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System Dynamics and Cybernetics: A Necessary Synergy

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1 Abstract

In line with the conference theme – „Collegiality" – the authors propose to build a bridge between two Systems Approaches, namely System Dynamics (SD) and Management Cybernetics (MC). This synthesis is aimed at opening a path for a better capability to deal with complex issues of actors in both organizations and society. With their respective strengths – modelling and simulation of content issues for SD, and providing a viable organizational context for MC - a combination appears to be potentially promising. The authors propose the Integrative Systems Methodology as a framework for combining SD and MC, and they give practical illustrations to support their argument.

2 Introduction

In this paper we identify a complementarity of the two fields, System Dynamics and Management Cybernetics for applications to social systems. We propose that this complementarity should be explored synergistically. We shall also give an outline for building a bridge between System Dynamics and Management Cybernetics. One does not build a bridge for the sake of construction, but because one wants to establish a necessary connection.

The purpose of this paper is to show why and how System Dynamics (SD) and Management Cybernetics (MC) are complementary. Both disciplines are rooted in the Systems Approach, and therewith have bred methodologies for dealing with complexity. Both originate from a common theoretical basis, General System Theory and Information Theory. But each one also has additional roots in disciplines or theories, which are specific to it, in particular, Neurophysiology and Set Theory for Management Cybernetics, Engineering and Control Theory for System Dynamics.

System Dynamics is based on a strong idea – capturing the underlying characteristics of complex systems by means of modelling and simulation, in order to understand them better, and to enable designing policies in ways

- To foster desirable developments, as well as
- To make errors along the way less likely.

The SD methodology, in combination with the development of excellent software packages has strengthened the momentum of both SD-based practical applications and SD theory-building.

SD has become a powerful approach to dealing with dynamic complexity. Even so, it is not a panacea, but it often needs completion from without. Depending on the issues under study, system dynamicists are well advised to include complementary methodologies into their toolkit.

Lane and Oliva (1998) have highlighted one such complementarity. These authors ascertained a lack within SD of theories for generating and representing diverse issues and for enhancing sensitivity to socio-political aspects. Therefore they proposed a synthesis between System Dynamics and Soft Systems Methodology (SSM) by Checkland (1981).

We agree with this proposal, which leads to complementing logic-based analysis of the issues at hand by an "extended cultural analysis" incorporating analyses of the intervention, the social system and the political system (op.cit.: 228). The present paper continues in that vein, with a focus on organizational change and pertinent problem-solving processes.

When dealing with complex issues or problems in organizations, content, context and process should be studied and designed simultaneously, as postulated by the organizational scientist Andrew Pettigrew (1985: 50). The rationale of our argument in a nutshell is as follows.

System Dynamics provides a methodology for modelling and simulating organizational issues dynamically. A large spectrum of issues of strategy or operations can be represented, and pertinent decision-making at the *content* level can be supported effectively. However for the analysis and design of the organizational *context* complementary models are needed, which Cybernetics can provide.

Therefore we propose the combination of System Dynamics with Management Cybernetics (also Organizational Cybernetics). In connection with the latter we refer to the Viable Systems Model (see Beer 1979, 1981, 1985). This is due to a distinctive feature of that model. It is not only a blueprint for modelling organizations as viable systems. To our knowledge, it also embodies the most mature organizational theory: the VSM specifies the necessary and sufficient structural preconditions for the viability of any organization. Furthermore, this model has not been refuted so far.

In order to understand the complementarities of System Dynamics and Management Cybernetics, we are first going to give a brief historical overview of their development and interrelatedness. Then we shall analyze both methodologies with a view to their respective strengths and weaknesses. This will then lead us to the complementarities and our proposal for integrating the two. Finally we are going to reflect on the further research needed in order to accomplish such an integration of SD and MC.

3 System Dynamics and Management Cybernetics – Commonalities and Differences

SD and MC have commonalities as well as differences as far as their origins are concerned. Cybernetics is not only the root of MC, but also one of the sources from which SD emerged. Over time, both SD and MC have pursued their own paths. Two different “schools” have evolved by and large independently of each other.

Both SD and MC have been classified as “functionalist systems approaches” (Jackson 2000), because they originated in the positivistic tradition. However, both have also learnt from the interpretive systems approaches (cf. Schwaninger 2004a).

In order to become more specific, it is worth going back a little bit further, and elaborating on a distinction between two major threads of the systems movement, as coined by Richardson (1991): the cybernetic thread, from which MC has emanated, and the servomechanic thread, in which SD is essentially grounded. As Richardson’s detailed study shows, the strongest influence on Cybernetics came from biologists and physiologists, while the thinking of economists and engineers essentially shaped the servomechanic thread.

Consequently, the concepts of the former are more focused on the adaptation and control of complex systems for the purpose of maintaining stability under exogenous disturbances. Servomechanics, on the other hand, and SD in particular, takes an endogenous view, being mainly interested in understanding circular causality as a source of a system's behaviour.

Cybernetics is more connected with communication theory, the general concern of which can be summarized as how to deal with randomly varying input. SD, on the other hand, shows a stronger link with engineering control theory, which is primarily concerned with generated by the control system itself, and the role of nonlinearities.

Finally, the quantitative foundations are more evident in the basic literature on SD than in the writings on MC, in which the mathematical apparatus underlying model formulation is confined to a small number of publications (e.g., Beer 1962). These are also less known than the qualitatively orientated treatises.

Essentially, the perspective of SD on systems is one of modelling them as continuous processes, by means of differential equations. Even though the focus of MC is on the continual adaptation and learning of organizations, these systems are often described from a discrete-event perspective, e.g., in set-theoretical terms. This however is not a difference prohibiting a combination of the two methodologies; even in SD models continuous functions are made discrete by the simulation algorithms.

4 System Dynamics: Strengths and Limitations

Among the distinctive features of SD, in the context of the multiple theories and methodologies of the systems movement, are:

- *Focus on feedback-driven, mainly internally generated dynamics*. The model systems are networks of closed loops of information. However, they are not "closed systems," in that (a) flows can originate from outside the system's boundaries, (b) exogenous factors or systems can be incorporated into any model, as parameters or special modules, and (c) new information can be accommodated via changes to a model. Neither are they deterministic (for a debate on SD determinism see Lane, 2001a); stochastic variables and relationships have been a standard modelling feature since Forrester's *Industrial Dynamics* (1961) was published.
- *High degree of operationality*. SD relies on formal modelling. This fosters disciplined thinking; assumptions, underlying equations and quantifications must be clarified. Feedback loops and delays are visualized and formalized; therewith the causal logic inherent in a model is made more transparent and discussable than in most other methodologies. Also, the achievable level of realism is higher than e.g. in econometric models.
- *Far-reaching possibilities to the combination of qualitative and quantitative aspects of modelling and simulation*. The focus is not on point-precise prediction, but on the generation of insights into the patterns of generated by the systems under study.
- *High level of generality and scale robustness*. The representation of dynamical systems in terms of stocks and flows is a generic form, which is adequate for an enormous spectrum of potential applications. This spectrum is both broad as to the potential subjects under study, and deep as to the possible degrees of resolution and detail.

- *Availability of powerful application software*. The packages (Stella/Ithink, Powersim, VENSIM and MyStrategy)[1] are easy to handle and give access to a high variety of mathematical functions. Some of them offer optimization procedures and validation tools. Some support for collaborative modelling and communication with databases are other useful features. These, however are still subject to further development.

These features of SD result in both strengths and limitations.

Its specific modelling approach makes SD particularly helpful to gain insight into the patterns exhibited by dynamical systems, as well as the structures underlying them. Closed-loop modelling has been found most useful to foster understanding of the functioning of complex systems. Such understanding is especially facilitated by the principle of modelling the systems or issues under study in the continuous mode and at rather high aggregation levels. With the help of relatively small, but insightful models, and by means of sensitivity analyses and optimization heuristics incorporated in the application software packages, decision-spaces can be thoroughly explored. Vulnerabilities and the consequences of different system designs can be examined with relative ease.

The generality of the methodology and its power to have operational thinking crystallize in realistic models have triggered applications in the most varied contexts. Easy-to-use software and the features of screen-driven modelling via graphical user interfaces provide a strong lever for collaborative model-building (cf. Vennix 1996; Andersen & Richardson, 1997). Given these strengths the community of users has grown at a fast rate. It has transcended disciplinary boundaries, ranging from the formal and natural sciences to humanities, and covering multiple uses from theory building to education and to the tackling of real-world problems at any conceivable level. Applications to organizational, societal and ecological issues have seen a particularly strong growth.

Its specific features also make SD an exceptionally effective tool to convey systemic thinking to anybody. Therefore, it also has an outstanding track-record of classroom applications. The pertinent audiences range from schoolchildren at the levels of secondary and primary schools to managers and scientists.

The flip side of most of these strengths forms the limitations of SD. SD is less efficient than various discrete event simulation programs for the modelling of certain complex discrete-event problems, which are typical for logistics systems, e.g. queuing and sequencing issues. Also, SD is an inherently dynamic modelling and simulation approach, which cannot compete with the features the static optimization packages provide. Also, its capabilities for bottom-up modelling, as is the case in agent-based modelling, to date are limited in comparison with multi-agent software packages. Even so, certain initiatives are under way, which link SD and agent-based modelling and simulation.

And while SD-related research on systems archetypes (cf. Senge 1992; Wolstenholme 2003) is about to gradually produce a theory of structures, this is the main area where SD is still lacking. The systems archetypes definitely ease the diagnosis and analysis of problems but they do not provide answers as to what desired or optimal structures are. Expressed differently, the archetypes help determining where one stands and what the potential flaws and future pitfalls are but not where to go from there.

SD therefore still does not provide a substantive theory or methodology for the design of organizations. In that respect it is indicated to revert to complementary models and methodologies. The reasons, why we consider Management Cybernetics an important candidate to provide such a synergy follow in the next part.

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[1] Of High Performance Systems Inc., Ventana Systems Ltd., Powersim A/S, and Strategy Dynamics Ltd. respectively.

5 Management Cybernetics: Strengths and Limitations

The cybernetic view on socio-technical systems has bred models and methods for management in general and for the diagnosis and design of organizations in particular. Laying out the whole theory of Management Cybernetics would transcend the scope of this paper. We shall focus on the Viable System Model (VSM) coined by Stafford Beer, the father of MC (Beer 1979; 1981; 1985; 1989), which is probably the most wide-ranging organisational theory Management Cybernetics has brought forth to date.

Among the distinctive features of the VSM are:

- *Focus on viability.* The VSM is a framework for the structuring of organizations as viable systems, which deal with complexity adaptively and recursively. This focus on viability does not preclude other theories of management, but it complements the many approaches focused on partial aspects of design and control with an integrative view. It provides a theory and methodology for the design of organizations and parts thereof as wholes, the viability and development of which is grounded in their ability of coping with complexity effectively.
- *High level of generality.* In a nutshell, the VSM specifies a set of functions, which provide the necessary and sufficient conditions for the viability of any human or social system. These functions and their interrelationships are specified in a comprehensive theory (Beer 1979; 1981; 1985), which is, in principle, applicable to any social system, particularly to organizations.
- *Theoretical propositions.* The main theoretical proposition stipulated by the VSM is that an organization is viable if and only if it has a set of management functions and their interrelationships as specified by the theory. To our knowledge, this proposition is stronger than those of any other theory of organization design. The second proposition is that any deficiencies in this system, such as missing functions, insufficient capacity of the functions or communication channels, or faulty interaction between the functions, impair or endanger the viability of the organization. The third proposition is that the viability, cohesion and self-organization of an enterprise depend upon these functions being operating recursively at all levels of the organization. A recursive structure comprises autonomous units within autonomous units. Moreover, a viable organization is made up of viable units and itself forms a part of more comprehensive viable units.
- *The set of management functions of the VSM.* The set of the management functions and their interrelationships identified and formalized in the model are as follows [Figure 2]:

  System 1: Regulatory capacity of the basic units, autonomous adaptation to their environment, optimization of ongoing activities

  System 2: Attenuation and amplification to dampen oscillations and co-ordinate activities via information and communication

  System 3: Establishing overall optimum among basic units, resource allocation, providing for synergies: the operative management

  System 3:* Investigation and validation of information flowing between Systems 1-3 and 1-2-3 via auditing/ monitoring activities

  System 4: Dealing with long-term and overall outside environment, diagnosis and modelling of the organization in its environment - the development function.

System 5: Balancing the interaction of '3' and '4', embodiment of supreme values, rules and norms - the ethos of the system.

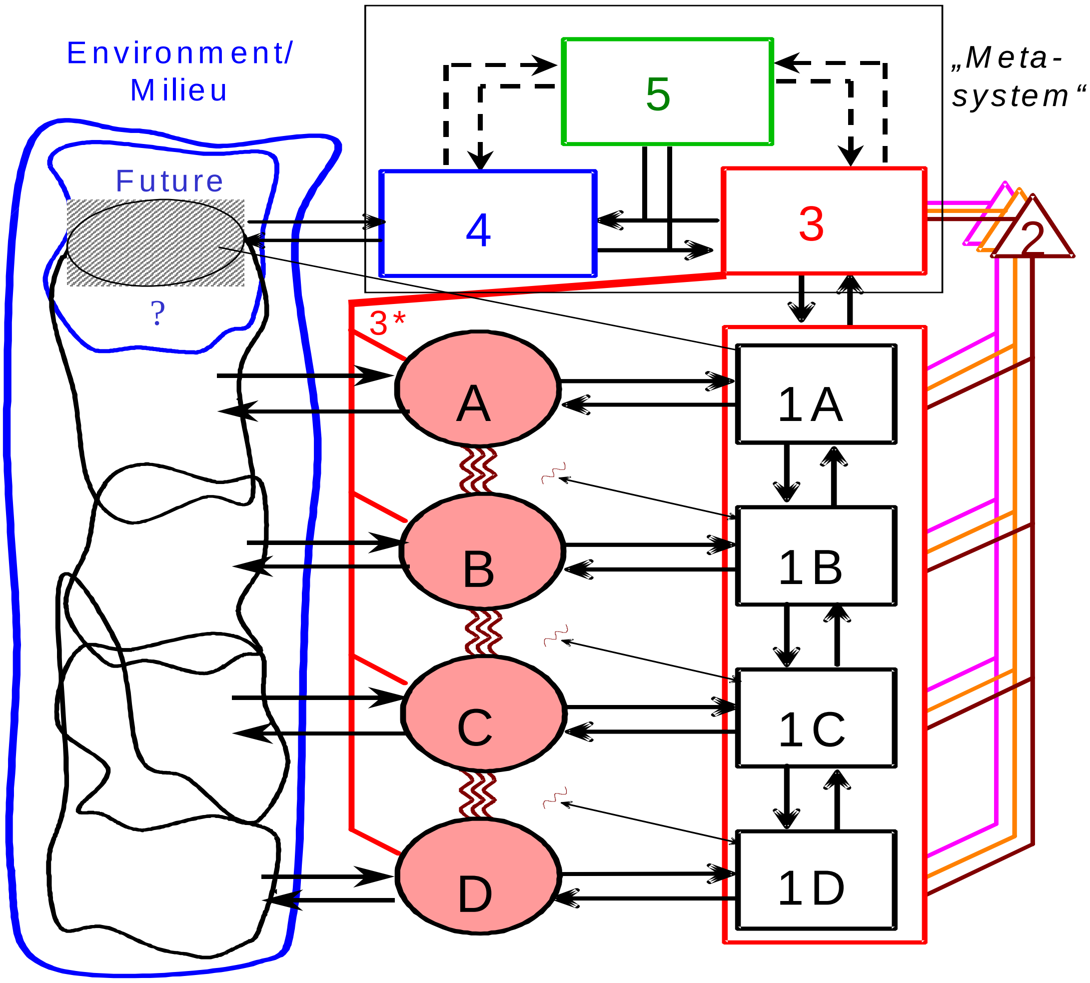

Figure 1: **Stafford Beer's Viable System Model (overview)**[2]

The strengths of the VSM are based on its powerful theoretical claim. The consequence is that the VSM is primarily effective as a device for diagnosing organizations. Beyond that it has proven to be a most helpful heuristic for organizational design. A further strength lies in its generality, which makes it a very strong conceptual tool for organizational diagnosis and design, independent of the specific features of the organizations under study, such as type of activity, size, location, products, markets, technology, and the like. The fact that the model has not been falsified to date, gives strong support to the assumption that its bold theoretical claim is justified. Finally, according to a comparison of theories of viability accomplished recently, also the concision and stringency of the theory, as well as its elaborateness and transparency, are considerable (cf. Schwaninger 2004b).

These strengths have led to an increasing interest in the VSM. As public response indicates, it is obviously attractive and exerts great fascination, at least as far as the community of academics and practitioners, interested in the Systems Approach, is concerned (cf. Schwaninger 2004b). This is shown by the fact that more and more people and organizations

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[2] This is a slightly simplified version (cf. Beer 1985).
[4] The conceptual basis of this postulate is the Conant-Ashby-theorem (Conant & Ashby 1981).

now work with it. The VSM is chiefly utilized in general management and consultancy. This applies to both the private and state sectors. Examples are to be found in company-wide organization designs, and diagnoses of the total organization of firms of all kinds and sizes as well as public and international authorities. The VSM has also been employed to analyze the political systems of whole nations, and VSM-based theses on themes related to Engineering have been completed at Technical Universities or Institutes in different countries (For details, see: Schwaninger 2004b, and literature quoted therein).

However, the VSM has not yet become as popular as SD. This is in part due to its later appearance and the fact that its originator never operated from a stable academic base, as opposed to the Jay Forrester, father of SD. In part it may also be due to its limitations, which are not altogether limitations of the model itself.

One limitation of the VSM is that its theoretical underpinnings are highly complex, and it is not an easy-to-use model. Also the methodology for applying it, which has gradually emerged, is not yet as accessible as are the sources on SD methodology and applications. Another limitation of the VSM is its lack of specific tools for the simulation and analysis of the dynamic behaviour of an organization and its environment, which enables the exploration of scenarios and assessing the impact of changes taking place or decisions made.

A much greater limitation is that while the VSM does allow one to figure out both the current and the desired state, it does not provide support on how to get from the former to the latter. One could assume that the knowledge of both states should suffice, especially since there is a theoretical body of knowledge on organizational change (see e.g., Beer & Nohria 2000). On the other hand, all such knowledge is highly dependent on the context, which is rarely sufficiently similar to enable one to copy the recommendations from theory to practice easily.

Just as Management Cybernetics seemed to compensate the major weaknesses we listed for System Dynamics, it seems to be the same the other way around. Namely, by building an SD model one can develop theories on the implementation of change, and put it to the test for the specific case at hand. These theories should suffice for providing a set of goals as well as design principles and strategies, and for alerting the practitioner as to what to expect if he applies them, in the sense of a "What-If-Analysis". In addition, SD models can predict conflict potentials and trade-offs before the change process has even started. They also enable one to design policies that take those into account and thereby minimise the unintended consequences of the required change.

With the advantages and shortcomings of both System Dynamics and Management Cybernetics laid out, we can proceed to the main part, where we show our proposed integration of the two approaches.

6 Dynamical Modelling and Simulation for Organizational Viability

In the previous paragraphs we have discussed the strengths and limitations of both the methodologies of SD and MC, the latter with a focus on the VSM. If we explore them we can see that frequently what is a limitation in one methodology it is a strength in the other methodology, at least at the actual stage of development of both methodologies.

For instance, SD - as mentioned - is a methodology, which does not provide a substantive theory for the design of organizations. That however, is precisely one of the greatest strengths of the VSM - it does provide an exceptionally complete, coherent and clear theory applicable to the diagnosis and design of any organization.

If we now take the VSM under scrutiny, as stated above, one of its limitations is the difficulty, which it has for analysing the dynamic behaviour of a complex system, e.g., an organization. The VSM does provide a conceptual model to depict the organization in its environment, with an emphasis on management control functions and interrelationships of control and communication. However, it does not provide any theory about the substantive issues confronted by that organization. In other words, the VSM does not help to deal with the content of the issues to be tackled, but it helps to design the organization so as to be fit for tackling those issues - it is about organizational context, not content.

The dynamic behaviour of the organization in its environment is an outcome of the interaction of the system with its environment over time. Modelling and simulating the consequences of different scenarios about the evolution of the environment, studying the impact of decisions, exploring the space of options with their consequences, etc., require a specific modelling and simulation approach, which the VSM itself does not provide. The extraordinary capability to meet these needs is precisely the strength of SD.

Given this complementarity of the two methodologies it is quite evident and logical that their combination is promising. It is time for joining the two threads, which Richardson (1991) described as following a kind of parallel track, to build a stronger rope.

In the following paragraphs we will explore in some depth where we think that the combination of both methodologies is most beneficial.

6.1 SD and the Development Function (System 4)

Earlier we enumerated the five management functions which are identified in the VSM as necessary and sufficient for an organization to maintain its viability.

One of these functions is System 4, which is responsible for dealing with the long-term and the overall outside environment, diagnosis and modelling of the organization in its milieu. We have to elaborate on this aspect.

Any system operates in a specific environment, which will change over time. If the system is to keep its viability, it must evolve according to the changes happening in its environment, which can have an impact upon it. It is convenient to distinguish between two kinds of environment. The first one can be called the accepted environment of an organization (or enterprise). By that term we refer to what is actually happening in that environment and what the trends are. We discern the second one as a more problematic kind of environment, one particularly related with the unknown future (Beer 1979).

As Beer specified in his theory, a system 4 is the fulcrum of the adaptation of a viable organization. It embodies the apparatus for the organization to control itself with regard to the changes happening in the environment and with a focus on the long term. To maintain this crucial regulatory function effectively, it must contain a sufficiently rich model of what it intends to regulate[4]. In this case, the object of (self-) regulation is the whole viable system. The object of regulation here is essentially the interaction between the organization and its environment.

The necessary model must embody two aspects:

a) The content of these interrelationships, i.e. the organizational activities.

b) The context of these organizational activities, i.e. the organizational structure which maintains these interrelationships.

A shorthand description of System 4 is contained in Figure 2. Here reference to the complementarity of SD and the VSM can be made. The need for dynamic images of organizational activities (content level) calls for SD modelling while the VSM is most helpful to depict the organizational structure of a whole Viable System (context level)[5].

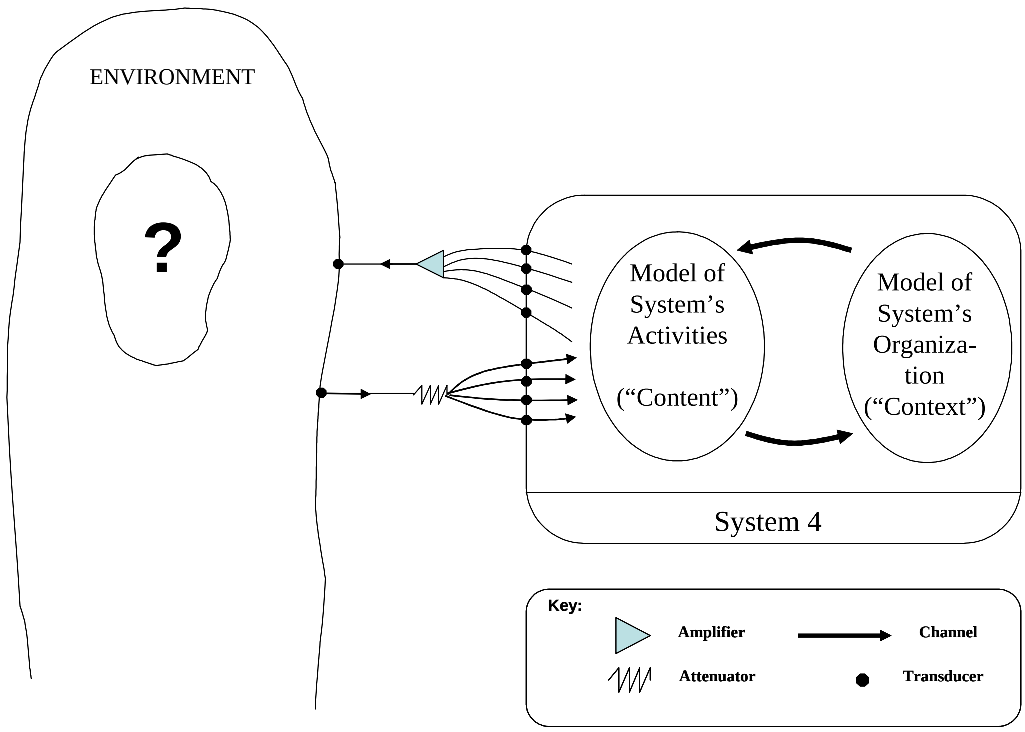

Figure 2: System 4: Overview

First, let us elaborate on the models at content level. Typical activities related to a System 4 of an enterprise are for instance Market Research, Research and Development, Product Design or Economic Forecasting. All of these handle issues related to the actual and future environment of the enterprise, and depending on how well they are able to deal with them, its viability will be more or less "safe".

The effectiveness of a System 4 hinges on how good its model of the enterprise in its environment is. It determines what the management for the long term can achieve or what will be out of reach. Stafford Beer called the System 4 activity management for the "outside and then" (Beer, passim). As this is a very broad and comprehensive task, the respective models must draw on different sources of knowledge. These sources are multi-disciplinary ("interdisciplinary"), but ultimately the integrated view must be one. Therefore, the quest is for a shared model, and the modelling task is trans-disciplinary. In addition, management not only needs to fill in content but also to ensure that change in the direction chosen as viable is also feasible. We will first look at the ability of System Dynamics to provide content and then go over some points regarding the use of SD in conflict resolution and prevention.

6.2 System Dynamics in Content Creation

In Figure 3, the creation of a shared understanding of a system by the representatives of different perspectives is visualized, with System Dynamics as a pertinent methodology for model building.

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[5] Schwaninger 1997 and 2004c has elaborated on these complementarities.

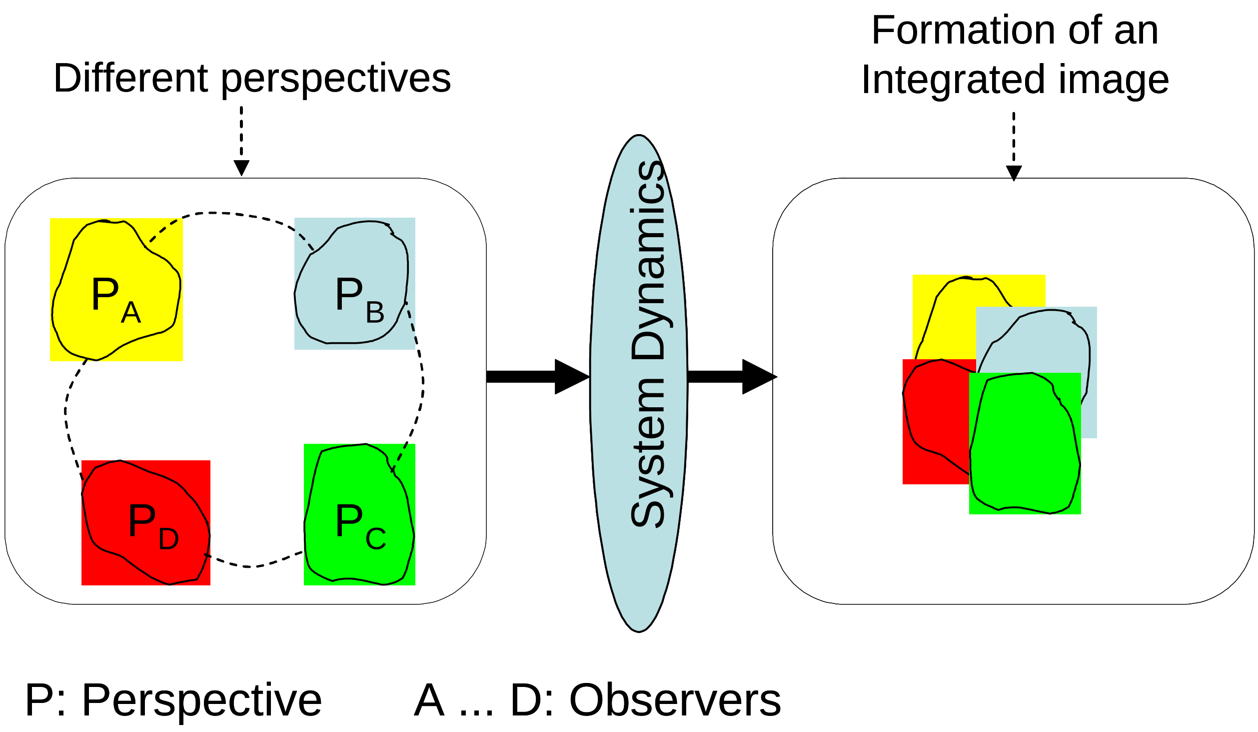

Figure 3: Formation of a shared understanding of a system

The techniques of qualitative System Dynamics are of great help for the purpose of creating a shared understanding of the system. At this point it is important to point out the difference between shared mental models and a shared understanding of the system structure or operation. While no empirical support exists for actors generally having mental models of the system structure (see Maxwell et al. 1994; Richardson et al. 1994) or of their system understanding increasing as a result of a creation of an SD model of their reference system (see Vennix 1990; Verburgh 1994), there is clear empirical evidence that SD models do align the actors' understanding of a system (see Huz et al. 1997).

The importance of a shared or aligned understanding is that this represents the only way to enable the adjustments necessary[6], in order to keep the structure viable in a changed environment.

On the other hand SD is very well suited to capture the various knowledge held by different actors, – required for the creation of a rich picture that shows the necessary changes, as shown above (cf. Vennix 1996). While the fact that only a very small part of the knowledge is usually shared (see Einhorn et al. 2003 and the literature quoted therein) is a potential hindrance it has been shown empirically that this can be overcome (Sterman 2000 and the literature quoted therein). A potential way of handling this would be to have separate meetings with small teams and then to consolidate the knowledge to a greater whole.

An example of a practical application is given below. In Figure 4, the process is illustrated with a SD project which supported the development of a Regional Innovation and Technology Transfer System (RITTS) in the region of Aachen, Germany. As reported elsewhere, in a first round a qualitative model of the system under study was established, in which the different

[6] Theory of Planned Behavior, see for instance Ajzen (1991).

views of different stakeholders were integrated.[7] Most of these stakeholders were represented personally by the participants of the two modelling workshops. The result of the qualitative modelling exercise was a shared mental model in the form of a CLD-Causal Loop Diagram (right hand of Figure 4).

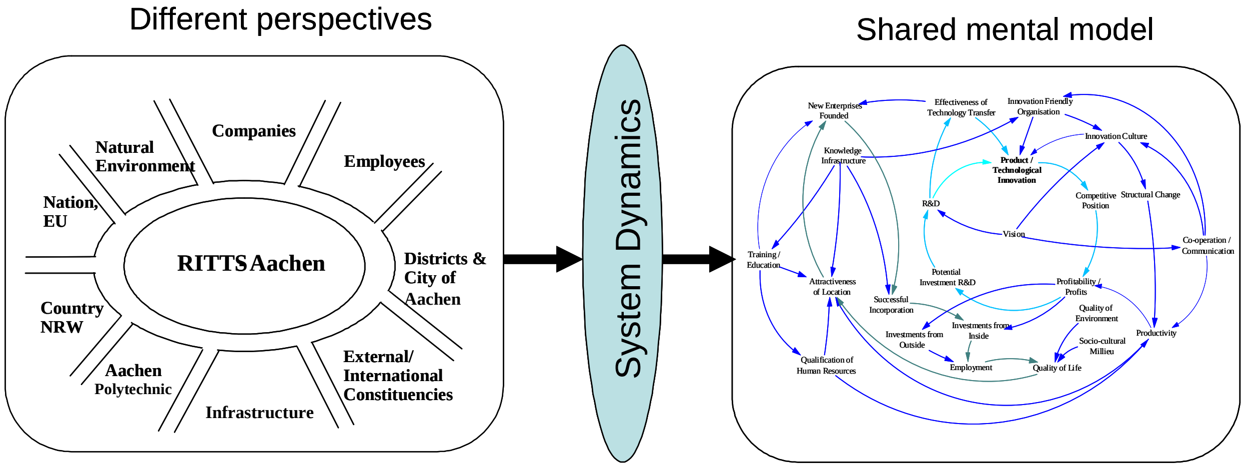

Figure 4: Formation of a shared mental model (Example)

In its essence, the qualitative SD-modelling process is a bold tentative of building knowledge and understanding concerning the problematic environment, about which little or nothing is known at the outset. As John Locke, in his essay concerning human understanding proposed, we necessarily know things relationally, by their dependence on other things (Locke 1987: IV 6.11). The CLD is a powerful vehicle for building knowledge and understanding by gradually uncovering interrelationships of this kind.

Building this kind of diagram is enormously helpful in the process of enhancing the understanding of a complex issue. It enables approaching the system under study very efficiently to gain an overview of the partial aspects of which it is made up, as well as their interrelationships. In the case of complex issues, the CLD is usually the product of a group modelling effort. At the same time it is a powerful vehicle to support the organizational discourse. The work of building the joint model is even more important than the result, because understanding is shaped and deepened all the way along the model building process.

Let us revert to our case study, the system 4 of the Aachen RITTS. The aim of the workshops, in which the CLD was elaborated, was to develop a common understanding of what a RITTS was about, and what would make it take off to foster the economic competitiveness of the region of Aachen. As the results of the project and a later follow up showed, the model building exercise contributed a lot to the cognitive capability and the cohesion of the project group. In addition to the qualitative model, an SD model was developed. For details, see Schwaninger (2004c).

6.3 System Dynamics for Conflict Resolution

The mechanisms helping in content creation, as described above, similarly help in conflict resolution. First of all, conflict is usually useful for externalising deep seated assumptions and if handled properly, has been shown to increase organisational performance (Eisenhardt et al., 1997a; 1997b, and the literature quoted therein). SD modelling can be a powerful tool in

[7] More details of that project have been documented in Pérez Ríos & Schwaninger (1996), Schwaninger (1997).

ensuring that such conflict is handled well and that it doesn't lower group cohesion or the ability of the group to work together.

Qualitative SD models might be able to produce a first understanding but here quantitative models are much more useful. This due to the fact that assumptions can be challenged, tested and then accepted or rejected on the basis of a fairly neutral tool, rather than on the basis of personal preference, position or power within the organisation (Sterman, 2000).

In addition to situations, where conflict is essential and management of such conflict is asked for, there are others, where conflict is best avoided. Again, with the use of SD modelling, one is able to recognise such conflict potentials early on and to design and test (through simulation) policies in order to minimise unwanted side effects or unintended consequences.

This now brings us to the discussion about the VSM as the appropriate theoretical framework to complement System Dynamics modelling.

6.4 Why VSM?

As far as the organizational model is concerned, we do not claim, that this must be necessarily a cybernetic model. We simply plead for using the VSM, because it is the most powerful diagnostic tool to tell us how viable an organization is. In the case of the RITTS, such a model of the organization was used, and it brought to the fore most valuable diagnostic points (Figure 5).

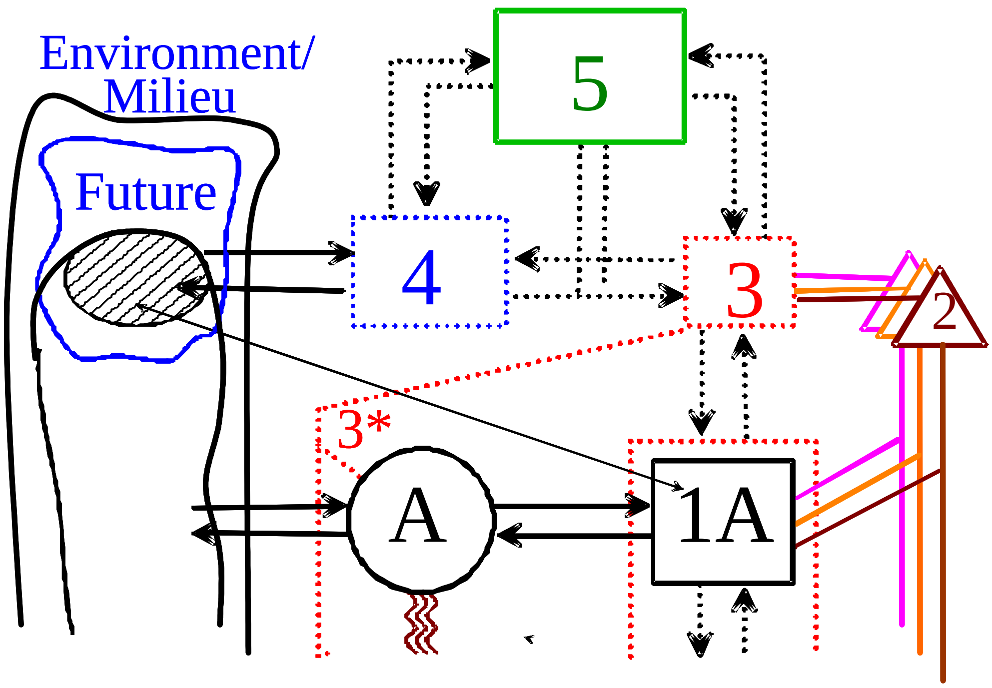

Figure 5: VSM - model at the level of the organizational context (RITTS case study)

A System 4 is an organ of self-reference. It is the organ through which the organization reflects what it is and what it does. This implies that a System 4 includes both, an image of the total Viable System and an image of itself. Concerning our case study, the diagram in Figure 5 does not give great detail about the latter. However, it indicates, that there already was a System 4 at that stage. The interdisciplinary team gathering for strategy workshops with the modelling exercises and reflections, as described, were an embodiment of system 4. The issue discussed was the future development of the Aachen RITTS. A broad perspective was guaranteed, because the different stakeholders were represented. The participants were highly knowledgeable and the strategy process worked well. However, this strategy team was not yet instituted as a permanent team; therefore, we have drawn the box representing System 4 with punctuated lines. Further diagnostic points concerned weaknesses of Systems 3 and 3* in particular.

6.5 The Systems 4 -3- homeostat

We have used the term "outside and then" for System 4. Similarly a short term description of System 3, in connection with Systems 2 and 1, is "management for the here and now". While the first is about the development of the organization as a whole in the middle- and the long term, the latter is about efficient response to instant requirements on a continual basis. Doubtlessly, these are two different issues. Both domains have their distinct logic, their specific goals and they need different "languages" to deal with them.

However, if System 3 and System 4 do not interact, the organization will sooner or later suffer from schizophrenia. Hence, an interaction of the two is a must; it should be a real dialogue about the organization's future and how to bring it about.

But if both systems have different languages, how can they engage in a fertile dialogue? The systemic solution is the creation of an interface which transduces the categories of one domain into the language of the other and vice-versa. This is precisely what a good SD model can provide.

To illustrate this, we shall revert to a conceptual framework which describes the interrelationships between the operative, strategic and normative management (roughly equivalent to the relationships between system 3, 4 and 5).

The scheme in Figure 6, called Model of Systemic Control (Schwaninger 2001), visualizes the three different languages required for a proper control at the three logical levels of management. The arrows however indicate, that an overarching SD model made up of the whole set of variables and their interrelationships, is within reach.

Comprehensive models of this kind have been established for different organizations[8].

[8] An example of a parsimonious model of that kind was published by Schwaninger (2003).

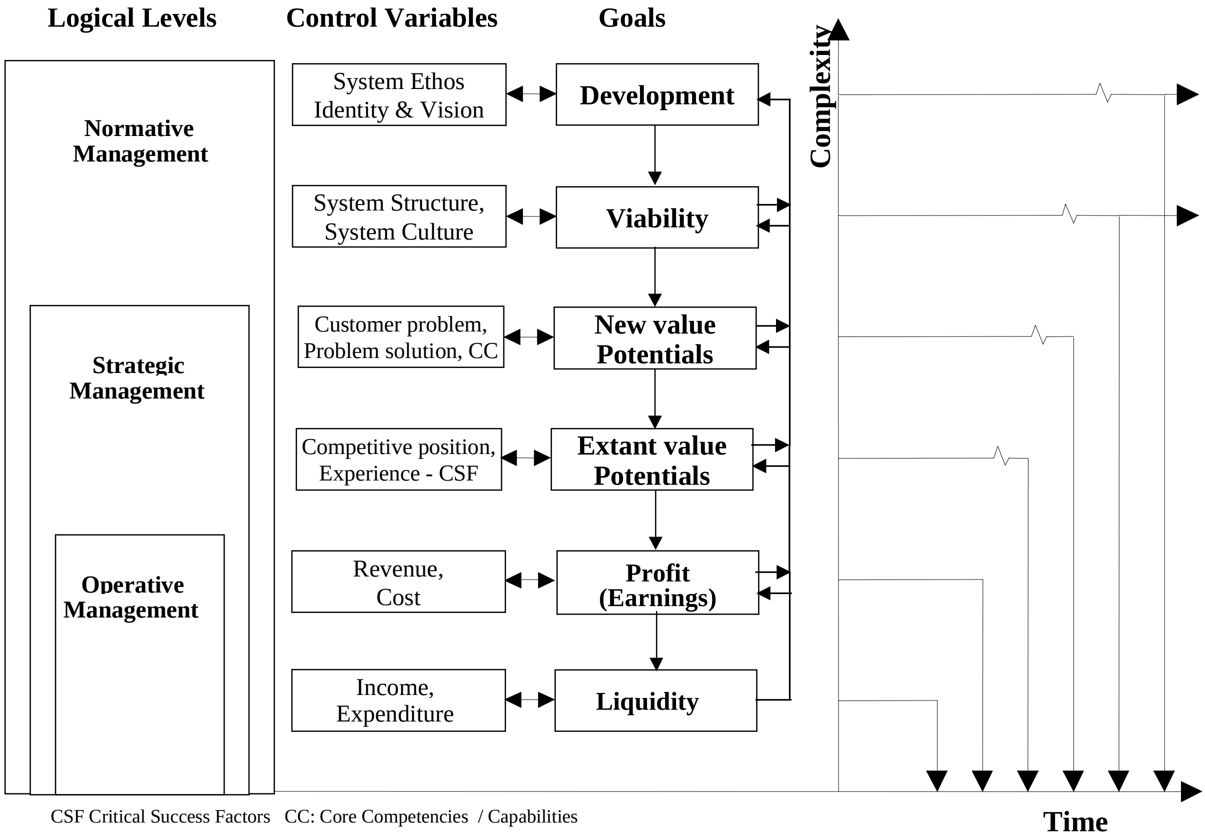

Figure 6: Conceptual framework of control variables: operative, strategic and normative management

Even so, comprehensive models are not always possible or necessary. Also, a widely shared consensus within the System Dynamics community suggests, that one should model issues rather than systems. One can also observe the following development. In the early decades of SD practice, modellers strove for large, complex models and they were proud of models with hundreds or thousands of variables. Recently, at least in research and education, we have rather observed an emphasis on relatively small, but insightful models.

The interaction between Systems 3 and 4 can be about different things. Three major types of issues however are pervasive.

1. Translating strategy options into operative categories and assessing their consequences.
2. Examining the implications of operations for the development of the firm, in terms of possibilities and restrictions.
3. Trade-offs between the short and the longer term. Imperatives and consequences of decisions.

The exploration of scenarios based on dynamic models can provide insights and clues, which are an important complement to exclusively qualitative deliberations. Similarly and even more importantly, trade-offs merely pondered in qualitative terms can hardly be dealt with competently, while making them tangible in quantitative terms is enormously helpful. Finally, strategy designs, which transcend the status quo can be made better discussible, if the discourse is accompanied and supported by an SD modelling exercise. Changes in the mental models will be made explicit and will lead to changes in the SD models, which immediately feed back results. This way, the intuition and judgement of decision makers may be honed in interaction with the model. Such a process should even breed rich insights, if this model-based discourse is led over a longer time - a process, in which conjectures and decisions will be followed by proofs and refutations, therewith providing a learning experience.

7 Software tools

A synthesis of SD and VSM modelling calls for closing the software gap mentioned earlier. While the SD software tools are excellent, the Cybernetics community has been devoid of any modelling software. This is changing now. Under the leadership of one of the authors (See Perez-Rios 2003a; 2003b and 2003c) a software tool has been developed, VSMod®, to support the application of the VSM.

In this way a model of the organization can be constructed in a manner familiar to SD modellers. The difficulty is correspondingly reduced as well, when compared to the case of no supporting software.

Figure 7 shows the look of the software (case of a Brazilian media group). For a detailed analysis of the functionality, see Perez-Rios (2003a; 2003b; 2003c).

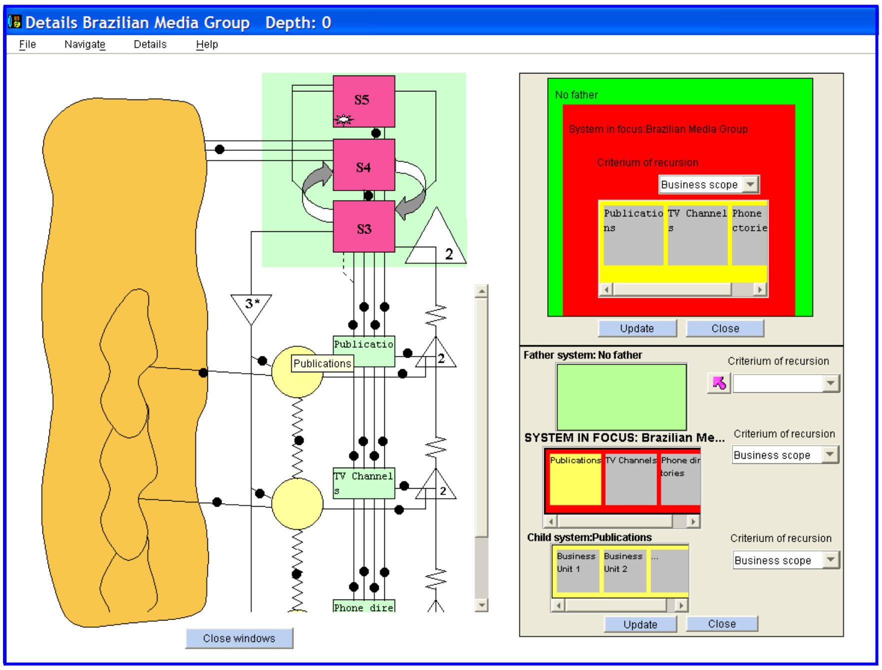

Figure 7: Screenshot of VSMod®, case of a Brazilian Media Group

VSMod® facilitates VSM based modelling, also in cases where multiple units and recursion levels have to be represented. One of the contributions of VSMod® to an integration of SD and MC is that it provides a repository in which SD models can be stored and used. For example, in the case of a multi-recursion enterprise, the representatives of Systems 4 at the different levels could deposit their respective SD models on the software and call upon them whenever necessary. This way, both content and context related modellers (as specified in Figure 2) will be readily available.

8 Conclusions

We have outlined the similarities and differences of both, System Dynamics and Cybernetics. Drawing on an analysis of the strengths and limitations of both methodologies, we have argued that the two approaches could result in additional benefits, if combined. We even claim that the synergy between System Dynamics and Cybernetics is a necessary one, if a more complete approach to deal with complex organizational issues is needed.

System Dynamics has been identified as a very powerful tool to deal with complexities at the level of the content of the organizational activities by modelling and simulating them dynamically. For the modelling and design of the context to enable organizational viability we have identified the VSM as an unmatched conceptual and methodological device. We have as well introduced a new software package – VSMod®, which is especially equipped to facilitate the application of the VSM and should therewith help remove one of the obstacles to its faster diffusion. Also, this new software allows the integration of SD-models on the same platform.

We have emphasized the complementarity of System Dynamics and Organizational Cybernetics. Two addenda are necessary. First of all, they can not be fused in an algorithmic way. However, they can be put to a combined use. Synthesized by a heuristic, they can become a powerful pair. Such a heuristic called "Integrative Systems Methodology" has been proposed elsewhere (Schwaninger 1997, 2004c). It shows how the synthesis of methodologies advocated here can be achieved. Secondly, we do not suggest that System Dynamics modelling and the VSM are the only methodologies available to deal with complex organizational issues. There are certainly other methods and methodologies that can be used and combined.

We have identified System Dynamics and Management Cybernetics as candidates with a marked synergetic potential, as far as applications to organizations and society are concerned, - for several reasons:

1. Both of them are rooted in the Systems Approach, which represents a new stage in the evolution of science - a stage of adaptation to new levels of complexity.

2. Both are highly generic and therefore applicable to a great variety of situations.

3. Their objectives are complementary and in harmony.

4. Their methodologies are individually incomplete, mutually exclusive, but collectively exhaustive or at least comprehensive.

5. They are connectable in functional and virtuous ways.

Therefore, in our view, the synergy between System Dynamics and Organizational Cybernetics is a powerful one. Even if not the only one, it is (almost) a necessity.

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