Development of a common communication and control system for system dynamics type of simulation models

Prof. Dr. H. Krallmann
Dr. B. Rieger
Dipl.-Ing. G. Hentzelt

Abstract

Today for managers or in general for non data processing experts the use and application of simulation models is of very high expenditure.

Editing and changing model parameters, studying the simulation language or applying e.g. a graphical standard software package are very unusual activities for this special user group. Due to this situation it cannot be expected that simulation models which deliver very important results for decision support get near to these people.

In this paper a user friendly communication and control system is presented, which offers an optimal user guidance in modifying and running simulation models, in creating a user friendly graphical output and in the interpretation of the model results.

1. Introduction

Characteristics both internal and external to the firm, such as sudden changes in environmental conditions or growing complexity of decision determinants, increasingly put management under pressure. Lack of suitable resources frequently compels reactive behaviour, whereby potentially profitable opportunities are not noticed or trends endangering the firm are recognized too late /KRALLMANN 81/. Dynamic modeling is one of a number of tools to support management in this area. There are three major problems, that restrain simulation models from a widespread and direct use by top management:

- the application of simulation packages
- the use of editors to change model parameters
- difficulties in model result interpretation

An easy to use communication and control system facing these problems can be a powerful tool to improve the acceptance of simulation models. The system presented in this paper in a first step integrates the use of DYNAMO /PUGH 76/ as simulation language with selected features of the statistical analysis system SAS /SAS 83/ as tool for the graphical representation of model results.

Since one major advantage of simulation models for management decisions lies in its parametric use, whilst the models themselves are still built by specialized staff personal, the system primarily concentrates on functions applying preformulated models.

Supplying these functions in a comfortable and easy to use way including automatic and quick generation of high resolution graphics, expressive to typical managerial questions such as "what if ?", the advantages of simulation models can better be transferred. In this way, acceptance by top management can be gained faster. This feeling for potential benefits is considered as a prerequisite for a wide spread and more direct use by managers /RIEGER 85/. Parallel to this development more sophisticated functions concerning the

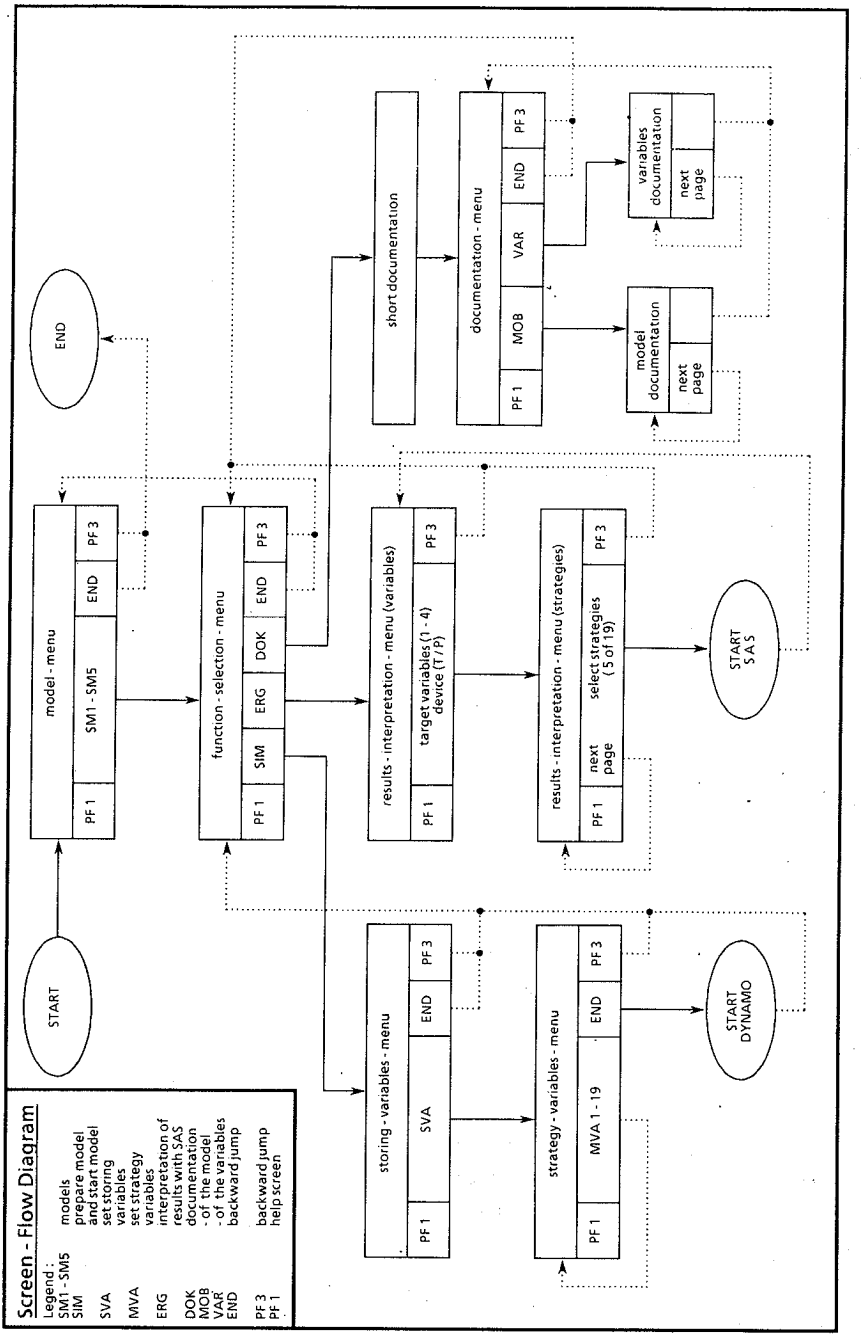


Fig. 1 System Control Diagram

structural modifications of models up to the formulation of new models can be added to the system.

2. Requirements

Due to this strategy the functional requirements for the first system version are the following /HENTZELT 85/:

- selection of preformulated simulation models
- generation of alternatives by variation of model variables representing the instruments of managerial policy
- interactive initiation and automatic control of simulation cycles including the storing and administration of selected result parameters
- interactive selection of result parameters and graphic processing for comparative analysis of alternative strategies
- model documentation inquiries on different levels of aggregation

3. System User Communication

To fulfil these and later requirements the functions have been aggregated to three logical blocks:

- Manipulation of simulation and model variables and start of the simulation runs
- Selection of stored simulation runs to start comparative plots
- Online documentation of the available models

The system user communication is controled by easy to use screen menus. For each of the menus a help screen exists, attainable with the permanent function key PF-1. The screen menus are designed in a common manner, and functions as well as function keys keep their meaning. The system is resistant against wrong user input and only warning messages will be displayed with a request for new input. An overview of the system control is shown in fig. 1.

The first menu (fig. 2) shows the different models available to the system. Model names are read from a directory file in the model management system and displayed on the screen mask. The user selects the desired model by a three letter identification (SM1...SM5). The identification END or depression of the permanent function key PF-3 ends the session. The PF-1 key displays a short description of all available models on the screen. Messages for the selection of a non existing model or for a wrong function selection are available.

```
TU - BERLIN                                        FG - SYSTEMANALYSE / EDV
**********************************************************************

          ***          M O D E L L A U S W A H L          ***

                       BITTE WAEHLEN SIE ===>  sm5

 SM1 : SIMULATIONSMODELL - Produktions- und Absatzstrategien -
 SM2 : SIMULATIONSMODELL - Marketing - Mix - Strategien      -
 SM3 : SIMULATIONSMODELL - Bestellpolitik                    -
 SM4 : SIMULATIONSMODELL - Qualitative Personalplanung       -
 SM5 :          SIMULATIONSMODELL  NICHT  IMPLEMENTIERT
 END : ENDE


----------------------------------------------------------------------------
 1=Help                      3=Quit
 WEITER MIT <ENTER>-TASTE   >>>SIMULATIONSMODELL NOCH NICHT IMPLEMENTIERT<<<
```

Fig. 2 Model-Selection-Menu

The next screen (fig. 3) is the function-selection-menu. It gives the opportunity to branch to the three major system functions. In further releases functions for model building will be added on this level. Function SIM passes control to the screens for manipulation of simulation and model variables and start of model runs. ERG branches to the graphical result interpretation. Selection of this function without any result of model runs available causes an appropriate

warning message and request new function selection. DOK branches to the online documentation function. END or PF-3 key branches back to the model menu. PF-1 key gives the online description of available functions for this screen. Other input is rejected with appropriate warning messages.

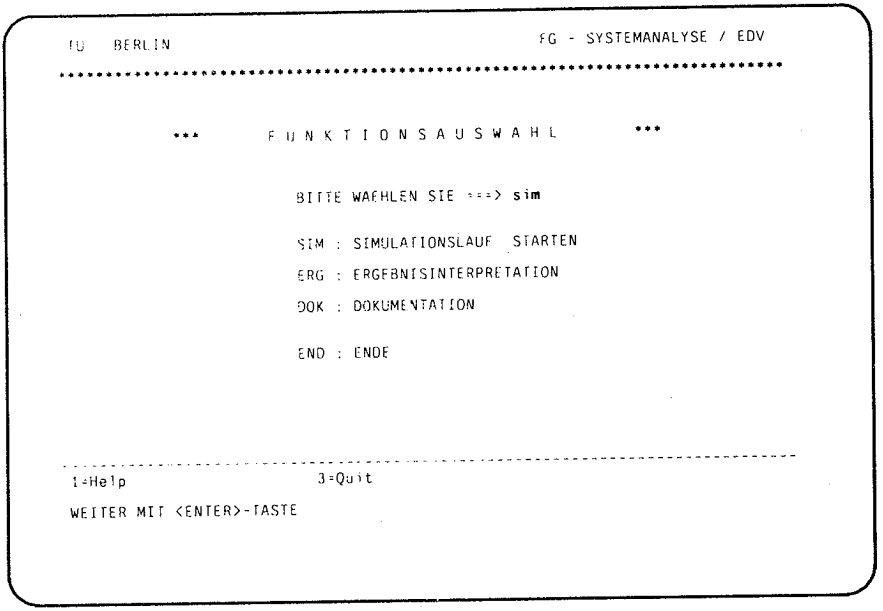


Fig. 3 Function-Selection-Menu

3.1. Simulation Runs

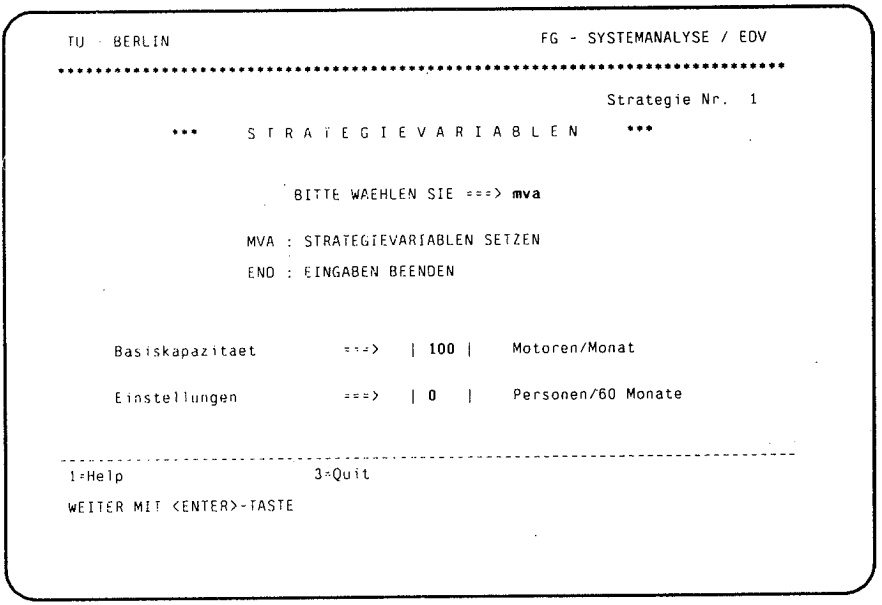
This function combines all the steps necessary to start a sequence of reruns and store the results for later comparative plots. It consists of two screens requesting and checking all needed parameters. To start simulation runs using the simulation processor DYNAMO information is needed about the control parameters LENGTH and SAVPER, describing the simulation length and the interval of TIME between the saving of results for later comparative plots. The communication system requests these parameters in the storage-variables-menu (fig. 4). In order to get convenient results, the system only allows input within bounds defined by the

model builder. Values outside these bounds are rejected and are changed to a marginal value. A message is displayed to attend to the online help available by the PF-1 key. The according help screen displays the description of the parameters and their value bounds as well as a short explanation of the input functions for this screen. Function SVA passes control to the strategy-variables-modificationmenu to prepare the model for different runs. Function END or PF-3 key gives control back to the function-selection-menu.

```
TU - BERLIN                                    FG - SYSTEMANALYSE / EDV
**********************************************************************

          ***     S P E I C H E R V A R I A B L E N     ***

                    BITTE WAEHLEN SIE ===> SVA

                SVA : SPEICHERVARIABLEN SETZEN
                END : ENDE

     Simulationsdauer        ===>   | 120 |    Monate

     Speicherintervall       ===>   |   6 |    Monate

----------------------------------------------------------------------
1=Help                    3=Quit
WEITER MIT <ENTER>-TASTE >>>PARAMETER GEAENDERT - HILFSMENUE BEACHTEN <<<
```

Fig. 4 Storage-Variables-Menu

The strategy-variables-modification-menu, shown in fig. 5, allows the preparation of the model for up to 19 runs. They can be compared in comparative high resolution graphs with the result interpretation facility lateron. The system again restricts variable modification to intervals defined by the model builder. Meaningless values for these variables will be rejected and values are changed. A message to attend to the help screen is displayed. The system rejects more than one run with the same combination of variable values with an



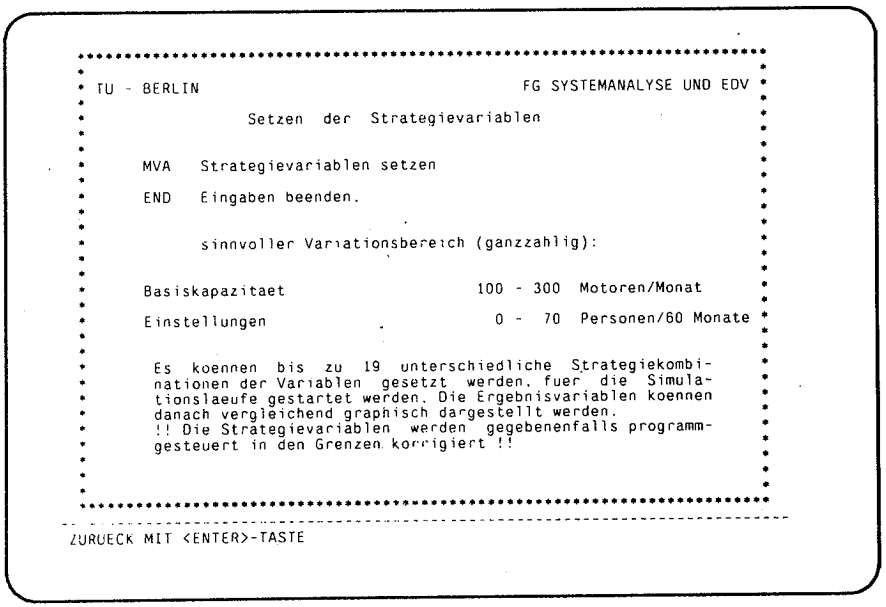


Fig. 5 Strategy-Variables-Modification-Menu

appropriate message. The input of MVA as selected function indicates continuation of variable modification for further runs, END indicates input termination and start of the DYNAMO processor to the system. PF-3 key branches back to the function-selection-menu.

3.2. Results Interpretation

After successful model runs the system comes back with the function-selection-menu, allowing the user to view selected results of the model runs in comparative plots by function ERG in this menu. This causes a branch to the result-interpretation-menu (fig. 6). Depending on the selected simulation model the according target variables defined by the model builder are displayed for selection. The user only has to mark the desired one with an X or he can get further information by PF-1. Additionally the output device, plotter or terminal, can be chosen.

```
TU - BERLIN                                        FG - SYSTEMANALYSE / EDV
**********************************************************************

          *** E R G E B N I S I N T E R P R E T A T I O N ***

                    FUER DAS SIMULATIONSMODELL NR. 1

               SIND LAEUFE MIT FOLGENDEN PARAMETERN GESPEICHERT:

                     Simulationsdauer      120  Monate
                     Speicherintervall       6  Monate

          BITTE EINE VARIABLE FUER VERGLEICHENDEN PLOT ANKREUZEN

                                                  x
                        Marktanteil             | x |
                        Istlieferzeit           |   |
                        Absatz                  |   |
                        Betriebsergebnis        |   |

               BITTE WAEHLEN SIE ===> T     T:  TERMINAL   P:  PLOTTER

----------------------------------------------------------------------
 1=Help                    3=Quit
 WEITER MIT <ENTER>-TASTE
```

Fig. 6 Results-Interpretation-Menu

The next screen presented is the menu for model run selection (fig. 7). In this screen all stored reruns are displayed with the corresponding values of the strategy variables. If the user defined more than ten runs in the modification menu, the rest is displayed on a second screen accessible by next page function. The desired model runs for comparative plots can be marked in this menu.

```
TU  BERLIN                                        FG - SYSTEMANALYSE / EDV
                                                                  SEITE NR. 1

          *** E R G E B N I S I N T E R P R E T A T I O N ***

                    FUER DIE VARIABLE   Marktanteil

     KREUZEN SIE BITTE DIE ZU VERGLEICHENDEN STRATEGIEN AN (MAX. 5 ):

       STRAT.  Basiskapazitaet      Einstellungen          x
          1        100                    0                x
          2        100                   30
          3        100                   70                x
          4        200                    0                x
          5        200                   30
          6        200                   70                x
          7        300                    0
          8        300                   10
          9        300                   20
         10        300                   30

BLAETTERN (J/N) ====> J
-------------------------------------------------------------------------------
1=Help                          3=Quit
WEITER MIT <ENTER>-TASTE
```

Fig. 7 Model-Run-Selection-Menu

No CPLOT card has to be typed by the user. It will be generated automatically by the system according to the user's selections. The system either sets up a SAS-graph job for the plotting device to produce a hard copy or starts the SAS-graphic processor to display the comparative plots on the screen (fig. 8). The selection of results-interpretation-menu is displayed again for further plots. PF-1 key displays help for these menus, PF-3 branches back to function-selection-menu from both of them.

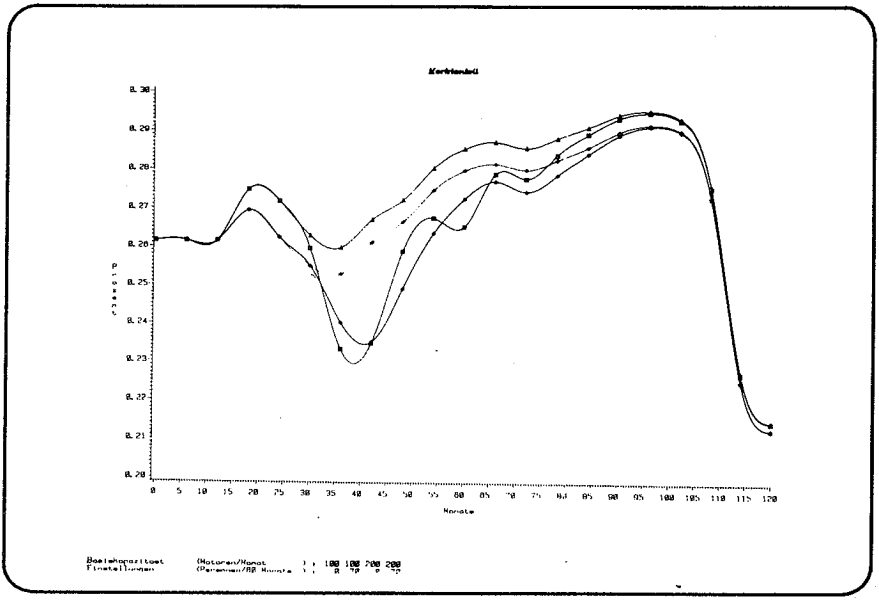


Fig. 8 Example of Generated Comparative Plot

3.3. Model Documentation

The third function accessible from function-selection-menu is the online documentation of the simulation model and its variables. It is subdivided into three dynamically filled screens in order to supply information on different levels of aggregation. The first screen of this function (fig. 9) shows a short model description. Then the user can decide whether he needs general model information (function MOB) or information about the action and target variables (function VAR)(fig. 10). The system will display the desired documentation and show up with this menu again. END or PF-3 key branches back to main functions menu, PF-1 explains the use of this screen.

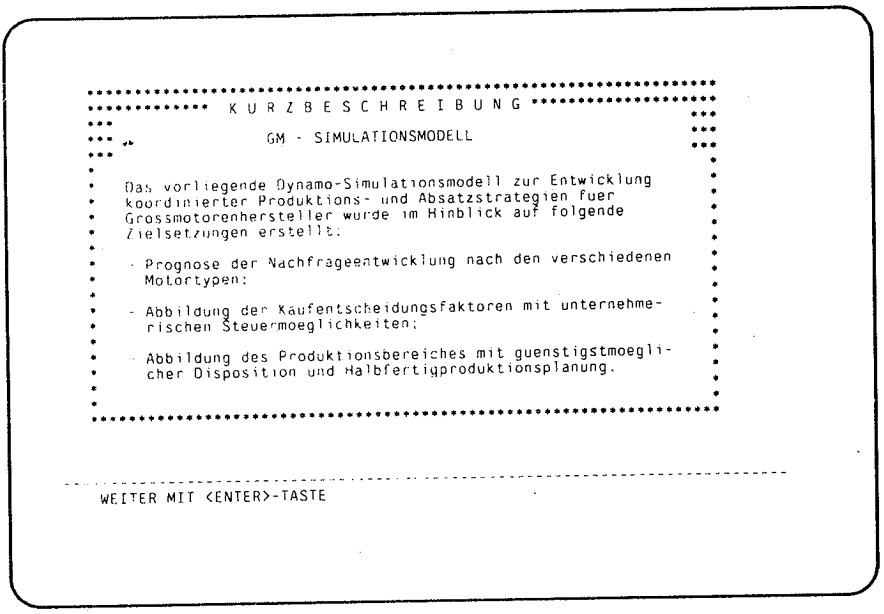


Fig. 9 Short Model Documentation

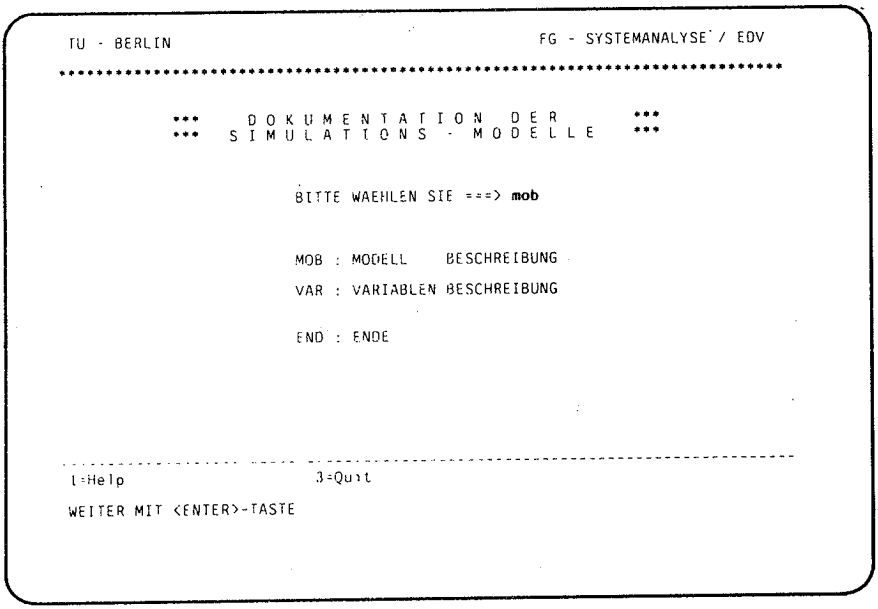


Fig. 10 Documentation Menu

4. Conclusions

The presented communication and control system has been tested with several applications in practice. The improved acceptance and gained success documents both the potential benefit of System Dynamics models for decision support in management and the gap between methodological power and practical use. However the presented system is only a first step into the direction of bringing data processing, or simulation modeling in special, nearer to the management. For the conception of the system very much effort was spent to keep the system independent of the simulation package used in it. The demand for a documentation of the models by the system keeps good models in use, because the contents of the model will not get lost. By modularisation of the system it is adaptable for other simulation languages and graphical output packages than those used in the system. However these packages should give the opportunity of bringing in other functions than those used in the system at present. With regard to sensitivity analysis, graphical or tabular presentation of target variables against strategy variables (instead of TIME) are of great interest. A prototype solution has already been realized by the integration of another software package. A further step on the systems development is an interactive support by formulating simulation models of the system dynamics type. For this type of simulation models a graphical definition tool could be considered. This might be especially useful as an education facility for simulation modeling on personal computers.

5. References

/HENTZELT 85/ Hentzelt, G.: Konzeption und Implementierung eines Entscheidungsunterstützungssystems zur Planung koordinierter Unternehmensstrategien. Diplomarbeit, TU Berlin, 1985.

/KRALLMANN 81/ Krallmann, H.: Strategische Entscheidungsunterstützungssysteme im Unternehmen. In: Bergner (Hrsg.): Planung und Rechnungswesen in der BWL. Berlin, 1981.

/PUGH 76/ Pugh, A. L.: Dynamo User's Manual. Cambridge (Mass.), 1976.

/RIEGER 85/ Rieger, B.: Leistungsfähigkeit von Entscheidungsunterstützungssystemen im Unternehmen - dargestellt am Beispiel der Preisgestaltung von Mehrproduktunternehmen. Dissertation, TU Berlin, 1985.

/SAS 83/ SAS Institute: SAS / Graph User's Guide. Cary (NC.), 1983.