The DDMKCC Decision Support Architecture in the Light of Case Studies

Stanislaw Stanek
General Tadeusz Kosciuszko Military Academy of Land Forces 51-150 Wroclaw ul. Czajkowskiego 109 POLAND
s.stanek@wso.wroc.pl

Jolanta Wartini Twardowska
Uniwersytet Ekonomiczny 42-287 Katowice ul. 1 Maja 50 POLAND
j.wartini_twardowska@ue.katowice.pl

Zbigniew Twardowski
CONSORG S.A. 41-506 Chorzów Al. Bojowników o Wolnosć i Demokrację 38 POLAND
ztwardowski@consorg.pl

Abstract—**What makes the development of decision support systems (DSS) particularly challenging is the change dynamics of the design space, the instability of initial specifications, and the lack of an adequate model of the decision making process. Facing these, one can appreciate a methodology that can drive the designer's creative effort within a particular decision context. The paper aims to outline the origin and the evolution of research on the DSS architecture commenced by Sprague and Carlson and carried on under the auspices of the International Federation for Information Processing (IFIP) and the International Society for Decision Support Systems (ISDSS)[1]. In particular, the paper presents insights, findings, recommendations and conclusions derived from case studies conducted in domestic medium-sized and large enterprises.**

I. Introduction

GROUND-breaking studies that gave rise to the computerized decision support strand appeared around mid-20th century[2]. By mid-1980s, a new science discipline emerged, concentrating a vast research potential. The term "decision support system" (DSS) has a number of connotations. Most scholars have accepted the term to mean "an interactive computer based system that helps decision-makers use data and models to solve ill-structured, unstructured or semi-structured problems" [1], although some argue that this definition is too narrow, pointing out that a DSS should be able to support ill-structured decisions as well as structured tasks. This leads to a more general definition ([4], [2]) as an interactive computer-based system or sub-system intended to help decision makers use communication technologies, data, documents, knowledge and/or models to identify and solve problems, complete decision process tasks and make decisions. In his seminal doctoral thesis, Steve Alter [3] put down the following three axioms of the unfolding paradigm which were approved by most of his fellow researchers: (1) that DSS are designed specifically to facilitate decision processes; (2) that DSS should support rather than automate decision making; and (3) that DSS should be able to respond quickly to the changing needs of decision makers.

However, neither theory-oriented research approaching decision support from the management science perspective nor the few experimental studies have been able to lay solid foundations for DSS designers to build upon. The following research outcomes have proved useful to developers:

- Recommendations concerning the architecture of computer decision support based on the Data – Dialog – Modeling paradigm. The principal idea behind the paradigm represents that the designer's responsibility in designing a decision support system is to build the data, dialog and modeling components and to ensure interaction among these. The idea underpins the theoretical work referenced above, e.g. in adopting a DSS definition. The paradigm has made it possible for Sprague and Carlson [1] to articulate an influential architectural model and helped their followers ([5], [4], [22], [12]) further advance it and extend it.
- The guidelines of "meta-design" methodology pioneered by Moore and Chang [6]: "(…) the classic MIS development life-cycle approach is insufficient as a prescriptive guide for building DSS [since it] (…) does not lay out a step-by-step procedure or even an exhaustive list of topics (…). We synthesize ideas from existing DSS design frameworks to produce a meta-design methodology from which individual DSS designers can develop their own design frameworks, appropriate to their particular needs." The meta-design approach had its advocates who undertook to further develop it (cf. [7], [8], [10]). Due to the volatility and change dynamics of the design space, frequently coupled with a need for organizational change entailed by IT

[1] Now known as Association for Information Systems Special Interest Group on DSS.

[2] One of those was definitely Michael S. Scott-Morton's Ph.D. dissertation written in 1964-1967 at Harvard Business School and published in book form by HBS Press in 1971 under the title "Management Decision Systems." Recalling his work on the dissertation in *DSSResources*, Scott-Morton mentions collaboration with such prominent scholars as H. Simon, J. McKeney, or F. Carr. Other famous contributors to the decision support concept include H. Leavit, T. Gorry, D. Ness, J. Little, T. Gerrity, P. Keen and C. Stabell. As regards institutional involvement, one could agree with P. Keen when he states that the concept originates in the theoretical studies of organizational decision making done at Carnegie Institute of Technology during the late 1950s and early 1960s and the technical work on interactive computer systems, mainly carried out at Massachusetts Institute of Technology in the 1960s.

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deployment, we see ongoing integration of current trends in system design and organizational change [11].

The paper seeks to address both these research areas. The following discussion draws on views that have been voiced in prior publications:

- "The traditional view of DSS components remains useful because it identifies commonalities between different types of DSS, but it provides only an initial perspective for understanding DSS architectures." [5]
- "The architectural design should set a common level of understanding among technical, non-technical and management participants." [9]
- "DSS (…) ideas and concepts were developing in the early 1970s, the technology became widely available at reasonable cost in the 1980s, and in 2008 are rarely used effectively. When they are, they are huge beneficial impacts; indeed some firms could not exist without them. (…) The general unresolved issue I see is one of understanding the management of change." [17]

A thorough analysis of refutations and cracks flawing the theoretical foundations of DSS has led us to propose the extended DDMKCC paradigm: Data – Dialog – Modeling – Knowledge – Communication – Creativity [7]. Further in the paper, a theoretical underpinning is provided alongside a description of architectural recommendations, resulting from our recent research as well as from a wealth of practical experience with the proposed paradigm. The research involved a group of 10 business companies selected from among some 200 in which DSS implementation projects were completed by Consorg S.A. between 2000 and 2012. Each implementation has been examined for the degree to which each of the DDMKCC architectural components is used in making decisions at (1) operational, (2) tactical and (3) strategic level.

I. Traditional DSS Architectures Based on the DDM Paradigm

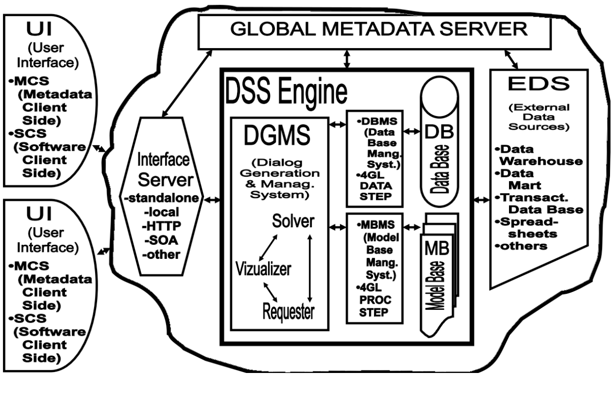

Fig. 1 A traditional DSS architecture in an IT development context

A traditional architecture, such as the one shown in Fig. 1, afforded a possibility to exploit available information technologies in implementing early computer decision support concepts founded on the DDM paradigm and embracing the reflection on interactions between architectural elements such as Data Base, Model Base, Visualizer, Generator, and Solver within a network environment. Looking back at the expansion of specific technologies and the evolution of theory, one easily recognizes the advances in technical solutions identified e.g. with multi-layer architectures, grid computing, data analysis and presentation using data warehouses, or Business Intelligence environments. One of the remaining challenges is to link the DSS model base with models existing in organizations. A lot of such models are in the form of hardly scalable spreadsheets developed by painstaking or enthusiastic users. Their flat meta-data structure is just another important weakness. By introducing further levels, we may be able to implement many of the proposals stemming from IFIP research on the problems of context within DSS ([16], [13]).

II. Origin of the DDMKCC Paradigm

We have already remembered the DSS design paradigm framed by Sprague and Carlson, demanding that DSS consist of three sets of capabilities belonging in the areas of dialog, data and modeling. Many researchers insist that a good DSS should retain balance among the three capabilities. It should be easy to use, too, allowing non-technical decision makers to interact freely with the system. It should be able to access a wide variety of data and provide ample analytical and modeling capabilities [18]. However, observation clearly demonstrates that practice does not fully raise to the promises of theory. Sprague and Watson [19], for instance, contend that many early systems would adopt the name DSS when they were strong in one area and weak in the other. Having analyzed 56 DSS cases, within the two main groups Alter distinguished seven sub-groups based on "the degree to which the system's output can directly determine the decision" [3]:

- Data-oriented DSS: (1) File Drawer Systems, whose purpose is to automate certain manual processes and provide access to data items; (2) Data Analysis Systems, which facilitate the analysis of current and historical data, in order to produce reports for managers; (3) Analysis Information Systems, which provide access to a multitude of support data bases for the decisional process, as well as a series of simple models in order to supply information necessary for solving particular decisional situations.
- Model-oriented DSS: (4) systems oriented on accounting and financial models. The models employed are of "what-if" and "goal-seeking" types and they are frequently utilized in producing profitability estimates for new products, estimative balances, etc; (5) systems oriented on representational models, which use simulation models to estimate consequences; they are used extensively in risk analysis, in production simulation etc.; (6) systems oriented on optimization models which help produce optimal solutions for different activities; (7) systems oriented on suggestion models which carry out the logical process leading to a suggested decision for activities with

a certain degree of structuring (such as determining the frequency of insurance renewal, models for the optimization of bond supply, etc.).

Further studies on existing decision support systems confirm the growing dynamics, diversity, complexity and diffusion of the DSS area. The outcomes become contradictory, the foundations of DSS are crumbling, and special cases are increasingly often reported that supersede or undermine prior research findings. Investigating the "cracks" enables (or compels) researchers to lay broad and solid foundations on which to build up the knowledge [20]. "Many software vendors, information systems consultants, and even some academic researchers are periodically tempted to create a revised vocabulary for existing concepts. Synonyms are variants on accepted concepts which can sometimes aid in understanding, but they can also lead to conceptual confusion. The globalization of discourse on topics like decision support has added to the challenge of communicating meaningfully about our research; more terms increase the difficulty. The academic community needs to control the word labels that are used in our research and discourse for important concepts and constructs. This task is important if researches want to manage and evolve a stream of systematic research on decision support." [21].

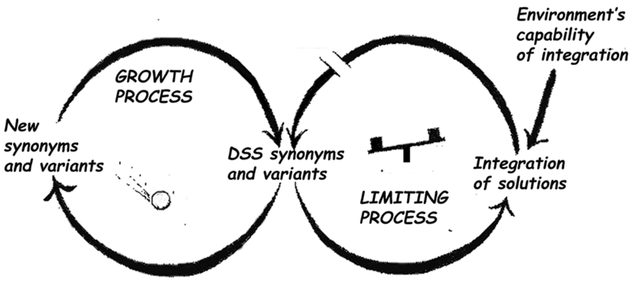

Fig. 2 A Casual loop diagram for a solution to the explosive growth of DSS synonyms and varieties in line with the Limits to Growth Systems Archetype

Theory-oriented research indicates the emergence of the birth effect: a growing number of DSS synonyms and variants generates a larger number of new concepts. For outcomes to be comparable with one another, integration of research sub-areas is required [22], which – according to the Limits to Growth Systems Archetype – involves a negative balancing loop (Fig. 2).

The extended DDMKCC (Data – Dialog – Modeling – Knowledge – Communication – Creativity) arises from the need for integration (cf. Fig. 3), in the context of existing "cracks" in the traditional DSS architecture, drawing on research on the deployment of information technology in organizations [26] and acknowledging the incorporation of soft systems methodology into DSS research. In subsequent publications, further architectural details are added or elaborated.

At the same time, Power [5] develops an integrated DSS classification aligned with the idea of pivotal component proposed by Sprague and Watson (cf. Table I).

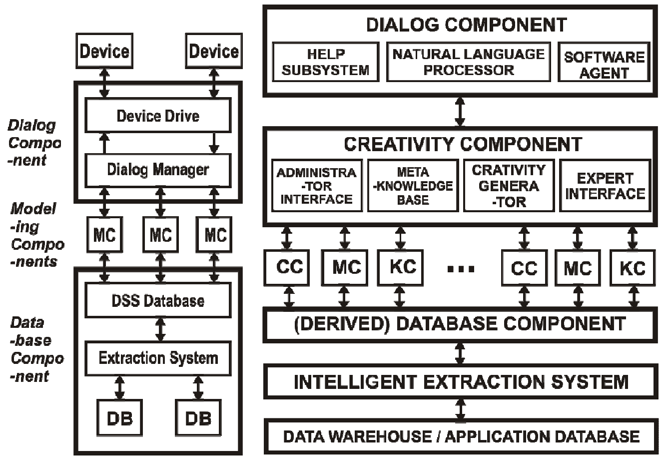

Fig. 3 The DDM architecture – the tower (left) and the DDMKCC. Source: [1], [7]

TABLE I.
A NEW DSS FRAMEWORK

Dominant DSS Component	User groups: Internal, External	Purpose: General, Specific	Enabling Technology
Communications **Communications-Driven DSS**	Internal teams, now expanding	Conduct a meeting Bulletin Board Help users collaborate	Web or Client / Server
Database **Data-Driven DSS**	Managers, staff, now suppliers	Query a Data Warehouse	Main Frame, Client/Server, Web
Document base **Document-Driven DSS**	Specialists and user group is expanding	Search Web pages Find documents	Web
Knowledge base **Knowledge-Driven DSS**	Internal users, now customers	Management Advice Choose products	Client/Server, Web
Models **Model-Driven DSS**	Managers and staff, now customers	Crew Scheduling Decision Analysis	Stand-alone PC

Source: [5]

In this paper, the central research question concerns the software architecture for a decision support system. Theoretical insights and prior validation efforts have led to an extension of the classical Sprague-Carlson DDM proposal toward the DDMKCC paradigm. The paradigm not only implies the building blocks of a decision support system but also provides a basis for addressing and analyzing a broad array of cases. In the following chapters, the findings of research on decision support system design are presented that substantiate the above propositions and underpin practical recommendations.

III. A STUDY OF THE PERFORMANCE OF DDMKCC MODEL COMPONENTS

We selected 10 out of 200 implementation projects run in 2000-2012 by Consorg S.A. In this way, we arrived at a group of 10 business organizations from both the production and the services sectors which we deemed the most representative for our analysis and appraisal of the proposed approach – viz. its performance and practical effects. The sample included large enterprises as well as capital groups. Some of them are listed on the Warsaw Stock Exchange, while 3 of them (being international capital groups) have parent companies based outside Poland. Most of the companies operate in production industries. The average number of DSS users ranges from 5 to 10 advanced users and 20 to 30 novices or occasional users (see Table II).

In all of the organizations support is centered on decision making processes in the area of financial control. The solution was implemented in an effort to support decisions at all (operational, tactical, and strategic) management levels. At each level, a different set of analytical tools was offered, following the classification of models proposed by Turban and Aronson [26] (see Table III).

TABLE II.
THE 10 SELECTED BUSINESS ORGANIZATIONS FROM THE MANUFACTURING AND SERVICES SECTORS

	Customer	Industry	Organization structure	DSS users	Project duration	Headquarters
1	**Tauron Wytwarzanie** (formerly Południowy Koncern Energetyczny S.A. [Southern Power Corporation]) Parent quoted on Warsaw Stock Exchange	power generation	one-layer capital group	50 primary users 150 other users	2000–2004	Katowice, Poland *www.pke.pl*
2	**Vattenfall Heat Poland S.A.** (Elekrociepłownie Warszawskie S.A.)	power generation	multi-layer capital group	25 primary users 20 other users	2002–2004 upgrade: 2009–2010	Warszawa, Poland (subsidiary) *www.ewsa.com.pl*
3	**Odra Trans S.A.**	inland navigation	multi-layer capital group, 20 subsidiaries (including a Germany based sub-group)	5 primary users 35 other users	implementation period: 2006–2007	Szczecin, Poland
4	**Black Red White S.A.**	furniture manufacturing	one-layer capital group, 30 subsidiaries	5 primary users 30 other users	2007–2008	Biłgoraj, Poland
5	**Pradyż / Ceramika Paradyż sp. z o.o.**	white ware	no capital group	10 primary users 30 other users	2006–2008	Opoczno, Poland
6	**Cersanit S.A.** Parent company quoted on Warsaw Stock Exchange	white ware	multi-layer capital group, 40 subsidiaries (including a Russia based sub-group)	10 primary users 25 other users	2009–2010	Kielce, Poland
7	**EC Będzin S.A.** Listed on Warsaw Stock Exchange	heat generation	member (subsidiary) of RWE capital group	12 primary users	2009–2010	Będzin, Poland (subsidiary)
8	**Kamis S.A.** Listed on Warsaw Stock Exchange	food industry	no capital group	12 primary users 92 other users	2010 –2011	Lubliniec, Poland
9	**Lentex S.A.** Parent company quoted on Warsaw Stock Exchange	chemical industry	one-layer capital group, 1 subsidiary		2010–2011	Poland
10	**Paccor S.A. / Veriplast S.A.**	food packaging	multi-layer capital group, 25 subsidiaries	5 primary users 45 other users	2010–2011	Luxembourg

TABLE III.
DECISIONS, TOOLS AND DECISION MAKING MODELS USED WITHIN THE DDMKCC MODEL

	DECISIONS — TOOLS and MODELS	
	Capital groups	**Other**
1	• Consolidation of financial statements for external reporting (IFRS) • Financial monitoring and budgeting • Corporate supervisory activities • Cash flow planning and monitoring under cash-pooling models	• Operating budget planning and financial analysis • Cash flow analysis models • Pricing models
2	• Simulations and financial monitoring using expert system reports • Benchmarking of functions and processes (diagnosing the causes of deviations in key performance indicators within capital group's strategy performance monitoring) • Models of asset allocation throughout the capital group	• Simulations and financial monitoring using expert systems reports • Benchmarking of the functions and processes of operating budget planning within the corporation's production units (diagnosing causes of deviations in key performance indicators) • Key investment project analysis models

3	• Multi-dimensional simulations of capital sub-group structures; strategic and financial monitoring for management purposes • Value management models for capital groups	• EVA corporate value management models • BSC strategic management models • Strategic resource planning models

where:
1. Operational decisions
2. Tactical decisions
3. Strategic decisions

Besides, the distinct nature of capital group management was reflected in specially tailored business models enabling decision support to be addressed at the parent company level [27]–[30].

Data Sources and Data Models

In the following discussion of the DDMKCC model's "data" component and its usage statistics, data sources and data models will receive separate treatment.

- Data sources

The taxonomy of data sources (cf. Table IV) was based on the classification proposed by R. Sprague and H. Watson [28]. The findings of our observations and analyses are consistent the widely known fact that, although data come from diverse sources, strategic decisions will involve greater use of external sources and less reliance on internal ones (e.g. ERP/MRP systems). The way corporate knowledge bases are exploited in making tactical decisions is notable, too. It is easy to see that relevant data are most commonly sourced from investment project analysis cases stored in archives, since such cases often provide valuable insights into how similar projects were evaluated in the past and offer analogies which can be instrumental in assessing the risk of new investments.

TABLE IV.
DATA SOURCES FOR THE DDMKCC MODEL

DECISIONS	1	2	3	4
Operational	xxx	x	-	-
Tactical	xx	xxx	xx	x
Strategic	x	xx	xxx	xxx

where:
1. Traditional ERP/MRP
2. Text processing and document processing systems; corporate knowledge bases
3. Open access data bases
4. Business information libraries; economic intelligence agencies

- Data models

Likewise, usage analysis of data models led us to believe that data warehouses were used the most when making strategic decisions (cf. Table V), and they were central to capital group management, particularly in groups that have not implemented a single transactional system. For them, a data warehouse can become a integrating DSS component, unifying data and processes across the group. This corresponds to employing a data warehouse to support both operational and strategic decisions.

Interesting observations can be made in examining the use of multi-dimensional OLAP data structures in business decision making processes. When a well designed OLAP cube is combined with an ergonomic viewer, all of the reporting process can be handled via multi-dimensional structures, regardless of the type of decision to be made. It does not matter at all whether OLAP is embedded in a data warehouse or the multi-dimensional repository accesses transactional data directly. Obviously, at the operational level the application of OLAP technologies is reduced to relatively simple (and repetitious) reporting. Advanced functionalities, on the other hand, such as those of data mining and hypothesis validation, are employed at the other decision levels. By surveying the businesses from our sample we were able to ascertain that wherever OLAP technology has been successfully implemented, reporting almost exclusively hinges on data supplied in this way, while other methods have been nearly abandoned.

TABLE V.
DATA MODELS EMPLOYED WITHIN THE DDMKCC PARADIGM

DECISIONS	1	2	3	4
Operational	xx	xx	xxx	x
Tactical	x	xx	xxx	x
Strategic	-	xxx	xxx	xxx

1. Relational data bases
2. Relational data bases – data warehouses
3. Multi-dimensional OLAP data base models
4. File system / document repository

Dialog and Communication Components

The discussion of the dialog component's functionality will be broken down in a pattern proposed by Bennett for the assessment of DSS user interface [4]: (1) knowledge base, conceived as a set of users' essential skills (knowledge) enabling them to work with the system, (2) command language – the way in which users operate the system, and (3) presentation language, i.e. the way in which output is represented [4].

- Knowledge base

Nearly every user highly appreciates the availability of complete system documentation including operating instructions (cf. Table VI). Few, however, actually use it and, as a result, most of them require individual training. As long as it is fairly sufficient for users at the operational management level, those having to cope with less structured decision problems will normally need to have a good understanding of the problem solving process and to know the applicable techniques. Without this know-how, users situated beyond the operational level might not be able to use the system resources efficiently: even if an expert system is activated to provide them with support in choosing the most suitable tools (models) for their problem, the choice has to be ultimately made by the user. Observation reveals that the most common reason why some systems are not used in tactical or strategic problem solving is not the technology itself but the relatively high demand they put on users' competence (knowledge base).

- Command language

No matter what kind of problems are solved, the ability to communicate with the system via standard and context menus is usually taken for granted or seen as a minimum requirement concerning functionality. Individuals solving tactical problems in companies where an enterprise data warehouse module has been implemented also demanded the option of similar case finding in knowledge bases.

TABLE VI.
THE KNOWLEDGE BASE OF THE DSS USER INTERFACE WITHIN THE DDMKCC MODEL

DECISIONS	1	2	3	4	5
Operational	xxx	x	xxx	x	x
Tactical	xxx	xxx	xx	xxx	x
Strategic	xxx	xx	x	x	xxx

1. Interactive operation manual
2. Examples suited to user skill level
3. Support functions for system navigation
4. Problem solving skills training facility
5. Support options for user learning

Users engaged in solving tactical and strategic problems will rather expect the system to become a "partner in problem solving." Interestingly enough, we found that the lowest skill levels are associated with the highest expectations from the system, including a proactive attitude in assisting the user. Conversely, the expectations of most advanced and creative problem solvers are limited to being offered an efficient technology and a rich collection of presentation tools.

TABLE VII.
USE OF COMMAND LANGUAGE FUNCTIONS IN THE DDMKCC MODEL

DECISIONS	1	2	3	4	5	6
Operational	xxx	xxx	xxx	-	-	-
Tactical	xxx	xxx	x	-	xxx	xx
Strategic	xxx	xxx	-	-	-	xxx

1. Standard system menu
2. Context menu
3. Data base query languages
4. Communication based on natural language processing
5. Knowledge base search for similar cases
6. Ability to guide user dialog toward problem resolution

- Presentation language

Our survey demonstrated that users' expectations concerning the presentation language are closely tied with the mental model of the decision maker being the end user of information output by the system. For example, financial analysts working for top executives expect the presentation language to be as rich as possible and hence capable of satisfying the needs of any user further enhancements to the system. The extent to which specific functions of the presentation language are used will vary largely depending on who uses the output information (e.g. corporate board members will have other preferences than line managers).

TABLE VIII.
FUNCTIONS OF THE PRESENTATION LANGUAGE IN THE DDMKCC MODEL

DECISIONS	1	2	3
Operational	xxx	x	x
Tactical	xxx	xxx	xx
Strategic	xxx	xxx	xxx

1. Data and report presentation in a variety of forms – tables, text, presentation graphics
2. Report definition in terms of detail level and format of delivery (PDF, HTML, Word DOC, etc.)
3. Parallel work with multiple data sections, presentation in multiple forms using multi-window technology

Knowledge and Modeling Components

Within the DDMKCC model, the knowledge component is defined as a resource comprising mathematical models and algorithms designed to transform data into information (deep knowledge) alongside heuristics used to support the decision making process (shallow knowledge) – rules, constraints, boundary conditions or any other information which may be generated within the DSS or acquired during the system's productive operation [5, p. 16]. This approach allowed us to perform usage analysis of specific knowledge components vis-á-vis the type of decision problem. The findings provide important insights that can inform further evolution of the DDMKCC paradigm.

First of all, addressing support to decision making processes at the operational management level does not involve any major modifications to the pre-defined decision making models. These are typically simple cause-effect models focused on explaining deviations of actual performance from plan. It is vital, nevertheless, that simulation and prediction functions be implemented in this class of models to enable "what if" and "what else" analysis (cf. Table IX).

TABLE IX.
FUNCTIONS OF THE PRESENTATION LANGUAGE WITHIN THE DDMKCC MODEL

DECISIONS	1	2	3

Operational	xxx	x	-
Tactical	x	xxx	xx
Strategic	x	xx	xxx

1. Pre-defined models embedded in the DSS
2. Expandable pre-defined models
3. Custom model development and integration tools

The conclusions will be very different as soon as we look at how the system supports strategic decision making processes. What is required of the system in such circumstances is, in the first place, adaptability and expandability by appending new decision models. The DSS not only has to offer the requisite tools to freely build decision models but also needs be able to instantly integrate (owing to two-way data interchange) with dedicated external systems addressing specific business problems. (This would be necessary, for example, in a situation where an investment bank will not agree to open a long-term credit facility unless project performance is assessed and monitored using a model preferred by the bank.).

Secondly, the DDMKCC model includes a special resource containing knowledge on business processes utilized in decision making (decision workflows). Identifying the key business processes and analyzing the decision making processes intrinsic to them makes it possible to accumulate knowledge needed to discover and assess relationships between decisions and their outcomes. This appears critical, in the light of our research, for decision analysis at all levels – operational, tactical, and strategic (cf. Table X).

TABLE X.
FUNCTIONS OF THE PRESENTATION LANGUAGE WITHIN THE DDMKCC MODEL

DECISIONS	1	2	3	4
Operational	xxx	xxx	x	x
Tactical	xxx	xxx	xx	xxx
Strategic	x	xxx	xxx	x

1. Mathematical models and algorithms
2. Workflow procedures
3. Heuristics based on expert knowledge
4. Algorithms founded on fuzzy expert rules

Thirdly, our observations suggest that other than deterministic models are used relatively rarely. The most common approach is that founded on deterministic scenario building techniques where the best- and the worst-case scenario are identified. Where probabilistic models are used, preference is given to approaches based on subjective probability.

TABLE XI.
FUNCTIONS OF THE PRESENTATION LANGUAGE WITHIN THE DDMKCC MODEL

DECISIONS	1	2	3
Operational	xxx	x	-
Tactical	xxx	xx	-
Strategic	xxx	x	x

1. Deterministic
2. Fuzzy
3. Probabilistic

Creativity Component

Our survey indicates that the most frequently used creative problem solving tools include: (1) context-sensitive help along with access to historical data and similar cases, (2) a multi-dimensional OLAP data base viewer for convenient hypothesis testing during the creative problem solving process, (3) group work support tools, such as dedicated discussion forums or widely popular instant messengers, (4) SWOT analysis support tools, (5) tools and models for multi-criteria "what if" analyses, and (6) context-oriented reports recapitulating the user's work outcomes; to deliver these outcomes, such reports make use of e.g. expert systems, presentation graphics, tabular views and layouts [6].

The use of each type of tool was examined by observing the subsequent stages of budget planning and budget control processes (monitoring deviations from targets) in capital groups – cf. Table XII.

TABLE XII.
CREATIVITY SUPPORT TOOLS MOST HEAVILY USED BY CAPITAL GROUPS WITHIN BUDGET PLANNING AND CONTROL PROCESSES TO MONITOR DEVIATIONS FROM PLAN

	PROCESS	1	2	3	4	5	6
1	setting budget targets for subsidiary companies	xxx	-	x	-	x	x
2	budget modeling in daughter companies	x	xxx	x	-	xxx	xx
3	management-led consolidation of financial budgets	x	xx	-	-	-	x
4	analysis of threats and opportunities to performance of consolidated group budget	x	xx	x	xxx	xxx	xxx
5	analysis of strengths and weaknesses of subsidiary companies' financial budgets	x	xxx	x	xxx	xxx	xxx
6	budget negotiations	-	xx	xxx	-	xxx	x
7	identifying KPIs/CSFs for subsidiary companies' and group's budgets	xx	x	x	-	xxx	xxx
8	monitoring deviations from plan, early warning of potential threats	xx	xx	xx	-	xxx	xxx
9	validation and control of financial budgets	xx	xxx	xx	xx	xxx	xxx

1. Intelligent context-based assistance for problem solving
2. Multi-dimensional OLAP data base viewer
3. Group work support tools
4. SWOT analysis support tools
5. "What if" analytical models

Importantly, we perceived the necessity to make DSS capable of fast and easy integration with specialized external solutions designed to support certain creative problem solving techniques (e.g. brainstorming or morphology analysis).

IV. Conclusions

Researchers dealing with computerized decision support exhibit growing interest in integrating individual and domain-specific insights and building common theoretical, methodological and applicational frameworks that can sustain systemic thinking.

In the long run, thinking in terms of software architectures facilitates DSS development and maintenance. A holistic view fosters diverse applications, iterative development and, in particular, this distinctive approach, perhaps unique to DSS, whereby systems are developed in response to changes in the decision space. Many DSS have evolved from a data-oriented system through modeling a specific domain, e.g. financial control, which became a starting point, then arousing broader interest in the system itself and inspiring innovative efforts at large. Next, there arises a need for group work and creativity support.

By investigating, across multiple aspects, the ways in which specific DDMKCC model components are used in the practice of making business decisions, we have identified the key determinants of an effective development context for computerized decision support systems. The paper presents research findings which encourage a belief that further development of context-dependent DSS design meta-methodology should be approached from the system designer's perspective.

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