Computer Aided Organizational Engineering: State of the Art in Germany and Assessment of the Existing Computer-Based Organization Design Tools

by

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1. Organizational Engineering: Need for Computer Support for the Tasks of Organization Design

Similar to software engineering, the concept of "organizational engineering" is based on the idea to open the organization design tasks for the engineering know-how within the field of industrial engineering; the roots for this idea can be found within the classical task/structure/process-oriented approaches of organization design theory in Germany, and they have also a long tradition within the "German Community of Organization Designers" respectively organization design experts. The keyelement of organizational engineering is the use of computer-based organization design tools to support the tasks of designing organizational structures (for example, in terms of task decomposition/specialization, decision autonomy/responsibility; static view) and processes (for example, in terms of workflow, information flow; dynamic view). The use of these tools aims to rationalize the organization design tasks, with regards to time, costs and quality of the (results of the) design process. The need to rationalize emerges from a certain "organization design crisis". This "crisis" results from the growing complexity of the organization design tasks in connection with the increasing significance of the utilization of the so-called "new" computer-based information and communication technologies. In comparison with the "old" technologies, it is not only a question of efficient technical design, but rather a problem of resolving the complexity of reciprocal influences on technology, strategy, organizational structures and processes, and staff aspects.

2. Overview of Computer-Based Tools for Organization Design

From the actual variety of software programs, standard software and research prototyps, for computer aided organizational engineering, only those tools will be considered which directly support the tasks specific to organizational de-

signers, i.e. the tasks of designing organizational structures and processes. Each of these tools provide build-in organizational knowledge. Taken into further consideration, they can be divided into two groups: information-oriented and problem-solving-oriented systems.[1]

2.1 Information-Oriented Tools

Information-orientation means that information — along with the production of material goods — tend more to be refined and purpose-oriented composed than to be renewed. This implies, for instance, to collect, to store and to recall information as well as to transform them into another mode of presentation. The feasible range of information-oriented organization design tools which are for the most part standard software products is very large: it extends from the development of computer-based organization design techniques (for example, organizational charts, task analysis and task-flow analysis, communication analysis) to the development of computer-based organizational "handbooks", "manuals", or "memories", which contain both aspects of structure and process organization design.
In the following, we will take into special consideration the computer-based task analysis technique by Dinkelbach, and the research project "Organization Data Base/Organization Information System".

2.1.1 Computer-based Task Analysis Technique by Dinkelbach

The aim of the computer-based task analysis technique by Dinkelbach [2] is to support the organizational structure aspects for the design of data processing departments. The underlying structure of this tool programed by "TurboPro-Log" consists of six function blocks. The first and the second block contain fields for (strategic) information systems which before being computer-entered can be decomposed in their hierarchy down to the operative levels of the corresponding software applications. The third block is reserved for those tasks of systems development, systems operations and systems management, which arise in their basic, undividable form; it will be specified how often and to what exent they occur in fields for (strategic) information systems on the one hand, and software applications one the other hand. Each task will be assigned to a task holder in the fourth block. Block five allots tasks to different so-called task fields. This is to offer possibilities to summarize tasks which are to be fulfilled in several fields for (strategic) information systems and in several software applications. Block six offers computer-based evaluations as regards the allocation fected (for example, the task holders responsabilities).

2.1.2 "Organization Data Base/Organization Information System"

The motivation for the research project "Organization Data Base/Organization Information System" (ODB/OIS) was the high expenses of production and updating of traditional organizations manuals as well as by the limited possibilities to evaluate completely the information furnished.[3] The **"Organization Data Base"** (ODB) has the goal to present all the aspects which are relevant to a corporation as regards its structure and process organization with the help of an (organization) data base. Moreover, it prepares various evaluations. In order to present them, objects of organizational structures and the attributes and relations attached to them are defined as tables in correspondance with the entity relationship model, say with the relational data base system "Professional Oracle".
For example, the object "place" serves to show an organization task unit which has been abstracted from the concrete task holder. Its specifications come from the place number and the designation of the place. When related by "position -equates- place" the objects "place" and "position" are connected. In the "Organization

Data Base" the object position is seen as an aggregation of similar places , i.e. several places can be described by one concrete position under a more general form.

The **"Organization Information System"** (OIS), which is connected with the "Organization Data Base" (ODB), supplies the following computer-based functionality:

- creation and maintenance of data;
- recalling of individual objects and their attributes;
- access to predefined "evaluations" (for example, to find all places alloted to a position);
- analyses of organizational variances (for example, to find tasks appearing twice);
- access to a system of organizational ratios;
- comparisons of the organizational structures, as to their temporal aspects or actual-vs.-target aspects;
- simulations and what-if analyses of structure and process organization; connections to existing application systems (for example, staff or management information systems).

The latter possibilities strived for in the "Organization Information System" (OIS) project come very close to the group of problem-solving-oriented tools which are discussed in the following section.

Both the "Organization Data Base" (ODB) and the "Organization Information System" (OIS) are not yet ready to be released on the market; they are still — at least partly incomplete — prototypes . This relates to the fact that neither the process organization component of the "Organization Data base" (ODB) is available as a software program, nor the task of organizational planing can be supported by the "Organization Information System" (OIS) sufficiently as indicated above.

2.2 Problem-Solving-Oriented Tools

Problem-solving-orientation means that the results from computer-based information processing can contribute directly to solve organization design problems, i.e. the information input is processed into an information output of higher value. Despite the broad range of problem-solving oriented tools, we will avoid further discussion of details of the computer-based mathematical approaches to computing organizational structures respectively organizational processes; the constraints of the mathematical models are too far from reality. Rather, to begin with, we will focus on examples of how the empirical organization theory research, developed during the 60s and 70s (contingency theory; situational approach) can be used as computer models for organization structure design. Secondly, we will describe the simulation attempts of office procedures, and finally the automatic generation of computer-based office procedures.

2.2.1 "ORganizational Structuring SYStem" (ORSYS): a Computer-Based Contingency Theory Tool

The research project "ORSYS" [4] is an example of how results of the empirical organization theory research respectively contingency theory can be used as computer models for organization structure design; in the case of "ORSYS" the aim is to support the internal (re-)structuring of data processing departments. Within the scope of this research area, there are efforts to show causal connections between specific (independent) "contingency factors" respectively situational variables (for example, environment) and (dependent) organizational structure parameters respectively design factors (for example, degree of centralization). To establish these connections, statistical methods were used. The results of these studies can be transformed easily into "If-Then" rules and then, with little effort applied to rule-based programming within expert systems; to develop "ORSYS" the expert system shell "Xi Plus, Version 1.10 C1" was applied. For example, one of the rules resulting from the empirical research of the creators of "ORSYS" says: "IF goal-of-the-company (as the situational variable) is reduce-product-development-time,

THEN specialization-criterium of the data processing department (as the structure parameter) is project".
The computer-based search for the ideal organizational structure for a company's data processing department results from an online dialog between an organization designer and "ORSYS". To start with, the "span-of-control" as one out of two relevant structure parameters has to be determined. The value of the span of control depends on the value of the situational variable "corporate identity" which itself depends on the values of seven other (sub-)factors, for example, "low motivation-of-the-employees" or "authoritarian leaderstyle". The result of this dialog is for example a "high" span-of-control. In a second step, the user enters maximum two out of a given list of potential goals-of-the-company (as the second situational variable), for example "customer-orientation". Each goal corresponds with a certain specialization-criterium (as the second structure parameter), for example, "customer-orientation" with "business-areas". Based on the entries, the system will offer a proposal for the prescribed organizational structure of the data processing department (for example, business-area structure with a high span-of-control); this structure proposal is the system's best approximation based on the contingency factors.
"ORSYS" is a prototype which initially was judged very positively. However, due to the limited suitability to practice this project could not be pursued.

2.2.2 Computer-based Simulation and Generation of (Computer-based) Office Procedures: the WISDOM Project

Computer-based process analyses offer the possibilities to design office procedures (workflows) with the help of computer-based organization design tools and to simulate them with regard to their economic characteristics (time, costs, capacity). The modeling works by splitting the tasks down into their elementary level, by establishing the incoming and outgoing information flows of each elementary task, by analysing the flow of information within different process streams, and, in the end, by considering staff aspects (for example, task responsibilities). As a rule, the basis for modeling is network models which have experienced further developments in terms of Petri Net Theory.
Along with computer-based process analyses there is the increasing tendency to take into consideration the so-called integrated systems, combining office procedures systems with planning systems for office procedures, which aid to support the process of organization design. The integration produces the so-called **generators of process organization design**. The difference between process analyses tools and process generators results from the fact that not only computer-based representation and simulation of processes respectively office procedures are possible, but also the generation of software programs to be used for carrying out office procedures. This generation takes place automatically and is paralleled by the efforts to automate within the concept of "computer aided software engineering".

The approach to the developments of process structure generators within the scope of the **WISDOM research project** [5] stems from the widespread inefficiency of planning approaches to ill-structured processes, for example, the time-consuming search for competent and responsible persons to turn to. The resulting goal to rationalize the process of organization design is to be achieved by connecting the "Electronic Organizations Manual" (EOM) with the planning system "Visual Interactive Planning System" (VIPS) and the processing system "DOMINO". These shall be combined into one process structure generator. The "Electronic Organizations Manual" (EOM) is a knowledge base developed with the help of the hybrid knowledge representation system "Luigi" and containing — similar to the "Organization Data Base" (ODB) — information on structure and process organizational rules. The architecture of "Visual Interactive Planning System" (VIPS) has three main

components: the user's interface "Visual Planning Interface" (VPI) maps and modifies procedures; a planning module accesses the "Luigi" knowledge base (the "Electronic Organizations Manual" (EOM)) with the help of a "plan file"; the CoPlan-S generator creates processing-capable DOMINO procedures.

The generation of a procedure begins when a planning context is selected from a given menu offered by the system (for example, an unspecified process of acquisition). "**Visual Interactive Planning System**" (VIPS) now presents an abstracted skeleton plan for this context, having access to the process organization knowledge from the "**Electronic Organizations Manual**" (EOM).

During the phases to follow, the user will develop with the help of the system a sequence of increasingly detailed plans, which will be mapped as graphical planning networks. During the simulation phase, the user has the possibility to optimize the plans with regard to the expense of costs or time. He also can examine the plans' applicability in practice based on the computer-based outcome. Eventually, the CoPlan-S generator generates automatically and transmits the procedure to the process system "DOMINO".

The system "**DOMINO**" supports the handling of structured, routine office procedures via an electronic mail system connected to it. Its method is to control gradually the implementation of these procedures occuring among a specified group of staff. A procedure is handled in the same way as an "intelligent" form, controlling actively its own work; it "knows" which persons are responsible for the individual tasks and their detailed activities.

The process structure generator of the WISDOM project is another prototype, which in the end can only be used in some ideal cases; due to a limited budget this project could not be pursued.

3. Assessment of the Existing Computer-Based Organization Design Tools

Beside the growing consideration of computer-based organization design tools, we can take different positions to what extent the computer can support this task. What is true for information technology in general, is also applicable to these tools: the capacity can be evaluated between enthusiasm and skepticism. Therefore, the aim of the following assessment of the existing organization design tools is to identify the feasible cost-benefit effects of the systems applied as tools to support the tasks of organization designers. However, to start with, the relevancy of the projects will be illustrated as to their **practical application**.

Compared to structure organization, process organization is of much greater significance and that implies a particular practical interest in computer-based process analyses and, if they were ready to market, process structure generators as well. Their practicality is high because they are discussed in connection with the introduction of new information and communication technologies; a task of increasing importance to organization designers.

As regards the structure organization, one might assume for the same reason that the computer-based task analysis technique by Dinkelbach will find its practical application, too.

The main application for the computer-based organization design tool "ORSYS", which is the reorganization of the data processing department's structure, will not be the day-to-day work of organization designers.

To establish the documentation of organizational structures, the creation and updating of organizations manuals is a very significant work, and organization data bases are supposed to find wide application in practice.

3.1. Feasible Benefit Effects

To analyse feasible benefit effects, we distinguish between phase-specific and phase-covering benefit effects.

3.1.1 Phases-Specific Benefit Effects

To analyse the phase-specific benefit effects first, we use the individual phases of the organization design process respectively the organizational problem-solving process, i.e. organizational planning, implementation, and control.

- **Organizational Planning**

The **problem identification** phase is the first sub-task of organizational planning, during which the so-called initial information plays an essential role indicating the existence of organizational problems. Only by using the "Organization Data Base" (ODB) or the "Electronic Organizations Manual" (EOM) the complexity of the segment for problems identification is restricted, which might supply some indirect benefits. However, if the information considered results exclusively or mainly from organization data bases, a certain restriction or bias might occur in the search for initial information.
Direct benefits can be achieved when predefined organizational variances or organizational ratios are used, as, for example, offered by the "Organization Data Base" (ODB). The more the ratios meet the specific problem and this guide the actions to be taken, the higher the specific benefit effect will be.
The process analyses and the process structure generators can deliver variances in the process organization, for example, the excessive throughput time.
If in the end the design recommendations produced by "ORSYS" can be considered the ideal pattern for organizational structures, potential differences between the current structures and the corresponding prescribed recommendations of the systems can be the impetus for further re-examination of existing solutions for organizational structures.

The **problem analysis** phase follows the problem identification phase. At first, the ***acquisition of information*** on structure and process organization is important, which is produced in more detail. Here, organization data bases will supply a high level of support, in particular, when predefined standardized evaluations exist. One might also expect an adequate potential of support from the computer-based task analysis technique by Dinkelbach where standardized evaluations are possible. However, we emphasize that the only reason for accessing information on standardized evaluations can lie in the easy access to this data without having verified their relevance to the actual problem situation ("information cemeteries"). The growing "bureaucratization" of the organization design process may be another problem, if "smooth", qualitative oriented instruments of information acquisition, for example workshops, are edged out by the ("hard", quantitative oriented) computer utilization.
On the one hand, the computer-based task analysis technique by Dinkelbach offers support potential for ***structured representations of information*** (after acquisition) within the problem analysis phase. For example, the so-called "probes of completeness" ensure that the structures for the software applications and the tasks of the software design process are complete and that the assignment of tasks is complete too. The support potential is useful for the consistent collection and structured representation, as well as for mapping, changing and deleting aspects with organization structure relevance during data entry. However, the applicability of the computer-based task analysis technique by Dinkelbach has its limits resulting from the fact that only parts of the design relevant aspects can be completed; for example, structural attributes, such as location or division, can not be assigned to task holders. Neither the arrangement of decision competen-

cies, nor the relation of directive authorities can be assigned in detail.
On the other hand the capabilities of organization data bases exceed the possibilities described for the support potentials, which are the consistent collection and structured representation of the acquired information. Objects and relations of the organization can be collected, changed or deleted via a menu control in the master and subsequent menus, both with the "Elecronic Organizations Manual" (EOM) as well as with the "Organization Data Base" (ODB). The system-supported control examines the consistency of the data by adhering to the defined conditions of data (for example, the object "authority-to-sign" may not accept any value exceeding $ 100,000). However, when changing the task assignment of a task holder, the "Organization Data Base" (ODB), for example, has no ability to "decide" to which extent the authorities directly given to task holders are also assigned anew and can therefore be deleted in the former position. An additional support potential arises, when further processing of the data from the "Organization Data Base" (ODB), for example, a condensing of data, is possible with the help of user-friendly tools for end-user computing. Unfortunately, the systems do not offer computer-based cause and effect analyses to identify on design problems. Interactions between problem areas are not derivable, either.

The computer aided **generation of alternatives** applicable to design and problem-solving processes within the organization is the aim of "ORSYS"; in addition, there are the computer-based process analyses and the process structure generators. When using them, the organization designer have at their disposal a heuristical support potential, for example, when the range of conventional solutions is broadened by computer-based solutions. At least the application of a computer-based organization design tool "forces" the organization designer to go as "deep" into the problems as it is necessary for the potential system entries. However, the contingency approach of organization theory gives cause to critical approach to the support potential of problem-solving-oriented computer-based organization design tools. For example, criticism may be due — at least in part — as according the partially inconsistent and contradictory research results of individual empirical studies which served as basis for "ORSYS", and fundamental criticism may be appropriate regarding the underlying assumptions of the contingency theory. Taken from the fundamental point of view, a principal point of criticism is emphasized: the proportion of context and structure is almost a "mechanistical", respectively a clearly determined relationship; whereas the significance of scopes for design, decision-findings and decision motives are misjudged. Finally, the low level of detail in the statements and the limited consideration given to the problems of efficiency (for example, there are no operationalized criteria which can explain the "fit" between environmental situation and organizational structure in detail) can be mentioned.

The assumption on which computer-based process analyses and process structure generators are based, is that the process organization must be designed before the structure organization of a company can be determined. This is in particular to prevent a structure-oriented procedure that reduces the degree of process-oriented flexibility to a very low level. Moreover, the process concept offers the advantage, for example, that when parts of the structure are reorganized, a total task analyses is not automatically required, but only the analysis of certain parts of the process structure.
However, besides the advantages, there are disadvantages, too. As the organization design in this concept is built upon the process organization, it is possible that certain impacts of the process organization may be neglected which have an effect on the structure organization. Furthermore, the pure analysis of current processes can not serve as a basis to build up new process structures when reorganizing, unless the total of actual activities corresponds to those to be realized after the reorganization has taken place.

Yet, within the process concept, it is especially stressed that the analysis of current processes is to be the starting point of reorganizations; in this context the process analysis is strictly limited to the well-known, i.e. the well-structured processes. On the whole, there is the possible advantage of a process oriented approach, in particular seen from the perspective of an introduction of new information and communication technologies, as compared to, for example, the classic structure-oriented approaches of the business organization theory in Germany (Nordsieck; Kosiol); however, this advantage must be qualified since from the angle of the organization theory, in the end there are advantages and disadvantages to both approaches; a simultaneous design of structure and process organization, each trying to use only the advantages, is impossible.

If we consider the **evaluation and selection of suggested solutions** as a final step in the organizational planning, the problem-solving-oriented systems will each identify a suggested solution described in more or less detail, the "evaluation" of which will come up to be more or less successful, depending on the assessment of the validity adhering to the underlying organization design theories. However, the final decision to implement the solutions will always remain with the corresponding person in authority.

- **Organizational Implementation and Organizational Control**

Only process structure generators are able to directly support to **organizational implementation**. For, it is their purpose to strive for a direct (automatic) implementation of a computer-generated alternative. We caution the decision maker, however, that an "immediate" introduction might involve major risks, for example, the company employees might not understand, apply or accept the new organizational solution, thus the dooming project being to failure; a "step-by-step" or "parallel" introduction might be better.

The computer-based process analyses, and "ORSYS" could support indirectly the organizational implementation by giving practical suggestions to be implemented immediately. However, the heuristical character of these suggestions points clearly to the need of interpretation by organization design experts. Furthermore, it is to be considered in this context that there might be considerable demand for justification when computer-based organization design tools named "expert systems" — for example, as it is true for "ORSYS" — are used, but in the end there are differences between the realized solutions and the computer-based suggested solutions. But one should not advocate the system's proposals withouth having at least critically scrutinized the theories underlying them.

As to the organizational planning process, the **organizational control** procedure largely resembles those of the problem identification phase; thus, the earlier description will suffice.

3.1.2 Phases-Covering Benefit Effects of Time Expence

From the perspective of saving time, the throughput time is one major benefit. In particular the computer-based task analysis technique by Dinkelbach as well as organization data bases can reduce the time consumed by storing and accessing information. Using problem-solving-oriented computer-based organization design tools can reduce time applied to generate information when solutions are to be found. However, special consideration should be given to the fact that the use of a computer can lead to simulating or generating such a variety of suggestions that the possible time savings is eliminated or even surpassed. Besides, an increasing demand for more specific suggestions, accompanied by the use of the computer, might have the same result of eliminating time savings, as is possible in the application of any computer-based organization design tools. In general however, the potential of computer-based sys-

tems to support or accelerate data processing can be harnessed with computer-based organization design tools.

3.2 Feasible Cost Effects

The **hardware costs** for the described tools are minimal: personal computers were largely used - partly integrated in networks. Thus it can be assumed that hardware costs do not exceed the amounts which corporations are willing to spend on such systems; the upper limit in Germany was indicated to be DM 10.000,- (ca. $ 6,000) approximately. One exception is the WISDOM project, where "Symbolics Lisp" machines were used (from the field of Artificial Intelligence); costs were substantially larger, with the stated amounts in the range of about $ 100,000 and more.
The **software** for organization design tools were created with the help of readily available programming languages; here again, the WISDOM project makes an exception where "Luigi" (for "Electronic Organizations Manual" (EOM)) and "CoPlan-S/X" (for "DOMINO") were developed internally. However, based on empirical investigations for Germany, the "pain threshold" for software costs lies at about DM 10.000,- (ca. $ 6,000); it is the limit to which companies are willing to introduce computer-based organization design tools.

Training is one of the major costs in introducing computer-based organization design tools. In most cases, organization designers can rely on at least some basic computer literacy, due to the growing introduction of information and communication technologies. Ongoing costs, for example, hardware/software maintenance and operation, can be assumed to be similar to those of other tools. Without an adequate empirical investigation there is no complete answer possible at this stage as to whether the use of organization design tools will allow for enable cost reductions, for example, resulting from replacement of staff, or other cost savings.

4. Conclusions

The particular aims of the computer-based organization design tools described here are to support the practical tasks of professional organization designers. For the time being, we cannot estimate the net effects of costs and benefits within the scope of the organization designer's practical application; for, up to now, computer-based organization design tools have been very rarely used. However, it can be mentioned at this stage that the possibilities to (partially) automate problem-solving-oriented organizational decision making are restraint. We should be careful with enthusiastic estimations of the support potential - though assessable - of computer-based organization design tools and should give preference to a more reserved attitude.
In addition, there seems to be the need for to manage the use of organization design tools to avoid the weaknesses and to emphasize the strengths of the tools.
Also there is a need for higher sophisticated organization design theories which then can be computerized. They should integrate both process and structure organization design aspects, include an explicit, consistent, and contextualized concept of organizational efficiency and effectiveness, and acknowledge the impacts of advanced information and communication technologies on organization design.
Finally, the development within the field of software engineering with regard to prototyping and other user oriented approaches (for example, evolutionary software design), and other theoretical approaches of organization design theory than the engineering approach (for instance, the behavioral, the political, or the symbolic approach) have to be considered to give grounds for discussion of a more realistic approach to the tools supporting possibilities and boundaries of such systems disposable to organization designers.

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