

**Paper to be presented to the 1995 System Dynamics Conference, Tokyo.**

**Systems Thinking, System Dynamics**

Eric F. Wolstenholme  
Professor of 21st Century Business Learning,  
Leeds Metropolitan University Business School/Cognitus Ltd.

**Abstract**

This paper attempts to build a coherent picture of the way in which various system problem solving methodologies relate to one another. The work builds on the discussions and views expressed at the 1994 System Dynamics Conference held at Stirling and expressed in the special edition of the System Dynamics Review entitled "System Thinkers, System Thinking".

The underlying premises, assumptions and terminology of a number of such approaches are reviewed, contrasted and summarised.

It is argued that, in philosophical and academic terms, Systems Thinking should be considered as a total framework which subsumes all systems approaches to understanding human activity. Further, that there exists a range of Systems Thinking methodologies which can be defined and contrasted by positioning them dependent on their degree of vagueness (to be relevant) and their degree of rigour (to be meaningful). It is also suggested that their base position may shift dependent on their area of application.

It is hoped that this paper or a derivative of it might be used as a reference by practitioners to explain to end-point users of systems methods how their own approach fits into a wider and integrated framework.

**Introduction**

The 1994 System Dynamics conference brought together a number of eminent systems practitioners with a wide range of views as to the meaning of systems thinking. The good news from the debate and interchange was that there was a very high level of agreement on the need for a holistic view of the world and for the development and use of systemic methods for practical purposes of assisting understanding of a world that grows increasingly complex.

However, differences of interpretation did occur between contributors and the purpose of this paper is to explore the patterns of difference.

To put the debate into context it should be said that the people and methods assembled in Stirling were all pro-active at the practical end of the systems spectrum and that a large body of theoretical systems work was by definition excluded from the agenda.

It was also recognised that to the world outside systems thinking some of the differentiation between the methods discussed might not be apparent. Nevertheless, people within the systems field and some organisations on the receiving end of applications of alternative approaches to systems thinking are keen to clarify and understand the major differences between approaches.

The purpose of this paper is to provide a personal analysis and overview of the outcomes of the

Stirling debate.

The literature under-pinning this paper is extensive. In order to save valuable space no references will be given other than the special edition of the system dynamics review (SES DR) emerging from the Stirling conference (Richardson, Wolstenholme and Morecroft, 1994). The papers in this reference, in turn, reference the whole of the systems field relevant to the analysis undertaken here.

## **Systems Thinking**

### ***Background***

During the last thirty to forty years a number of approaches to systemic enquiry have emerged from the back cloth of theoretical systems methods.

At the practical and management end of the systems spectrum, these methods fall roughly into two camps. Firstly, there is the work in system dynamics (SD) which has its origins in the U.S.A. and secondly there is the work in soft operational research (SOR) which has largely evolved in the U.K.. Soft O.R. subsumes a number of strands of systems thinking and its main methodologies are listed in Lane's paper within the SES DR and reproduced here in Appendix 1.

It is interesting to point out that both system dynamics and soft operational research were instigated for the same reasons. This was the inability of hard methods of problem solving such as traditional operational research (TOR), systems engineering (SE) and computer systems analysis (CSA) to provide convincing change to human activity systems. That is, organisations constructed and operated by people, whether in the private or public sectors of business or government. The generic name for hard techniques is now taken to be hard operational research (HOR).

The main factors which have come to differentiate soft OR from hard OR are:

- that soft meant qualitative and strategic issue structuring and hard meant quantitative and operational.
- that soft meant working with system actors in a facilitation role and hard mean providing solutions for system actors.
- that soft meant being in the systems (virtual) world and hard meant being in the real world.
- that soft meant U.K. hard meant U.S.A..

As indicated later in this paper these characteristics of the soft/hard split are neither universally accepted nor very real. It should also be noted that in the U.K. soft OR was developed alongside and in cooperation with hard OR. This contrasts with the situation in the U.S.A where system dynamics was developed in isolation from, and is still totally independent from, hard OR.

### ***Soft OR and System Dynamics***

The pioneering methodology of soft OR was that of Soft Systems Thinking developed by Checkland at Lancaster University. This method now has extensive secondary literature and all

other methods of soft OR were built on the back of this approach in an attempt at maintaining the relevance of rational analysis in an increasingly irrational world.

Until the last two decades the work in System dynamics was almost entirely centred on Forrester's group at MIT and most work in System dynamics around the world still follows the MIT style.

The highly successful emergence of Senge's work from a U.S. system dynamics base in 1990 led to an interesting link between systems dynamics and soft OR. To try to avoid confusion from here on the original work of Forrester will be referred to as traditional system dynamics (TSD) and Senge's work as Senge's system dynamics (SSD). Senge's assertion that System dynamics simulation was useful but not sufficient to change assumptions and beliefs in human activity systems links closely to soft O.R.. His work has helped considerably to bring the worlds of soft or and system dynamics together. However his choice of the words system thinking to describe what was still essentially a qualitative system dynamics approach has brought the two together rather explosively.

It should be noted that the idea of qualitative system dynamics had been evolving for some time prior to Senge's work. The idea of using causal and flow maps other than as a prerequisite to simulation and the use of organisational boundaries on these essentially process maps began in the early 1980s Wolstenholme, Meadows, Randers and others.

### **The Contribution of the Stirling Debate to the Nature of Systems Thinking**

In order to shed light on the factors emerging from the Stirling debate on the nature of systems thinking, I will attempt to classify opinions as put forward at Stirling by their degree of deviation from traditional system dynamics. Not all soft OR methodologies were represented in the Stirling debate and the analysis here is restricted to variants of system dynamics, the soft systems methodology (SSM), strategic options development and analysis (SODA) and total systems intervention (TSI).

#### ***Traditional System Dynamics***

The traditional system dynamics approach, as depicted by Forrester, Sterman and Peterson, centres on the idea that the only valid way to provide understanding and insight into complex systems lies in quantitative simulation modelling and that more rather than less sophisticated quantitative analysis is necessary to be convincing. These authors would point out that there can be serious misunderstanding and chance of error if any shortcuts to this procedures are used and that even rich maps can be unreliable. It is the quality of the model which is all important.

#### ***Richmond's System Dynamics***

The next most purist view of system dynamics comes from Richmond who recognises the existence of a systems thinking world outside system dynamics but perceives that system dynamics is a large part of this world and that ultimately only flow diagrams and simulation can tease out real issues. However, there appears to be a recognition that models can be condensed down to archetypes to help explain insights.

#### ***Senge's Systems Thinking***

Senge's stance is that limiting oneself to system dynamics simulation modelling both limits the audience that can be reached and the power of the systems approach to understanding and learning. He maintains that system dynamics alone is inadequate to implement serious change in peoples understanding of current reality, visions, aspirations and the implementation of effective change. Put simply Senge believes that much modelling insight can be reduced to qualitative maps and archetypes and given to managers as seeds of change. His is effectively a very appealing version of qualitative system dynamics linked to human activity systems.

It at this point that the U.S. view of systems thinking starts to interface with the U.K. view.

All U.K. systems thinkers are strongly of the view that system dynamics is but a very small subset of effective systems thinking.

### ***Checkland's Soft Systems Methodology (SSM)***

Checkland and Haynes would take this further and argue that any enquiry must never limit itself by assuming the use of specific tools of enquiry since in doing so it becomes biased. They argue that systems thinking in its broadest sense takes place not in the real world but in the systems or virtual world inside peoples heads and that it is useful to picture the systems world as separate from the real world. The idea is that we observe real world messes and then move across a boundary into the systems world. Here, we take with us some framework or representation or metaphor of our beliefs. Within the systems world we undergo a process of designing a system for the real world which might avoid the mess we observed.

There are a number of steps in this process for guidance and developers of the method have progressively introduced more and more. Checkland original concept was to allow the user of the methodology to maintain a stance which allowed sufficient vagueness to be relevant, whilst having sufficient rigour to be meaningful and, in the second wave of the method, which emerged in the late 1980s, tries to restate the need to be totally flexible of the process of redesign of organisations.

### ***Eden's Strategic Options Development and Analysis (SODA)***

Eden would point out that qualitative cause and effect mapping is a serious way of capturing the richness of debate in a way which facilitates sharing and understanding. The suggestion here is that rich maps add value and that converting these to simulation models possibly loses more than is gained. The argument is made that in many ways hard models can (perhaps counter intuitively) be more subjective and dangerous than soft models. What is important is to provide people with tools to help them formulate change and to shed light on alternative perceptions of reality. Any single model hard or soft is not perfect in providing this capability. However, contrasting alternative perceptions and the process of modelling is important.

### ***Flood and Jackson's Total Systems Intervention (TSI)***

Flood and Jackson's contribution to system thinking centres on the powerful idea that there has emerged a system of system methodologies. Therefore would it not be a good idea to classify perceived experiences of reality into sets and to recommend that particular methods are applied to particular perceptions. Their method is referred to as Total Systems Intervention and this approach is in the process of being redefined.

The major concerns with the TSI concept is that firstly, like the techniques of hard OR, there is a danger of fitting problems to the methodologies and, secondly, how can managers become conversant with all the methodologies. This approach has tended to classify system dynamics as a hard OR method and raise some controversy by suggesting that traditional system dynamics is not applicable to shedding light on some complex issues, particularly those centred on multiple ownership (pluralistic) situations where multiple perceptions of problems are essential.

## **Towards an Integrated Map of Alternative Approaches to Systems Thinking**

### ***The framework.***

In order to provide a basis for an integrated approach to systems thinking, the stance taken here is to think of Checkland's soft systems methodology as the general case of systems thinking and of the other methods as special cases of this. The justification for this stance is that SSM was the original soft OR approach and, more importantly, it represents the greatest degree of abstraction in systems thinking. There is no suggestion in assuming this position that any particular method is superior or inferior to any other.

The idea is to contrast other methods with SSM in terms of the concepts and tools by which they choose to perceive reality and think about change.

Before pursuing this idea it is, however, necessary to develop a little further the concepts of soft systems and to try to do this without the very unambiguous, but complex, jargon used by Checkland.

### ***More on SSM***

Checkland argues that, ultimately, how we describe the real world and how we think in the systems world is governed by our perceptions, beliefs and experience of the real world. These elements are viewed through different filters and govern our intellectual constructs by which we think, debate and design real world change. The process of design is basically a methodology or series of steps which might involve a range of tools. See Figure 1.

The key to systems thinking is one of how to base our thinking in a systemic way on holistic constructs. He uses the world holon here to describe both the wholes we might use to interpret the real world and the methodologies we might employ to change them.

Whilst this concept is an abstract one it provides an over-arching framework to help understand the ideas behind alternative approaches to systems thinking.

This paper will focus on the idea of defining the objective, main tool set and the holons employed by each of a number of system methodologies as a basis for developing understanding both about the nature of systems thinking and about the major differences between the methods. Figure 2 summaries the analysis.

### ***Discussion***

Figure 2 is divided into three blocks. Block 1 references TSD and SSM. Block 2 references a

number of variants of soft OR and block 3 references the Senge's systems dynamics (SSD).

### *Block 1*

The objective of SSM is to design relevant human activity systems which are more capable of resolving the messes inherent in complex organisations than currently exist. The method itself is holistic and the holons used are many and varied to suit beliefs and perceptions. In redesigning the criminal justice system the new design would depend upon, for example, whether we perceive criminals as 'louts deserving punishment' or 'victims of society deserving sympathy and rehabilitation' and whether we see prison as purging or educating people in the ways of crime.

The objective of traditional SD is to develop deep understanding of how process and strategy interact to determine the behaviour of complex organisations over time. The method uses 'feedback' as a holon both to describe the real world and for the purpose of redesign. In system thinking terms there is nothing wrong with this stance other than the need to recognise that it may limit thinking and lead without care to a single perception of change. For example, in using feedback and process to study the criminal justice system might lead (without care) to the conclusion that rates of flow or throughput of crime and criminals determines the propensity to commit crime, when in fact this may depend more on any of a number of attributes of throughput or the predisposition and perceptions of the modeller.

### *Block 2*

The methodologies in block 2 will be discussed together. These are primarily described as holistic both in terms of the way in which they interpret the real world and at the methodological level. They have very high level objectives aimed at developing communication and team consensus in human activity systems using facilitation and debate to uncover assumptions and values. The tools provided are more specific than in SSM. For, example in the case of SODA, cognitive maps might be described as qualitative feedback tools which, whilst perhaps maintaining a pluralistic ability, could be claimed to suffer from some of the restrictions associated with SD.

### *Block 3*

Block 3 is reserved for the Senge version of SD which falls between SSM and SD. It retains the holon of feedback, but has an objective beyond traditional SD in that it, like block 2, is targeted at developing change and understanding in human activity systems.

## **Conclusions**

My personal conclusion from the Stirling debate and from this paper concerning the whole debate about alternative methodologies for systems thinking is surprisingly simple. It centres on the statement of Checkland that systems thinking is about being sufficiently vague to be relevant whilst being sufficiently rigorous to be meaningful.

Each of the methodologies referred to in this paper, when reduced to their objectives and holons, can be thought of as being based on the different interpretations by their creators of the degree of vagueness and specificity which is important in rational analysis.

To emphasise this point, Figure 2 places each methodology on a spectrum between vagueness\relevance and specificity\rigour. However, it is considered that these locations are not permanently fixed but are more the normal home base position for them. This stance implies that the method can shift position dependent on its area of application or on the flexibility of the user. Some applications of a particular method may move it up the spectrum and others may move it down the spectrum.

SSM is the methodology shown furthest to the left in Figure 2 and this home base position justifies the stance taken in this paper that this is the reference point for the other methodologies. If anything Checkland has progressively fought to keep SSM towards the vagueness end of the spectrum to the point where the user can almost make up the elements of the steps in the method to suit a particular situation. At the same time he has sought to emphasise that the method could embrace any aspect of other methods, including hard methods such as simulation, as appropriate. In such a mode it might be thought of as being applied further to the right of the spectrum.

The home base of Hard OR is positioned well to the right of the spectrum and so is TSD. However, there are many applications of TSD which attempt to move it toward the area of SSM. This is particularly true of the qualitative use of flow diagrams and attempts to use maps and models to change culture, values and beliefs though understanding of process, strategy and organisation. Similarly, there are other applications of TSD such as in business process re-engineering, which place it to the right of the spectrum on a par with methods such as discrete entity simulation.

Senge's System Dynamics is placed more to the middle of the spectrum but there are applications in unblocking defensive routines which place it almost as far left as SSM.

The home base positioning of CSH, SAST, SC and SODA are to the left of the spectrum, but again variable by application.

It should also be remembered that some of the methodologies considered here are not totally independent but complement one another and can often be usefully used together. For example, SODA forms an excellent front end knowledge gathering method to TSD and, conversely, TSD provides a way of quantifying the cognitive maps of SODA.

### **Final Comments**

Ultimately, in studying and contrasting alternative systems methods we should not lose sight of the purpose of these methods. That is to assist people in complex organisations with redesign and change. Whatever methods are provided at whatever level of rigour, some speculation will still be necessary beyond the analysis completed. Hence, it is possible to think of a methodology as providing a substitute for speculation and to think of alternative methods as doing this to different degrees.

In general in contrasting TSD with soft OR and SSD, there is a simple trade-off. Hanging onto a holon such as feedback forces the rigour of thinking and minimises post analysis speculation but can, without care, limit the breadth of thinking. Soft OR and SSD open up the breadth of thinking but leave far more post analysis speculation to be undertaken by system actors.

### **Reference**

Richardson G.P., Wolstenholme E.F., and Morecroft J.D.W., (Eds), 'Systems Thinkers, Systems Thinking', System Dynamics Review, Vol.10. numbers 2-3, 1994.

## Appendix 1

### A Brief Summary of some Soft OR Methods (After Lane SD Review (1994))

**THE STRATEGIC CHOICE APPROACH.** Resulting from joint action-research work by the OR Society and social scientists of the Tavistock Institute of Human Relations in the 1960s and 1970s, Strategic Choice is a set of methods used with groups to facilitate communication about complex decisions. The approach focuses on the interlinked decisions to be made and the uncertainties involved. It is incremental and highly interactive. There are three reference points for any study. The classifications of uncertainty contrasts uncertainties of "the working environment" (needing analysis), "guiding values" (needing clarification of objectives and perhaps conflict handling), and "related choice" (needing negotiation and wider collaboration). The four modes of decision making in Strategic Choice define procedures for "shaping" (forming an agreed view of the problem structure), "designing" (identifying courses of action), "comparing" (evaluating actions against criteria), and "choosing" (agreeing on an incremental process for decision making). The commitment package closes the process and expresses the decisions taken and deferred, and the conditionalities on them.

**CRITICAL SYSTEMS HEURISTICS (CSH).** This is an approach for studying existing or planned systems by uncovering the interests that the system services. The process involves the use of 12 "boundary questions" aimed at the systems planners but also at those people affected by the system. The questions seek out sources of motivations, control, expertise and legitimation, and can be used by planners and other concerned actors to reveal the underlying value assumptions of the system design. The aim is to expose and, ideally, to free the design from individual, organizational, cultural societal, and political value assumptions that may be hidden and coercive. Although the process of revealing the true interests and motivations underlying planning proposals may of itself lead to counterproposals, CSH has perhaps too little to say about the formulation of these or about how any changes by which the design is freed from hidden value assumptions might actually be effected.

**STRATEGIC OPTIONS DEVELOPMENT AND ANALYSIS (SODA).** SODA is a method for dealing with complex, messy problems, taking into account both their qualitative and quantitative aspects. Equal emphasis is given to the process of discussion and the content, so great importance is attached to the use of "facilitative devices" (cognitive maps). SODA is axiomatically subjective, centring on each individual's psychological construction of his or her world rather than on the perception of an objective reality. Interest rests on participants' interpretation of events and the meaning that they impart to situations. SODA's grounding theory arises from cognitive psychology and is Kelly's "Personal Construct Theory". The approach involves the use of cognitive mapping as a language to express personal constructs. Maps are drawn in a participative style and display the meaning ascribed to a concept by recording its relations with other concepts. Other forms of modelling may be suitable for studying parts of a map. Cognitive maps are drawn during one-to-one interviews and are then merged for use in workshops, where they are employed to facilitate team negotiation with the emphasis on action rather than description. The (desired) outcome of a SODA workshop is consensus and a commitment to action. The package COPE offers computer support for

cognitive mapping.

**SOFT SYSTEMS METHODOLOGY (SSM).** Developed by Checkland in response to what he saw as the breakdown of hard system engineering concepts, the core notion of SSM is that a real-world problem situation may usefully be viewed as a case of organised purposeful activity, or a "human activity system." Since "purpose" and "meaning" are imparted by those involved in such a system. SSM accepts subjectivity as a serious and crucial element of human actions. SSM proposes a flexible enquiring process for articulating, challenging, and comparing the meaning imparted by various actors and their understanding of the problem situation. The enquiry probes the "tasks" (purposeful actions) and "issues" (perceptions causing disagreements) using two streams of analysis, one logic-based, the other concerning cultural matters. This latter involves study of the "social system," the "political system," and the intervention itself. Word and diagram models using devices such as the "root definition" and "rich picture" are deceptively simple; their use can generate deep insight. Comparison between such "ideal type" models and the real world leads to an "accommodation" among relevant actors to implement changes to the problem situation that are both systemically desirable and culturally feasible. Although its attention to subjectivity means that an SSM study is, in principle, never-ending (ending being an arbitrary act), its attempt to treat the subjectivity in a rigorous way offers a powerful team method of learning about a situation, such learning being the explicit goal of SSM.

**STRATEGIC ASSUMPTION SURFACING AND TESTING (SAST).** This approach was designed for groups lacking a common set of values and goals. Advanced by Churchman and developed by Mason and Mitroff. SAST is based on the Hegelian dialectic. Two (or more) subgroups are formed around positions for which each subgroup does show consensus. Various techniques are then used to "surface" (articulate) the assumptions behind the views so that the subgroup is aware of its key assumptions and the world view (Weltanschauung) that makes these meaningful. "Dialectical debate" is then encouraged between subgroups so that each position is clearly presented, attacked, defended, and so on. This clash of thesis and antithesis is intended to help participants understand different points of view and to develop a synthesis, (temporary) consensus, or agreement regarding assumptions, which then acts as a basis for decision making or planning.

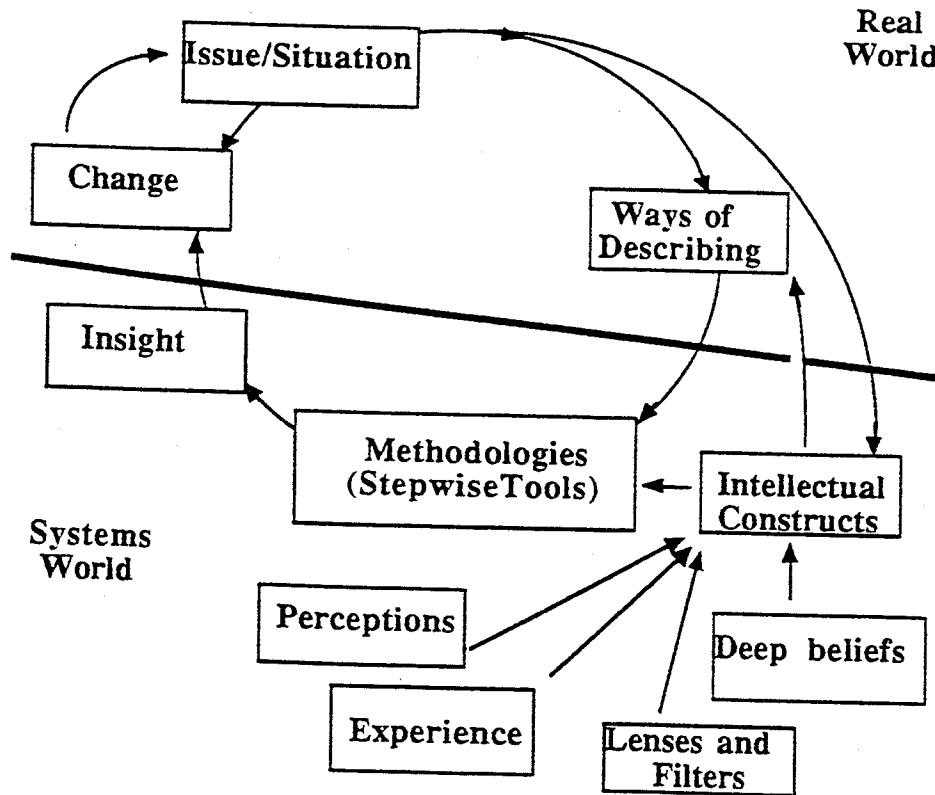


Figure 1 An Overview of Systems Thinking

## Plenary Program

---

**Fig 2 A Summary of Some Systems Methodologies**

Methodology	Objective	Holons	Main Tools
Soft Systems (SSM)	Creation of Relevant Human Activity Systems	Varied to suit purpose	Root definitions CATWOE*
System Dynamics (SD)	Development of Understanding	Feedback	Mapping simulation
Strategic Options Development & Analysis (SODA)	Creation of Personal Constructs of Problem Situations	Feedback, Consensus	Cognitive Maps
Strategic Choice Appraisal (SCA)	Development of Communications and Consensus, Recognising risk	Consensus	Structure, Facilitated Debate around Decisions
Strategic Assumption Surfacing & Testing (SAST)	Consensus Building	Consensus	Structure, Facilitated Debate around Decision
Critical System Heuristics (CSH)	Defining & Designing purpose of Human Activity Systems	Individual & Group Values	Questioning of Values and Assumptions
Systems Thinking (Senge) (STS)	Understanding & Learning	Feedback, Sharing	System Archetypes

\*Customers, Actors,  
Transformation, World View,  
Environment, Ownership

