, H., and M. Habedank. 1980. Multilevel Planning Game, "KOMBINAT". Proceedings of the 7th International Seminar on Management Games. Prague. (in Russian)

Klabbers, J.H.G. 1975. Interactive Simulation on-line Interaction between Man and Machine for the Study and Management of Social Systems. 6th Annual Conference on IIASA, Milano

MacWilliams, H., Mozes, L., and M. Uretsky. 1980. Transfer of Gaming Technology--A US-Hungarian Case. IIASA Seminar on Management Games.

Mesarovic, M.D. and E. Pestel. 1974. Multilevel Computer Model of World Development System. Proceedings of the Symposium, IIASA.

Mironosezki, N.B. 1978. Active Educational Methods in the Training of Managerial Staff. Proceedings of the 5th International Seminar on Management Games, Sofia. (in Russian)

Morgenstern, O., and J. von Neumann. 1944. Theory of Games and Economic Behavior. Princeton University Press.

Nash, J. 1951. Non-Cooperative Games. Annals of Mathematics.

Naylor, T.H. 1971. Computer Simulation Experiment with Models of Economic Systems. John Wiley & Sons Inc.

Nikolov, I. 1971. Cybernetics and Economics. Izdatelstvo "Nauka i Izkustvo", Sofia. (in Bulgarian)

Panov, O. 1978. Choice of the Type and the Characteristics of Management Games for Research and Training Purposes. Proceedings from the 5th International Seminar on Management Games for Research Purposes, Sofia. (in Russian)

Repinski, J. 1978. Use of Management Games in Educational Courses and Seminars. Proceedings of the 5th International Seminar on Managment Games, Sofia. (in Russian)

Siebecke, R. editor. Die Experimentelle Methode in der Sozialistischen Betriebswirtschaftslehre. P. 143, No 3/1, Okonomisches Labor Fridrich Schiller Universitaet Jena.

Vieviger, B. 1978. A Methodology for Development Simulation Models. Proceedings of the 5th International Seminar, Sofia. (in Russian)

Wach, T. 1978. Participants Behavior in the Decision Making Process in theGame. Proceedings of the 5th International Seminar on Management Games, Sofia. (in Russian)