# SYSTEM DYNAMICS MODELS AS DECISION SUPPORT SYSTEMS (DSS)

Hermann Krallmann
Department of Informatics
Technical University of Berlin
Berlin

Abstract

This abstract describes the further development of the project "Introduction of innovative Products into a competitive Market", the former stages of which have been already described in the Proceedings of the 1980 International Conference on Cybernetics Society, Cambridge 1980 (Krallmann (1980)).

The management of the company we cooperated with wanted to get support in the decision making process of introducing innovative but similar products into a competitive market. These different products for sterile (pure) water processing

- are based on the same idea of performance but different attributes (or properties)
- are of high quality
- use the same logistic
- operate in different markets.

Based on the two already developed System Dynamics models for two different products (see Krallmann (1980)), the idea was born to create a model base system. In the first step this model base system should contain

- a number of optimization routines (razor search, evolution strategies and other heuristic search algorithms)
- a planning language beside general statements which can handle the modules and algorithm routines with user friendly commands and which takes care of the execution process on different computers.



The second stage is to design an interface between the model base system and a data base system to get access of company's internal (e.g. cost accounting system) and external data. This step is now in the phase of design.

The planning language now under development can be characterized by interactive, flexible, transparent and user friendly. Further on the surface of this language is easy to use, reliable, reasonably self-explanatory, and responsive - just like a staff assistance. This points out an important conclusion: management wants to become directly involved in the model building process so that they may understand it and so that the model has credibility.

Another major additional change had to be performed at the DYNAMO-Compiler and its produced FORTRAN-Code.

Special software has been developed to present the results from the simulation models being investigated and data of the cost accounting system in integrated figures (in any desired arrangement of rows, columns, and headings). Report formats may be called from storage or specified as needed.

The main advantage of such a decision support system (model base system + planning language + report generator + data base system) consists in the fact that the manager can formulate and simulate very easily his own problems based on System Dynamics in this specific field at this time.

The requirements at decision support systems caused by growing problem complexity and organizational structure demand in the process of man machine communication the support of human inabilities as

- human memory through data base systems

- simultaneous consideration (analysis) of complex facts (problems) through model base systems.

These tools can give an important support to human capabilities as creativity and association of ideas.





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# I. Decision Support Systems - General Introduction

## 1. Operationality and Practicability

### 1.1 Flexibility

The demand of high flexibility of the DSS to be developed is derived from the essential characteristics in the case of strategic decisions in connection with occurring problem complexities, as unprecedented, novel and badly structured (see Vazsonyi (1978), p. 73). In the phases of system generating (identifying, defining and structuring of problems, hypothesis building) and of system building (definition of a qualitative model, application of method and model bases), the variation of structure and variable integration must be ensured. The understanding and the perceptions which the user has obtained during the process of model building and model validating must at every time be subject to easy implementation. Due to the interest of a most possible integration of the advantages of men (creative power, association, intuition) and machine (arithmetical command, accuracy, storage capacity), the area of development must not be affected neither in the phase of the model building process nor in the phase of search and choice of the decision alternatives. The DSS must adapt by its variable proceeding manner to the manner of reasoning of the decision maker and must attach main importance to the intuition as well as to the experience (see Neumann and Hadass (1980), p. 79, see further Wagner (1980 c), p. 5 "Instead, we are actually enhancing and amplifying the inherent mental powers of people by means of special tools, and stimulating their creativity.").

1.2 Transparency and Acceptance

The DSS must always have only the character of an auxiliary variable which is essentially impressed by the system components, as structure transparency, method comprehension and communication capability. Processes of transformation within the DSS must be transparent resp. reconstructable by decision makers so that a far reaching acceptance of the system procedure ensures an efficient application. "This points out an important conclusion: management wants to become directly involved in the model building process so that they may understand it and so that the model has credibility" (Wagner (1979), p. 15).

1.3 Computer supported integration of methods and data

As a result of the function exceeding character of the strategic decision problems to be solved. the DSS must overtake apart from providing procedure suited program elements a computer supported integration, i.e. especially the CCITT 24 management (see Bonczek among others (1980), p. 340). Such a method integration realizes the demand of best possible congruity of the characteristics of the problem complex to be analyzed and the characteristics of the methods to be applied. Already in the early 70 years v. Kortzfleisch pointed out the solution possibility of such a described method which has been realized in the scope of the chemical industry in projects with regard to the forecasts of economical consequences of the development in direction of a long life car and of an investigation of problems of raw material consumption (see also Assmann, Bellmann, Braess (1976); Seetzen, Krengel, v. Kortzfleisch (editors) (1979)). Beside the method integration the system user should be supported



at the adjustment between the model and the required data and should be helped by a computer supported data supply (see Preßmar (1980), p. 33).

1.4 Result generators

For reasons of enhancement of efficiency, working practicability as well as acceptance, a limited class of printed pictures and layouts with a view to a graphic, easily understandable and expoundable presentation of data evaluation and alternative analyzing must be put at the disposal by the DSS. In this connection Preßmar claims for report systems for the data editing and in accordance with the technical presentation-medium for the data presentation (see Preßmar (1980)), p. 35, further Keen and Wagner (1979), p. 120). Just for the user not so very familiar with the methods an assistance in interpretation of the results is of great importance, in which respect parameters of the informative, the forecasting and the pragmatic relevance serve the determination of the aim to be accomplished of the DSS (see Mertens and Bodendorf (1979), p. 533 f.).

1.5 Command and planning languages

The conversational language between decision maker and machine should comprise linguistic elements and integration rules which follow the expert languages of the decider in mnemonic technical respect. The user surface of this language "must be flexible, easy to use, reliable, reasonably self-explanatory, and responsive - just like a staff assistant" (Keen (1980), p. 41). If possible, the command language should be nonprocedural for supporting a thematic classification of the model structure in respect of the model building (see Keen and Wagner (1979), p. 119).

For a future orientated DSS a user friendly control system (also called method monitor) for the realization of complex program systems will be evident. The final user can integrate methods to parameterless procedures which can be established by a simple command language. The procedures are registered in a relevant file and are called with their names. Such a structured control ensures for the user an excellent combination of the methods without establishing a program.

Beside the process of model building and of program realization the phases of alternative finding and evaluation are to be realized computer supported. The procedures which always repeat in situations as alternative evaluation can be simulated by special simple commands. A "what-if" command allows after input of the strategy to be analyzed the automatic output of the results of selected objective variables in relation to the defined standard run. For supporting the alternative finding in the case of a planning with defined objective variables, the generating of a "goal-seeking" or "what-to-do-achieve" command is recommended which describes the planning measures to be performed in order to achieve a certain objective (see Wagner (1980 a), p. 210). The evident demand of the interactive equipment of the command and planning language (of the DSS) can at every time be argued as follows:

- direct use of the DSS by the decision maker
- considerable enhancement of efficiency by immediate reaction in group conferences and
- positive influence on the creativity and intuition of the decision maker (see Vazsonyi (1978), p. 76; Keen and Wagner (1979), p. 119).



An extremely comfortable handling of the unformatted data input up to normalized output routines, e.g. for tables and histograms, is a necessary request for the use of the system by the decision maker. He is an expert in the scope of application and disposes only of basic knowledges of the methods, who needs, however, explanation and decision supports for the efficient operating because of his limited know-how of EDP.

## 2. Modules of a DSS

### 2.1 Data base systems

Under the point of view of an extension of the possibilities of application of data for many different applications as well as for many different users the storage must be transmitted from the so far usual orientation on a special application to a general data orientation. The increasing data application on higher decision levels in the case of problem solutions which go across functional and organizational limits recommends the development of a data architecture plan for processing the concentrated information requirements of the enterprise. The development in the data management can be characterized by an

- increasing storage with direct access in the case of decreasing costs and increasing capacity
- data structuring with the capability to describe more complex data concatenation.

Thus the data base system becomes a necessary condition for a strategic DSS. The transition from data files over data file administration systems up to data bases considers the importance of the data as a basic auxiliary for decision functions. Data bases have been created for the following reasons:

- The flexibility of the different applications resp. data applications should be supported and not prevented.
- The redundant storage of similar data should possibly be prevented.
- The security of the data should be given by a consistent data base.
- User programs should become independent of the physical data organization.

## 2.2 Method base systems

As a second essential component of a strategic DSS, apart from the data base system a methods model base system is required with the function to support the decision maker (model builder) in the phase of modeling, i.e. of representing the real problem to be solved in quantitative termini by far-reaching standardized, often required, procedure appropriate program units (see Hauer (1979), p. 262).

A method base system is composed of

- a file of prefinished, documentated program elements (methods); these can be derived from existent method base packages of the producers or can be supplied by the final user himself.
- A method monitor (control system) with a data administration, a formula interpreter, a data base connection and procedures for integrating user own programs as well as
- software components for the user friendly support (i.e. choice of methods, interpretation and representation of methods, results of methods etc. (see Gernert (1979), p. 94 ff).



Concepts of development resp. tendencies in realized resp. method base systems to be realized have been formulated ·· Mertens and Bodendorf (1979), p. 533 ff):

- interactive operation
- extendable model (module) collection
- documentation of methods and, effected interactions between user and system
- system relevant method choice on the basis of descriptors under consideration of method and problem characteristics
- easy method integration
- Problem and data orientated supply with model parameters
- far reaching automated data supply
- interpretation supports for method and model results
- system relevant parameter variation in the case of objective searching methods
- computer support when handling the method base system (teachware)
- portability (transferability on other computers) (see also Lockemann and Mayr (1978), p. 310 f).

## 2.3 Integrative concept

The DSS for the time being in the process of investigation and development are characterized by the integration concept with the essential functions data manipulation and model building, which are resp. have been so far represented in the scope of data and model base systems (see Wagner (1980 a), p. 209). The realization of an efficient strategic DSS needs the integration of the functions "data handling" and "modeling" in the case of mutual direct involvement of the end user. Out of this fact three critical interfaces result which have to be got under control by the software of a DSS (see Bonczek, Holsapple and Whinston (1980 a), p. 345) on the one hand by the transfers between the system components data base and method base with regard to the user, on the other hand by the system internal interactions of data bases and model base (see fig. 1, next page).

## II. Decision Support System with regard to sales planning of innovative products

### 1. Description of the praxis project

### 1.1 Introduction

In the scope of the sales planning of innovative products, the following economical cybernetic approach serves for the analysis and for the representation of the structure as well as of the dynamic processes of the real phenomenon. Under consideration of exogenous quantities of deterministic and stochastic character (e.g. marketing strategies, price movements, quality requirements and awareness etc.) with the system dynamics approach by J.W. Forrester (1969) a model system for the decision support has been realized and implemented in the enterprise.

The below mentioned organizational criteria by Keen and Wagner for a DSS (see Keen and Wagner (1979), p. 118) should already be in this place on the one hand a standard for the valuation of the conception and on the other hand a standard for describing the big discrepancy which the here described DSS has to run through in the phase of development and implementation by steps up to the complete congruity with the following criteria catalog:



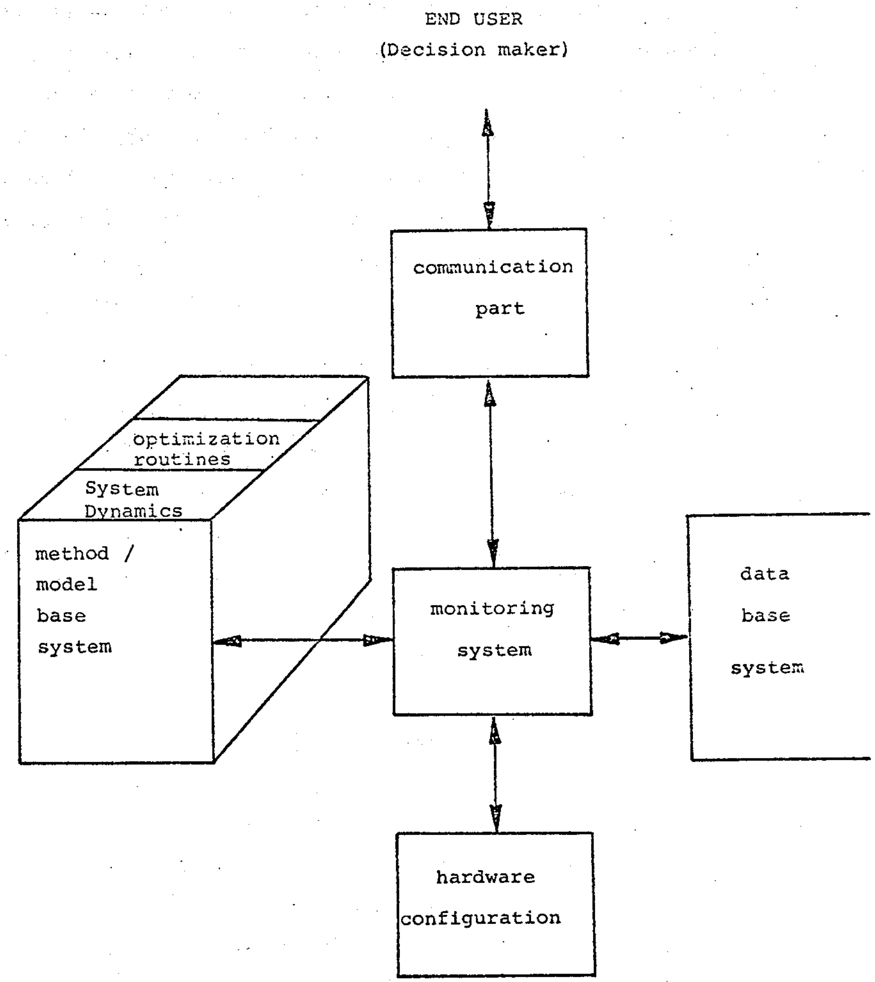



Fig. 1: Decision Support Systems

- flexible user language for a quick generation and use of DSS for specific applications
- a system architecture which enables quick and easy extensions resp. modifications
- interfaces, similar to the vocabulary and the turn of mind of the user, for the definition of his decision problem
- communication capable equipments (interactive screens) as well as generators for documentation of the results.

1.2 <u>Representation of the problem</u>

After several years of work of investigation and development a known German enterprise has introduced into the market a product for the disgerminating of water on the technologically new basis of the anodic oxidation. The competition advantage resulting of the innovative character as well as the high technical reliability of the product in the case of at the same time missing negative accompanying symptoms of other classical procedures (taste changing by chloric tablets etc.) has given a justified argument for good market expectations. However, within the first year the expected market success could not be realized. As a consequence, the enterprise initiated an investigation of the problem complex for documentating the small turn-over. For this purpose a project team of the responsible managers and external consultants was established (see Neumann and others (1980), p. 80).

It was intended to fulfill the following tasks successively by the project study:

- Analysis of the essential variables as well as of the



relevant structure of the existing problem complex (analysing the bottlenecks in the marketing process of the relevant product)
- Definition and analysis of different marketing strategies for increasing the turn-over
- Documentation of the consequences of different market strategies on the profitability of the product.

1.3 <u>Actual analysis</u>

In first discussion circles with brainstorming character first of all an analysis of the problem at this time was performed. On this occasion a qualitative model was contructed based on description techniques which documented particularly the following matters of facts:

- detailed structure of the main objective variables (customers' potential)
- influence factors on the main objective variables and their characteristics
- detailed structure of the sales canals
- influence factors on the intermediate persons and their acting characteristics within the sales structures.

Important conclusions of this first phase of the project study consisted in:

- The importance of system variables which had so far been negated (i.e. trade cycle, three devided trade structure), and
- the great importance of reciprocal influence of the observed determinants (i.e. delivery delays).

Because of the enormous complexity, non-linearity and dynamic of the problem only an exclusive presentation was excluded by a qualitative model. A computer supported economical cybernetic model should be established. In the first phase of this system realization, the system dynamics approach, developed by J. Forrester, was chosen out of the present pool of the methods under consideration of the present problem and objective characteristics. Applying this method the statements of the qualitative model in the direction of a formalized quantitative model system were specified. The flexibility of the method enabled a far reaching adaptation of the model system to the present data base in this case.

1.4 Model description

In the scope of the model development the results of different method strategies were quantitatively registered by a market research institute. The single phases of the model building process occurred in an iterative feedback process between the external consultants and the responsible members of the enterprise in order to enhance on the one hand the quality of the model and to strengthen on the other hand the acceptance and the confidence of the model users (see Keen (1980), p. 36). The model system to be developed was classified into five functional submodels with the intention to reuse it for sequence products with the same distribution structure (producer - trade - final user). The standardization of these subsystems (i.g. subsystem 4 - execution of order by trade) was effected under the points of view of larger modification tendency and modular extension. The result is represented in fig. 2 as a raw structure of the model (see next page).



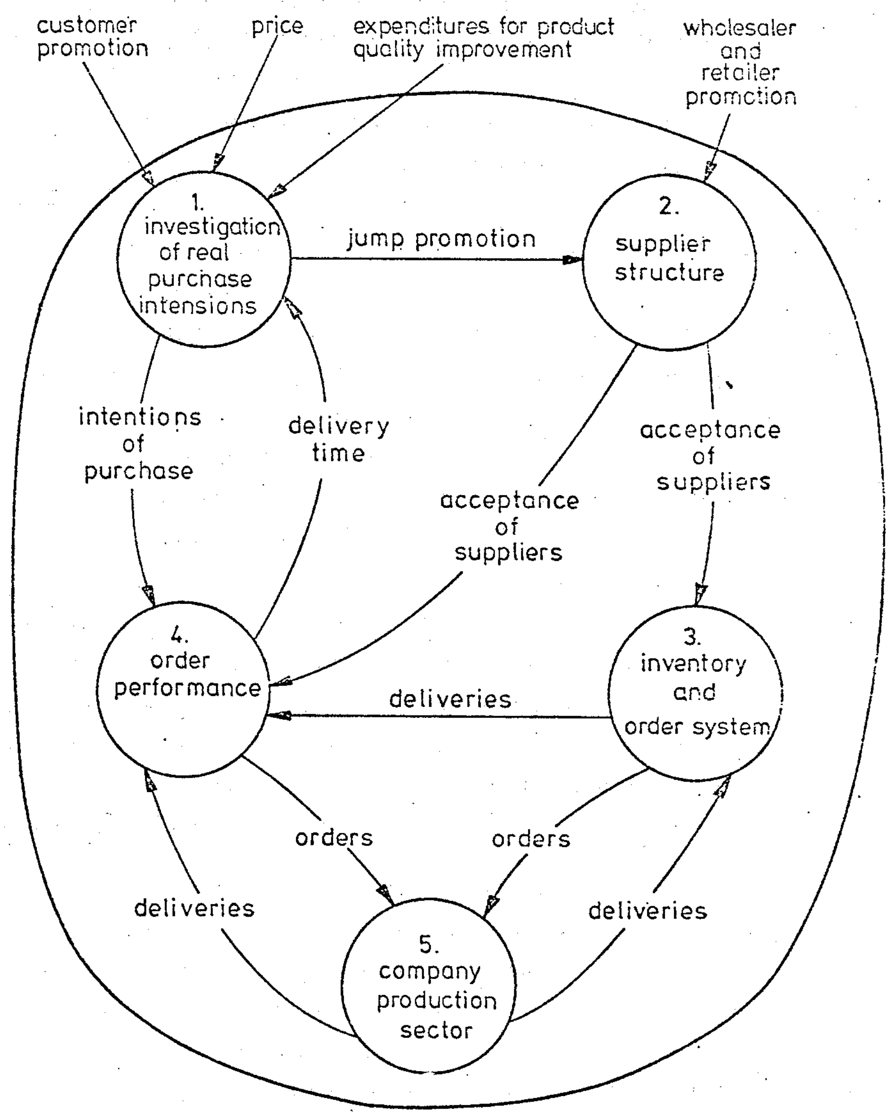



Fig. 2: Basic Structure of the Model

The decision to represent the introduction process of an innovative product line in a computer supported manner was the basis for the development of a future model base system. The functional submodels are concepted in a modular manner, independently practicable as well as exchangeable in the case if relevant model parts shall be substituted resp. completed with regard to other submodels for the numeric simulation of a sequence product. A user friendly command language, which is realized for the time being, defines the respective model building process.

In the subsystem 1 "investigation of real purchase intensions" all the behaviour manners and relations are summarized which are determinant for the monthly number of firmly determined buyers. Exogenous, i.e. from outside the system boundary coming input variables into this subsystem are represented by

- the recommended standard price for the product
- expenses of the enterprise for quality improvements as well as
- the promotion activities adjusted to the client and to the consignees of the mailing action (physicians and pharmacists).

An endogenous, i.e. an input variable coming from another subsystem within the system boundary is the

- average time of delivery

generated in the subsystem 4, which influences in a negative manner the number of firmly determined buyers with increasing tendency.



In the subsystem 2 "supplier structure" the development of the trade's opinion with regard to the product is modeled. As an endogenous variable the customers' demand of the subsystem 1 (jump promotion) has a positive influence on the dealer; as an exogenous variable the promotion activities of the producer have a positive influence on the trade.

In the subsystem 3 "inventory and order system" the stock-keeping policies and the order attitude of those dealers are shown who could be interested for the inclusion of the product into their assortment. In this respect the acceptance of the subsystem 2 "dealer structure" by the dealers as an endogenous input is necessary. For filling up the relevant stock, further informations concerning the supply on the producer's part (subsystem 5) become necessary.

In the subsystem 4 "order performance" the whole transaction of the order of firmly decided buyers is simulated. The endogenous input into the subsystem are on the one hand the real monthly buying intentions (subsystem 1), on the other hand the acceptance of the trade, measured in the readiness to reorder the product for the customer (subsystem 2). Further endogenous inputunits are given by the supply with the purpose of execution of the order, on the one hand by the subsystem 3, stock-keeping and ordering in the case of high supply readiness of the trade, and on the other hand by the subsystem 5 (company production sector) in the case of repeat and direct order of the product from the producer.

In the subsystem 5 "company production sector" the reactions of the producer are shown on orders of the trade, especially the time of the order transaction. Input into this subsystem are consequently the order of the trade (supplier) to take care of their stock resp. the direct supply of the customers out of the subsystems 3 resp. 4. By analogy, the output of this subsystem in form of deliveries is rendered to the same subsystems.

Each of these subsystems was formulated in accordance with the structures found out as a system of function equations. The so formalized quantitative model was implemented on a computer and adapted in an iterative process in its attitude to the observed real world (validation process).

1.5 Model application

The experiences and understanding in sensible parameters and bottleneck relations obtained in the process of validation yielded first starting points for a modification of strategies of the enterprise. Thus, for instance, the importance of the acceptance by the trade and the important position of the retailers were underestimated in the beginning. Furthermore, only by the systematic analysis, especially of dynamic market processes( e.g. buyer attitude, objective groups communication etc.), the occurred partial fizzling out of promotional measures could be explained and starting points for a more efficient use of strategies could be developed.

With the grown spectrum of use it had become necessary to extend the model by evaluation systems in order to enable a comparison of alternative strategies, also with a view to the product rentability (profit and loss account). For this purpose the enterprise internal bill of costs system was integrated into the existent model as a self-reliant subsystem. As a result of the modular construction this was connected with a very small



coupling expenditure. In the interface only input resp. output units in resp. out of already existing subsystems are occurring.

Considered in a long term manner, in this place the integration to a data base system with access to enterprise internal (e.g. bill of costs system) and external data shall be realized (see Müller 1980), p. 1 ff).

For finding out strategies for the improvement of different objective variables two procedures had been chosen:

1. For each parameter of the enterprise first of all the development of selected objective variables (e.g. monthly turnover) under variation of the relevant control variables was separately investigated. These results for price variations, customer promotion and dealer promotion modifications represented the decision supported basis for the planning of the marketing mix strategies, variable in time, by the enterprise management. By iterative feedback of the model results of such marketing mix strategies the real strategies were permanently developed.

2. By integrating the total model system to a defined feedback loop (structure) with a heuristic optimizing algorithm the development of an approximately optimal, time variant marketing mix strategy was transferred to the computer (see Krallmann (1976)). The approach for optimizing of simulation models of the type system dynamics with the direct search procedures(razor search, evolution strategy etc.) is the first step to establish an extensive method base system. The integration of the models which are realized in the DYNAMO language (with FORTRAN connection) (see Pugh (1976), p. 118 f.) is performed by an extensive software system in order to ensure highest

user friendliness.

The integration of the DYNAMO model, the manipulation of the FORTRAN code, based on the DYNAMO source and the choice of the logic switches which control the simulation resp. optimization process are realized by the software system. In principle, the end user indicates only the following variables:

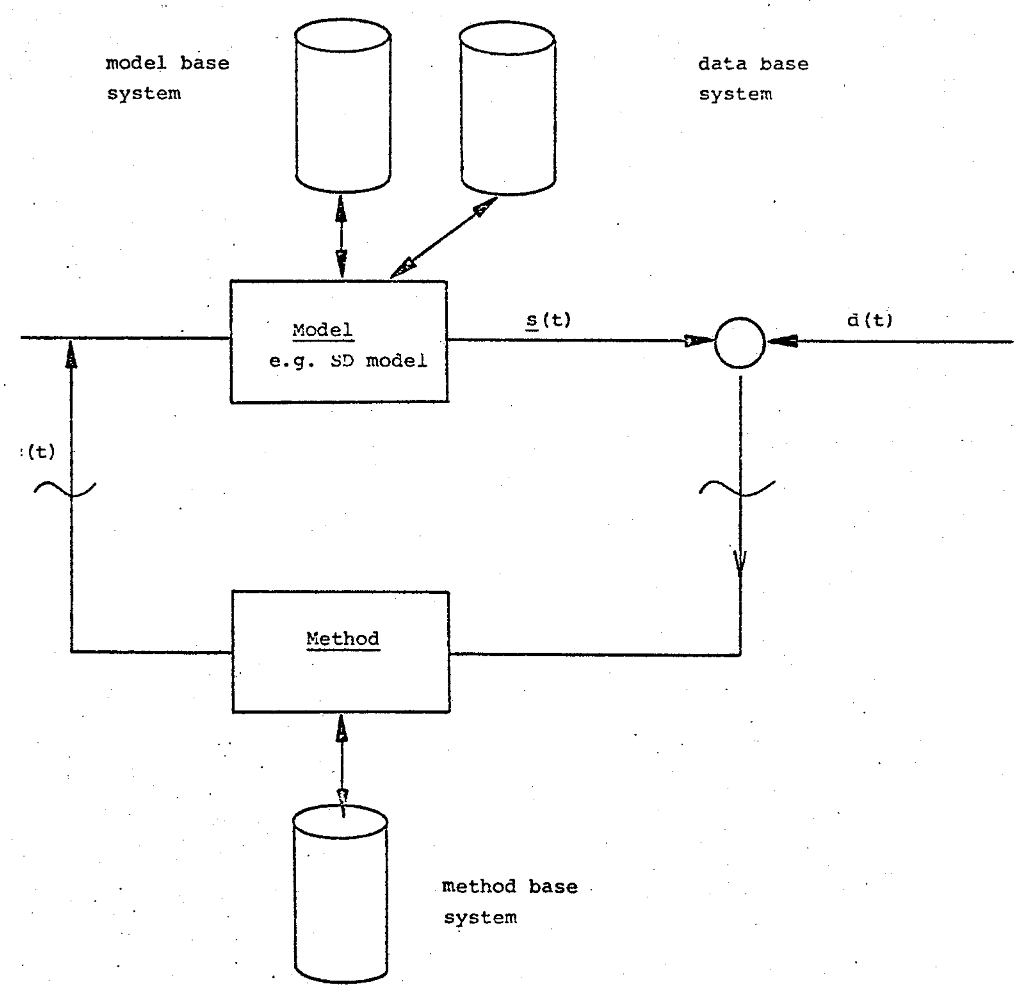
- the decision variables with the bandwidths in which they may be varied
- the objective resp. state variables and their requested upper and lower limits and
- some model based technical specifications (e.g. time of simulation in advance) (see Krallmann and Lehmann (1977), p. 35 f.).

With the user definition of bandwidths for the objective variables to be controlled due to the relevant optimization of the decision variables, the demand for a goalseeking command is in some way realized (see Wagner (1980 b), p. 36).

The choice of the dimension of these bandwidths (upper and lower limits) or guide lines (as they are named by v. Kortzfleisch) considers in an implicit manner a probability component of the computed state variable (see Keen and Wagner (1979), p. 119).

The total system configuration in its final phase of development is shown in fig. 3. The separation lines in the picture describe the interfaces for the integration of the method base system with a view to optimize the relevant model.






c(t): control vector
s(t): state vector
d(t): desired vector

Fig. 3: Total System Configuration

1.6 Results

Useful knowhows for the enterprise could be obtained during the system analytic study in different phases:

a) Insights into the problem determinants and structure in the phase of system generating

b) Insights into the quantitative dimension of the problem determinants and structures in the phases of system creation and implementation.

c) Insights into the margins of actions and results of alternative strategies in the phase of model application (model experiments).

## 2. Softwaretechnical Integration of Model and Method Base System

### 2.1 Software systems and their control process

The here presented optimization process according to the feedback principle is based on four essential program systems:

- the system dynamics model established by the user in the simulation language DYNAMO (Pugh (1973))
- the procedure "SHOOT"
- the model base system for the optimization routines
- the modules for representing different objective functions.

The system dynamics models are realized in the simulation language DYNAMO III/F, i.e. the DYNAMO compiler is a preprocessor, the generated source program of which is given in the programming language FORTRAN. The DYNAMO preprocessor consists of two different subsystems: the precompiler system and the run time system. In the run time system all subprograms are summarized which are used during the run time of a model. The precompiler system generates of the DYNAMO model an equivalent FORTRAN program



(ZZMOD) and a data file. The data file with the generated FORTRAN program serves the procedure "SHOOT" as input. This generated, efficient and complex EDT routine[1] modifies the control process of the original FORTRAN (DYNAMO) programs demonstrated in fig. 4.

The run time subroutines with names (capital letters) and functions are shown in fig. 4.

In detail, the EDT routine "SHOOT" performs the statements shown in fig. 5. The edited FORTRAN program (see fig. 5 last block) is then called by the optimization algorithm (razor search or evolution strategy).

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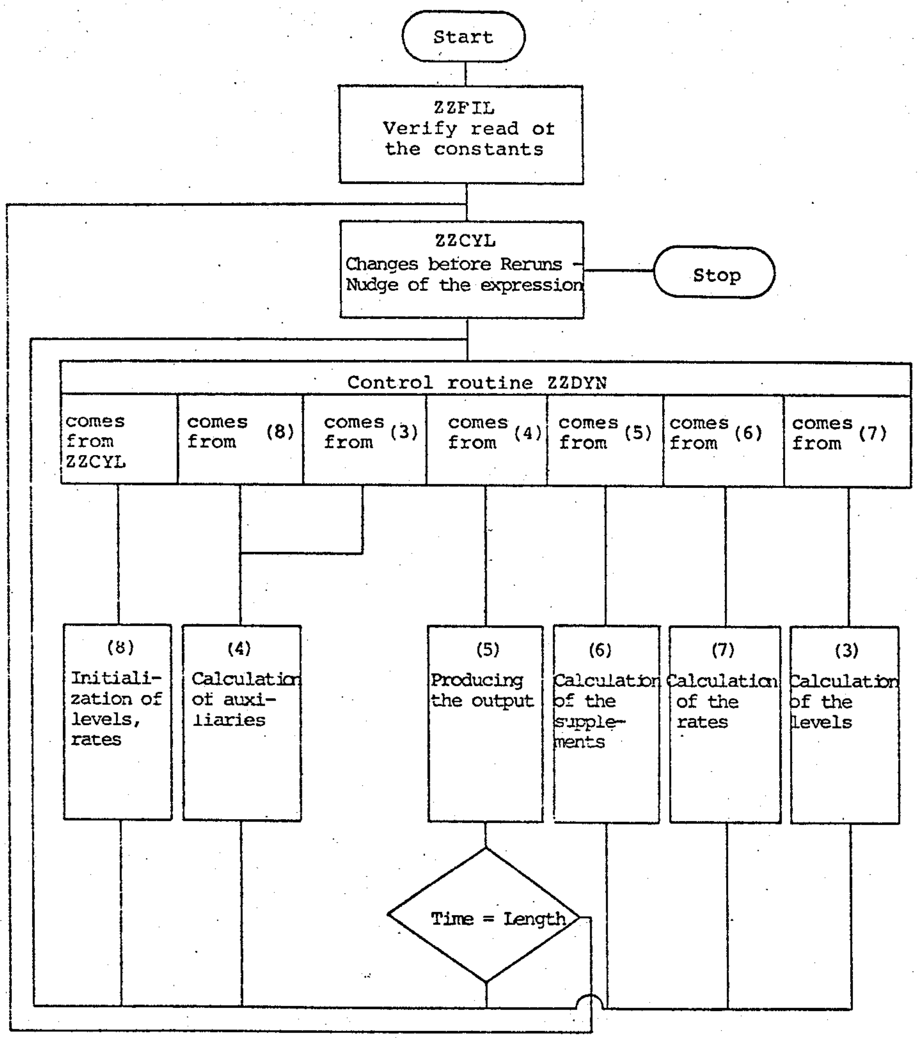


Fig. 4: Procedure of the original model

[1] The data file processor EDT is a user orientated dialog text editor. It enables the providing of data files; the adding, deleting and modifying of the text; the deleting, copying, comparing and concatenating of data files. The EDT can edit data files in the virtual storage or on the disk and contains advantages which permit EDT to become a text processing language (SIEMENS system 4004 (1975)).



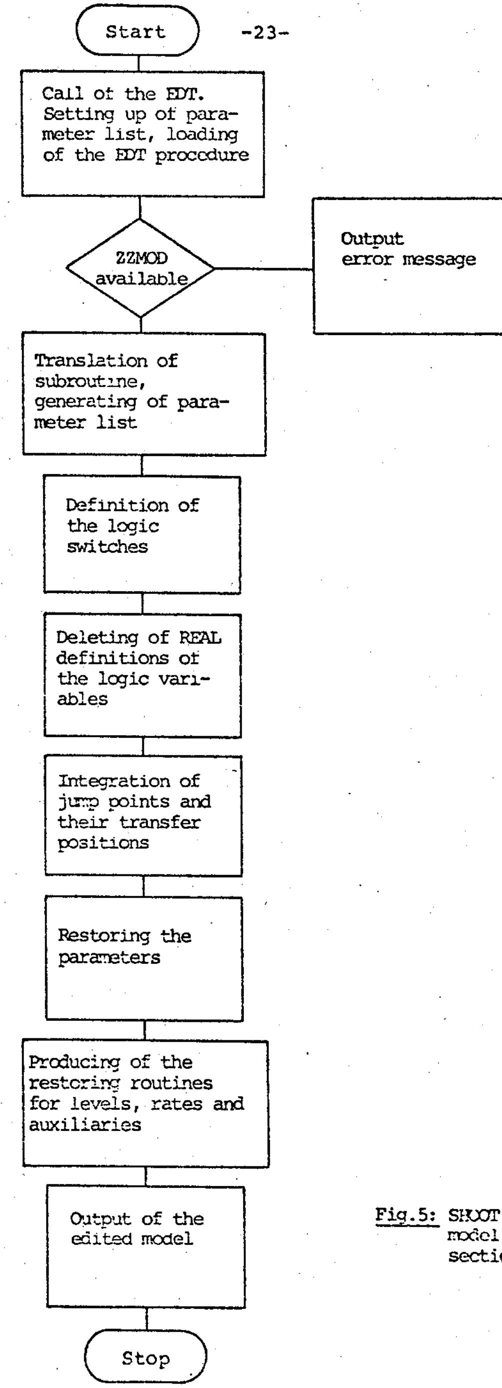


Fig.5: SHOOT: Editing of the DYNAMO model for continuous and sectional optimization

The logic switches in the objective function and in the model (FORTRAN program) administrate the flow of control, the single operations of which (from INITA to SAVE) are to be seen in table 1:

INITA : Starting inizialization of the model

INIT : Set back to time point t = 0

INITS : Set back to time point t = 0 and storing the model values as well as producing the output

OPT : Simulation in advance

OPTA : Set back to the last valid time point $t = t_i$ and simulation up to the time point $t = t_{i+1}$

OPTAS : Set back to the last valid time point $t = t_i$ simulation up to the time point $t = t_{i+1}$, storing the model values and producing the output

COMPUTA : Set back to time point t = 0, calculation of the optimized value for t = 0 and its output

COMPUT : Calculating and printing of the optimized values $t = t_1, \dots t_{end}$

SAVE : Calculating and intermediate storing of the last valid time point $t = t_i$.



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Logic switches for the flow of control of the model administrated by:

| Switch / Constellations | Objective function | | | | model |
|---|---|---|---|---|---|
| | FLAG 2 | T Ø | SAV 1 | SAVE | FLAG 1[1)] |
| INITA | +) | +) | - | - | +) |
| INIT | +) | +) | - | - | - |
| INITS | +) | +) | +) | +) | - |
| OPT | - | - | +) | - | - |
| OPTA | - | +) | - | - | - |
| OPTAS | - | +) | +) | +) | - |
| COMPUT | - | - | - | +) | - |
| COMPUTA | +) | +) | - | +) | - |
| SAVE | - | - | +) | - | - |

+) Switch = TRUE
- Switch = FALSE

table 1: Switch constellation for flow of control of the model

1) FLAG 1 is set by the model itself. It performs the unique call of the two initialization routines "ZZFIL" and "ZZCYL". It does not influence the proper model flow.

The variety of the operations has been effected on the basis of the logic switch constellations on the one hand

- by the manifold combination of the simulation and optimization variants:
  - Simulation of the model from $t_{start}$ up to $t_m$ following optimization of the model for every time point $t_i$, $t_m \leq t_i \leq t_{end}$;
  - Optimization of the model for every time point $t_i$, $t_{start} \leq t_i \leq t_{end}$.
  - Optimization of the model for the time point $t_i$; following simulation with the optimal parameter values for a definite interval $t_i + t_D$; with relevant combination (optimization + simulation) up to $t_{end}$

and on the other hand

- due to the time period of realization, in which connection a certain redundancy of the logic switches could not be avoided (or only subsequently with additional amount of time).

For the continuous optimization fig. 6 shows the procedural scheme.

Furthermore, the possibility must be provided that the optimization algorithm relative to a default number of iterations or due to a limited CPU time per optimization time point $t_i$ is not able to determine an optimal parameter constellation of the control vector with regard to the objective function.

The already effected and subsequent process of the total integrated software system will be realized by a control routine which is initiated by the end user by means of a user friendly communication part.





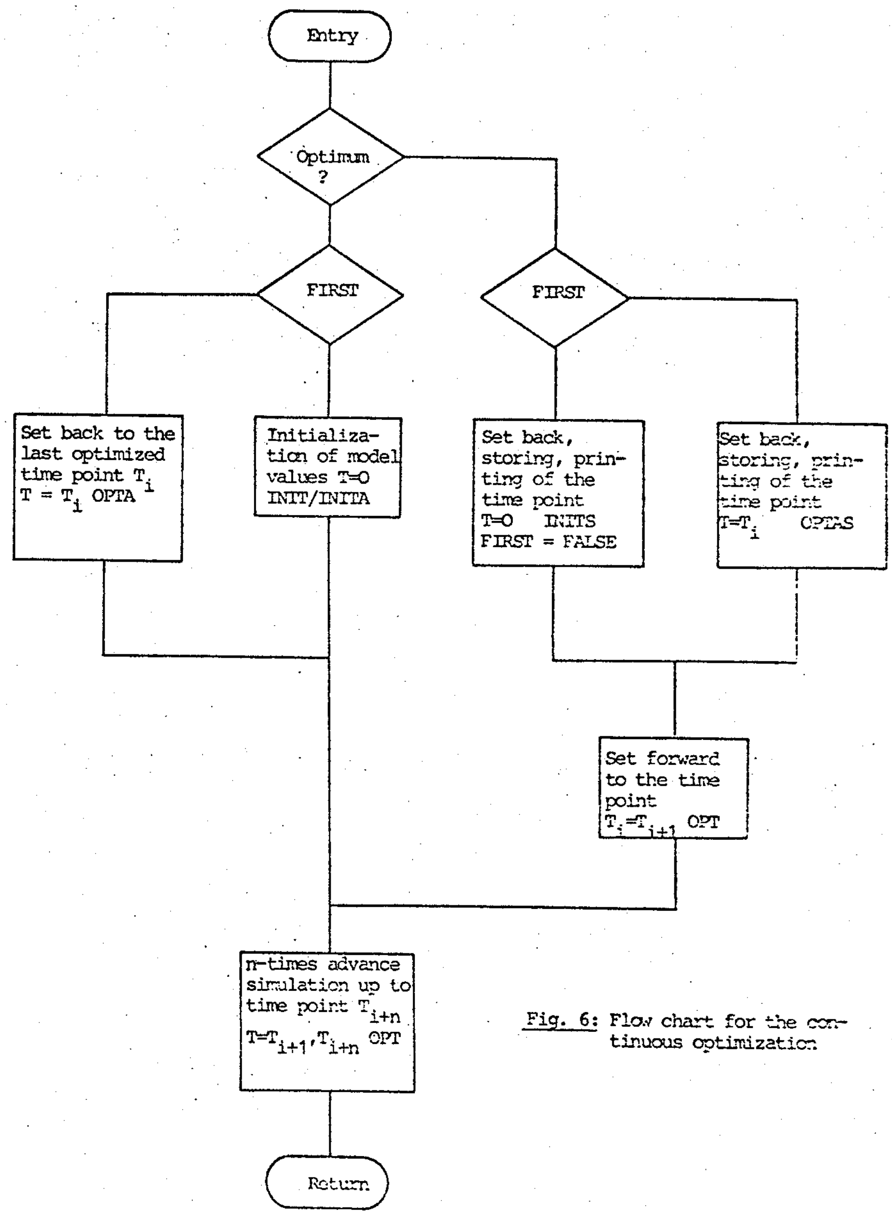


Fig. 6: Flow chart for the continuous optimization

## 2.2 User friendly communication part

The above described software system serves the absolute priority of the realization of a user friendly, computer supported planning system (see chapt. III). The integration of the end user, the reduction of his acceptance problem by a user friendly communication part, which is on the one hand extremely robust and on the other hand easy to learn were the central point of this software development. The easiness of use and the minimal EDP specific know-how are demonstrated by the computer supported dialog in the communication part (see fig. 7).

In principle, only the following informations are required of the end user:

- Number, name and restrictions of the control variables
- Number and names of the state variables
- Specification and parameters of the objective function
- Declarations regarding the simulation/optimization variants
- Choice of the optimization algorithm and the relevant parameters (documented in a self-explanatory manner).





```
(OUT)   YOU ARE IN SEGMENT:
(OUT)        TEXT
(OUT)   DO YOU WANT FURTHER RESP. REPEATED INFORMATION:
        ANSWER (Y/N)
        OR DO YOU WANT TO SKIP: ANSWER (C,&lt;SEGMENT&gt;)
(IN)  Y
(OUT)   YOU HAVE THE POSSIBILITY TO OPTIMIZE CERTAIN VARIABLES
(OUT)   OUT OF YOUR ALREADY DEVELOPED SIMULATION MODEL BY MEANS
(OUT)   OF AN OPTIMIZATION PROCEDURE (FURTHER ON CALLED OPTPARMS).
(OUT)   FURTHERMORE YOU CAN OBTAIN STATE VARIABLES OUT OF YOUR
(OUT)   MODEL (FURTHER ON CALLED ZUPARMS), WHICH YOU CAN USE IN
(OUT)   YOUR OBJECTIVE FUNCTION.
(OUT)
(OUT)   EXAMPLE:   OBJ.FUNCT.=WEIGHT1 * ZUPARM1 + WEIGHT2 * ZUPARM2
(OUT)   YOU ARE GUIDED IN THIS INTERACTIVE PHASE OF THE OPTIMI-
(OUT)   ZATION BY QUESTION AND ANSWER. IF YOU ARE IN A TEXT PART
(OUT)   (LIKE NOW) THE SIGNS  *+-O   APPEAR FOR TURNING OVER.
(OUT)    + OR * MEANS TURN OVER ; - IS  TURN BACK ; O  FINISH
(OUT)   THE TEXT.
(OUT)
(OUT)
(OUT)   *+-O
(IN)    *
(OUT)
(OUT)   YOU ARE IN SEGMENT:
(OUT)        TEXT
(OUT)   DO YOU WANT FURTHER RESP. REPEATED INFORMATION:
        ANSWER (Y/N)
        OR DO YOU WANT TO SKIP: ANSWER (C,&lt;SEGMENT&gt;)
(IN)   N
(OUT)   YOU ARE IN SEGMENT:
(OUT)   EPROC. COMMON
(OUT)   DO YOU WANT FURTHER RESP. REPEATED INFORMATION:
        ANSWER (Y/N)
        OR DO YOU WANT TO SKIP: ANSWER (C,&lt;SEGMENT&gt;)
(IN)   N
(OUT)   ENTER THE VARIABLE LIST, SEPARATED BY COMMATA,
        MAXIMUM THREE DISPLAY LINES (80 SIGNS EACH)      !!!
(IN)    A1, A2,A3,A4,A5,A6,A7,Z1,Z2,Z3,Z4,Z5
(OUT)   A1,A2,A3,A4,A5,A6,A7,Z1,Z2,Z3,Z4,Z5
(OUT)   WAS THE ANSWER CORRECT? : ANSWER (Y/N)
        OR DO YOU WANT ONCE AGAIN THE EXPLANATION ? : ANSWER (R)
(IN)    Y
(OUT)   PLEASE WAIT !!
(OUT)       E N D  COMMON
(OUT)   YOU ARE IN SEGMENT:
(OUT)       EPROC.OPTPARM
(OUT)   DO YOU WANT FURTHER RESP. REPEATED INFORMATION:
        ANSWER (Y/N)
        OR DO YOU WANT TO SKIP : ANSWER (C, &lt;SEGMENT&gt;)
(IN)   N
(OUT)  THESE ARE ALL YOUR POSSIBLE VARIABLES
(OUT)  A1,A2,A3,A4,A5,A6,A7,Z1,Z2,Z3,Z4,Z5
(OUT)    PLEASE ENTER FIRST THE NUMBER AND VARIABLE LIST
         SEPARATED BY COMMATA, MAXIMUM 10, MAXIMUM THREE
         DISPLAY LINES (A 80 SIGNS)          !!!
```

```
(IN)     3,A1,A3,A5
(OUT)    3,A1,A3,A5
(OUT)    WAS THE ANSWER CORRECT? : ANSWER (Y/N)
         OR DO YOU WANT ONCE AGAIN THE EXPLANATION? = ANSWER (R)
(IN)    N
(OUT)       ENTER FIRST THE NUMBER AND VARIABLE LIST, SEPARATED
            BY COMMATA, MAXIMUM 10, MAXIMUM THREE DISPLAY LINES
            (A 80 SIGNS)                      !!!
(IN)    3,A1,A3,A5
(OUT)   3,A1,A3,A5
(OUT)   WAS THE ANSWER CORRECT? : ANSWER (Y/N)
        OR DO YOU WANT ONCE AGAIN THE EXPLANATION ? : ANSWER (R)
(IN)   Y
```

Fig. 7: Computer supported communication part

A communication part realized in this manner enables end users with different know-how (EDP training etc.) and different professional career to handle computer aided decision support systems (see also chapt. III), by having realized first steps with a view to individual adaptability.



## III. Critical Summary

For judging the presented DSS the criteria by Sprague and Watson ((1975), p. 35 ff.) shall be taken:

- Collection of modular models for support in different functional fields and on different management levels;
- Modular model elements which are transferable single or in any combination;
- Mechanisms for direct automatic data supply of models out of the data base;
- Common end user language for data handling and for model building resp. execution.

Critically seen, it must be said that with the DSS for the sales' planning of innovative products only proportional parts of the criteria of Sprague and Watson resp. Keen and Wagner could be realized, but the basic conception as well as principle ideas could be performed.

Some experiences and understandings of these first phases of development resp. implementation process can be summarized as follows:

- The application spectrum and the extension of the DSS should grow in a stepwise manner with the degree of maturity and comprehension of technology resp. of personal, i.e. only modules should be added which are applicable in technical, organizational and economical respect.
- The development of the DSS and the implementation into an existent EDP system of the enterprise should be directly supported and realized in cooperation with the end user himself.

If the demand of the DSS is defined in the improvement of the efficiency of the strategic decision processes and in the synergistic connection of the qualifications of men and machines, there is still a far road to success.



References


1. Assmann, W., Bellmann, K. and H.H. Braess and others: Aspekte einer Verlängerung der Lebensdauer von Personenkraftwagen im Hinblick auf technische Entwicklungsfortschritte, Umweltfragen, Verkehrs- und Industriestrukturprobleme, Phase I - (Langzeitauto), München (1976)
2. Bonczek, R.H., Holsapple, C.W. and A.W. Whinston: The Evolving Roles of Models in Decision Support Systems. In: Decision Sciences, Vol. 11 / No. 2/ April (1980), p. 337-356.
3. Gernert, D.: Möglichkeiten und Probleme der Integration von Daten- und Methodenbanken. In: Informatik-Fachberichte, GI-Fachtagung, Tutzing, Berlin u.a. (1979), p. 94-109.
4. Hauer, K.H.: Methodenbank-Monitorsysteme und ihre Einsatzmöglichkeiten. In: Informatik-Fachberichte, Berlin u.a. (1979), p. 262-273.
5. Keen, P.G.W. and G.R. Wagner: DSS: an Executive Mind Support System. In: Datamation, Nov. (1979), p. 117-122.
6. Keen, P.G.W.: Decision Support System: Translating Analytic Techniques into Useful Tools. In: Sloan Management Review : Vol. 21 / No. 3 / Spring (1980), p. 33-44.
7. Krallmann, H.: Heuristische Optimierung von Simulationsmodellen mit dem Razor Search Algorithmus, Basel u.a. (1976).
8. Krallmann, H. and G. Lehmann: "Optimierung dynamischer, nichtlinearer Systeme mit dem Razor Search-Verfahren. In: Angewandte Planung, Vol. 1 (1977), p. 30-40.
9. Krallmann, H.: System Dynamics, a Tool for Corporate Planning, in: System Dynamics and Analysis of Change (Ed. B.E. Paulré), AFCET 1981.
10. Lockemann, P.C. and H.C. Mayr: Rechnergestützte Informationssysteme, Berlin u.a. (1978).
11. Mertens, P. and F. Bodendorf: Interaktiv nutzbare Methodenbanken, Entwurfskriterien und Stand der Verwirklichung. In: Angewandte Informatik 12 / (1979), p. 533-541.

12. Müller,G.: Perspektiven des Einsatzes relationaler Datenbanktechnologie im betrieblichen Rechnungswesen. In: 6. Wirtschaftsinformatik-Symposium, Bad Neuenahr, Sept. (1980), p. 1-39.

13. Neumann,S. and M. Hadass: DSS and Strategic Decisions. In: California Management Review / Vol. 2 / No. 3/ Spring (1980), p. 77-84

14. Preßmar, D.B.: Methoden und Probleme der computergestützten Unternehmensplanung. In: Schriften zur Unternehmenführung (Ed.): H. Jacob, Vol. 28, (1980), p. 7-45.

15. Pugh, A.L.: DYNAMO -User's Manual, Fifth Edition, Cambridge, Mass. (1976).

16. Seetzen,J., Krengel,R. and G.v.Kortzfleisch: Makroökonomische Input-Output-Analysen und dynamische Modelle zur Erfassung technischer Entwicklungen, Basel u.a. (1979).

17. SIEMENS - System 4004 Betriebssystem BS 2000 Dateibearbeiter (EDT) Beschreibung, Version 2, München 1975.

18. Sprague, R.H. and H.J. Watson: MIS-Concepts - Part II. In: Journal of Systems Management, Vol. 26 / No. 2 /(1975), p. 35-40.

19. Vazsonyi,A.: Information Systems in Management Decision Support Systems. In: Interfaces, Vol.9 /No.1 / Nov.(1978), p. 72-77.

20. Wagner,G.R.: Enhancing Creativity in Strategic Planning through Computer Systems. In: Managerial Planning, July-Aug. (1979), p. 10-16.

21. Wagner, G.R.: Optimizing Decision Support Systems. In: Datamation / Vol. 26 / No.5 / May (1980a), p. 209-214.

22. Wagner, G.R.: Things to Come in Planning Technology. In: Financial Executive, Vol. 48, No. 5 / May (1980b),p.34-40.

23. Wagner, G.R.: Decision Support in the Office of the Future. In: Managerial Planning, Vol. 28 / No. 6 / (1980c), p.3-5.