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System Dynamics and the Evolution of Systems Movement

A Historical Perspective

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1. Introduction

The purpose of this contribution is to give an overview of the role of System Dynamics in the context of the evolution of the systems movement. ”Systems movement”—often referred to briefly as ”systemics”—is a broad term, which takes account of the fact that there is no one systems approach, but a range of different ones. Indeed, the development of the System Dynamics methodology, and the worldwide community that applies SD to the modeling and simulation in the most different contexts, suggest it is a ”systems approach” on its own. Nevertheless, taking ”System Dynamics” as the (one and only) synonym for ”systemic thinking” would go too far, as there are other approaches to systemic thinking as well as a variety of systems theories and methodologies, which – to a certain extent – are complementary to SD. The purpose of this article implies working out the actual and potential relationships between System Dynamics and the other strands of the systems movement.

An overview on the temporal sequence of some milestones in the evolution of the Systems Approach in general and System Dynamics in particular is given in the Appendix. Elaborating on each one of the sources and dates quoted therein would reach beyond the possibilities of this paper.

2. The Emergence of the Systems Approach

The systems movement has many roots and facets, with some of its concepts going back as far as ancient Greece. What we call ”the systems approach” today materialized in the first half of the twentieth century. At least, two important components should be mentioned, those proposed by von Bertalanffy and by Wiener.

Ludwig von Bertalanffy, an American biologist of Austrian origin, developed the idea that organized wholes of any kind should be describable, and to a certain extent explainable, by means of the same categories, and ultimately by one and the same formal apparatus. His *General Systems Theory* triggered a whole movement, which has tried to identify invariant structures and mechanisms across different kinds of organized wholes (for example, hierarchy, teleology, purposefulness, differentiation, morphogenesis, stability, ultrastability, emergence, and evolution).

Norbert Wiener, an American mathematician at Massachusetts Institute of Technology, building on interdisciplinary work, accomplished in cooperation with Bigelow, an IBM engineer, and Rosenblueth, a physiologist, published his seminal book on *Cybernetics*. His work became the transdisciplinary foundation for a new science of capturing, as well as designing control and communication mechanisms in all kinds of dynamical systems. Cyberneticians have been interested in concepts such as information, communication, complexity, autonomy, interdependence, cooperation and conflict, self-production (”autopoiesis”), self-organization, (self-) control, self-reference, and (self-) transformation of complex dynamical systems.

Along the tradition which led to the evolution of General Systems Theory (Bertalannfy, Boulding, Gerard, Miller, Rapoport) and Cybernetics (Wiener, McCulloch, Ashby, Powers, Pask, Beer), a number of roots can be identified, in particular:

- Mathematics (for example, Newton, Poincaré, Lyapunov, Lotka, Volterra, Rashevsky);
- Logic (for example, Epimenides, Leibniz, Boole, Russell and Whitehead, Goedel, Spencer-Brown);
- Biology, including general physiology and neurophysiology (for example, Hippocrates, Cannon, Rosenblueth, McCulloch, Rosen);
- Engineering, including its physical and mathematical foundations (for example, Heron, Kepler, Watt, Euler, Fourier, Maxwell, Hertz, Turing, Shannon and Weaver, von Neumann, Walsh); and
- Social and human sciences, including economics (for example, Hume, Adam Smith, Adam Ferguson, John Stuart Mill, Dewey, Bateson, Merton, Simon, Piaget).

In this strand of the systems movement, one focus of inquiry is on the role of feedback in communication and control in (and between) organizations and society, as well as in technical systems. The other focal interest is on the multidimensional nature and the multilevel structures of complex systems. Specific theory building, methodological developments and pertinent applications have occurred at the following levels:

- Individual and family levels (for example, systemic psychotherapy, family therapy, holistic medicine, cognitivist therapy, reality therapy);
- Organizational and societal levels (for example, managerial cybernetics, organizational cybernetics, sociocybernetics, social systems design, social ecology, learning organizations); and
- The level of complex technical systems (systems engineering).

Furthermore, the notion of ”socio-technical systems” has become widely used in the context of the design of organized wholes involving interactions of people and technology (for instance, Linstone's multi-perspectives-framework, known for the mnemonic TOP (*t*echnical, *o*rganizational, *p*ersonal/individual).

As can be noted from these preliminaries, different kinds of system theory and methodology have evolved over time. One of these is Jay W. Forrester's theory of dynamical systems, which is a basis for the methodology of System Dynamics*.* In SD, the main emphasis is on the role of structure, and its relationship with the dynamic behavior of systems, modeled as networks of informationally closed feedback loops between stock and flow variables. Several other mathematical systems theories, for example, mathematical general systems theory (Klir, Pestel, Mesarovic & Takahara), as well as a whole stream of theoretical developments, which can be subsumed under the terms "dynamical systems theory" or "theories of non-linear dynamics," for example, catastrophe theory, chaos theory, complexity theory have been elaborated. Under the latter, branches such as the theory of fractals (Mandelbrot), geometry of behavior (Abraham) and self-organized criticality (Bak) are subsumed. In this context, the term "sciences of complexity" has also been used. In addition, a number of essentially mathematical theories, which can be called "system theories," have emerged in different application contexts, examples of which are discernible in such fields as:

- Engineering, namely information and communication theory and technology (for example, Kalman filters, Walsh functions, hypercube architectures, automata, cellular automata, artificial intelligence, cybernetic machines, neural nets);
- Operations research (for example, modeling theory and simulation methodologies, Markov chains, genetic algorithms, fuzzy control, orthogonal sets, rough sets);
- Social sciences, economics in particular (for example, game theory, decision theory); and
- Ecology (for example, H. Odum's systems ecology).

Examples of essentially non-mathematical system theories can be found in many different areas of study, for example:

- Economics, namely its institutional/evolutionist strand (Veblen, Myrdal, Boulding);
- Sociology (for example, Parsons' and Luhmann's social system theories, Hall's cultural systems theory);
- Political sciences (for example, Easton, Deutsch, Wallerstein);
- Anthropology (for example, Levi Strauss's structuralist-functionalist anthropology);
- Semiotics (for example, general semantics (Korzybski, Hayakawa, Rapoport)); and
- Psychology and psychotherapy (for example, systemic intervention (Bateson, Watzlawick, F. Simon), fractal affect logic (Ciompi)).

Several system-theoretic contributions have merged the quantitative and the qualitative in new ways. This is the case for example in Rapoport's works in game theory as well as General Systems Theory, Pask's Conversation Theory, von Foerster's Cybernetics of Cybernetics (second order cybernetics), and Stafford Beer's opus in Managerial Cybernetics. In all four cases, mathematical expression is virtuously connected to ethical, philosophical, and epistemological reflection. Further examples are Prigogine's theory of dissipative structures, Mandelbrot's theory of fractals, Kauffman's complexity theory, and Haken's Synergetics, all of which combine mathematical analysis and a strong component of qualitative interpretation.

A large number of systems methodologies, with the pertinent threads of systems practice, have emanated from these theoretical developments. Many of them are expounded in detail in specialized encyclopedias [e.g., François 1997, and, under a specific theme, named *Systems Science and Cybernetics,* of the Encyclopedia of Life Support Systems, 2002]. In this article, only some of these will be addressed explicitly, in order to shed light on the role of SD as part of the systems movement.

3. Common Grounds and Differences

Even though the spectrum of system theories and methodologies outlined in the preceding section may seem multifarious, all of them have a strong common denominator: they build on the idea of systems as organized wholes. An objectivistic working definition of a system is that of a whole, the organization of which is made up by interrelationships. A subjectivistic definition is that of a set of interdependent variables in the mind of an observer, or, a mental construct of a whole, an aspect that has been emphasized by the methodology of constructivism. From a standpoint of operational philosophy, a system is, as Rapoport [1953] says, ”a part of the world, which is sufficiently well defined to be the object of an inquiry or also something, which is characterized by a structure, for example, a production system.”

In recent theory building, the aspect of relationships has been emphasized as the main building block of a system, as is discernible from a recent definition published by ISSS (the International Society for the Systems Sciences): ”A system is a family of relationships between its members acting as a whole.” [Shapiro/Mandel/Schwaninger 1996]. Also, purpose and interaction have played an important part in reflections on systems: systems are conceived, in the words of Forrester [1968], as ”wholes of elements, which cooperate towards a common goal.” Purposeful behavior is driven by internal goals, while purposive behavior rests on a function assigned from the outside. Finally, the aspects of openness and closedness have been emphasized. Open systems are characterized by the import and export of matter, energy and information. A variant of particular relevance in the case of social systems is the operationally closed system, that is, a system which is selfreferential in the sense that its self-production (autopoiesis) is a function of production rules and processes by which order and identity are maintained, and which can not be modified directly from outside.

At this point, it is worth elaborating on the specific differences between two major threads of the systems movement: the cybernetic thread, from which Managerial Cybernetics has emanated, and the servomechanic thread in which SD is grounded [Richardson 1999]. 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, take an endogenous view, being mainly interested in understanding circular causality as a source of a system's behavior. 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 behavior generated by the control system itself, and the role of nonlinearities. Managerial cybernetics and SD both share the concern of contributing to management science, but with different emphases and with instruments that are, in principle, complementary. Finally, the quantitative foundations are generally more evident in the basic literature on SD, than in the writings on Managerial Cybernetics, in which the mathematical apparatus underlying model formulation is confined to a small number of publications [e.g., Beer 1962, 1981], which are less known than the qualitative treatises.

4. The Variety of Systems Methodologies

The methodologies that have evolved as part of the systems movement cannot be expounded in detail, here. Two methodologies in which they are grounded can be identified - the positivist tradition and the interpretivist tradition.

Positivist tradition denotes those methodological approaches that focus on the generation of "positive knowledge," that is, a knowledge based on "positively" ascertained facts.

Interpretivist tradition denotes those methodological approaches that emphasize the importance of subjective interpretations of phenomena. This stream goes back to the Greek art and science of the interpretation and understanding of texts.

Some of the systems methodologies have been rooted in the positivist tradition, others in the interpretivist tradition. The differences between the two can be described along a set of polarities, namely:

- an objectivist versus a subjectivist position;

- a conceptual–instrumental versus a communicational/cultural/political rationality;
- an inclination to quantitative versus qualitative modeling; and
- a structuralist versus a discursive orientation.

A positivistic methodological position is tendentially objectivistic, conceptual–instrumental, quantitative, and structuralist–functionalist in its approach. An interpretive position, on the other hand, tendentially emphasizes the subjectivist, communicational, cultural, political, ethical, and esthetic: the qualitative, and the discursive aspects. It would be too simplistic to classify a specific methodology in itself as ”positivistic” or as ”interpretative.” Despite the traditions they have grown out of, several methodologies have evolved and been reinterpreted or opened to new aspects (see below).

In the following, a sample of systems methodologies will be characterized and positioned in relation to these two traditions:

- *”Hard” OR methods.* Operations research (OR) uses a wide variety of mathematical and statistical methods and techniques—for example of optimization, queuing, dynamic programming, graph theory, time series analysis—to provide solutions for organizational problems, mainly in the domains of operations, such as production and logistics, and finance.
- *Living Systems Theory.* In his LST, James Grier Miller [1978], identifies a set of 20 necessary components that can be discerned in living systems of any kind. These structural features are specified on the basis of a huge empirical study and proposed as the ”critical subsystems” that ”make up a living system.” LST has been used as a device for diagnosis and design in the domains of engineering and the social sciences.
- *Viable System Model*. Stafford Beer’s VSM specifies a set of control functions and their interrelationships as the sufficient conditions for the viability of any human or social system [cf. Beer, 1981]. These are applicable in a recursive mode, for example, to the different levels of an organization. The VSM has been widely applied in the diagnostic mode, but also to support the design of all kinds of social systems. Specific methodologies for these purposes have been developed, for instance, for use in consultancy. The term viable system diagnosis (VSD) is also widely used.

The methodologies addressed up to this point have by and large been created in the positivistic tradition of science. However, they have not altogether been excluded from fertile contacts with the interpretivist strand of inquiry. In principle, all of them can be considered as instruments to support discourses about different interpretations of an organizational reality or alternative futures studied in concrete cases.

- *Interactive Planning*. IP is a methodology, designed by Russell Ackoff [1981], and developed further by Jamshid Gharajedaghi, for the purpose of dealing with ”messes” and enabling actors to design their desired futures, as well as bring them about. It is grounded in theoretical work on purposeful systems, reverts to the principles of continuous, participative, and holistic planning, and centers on the idea of an "idealized design."

- *Soft Systems Methodology*. SSM is a heuristic designed by Peter Checkland [1981] for dealing with complex situations. Checkland suggests a process of inquiry constituted by two aspects: a conceptual one, which is logic based, and a sociopolitical one, which is concerned with the cultural feasibility, desirability, and the implementation of change.
- *Critical Systems Heuristics*. CSH is a methodology, which Werner Ulrich [1996] proposed for the purpose of scientifically informing planning and design in order to lead to an improvement in the human condition. The process aims to uncover the interests that the system under study serves. The legitimacy and expertise of actors, and particularly the impacts of decisions and behaviors of the system on others – the "affected" – are elicited by means of a set of boundary questions.

All of these three methodologies (IP, SSM, and CSH) are positioned in the interpretive tradition. They were designed to deal with the qualitative aspects in the analysis and design of complex systems, emphasizing the communicational, social, political, and ethical dimensions of problem solving. Several of them mention explicitly that they do not preclude the use of quantitative techniques.

Both of these traditions—positivist and interpretivist—are synthesized in an advanced understanding of System Dynamics. SD modeling and validation, as introduced by Jay Forrester [e.g. 1961, 1968] and his associates, and especially the respective validation methodology conceive of model building and validation as a semi-formal, relativistic, holistic social process. Validity is understood as usefulness or fitness in relation to the purpose of the model, validation as an elaborate set of procedures – including logico-structural, heuristic, algorithmic, statistical, and also discursive components – by which the quality of and the confidence in a model are gradually improved [cf. Barlas/Carpenter 1990, Barlas 1996].

5. Distinctive features of SD

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 limited to the representation of "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; stochastic variables and relationships have been a standard modeling feature since Forrester's *Industrial Dynamics* was published.

- *High degree of operationality*. SD relies on formal modeling. 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 better 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 modeling and simulation*. The focus is not on point-precise prediction, but on the generation of insights into the patterns of behavior 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) are easy to handle and give access to a high variety of mathematical functions. Some of them offer optimization procedures and validation tools. Also, some support for collaborative modeling and the communication with databases is provided.
- *Potential synergies*. Combination with many other tools and methodologies is possible, both conceptually and technically.

Given these strengths, the community of users has recently grown significantly. 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.

SD also has an outstanding record in classroom applications. Its specific features make it an extraordinarily effective tool to convey systemic thinking to anybody. The pertinent audiences range from schoolchildren at the levels of secondary and primary schools to managers and scientists. In any one of these contexts, closed loop modeling has been found useful to convey insights into the functioning of complex systems.

Other methodologies exhibit certain features that traditionally were not incorporated, or at least not explicit, in the SD methodology. One aspect concerns the features that explicitly address the subjectivity of purposes and meanings ascribed to systems. In this context, support for problem formulation, model construction, and strategy design by individuals on one hand and groups on the other are relevant issues. Also, techniques for an enhancement of creativity (e.g. the generation and the reframing of options), of both individuals and groups, are a matter of concern. Two further aspects relate to methodological arrangements for coping with the specific problematiques of negotiation and alignment in pluralist and coercive settings.

One clarification as to the positioning of SD is necessary. SD, much like the VSM, has been positioned by outsiders as inherently positivist and only adequate for unitary contexts (i.e. agreement among decision-makers). However, at least part of SD practice and conceptual work on collaborative modeling [especially Vennix 1996] has refuted this attribution. Features for the discourse in pluralistic settings, such as dialectical inquiry, as well as methods which address the aspect of the subjectivity individual interpretations (for example, Nominal Group Technique) are increasingly being incorporated into the model building process repertoires of seasoned system dynamicists.

6. Actual and Potential Relationships

It should be clear by now that the systems movement has bred a number of theories and methodologies, none of which can be considered all-embracing or complete. All of them have their strengths and weaknesses, and their specific potential and limitations.

In the past, the different methodologies have led to the formation of their own traditions and ”schools,” with boundaries across which not much dialogue has evolved. The methodologies have kept their protagonists busy testing them and developing them further. Also, the differences between language games and epistemological traditions have often suggested incommensurability, and therewith have impaired communication. Prejudices and a lack of knowledge of the respective other side have accentuated this problem: ”hard” systems scientists are suspicious of ”soft” systems scientists. For example, many members of the OR community, not unlike orthodox quantitatively oriented economists, adhere to the opinion that ”SD is too soft.” On the other hand the protagonists of ”soft” systems approaches, even though many of them have adopted feedback diagrams (causal loop diagrams) for the sake of visualization, are all too often convinced that ”SD is too hard.” Both of these judgments indicate a lack of knowledge, in particular of the SD validation and testing methods available on one hand and the technical advancements achieved in modeling and simulation on the other [see Barlas & Carpenter 1990, Sterman 2000].

In principle, both approaches are complementary. The qualitative view can enrich quantitative models and it is linked to their philosophical, ethical, and esthetical foundations. However, qualitative reasoning tends to be misleading if applied to causal network structures without being complemented by formalization and quantification of relationships and variables. Furthermore, the quantitative simulation fosters insights into qualitative patterns and principles. It is thus a most valuable device to validate and hone the intuition of decision makers, via corroboration and falsification.

Proposals that advocate mutual learning between the different ”schools” have been formulated inside the SD community [e.g., Lane 1994]. The International System Dynamics Conference of 1994 in Stirling, held under the motto ”Transcending the Boundaries,” was dedicated to the dialogue between different streams of the systems movement.

Also, from the 1990s onwards, there were vigorous efforts to deal with methodological challenges, which traditionally had not been an important matter of scientific interest within the SD community. Some of the progress made in these areas is documented under this theme (see for example: special edition of Systems Research and Behavioral Science, Vol. 21, No. 4, July-August 2004). The main point is that much of the potential available is based on the complementarity, not mutual exclusiveness, of the different systems approaches. In the future, much can be gained from leveraging their complementarities. Here are two examples of methodological developments in this direction, which appear to be achievable and potentially fertile: the enhancement of qualitative components of ”soft” systems methodologies in the process of knowledge elicitation and model building, and the combination of cybernetics-based organizational design with SD-based modeling and simulation [cf. Schwaninger, Pérez Ríos, Ambroz 2004].

From a meta-methodological stance, generalist frameworks have been elaborated, which contain blueprints for combining different methodologies, where this is indicated. Two examples are:

- *Total Systems Intervention*. TSI is a framework proposed by Flood and Jackson [1991], which furnishes a number of heuristic schemes and principles for the purpose of selecting and combining systems methods/methodologies in a customized way, according to the issue to be tackled. SD is among the recommended tools.
- *Integrative Systems Methodology*. ISM is a heuristic to provide actors in organizations with requisite variety, developed by Schwaninger [1997]. It advocates (a) dealing with both content- and context-related issues, and (b) placing a stronger emphasis on the validation of qualitative and quantitative models, as well as strategies, in both dimensions: content and context. For this purpose, the tools of SD (to model content) and Management Cybernetics – the VSM (to model context) - are cogently integrated.

These are only two examples. In principle, SD could make an important contribution in the context of most of the methodological frameworks, far beyond the extent to which this has been the case. Systems methodologists and practitioners can potentially benefit enormously from including SD methodology in their repertoires.

7. Outlook

There have recently been calls for an eclectic ”mixing and matching” of methodologies. In the light of the epistemological tendencies of our time towards radical relativism, it is necessary to warn against taking a course of ”anything goes.” It is most important to emphasize that the desirable methodological progress can only be achieved on the grounds of scientific rigor. This postulate for ”rigor” is not to be confounded with an encouragement of ”rigidity.” The necessary methodological principles advocated here are disciplined thinking, a permanent quest for better models (that is, thorough validation), and the highest achievable levels of transparency in the formalizations as well as of the underlying assumptions and sources used. Scientific rigor, in this context, also implies that combinations of methodologies reach beyond merely eclectic add-ons from different methodologies, so that genuine integration towards better adequacy to the issues at hand is achieved.

The contribution of System Dynamics can be in the realms of

- fostering disciplined thinking,
- understanding systemic behaviors and the structures that generate them,
- exploring paths into the future and the concrete implications of decisions, and
- assessing strategies as to their robustness and vulnerabilities, in ways precluded by other, more philosophical, and generally ”soft” systems approaches.

These latter streams can contribute to reflecting and tackling the meaning- and value-laden dimensions of complex human, social, and ecological systems. Some of their features should and can be combined synergetically with System Dynamics, respectively incorporated into the repertories of system dynamicists. From the reverse perspective, for the broad methodological frameworks, incorporating System Dynamics as a standard tool will be of great benefit. Model formalization and dynamic simulation may even be considered necessary components for the study of the concrete dynamics of complex systems.

Finally, there are also many developments in the ”hard”—mathematics, statistics, logic, and informatics-based—methods and technologies, which are apt to enrich the System Dynamics methodology, namely in terms of modeling and decision support. For example, the constantly evolving techniques of time series analysis, filtering, neural networks, and control theory can improve the design of system-dynamics-based systems of (self-)control. In combination with advanced database-management, cooperative model building software, and the qualitative features of the ”soft” systems approaches, a promising perspective for the design of genuinely ”intelligent organizations” emerges.

The approaches of integrating complementary methodologies outlined in this contribution definitely mark a new phase in the history of the Systems Movement.

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Appendix:

Milestones in the Evolution of System Dynamics and the Systems Approach in General

Foundations of General System Theory		
Bertalanffy	Zu einer allgemeinen Systemlehre	1945
	An Outline of General System Theory	1950
	General System Theory	1968
Bertalanffy, Boulding, Gerard, Rapoport	Foundation of the Society for General Systems Research	1953
Klir	An Approach to General System Theory	1968
Simon	The Sciences of the Artificial	1969
Pichler	Mathematische Systemtheorie	1975
Miller	Living Systems	1978
Mesarovic & Takahara	Abstract Systems Theory	1985
Rapoport	General System Theory	1986
Foundations of Cybernetics		
Wiener	Cybernetics or Control and Communication in the Animal and in the Machine	1948
Ashby	An Introduction to Cybernetics	1956
Pask	An Approach to Cybernetics	1961
McCulloch	Embodiments of Mind	1965
Foundations of Organizational Cybernetics		
Beer	Cybernetics and Management	1959
	Towards the Cybernetic Factory	1962
	Decision and Control	1966
	Brain of the Firm	1972
Foundations of System Dynamics		
Forrester	Industrial Dynamics	1961
	Principles of Systems	1968
	Urban Dynamics	1969
	World Dynamics	1971
Meadows et al.	Limits to Growth	1972

Systems Methodology		
Churchman	Challenge to Reason	1968
	The Systems Approach	1968
Vester & von Hesler	Sensitivitätsmodell	1980
Checkland	Systems Thinking, Systems Practice	1981
Ackoff	Creating the Corporate Future	1981
Ulrich	Critical Heuristics of Social Planning	1983
Flood & Jackson	Total Systems Intervention	1991
Schwaninger	Integrative Systems Methodology	1997
Selected Recent Works in System Dynamics		
Senge	The Fifth Discipline	1990
Barlas & Carpenter	Model Validity	1990
Vennix	Group Model Building	1996
Lane & Oliva	Synthesis of System Dynamics and Soft Systems Methodology	1998
Sterman	Business Dynamics	2000
Warren	Competitive Strategy Dynamics	2002
Wolstenholme	Archetypal Structures	2003

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[1] System Dynamics within the Evolution of the Systems Movement. A Historical Perspective, in: Cybernetics and Systems 2004, Proceedings of the Seventeenth European Meeting on Cybernetcis and Systems Research, edited by Robert Trappl, Volume 2, Vienna, Austria: University of Vienna and Austrian Society for Cybernetic Studies, 2004, pp. 786-791.

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