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Soft System Dynamics Methodology (SSDM): Combining Soft Systems Methodology (SSM) and System Dynamics (SD)

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Soft System Dynamics Methodology (SSDM), a systemic methodology product of the combination of two widely used systems-based methodologies from two different systems thinking paradigms, Systems Dynamics (SD) and Soft Systems Methodology (SSM), is presented. The paper argues that by combining some of SD and SSM stages, within the intellectual framework proposed by SSDM, a methodology developed by one of the authors[1] much can be gained in a systemic intervention to tackle complex social problematic situations. A framework for comparing the ontological, epistemological and methodological principles of SD, SSM and SSDM is proposed and the synthesizing and dialectical role of SSDM is advanced. The 10 stages of SSDM are outlined and illustrated by an application on a small Peruvian company; and a set of conclusions and points for further research are discussed.

KEY WORDS: Systems Dynamics; Soft Systems Methodology; Systems; Multi-methodology; Modelling.

1. INTRODUCTION

Multi-methodology (Mingers, 1997a) is the name given to the practice that combines and links techniques, methods and methodologies from the same or different systems thinking paradigms, Mingers (1997a,b), Mingers and Brocklesby (1996), Jackson (1997, 1999) amongst others. Multi-methodological practices that combine methods from across the hard–soft systems methods spectrum have been widely reported in Mingers (1997a), Munro and Mingers (2002), Brocklesby

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(1995), Brocklesby and Cummings (1997), Lane and Oliva (1994) amongst others. Also, over the last years there have been concerns and debate, amongst members of the System Dynamics community, about System Dynamics (SD) links with other systems methodologies and about its philosophical principles, role and position within more wider social theories (Lane, 1999, 2001a,b; Vennix, 1996; Richardson and Andersen, 1995; Vennix *et al*., 1997a,b.)

The paper is largely based on the work of Rodríguez-Ulloa whose long action research work that started in 1992 culminated with the formal appearance of Soft System Dynamics Methodology (SSDM) around 1999, Rodríguez-Ulloa (1995, 1999, 2002a, in press). Essentially, SSDM can be regarded as a synthesizing and dialectical methodology that had emerged from the combination of two widely used systems-based methodologies from two different systems thinking paradigms, Soft Systems Methodology (SSM) and SD. The methodology, through its careful application, aims to demonstrate that much can be gained in a systemic intervention. In this paper, this largely used methodology in Latin American setting is formally re-visit here, and the main stages of SSDM are described in some detail, emphasizing that this constitutes a new and creative intellectual framework that has emerged from combining some of the stages of SD and SSM. To some extent, SSDM underpins the SD approach by the SSM philosophical principles, concepts and steps; this, in a way, resonates with Lane's claims when he describes to be working in the agent/structure SD paradigm and his Holon Dynamics or Interactive Dynamics approach (Lane, 1999, 2001a,b). The framework that SSDM proposes can also be seen, in general, in line with the works of other system dynamics academics and practitioners (Vennix, 1996, 1999; *Vennix et al*., 1996, 1997a,b; Andersen and Richardson, 1997; Rouwette *et al*., 2002; Lane and Oliva, 1994; Morecroft and Sterman, 1994).

To those in the systems community interested in the application of a combination of systemic methodologies, the main SSDM's contribution is that it advances a general framework, with clear steps to follow, which not only helps the analysts (i.e. decision makers) to make sense of the problematical situation but also to model the real world under what it can be called the feedback paradigm and to intervene in the implementation of systemically desirable and culturally feasible changes in the real world and culminating with a learning process from all the experience including the implementation of those changes in the real world. We believe that these aspects that SD and the other approaches commentated by the afore mentioned authors have not been tackled.

The structure in this paper is as follows: (1) the two systems-based methodologies SD and SSM are briefly outlined together with their epistemological and ontological assumptions underpinning their correspondents paradigms; (2) a framework highlighting the assumptions of SSM, SD and SSDM, as a synthesis of both approaches, is reviewed; (3) the 10 steps of SSDM are presented together

with abbreviated account of a systemic intervention carried out in Peru; and finally (4) conclusions and discussion for further research are suggested.

2. THE TWO SYSTEMS-BASED METHODOLOGIES: SYSTEMS DYNAMICS AND SOFT SYSTEMS METHODOLOGIES

Before describing the combination of the two methodologies into SSDM, a brief outline of the two methodologies involved is presented in the next section. A summary of the main ontological and epistemological assumptions embedded in SD and SSM paradigm is then presented followed by a summary of, what we argue, are the main limitations of each methodology.

2.1. Systems Dynamics

Systems Dynamics originally known as Industrial Dynamics is a creation of Jay Forrester in the 1960s in the Massachusetts Institute of Technology (Forrester, 1961). System Dynamics is essentially a methodology which uses theory of information feedback and control in order to evaluate businesses. The basic idea underpinning this approach is that any complex situation can be described in terms of elements and flows; flows being the relationships between the elements. The main focus of the methodology is the structure composed by the interactions of the elements (flows and levels) between them. This description constitutes the dynamic behaviour of the system. Essentially, SD aims to predict the behaviour of a system, and for doing this, it relies heavily on the use of a model which must contain the intricacies of a complex structure and the multiple feedback loops that link each element within that structure.

The SD process follows three steps that can be summarised as follows:

(a) Understanding of situation/problem definition: The purpose of the study has to be stated clearly for an SD intervention: a problem, an issue or a system whose behaviour needs to be corrected. The problem is described together with the factors that appear to be causing it and the relationships between them. Forrester (1961) emphasis on problem definition is one of the key steps on the SD methodology. Problem, possible factors causing it are framed into information–feedback loops that then are used in the modelling part.

(b) Model conceptualisation/model building: Since SD is concerned mainly with structure, the first thing that we need to solve is the level of resolution at which we need to model the situation. This is the 'order of the system.' A sign causal diagram helps to understand the influences between the variables/elements. Model building uses explicit concepts

of SD that are transforming the flows into levels, rates and auxiliary variables. The model formulation is done using one of many computer software developed to assist SD modelling logic.

(c) Running the simulation model/using the results: Once the model is built, different scenarios are analysed and used to test different policies/decisions. People involved can explore different what–if situations. The model is used as an ontological description of the situation perceived and if successfully accepted by the people involved both structural changes and recommendations for policy making can be introduced.

2.1.1. Systems Dynamics Paradigm

The basic assumption underpinning the SD paradigm is based around the belief that although the real world exhibits a high degree of complexity, it is possible to capture that complexity in a model. These assumptions have been articulated by Forrester (1961), Richardson (1991) amongst others. Jackson (1992) places SD under the functionalistic, deterministic, hard end of the Management Sciences methodologies. To discuss fully the SD paradigm development is outside the scope of this paper but it is worth to report that in recent years SD has been 'relocated' due to the attention to its actual practice and its involvement in the more general Systems Thinking movement and Systems practice. As Lane (2000, p. 4) states 'On a superficial level, systems dynamics appears to be locatable within the functional sociology paradigm of social theories, . . . However, the craft of systems dynamics, and hence its theory in use, has many links with more interactionist schools of thought and even some connections with interpretivism.'

It is fair to say that in the 1970s and 1980s, SD was seen as an outsider in the systems movement and perhaps most of its practitioners were, in general, situated on the hard end of the systems approach. However, as it has been said earlier, during the 1990s, a number of SD and systems commentators have been making bridges between SD and the general developments of systems thinking (Senge, 1990; Lane and Oliva, 1994; Lane, 1999, 2000, 2001a,b; Vennix, 1996, 1999; Vennix *et al*., 1996, 1997a,b; Andersen and Richardson, 1997; Rowette *et al*., 2002; Lane and Oliva, 1994; Morecroft and Sterman, 1994; Sterman, 2000; Warren, 2002, amongst others). These attempts have moved SD from the hard end of the management sciences spectrum to a much softer interpretive paradigm.

2.1.2. Systems Dynamics 'Limitations'

Although SD was seen as a methodology suitable for Peruvian problem situations, Rodríguez-Ulloa (1995, 1999, 2002a,b, 2004), became increasingly aware, from his experience of working in several Peruvian cases, that certain limitations embedded in the SD's assumptions were not taken into consideration

by the SD's practitioners, specially when, during the diverse interventions the following questions were faced (Rodríguez-Ulloa, 1999, 2004):

- Under which world views (weltanschauungen) are constructed the causal models representing the problem situation occurring in the real world?
- Who are the observers and why they observe the real world under a specific weltanschauung and not through others?
- Do human affairs and natural phenomena existing in the real world can be described on the basis of human rationality?
- In case the real-world phenomena behave in an 'irrational' and unexpected way, is it possible to delineate a logical framework of its behaviour?
- Which are the constraints and motivations which make an observer to choose a particular perspective to observe a specific problem situation? Which kind of interests and values lead he/she to observe the real world in that way?
- How can someone give a 'solution' about something, if the 'problem' has not been clearly understood or formally defined or if he/she has not realized himself/herself on the world view under which he/she is observing the real world?
- Is the 'solution' provided by the SD approach culturally feasible and systemically desirable to be possible to implement in the real world?
- What learning points can be obtained from constructing problem-oriented and solving-oriented system dynamics models and implement them in the real world?
- Also, one of the SD's main weaknesses encountered in real-world problem intervention was that it does not clearly distinguish between what in SSM terminology are known as the Problem Solving System (PSS) and Problem Content System (PCS) (Checkland, 1981; Rodríguez-Ulloa, 1988), two basic aspects to be considered in any systemic intervention. SSDM assimilates these two concepts in its methodological framework.

During the interventions that were carried out, it was felt that SD by itself did not answer fully these vital questions and there were areas in which stages of another systems-based methodology such as SSM could help and complement SD in a systemic intervention. Feeling fully conversant in both SD and SSM paradigms and using a critical position in its application, we followed what Jackson (2003, p. 83) states: 'Rather than believe that system dynamics can do everything, a critical system thinker is likely to want to combine the strengths of system dynamics with what other systems approaches have learned to do better.'

At the same time that SSDM was emerging in the LA context, as it was acknowledged earlier, SD academics and practitioner were also raising and debating similar concerns. According to Lane (1999, 2000, 2001a,b), what was happening to system dynamics can be seen as an intellectual evolutionary journey that has

started from its initial conception by Forrester (1961) in the 1960s, where great care was given to both the mathematical modelling and the replication of the behaviour of the real-world using a clear positivistic/objectivistic position, a philosophical paradigm under which SD was created at MIT, called 'austere SD' by Lane. The journey has continued to the present time in which SD claims to be abandoning its functionalistic beginnings an immerse in epistemologies closer to interventions in a more phenomenological strands, thus arising what is called Holon Dynamics, Interactive Dynamics, Group Model Building, Modelling as Radical Learning, Agency Dynamics (Lane, 1999; Vennix, 1996), which are approaches near to the interpretive and learning paradigm.

2.2. Soft Systems Methodology

Peter Checkland's SSM is one of the most-developed systems methodologies in terms of its theoretical premises and philosophical underpinnings. It is also one of the most widely used in the UK and in other parts of the world (Mingers and Taylor, 1992; Ledington *et al*., 1997; Macadam and Packham, 1989; Macadam *et al*., 1990, 1995; Rodriguez-Ulloa, 1994a, 2003; Wilson, 1984, 2001, amongst others). During the 1970s, Checkland and his colleagues at Lancaster University questioned the use of hard systems thinking to real-world situations and started to test a new methodology that shifted the systemicity from the real world to the process of enquiry itself.

SSM articulates a learning process which takes the form of an enquiry process in a situation that people are concerned. This process leads to action in a never ending learning cycle: once the action is taken, a new situation with new characteristics arises and the learning process starts again.

The methodology is summarised in Fig. 1. This is the SSM best-known methodology and although Checkland has expressed a most flexible way of applying his ideas in his latest book (Checkland and Scholes, 1990), the seven stage methodology is still the most convincing and helpful account of the SSM enquiry.

The basic structure of SSM rest on the idea that in order to tackle real-world situations, we need to make sure that the 'real-world' is separated from the 'systems thinking world.' This distinction is crucial for SSM because that assure that we will not see systems 'out there'; that is in the real world. SSM urges us to consider 'systems' as abstract concepts (preferably, the word 'holons' should be used) which, when use against the real world, can eventually help to bring some improvements to the situation concerned.

2.2.1. SSM Paradigm

SSM paradigm location is clearer than SD's. SSM follows an interpretive perspective (Checkland, 1981, 1986; Checkland and Scholes, 1990; Wilson, 1984, 2001; Jackson, 1992). This can be summarised as follows: According to

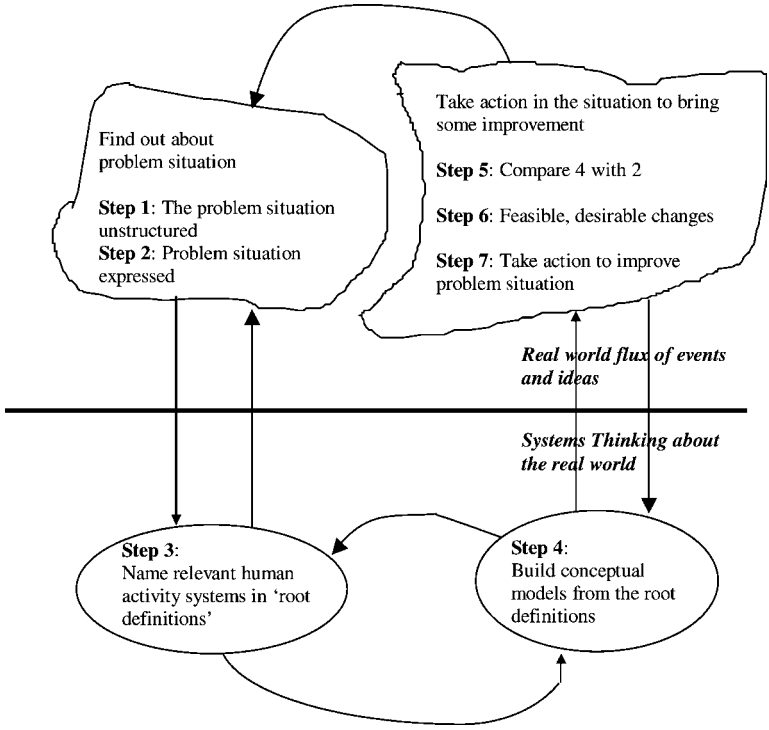

Fig. 1. The basic structure of Soft System Methodology—SSM.

Checkland, life world is an ever changing flux of events and ideas and 'managing' means reacting to that flux. We perceive and evaluate, take action(s) which itself becomes part of this flux which lead to next perceptions and evaluations and to more actions and so on. It follows that SSM assumes that different actors of the situation will evaluate and perceive this flux differently creating issues that the manager must cope. Here, SSM offers to managers the systems ideas as a helpful weapon to tackle problematic situations arising from the issues. The world outside seems highly interconnected forming wholes; therefore, it seems that the concept 'system' can help us to cope with the intertwined reality we perceive.

2.2.2. SSM 'Limitations'

SSM Limitations have been exposed mainly by Jackson (1992, 2003), Flood and Jackson (1991), Mingers (1984), and Lane and Oliva (1994), amongst others. Essentially, they argued that because of the interpretive underpinning, SSM is not a 'problem-solving methodology' and that can cause concern and uneasiness amongst practitioners. SSM according to Lane and Oliva (1994) is a methodology

to explore the real world and because its models are not descriptions of the real world (SSM firmly believe that the real world is difficult to grasp) they are not normative; they are 'ideals' only faithful to one particular world view.

Although the authors of this paper acknowledge the fact that SSM has been successful in its application to real-world complex management situations, they are aware of its limitations raised earlier; in particular the modelling step, it was found to limit the intervention, (Rodriguez-Ulloa, 1994a,b, 1995, 1999, 2003, 2004), because it did not offer a technological tool to help grasping the consequences and sequels of the assumedly culturally and feasible models suggested; the analyst(s) therefore could not realize about the real impact of the changes proposed. It was felt then that through the incorporation of some of the SD quantitative modelling features, the intervention could be largely enriched. So, Rodríguez-Ulloa (1999, 2002a,b,c, 2004) started to unify both approaches into one intellectual tool by taking the valuable aspects of each. This combination allowed to build up a working framework which has proved to be useful to understand and to deal with the different perceptions of the people involved in real-world complex problem situations, in both qualitative and quantitative terms.

3. SOFT SYSTEM DYNAMICS METHODOLOGY

As mentioned before, SSDM arose as a product of an action research project started by the end of 1992 at the Andean Institute of System—IAS (Lima— Peru), when Rodríguez-Ulloa (1994a,b, 1995) began to lecture SD for under and graduate students in diverse academic Peruvian institutions and finished in 1999 with a framework of 10 steps as it is shown in Fig. 2. Thus, examining the SD approach he noticed that important concepts coming from SSM, which are very important for understanding real-world problem situations, were not considered explicitly in the formal analysis of SD. He thought, then, that *combining* both approaches could allow the emergence of a synergistic intellectual tool for systemic studies of complex situations.

3.2. SSDM Paradigm

During the 1990s there has been a great debate in the systems community around issues concerning the use of more that one methodology (combinations of them or parts of them) when intervening in complex situations. The general term of multi-methodology (Mingers, 1997a; Paucar-Caceres, 2002) has been coined to group systemic practices that combine and link various methodologies or some stages of two or more methodologies. SSDM paradigm (Rodríguez-Ulloa, 1995, 1999, 2002a,b,c, 2004) follows what Mingers calls a multi-paradigm/multi-methodology approach.

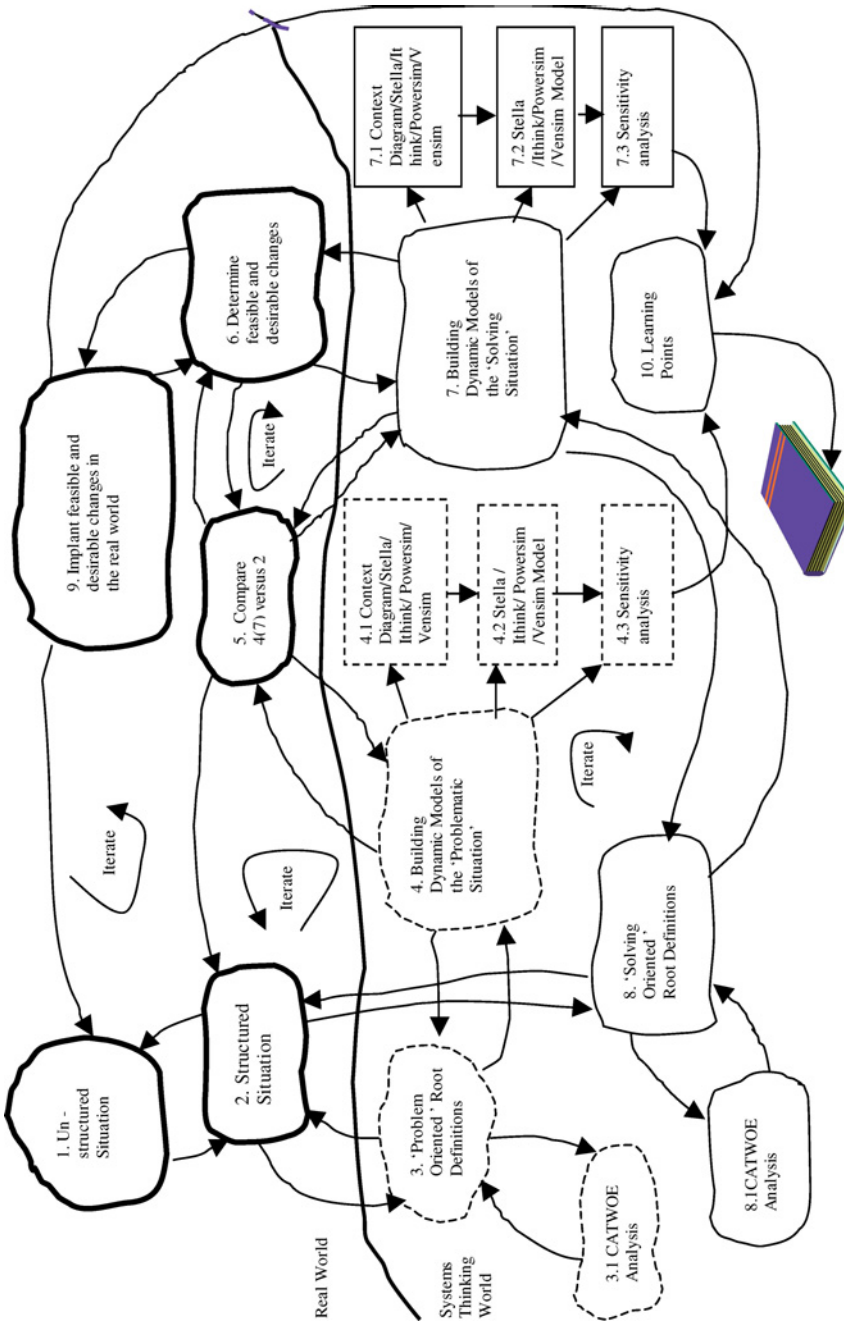

Fig. 2. Soft System Dynamics Methodology (SSDM): A general view (after Rodríguez-Ulloa, 1999, 2002a,b,c, 2004).

Mingers (1997a, 1999) argues that Critical Systems Thinking and Total Systems Intervention (Jackson, 1992, 2000, 2003; Flood and Jackson, 1991) are only one particular form of multi-methodology and takes the view that any intervention should gain benefits from being approached with a variety of management science methodologies in what he calls 'strong pluralism' arguing that agent(s) (i.e. person(s)) intervening in the situation would benefit if the intervention is tackled using a 'blend of methodologies.' In Mingers' view, the following arguments favour an application of a multiplicity of methodologies: (1) Any situation is in itself complex that not a single methodology can claim to be able to tackle it completely, rather we should pay attention to three aspects involved in any intervention: material, social and personal. Some methodologies will bring more enlightenment to some of the three aspects; (2) An intervention is not a discrete event but continuous and therefore some methodologies are more suitable to certain phases of the intervention. We should not disregard the possibility of combining methodological stages, methods or tools from different methodologies serving to different paradigms; (3) Finally, there are practical reasons in favour multi-paradigm multi-methodology: many systems practitioners have already started to practice it. Mingers provides numerous examples supporting his claim and uses five dimensions to characterise the different types of multi-methodology practice: (a) one/more methodologies; (b) single/multi-paradigm; (c) same or different intervention; (d) whole/part methodology; and (e) imperialist/mixed (Mingers, 1997b). We argue that SSDM will be a particular case of (b) and (d) that is multi-paradigm and multi-methodology.

Although there have been intents to merge this two approaches (Lane and Oliva, 1994) and although some system dynamics academicians and practitioners have been already working in the arena of messy problems (Lane, 1999, 2000, 2001a,b; Vennix, 1996, 1999; Vennix *et al*., 1996, 1997; Andersen and Richardson, 1997; Rowette *et al*., 2002; Lane and Oliva, 1994; Morecroft and Sterman, 1994; Sterman, 2000; Warren, 2002), we argue here that SSDM contribution lies on in the elucidation of a methodological framework (i.e. 10 clearly defined steps are proposed), where the principles, concepts, philosophies, techniques and technologies from both sides are taken into account and put them to work together. SSDM, thus, is an intellectual tool that can be regarded more than just a merging between SD and SSM but a synergistic systemic framework that Rodríguez-Ulloa arrives from the fusion of these two methodologies.

Table I, based on Rodríguez-Ulloa (1999, 2004) and Mingers (1997b), shows a comparison on the ontological, epistemological, and methodological foundations between both approaches (SSM and SD) and those of the emerging one (SSDM).

4. THE 10 STAGES OF SOFT SYSTEM DYNAMICS METHODOLOGY

It is important to emphasize that the 10 steps of SSDM work across of what we define as three worlds: (1) the Real World; (2) the Problem–Situation-Oriented

Table I. Ontological, Epistemological and Methodological Comparison of SSM, SD and SSDM (After Rodríguez-Ulloa, 1999, 2004; Mingers, 1997b)

	SSM	SD	SSDM
Ontological principle	Systems are not assumed to exist in to exist in real world; social world of attributing meaning	Systems exist in the real world	Systems are not assumed to exist in to exist in real world. The social world has meaning for the observer
		Describe the real world in ontological terms (use of nouns)	
Epistemological principles	Interpretivist, phenomenology and (possible) hermeneutical claims.	Mainly positivistic assumptions	Interpretivist, rationalistic, phenomenological and hermeneutical assumptions
	Describes the real world in epistemological terms (use of verbs)	Describe the structure underlying the real world in terms of flows and rates (verbs, nouns and adverbs)	Describes the realworld in epistemological and ontological terms (verbs, nouns and adverbs)
	Separation of the real world and Systems Thinking world; systemiticity is in the process;	Separation of real world and systems world is not very clear	Separation of real world and systems thinking world is clear; Divides SSDM systems thinking world into two: (1) Problem, Situation–Oriented Systems Thinking World; and (2) Solving, Problem–Situation-Oriented Systems Thinking World
Methodological stages	Systemic approach based on 'logical' linked human activity systems	Systemic approach based on 'rational' cause–effect relationships	Systemic approach based on 'logical' linked human activity systems and 'rational' cause–effect relationships
	Seeks for cultural feasible and systemically desirable changes in the real world	Does not mention explicitly this important issue	Looks for cultural feasible and systemically desirable changes in the real world
	It is a problem and solving-oriented methodology	It is a problem–solving-oriented approach	It is a problem-and solving-oriented methodology
	Unable to measure and assess the possible changes by itself through the time	Able to measure and assess the changes by itself through time	Able to measure and assess the problematic and improved situation by itself through time

Table I. Continued

SSM	SD	SSDM
Clearly establishes the 'what' and 'how' transformation process performed or to be performed in the real world, to 'improve' it	The 'what' and 'how' transformation process implemented or to be implemented in the real world is not clear	Clearly establishes two transformation processes (1) which explains 'what' is the problem situation and 'how' it behaves; and (2) which explains 'what' and 'how' should be the transformation process to 'improve' or 'alleviate' that problemsituation and 'how' the improved situation should behave
It is not a dialectic approach It finishes with a learning process from the application of the whole methodology in an informal way	It is not a dialectic approach It finishes with a learning process of the modelbuilding process in an informal way (Interactive Dynamics, Holon Dynamics, Group Model Building, Modelling for Radical Learning)	It is a dialectic approach It finishes with a formal process of learning since three positions: (a) From the problematic view of the Problematic Situation (SSDM's World 2); (b) From the solucionatic view of the Problematic Situation (SSDM's World 3) and (c) From the Implementation process in the Real World (SSDM's World 1).

System Thinking World; and (3) the Solving–Situation-Oriented System Thinking World.

We argued that SSDM when applied provides a dialectical view of the real-world situation. This becomes clear when it is applied to a real-world intervention. Thus, the first approach in intervening the real world (World 1) using SSDM is just to appreciate the Problem-Situation and to understand its behaviour in a holistic manner (called here World 2). On the opposite (dialectical) side, after having understood the way the Problem-Situation behave, then, systemic thinking of ways to 'solve,' 'finish' or 'alleviate' the Problem-situation are studied and proposed in the Solving–Situation System Thinking World (called here World 3).

Figure 2 shows the 10 stages of SSDM. The three 'worlds' are clearly illustrated in SSDM: (1) Real World (thick line steps); (2) Problem-Situation-Oriented Systems Thinking World (dashed line steps); and (3) Solving–Situation-Oriented Systems Thinking World (fine black lined steps). The 10 stages of the methodology are iterative (feedback is recommended and encouraged) but for illustration purposes, it helps to think that the first pass (what we called here the 'first loop') is to do with the 'Problem–Situation-Oriented Systems Thinking World' and the 'second loop' deals with the 'Solving–Situation-Oriented Systems Thinking World.' In the following sections these stages are outlined. A full account of the detailed the stages of the methodology can be found elsewhere (Rodríguez-Ulloa, 1995, 1999, 2002a,b,c, 2004).

5. REAL WORLD: STAGE 1 (UN-STRUCTURED PROBLEM-SITUATION) AND STAGE 2 (STRUCTURED SITUATION)

SSDM's Stages 1 and 2 are borrowed from SSM. It has been acknowledged that the first two SSM stages: (1) (Looking at the Unstructured Problem-Situation); and (2) (Structured Problem-Situation or 'Rich Picture') are powerful steps to help to understand and comprehend of the phenomena and events occurring in a System of Reference (i.e. a portion of the real world, defined and delimited by the analyst for purposes of systemic study), where something is not working 'well' and something needs to be done to 'improve' the problem situation.

According to SSM, in order to study the problem situation in a holistic manner, the problematic situation must be regarded in an open manner and trying not to see the situation as a system itself (not to see the real world as systems yet!); the use of a rich picture as a epistemological device is important to capture the real situation. Then these two stages were incorporated as part of SSDM, in more or less the same way they are established in the SSM seven-step mode of application. However, in order to enhance the way 'rich pictures' are built up, some concepts[4]

[4]For example, the use of the concepts like: weltanschauung, human activity systems, infra systems, hetero systems, supra systems, iso systems, system of reference, emotional states of the stakeholders, ideological systems, power systems, etc., helps very much in structuring problem situations.

and tools[5] were added according to the experience gain in using SSM in Peru and other Latin American countries (Rodriguez-Ulloa, 1994a,b, 1999, 2002a,b,c, 2003, in press).

System Dynamics approach starts any systemic study with the construction of a 'systemic structure' known as the Context Diagram, composed by 'nouns' (i.e. an ontological way of describing the real world) which represent the 'sectors' of the system. These sectors are linked in between themselves by causal relationships, as the basis to represent and understand the structure and patterns of behaviour of the problem situation encountered in the real world. Then the structure built up is a particular way, used by the traditional system dynamics practitioner (the analyst), to interpret about what is happening in the real world. However, he/she does it without considering different important aspects and events that are part of the real world (i.e. problem owners, clients, actors, their world views, level and kind of power, and degree of influence in the situation, their relationships among themselves, the kind of these relationships, etc.) which precisely makes the situation problematic, messy and difficult to understand if someone tries to come out with recommendations for its improvement.

Recently, the SD community has been very active informing practitioners of the advantages of group model building and the ways of incorporating the different stakeholders using the SD approach and shifting the paradigmatic practitioner's view to the so called the learning paradigm, see amongst others, Lane, 1999, 2000, 2001a,b), Vennix (1996, 1999), Vennix *et al*., 1996, 1997), Andersen and Richardson (1997), Rowette *et al*., 2002; Lane and Oliva (1994), Morecroft and Sterman (1994), Sterman (2000), Warren (2002), Senge (1990), Wolstenholme (1990). However, the other two important pair of concepts of the *Problem Content System* and the *Problem Solving System* (Checkland, 1991; Rodriguez-Ulloa, 1988), are not very clearly distinguished in these recent SD developments, which we argue it could be the root for misunderstandings in any system intervention. The richness accumulated by SSM on these issues after of more than 30 years of existence, persuaded the authors to keep these SSM stages in mind when structuring SSDM

Thus, SSM's Stage 1 (Looking at the Unstructured Problem-Situation); and Stage 2 (Structured Problem-Situation or 'Rich Picture'), were preferred over the SD first stages because it was felt that they empowered with the concepts and tools mentioned previously, allowing to consider all these aspects adequately, so that the importance of being considered as part of SSDM.

[5]For example, the use of colours and diverse signals to express different kind of relationships (i.e. considering and expressing the level and kind of power of the problem owners, clients and actors; the informal relationships, the familiar linkages and so on), as well as the addition of cause–effect relationships among the elements of the structure or specifying timing links, to be consequent with the hermeneutic description of the phenomena occurring in the problem situation analyzed through time.

6. FIRST SSDM SYSTEMIC LOOP: PROBLEM-SITUATION SYSTEMS THINKING WORLD

6.1. Stage 3 (Problem-Oriented Root Definitions)

SSDM's Stage 3 (root definitions) has also been borrowed from SSM because of its importance for describing transformation processes and situational changes that arguably are made in the real world.

It was found (Rodríguez-Ulloa, 1994, 1995, 1999, 2003, 2004), on the other side, that most of the times where SSM has been used, root definitions usually describe human activity systems that performs transformation processes oriented to 'improve' the problem situation encountered in the real world.

At this stage, SSDM expresses the problematic transformation process that it is assumed to occur in the real world. For example: having all the mineral resources Peru has, why there are a lot of poverty around the country?; why, if Peru is one of the few countries in the world with more climate varieties, it has not yet developed a world class agricultural industry?; why, if there are more educated people than before, it is still now 'underdeveloped'? Root definitions, then, were used here in order to describe in phenomenological, epistemological, systemic and hermeneutic terms these types of 'irrationalities' or 'pathological' behaviours of the phenomena in the real world. Then the transformation processes described at this stage are '*problem oriented*' *transformation processes* which are supposed to be occurring in the real world and expressed in the 'rich picture' (Stage 2). This is, according with the findings of Rodríguez-Ulloa (1995, 1999, 2002a,b, in press), a different way of using root definitions, in the sense that, under this perspective, root definitions are used to express 'problematic' transformation processes instead of expressing transformation processes oriented to provide 'solutions,' 'alleviations' or 'improvements' to the problematic situation encountered, as it is usually used in SSM. Additionally, the analyst must be aware that there would be as many descriptions of 'problematic situation' transformation processes as problematic worldviews (i.e. weltanschauungen) can be used to understand that problematic situation, so that the number of 'problematic oriented' root definitions can be abundant.

6.2. Stage 4: Building System Dynamics Models of the 'Problematic Situation'

Once Stage 3 has been completed, each root definition of a 'problematic situation' serves as the basis for starting the modelling process. This modelling process is done in terms as usually SD expresses the phenomena occurring in the real world: through causal loops. Then, SSDM's Stage 4 is a stage where, first of all, a *problematic* context diagram of the situation is built up at a first resolution level of complexity. This context diagram must correspond to a particular weltanschauung (W) that the observer has emphasized in a particular problematic root definition,

done at Stage 3. If the observer changes the W under which he/she observes the real world, this will change the root definition which affects the *structure* of the problematic SD context diagram as well. On the contrary, if some changes are made in the structure of the problematic context diagram, then some adjustments and changes have to be made in the problematic root definition in order to have a mutual correspondence in between them. In other occasions it may be justifiable to observe the problematic situation from a different W which will originate a complete redefinition of the initial root definition, affecting the structure of the original problematic SD context diagram.

Once the problematic SD context diagram has been built up successfully, it serves as the basis for developing causal loop diagrams at a second resolution level of complexity, which express the analyst's particular interpretation of the detailed structure and behaviour of the problem situation. Thus, second resolution causal loop diagrams explain the 'logic' and 'rationality' that, assumedly, is underneath in a particular 'irrational' behaviour structure encountered in the real world and which is described by a particular problematic root definition (SSDM's Stage 3).

As part of SSDM's Stage 4, after considering the SD context diagram (which, as mentioned before, depends of a particular W under which the observer views the real-world problem situation), the structure of the problematic situation in a more detailed way is modelled, using for this purposes a system dynamics approach with the support of an ad-hoc software (i.e. Stella, Ithink, Dynamo, Powersim, Vensim, among others).

Having obtained a logically coherent causal loop computerized model of the problematic situation's behaviour (observed under a particular W), it goes on with its calibration and sensitivity analysis in order to see diverse consequences and sequels that the problematic situation, interpreted in a particular way, could bring about, under different conditions of the causal variables.

The study and understanding of the relationships between the causes and the consequences and sequels (i.e. the outcomes) while iterating among diverse Ws, problematic root definitions, context diagrams and second resolution causal loops, is a key aspect of the learning process that the group of analysts (i.e. the observers) can do in order to comprehend and understand the patterns of behaviour of the problematic situation, using this framework. We consider this a very important contribution of SSDM to the understanding of the behaviour of a messy problematic situation, under an holistic way, which radically differs from the previous approaches encountered elsewhere (Lane, 1999, 2000, 2001a,b; Vennix, 1996, 1999; Vennix *et al*., 1996, 1997; Richardson and Andersen, 1995; Andersen and Richardson, 1997; Rouwette *et al*., 2002; Lane and Oliva, 1994; Morecroft and Sterman, 1994; Sterman, 2000; Warren, 2002; Senge, 1990).

Consequently, this process can be replicated n times according to the number of root definitions the observer has elaborated at SSDM's Stage 3; having as their objective, to obtain different problematic system dynamics computerized models,

just to comprehend the variety of interpretations under which the behaviour of a problematic situation can be understood according to each interpretation and its consequences.

7. REAL WORLD

7.1. Stage 5: Compare Stage 4 (Stage 7) Against 2

Stage 5 consists, on the comparison, in the first SSDM systemic loop, of the problematic-oriented system dynamics models against the rich picture built up at Stage 2. The comparison emphasizes in observing and validate, if possible, all the nouns, verbs, adverbs and relationships established in the problematic system dynamics models (problematic context diagram and detailed causal loop models, originated by each problematic root definition) compared to the rich picture description, observing at the same time if the outcomes of the sensitivity analysis reproduce the behaviour of the problematic situation, that is, if it expresses adequately the real world situation (or part of it) shown in the rich picture (i.e. if the models (problematic context diagram and system dynamics models based on particular Ws) express adequately what is happening in the real world).

Stage 5, also consists, on the comparison, in the second SSDM systemic loop, of the solving-oriented system dynamics models, against the rich picture built at Stage 2. The comparison in this case, emphasizes in observing and validate, where possible, all the nouns, verbs, adverbs and causal relationships made in the solving system dynamics models (solving context diagram and detailed causal loop models done at Stage 7), compared with the rich picture, observing if the outcomes of the sensitivity analysis reproduce the behaviour of a solving situation for the problem situation being studied and if the changes proposed, can be culturally feasible and systemically desirable changes.

8. SECOND SSDM SYSTEMIC LOOP: SOLVING-SITUATION SYSTEMS THINKING WORLD

8.1. Stage 6: Determine Culturally Feasible and Systemically Desirable Changes

After Stage 5 has been done, and the mode(s) proposed at Stage 4 have been validated, then to look for culturally feasible and systemically desirable changes (SSDM's Stage 6), in order to improve that problematic situation described through the model(s) at Stage 4. In other words, through Stage 6 we look for obtaining culturally feasible and systemically desirable changes, in terms of which variables (at the context as well as in detailed levels of the models done at Stage 4) and links have to be removed, varied and/or added (if possible all of this) in order to 'improve' (i.e. change) the problematic behaviour of the situation encountered

at SSDM's Stages 3 and 4. A way to manage this stage could be using PERT and CPM techniques as well as with the contribution of what is called Project Dynamics (Abdel-Hamid and Madnick, 1991; Williams, 2002).

As this analysis of feasibility and desirability is not possible to do without seeing the effects through time, it is necessary to go to SSDM's Stage 7 in order to simulate the prospective 'solving' alternatives the analysts can propose to the problematic situation encountered.

8.2. Stage 7: Building System Dynamics Models of the 'Solving Situation'

In this stage, we draw support from the SD approach to SSM in the sense that with the use of this computerized systemic modelling tool (i.e. SD), it is possible to delineate and prospect possible courses of action to 'improve' the problematic situation, proposed by different assumedly feasible and desirable changes obtained at Stage 6. As it has been seen in our experience using SSM in the past, very often, what was intuitively supposed to be a possible 'good' change, was not like that, in the real world.

Stage 7 helps, through the simulation process, in understanding precisely if the proposed changes are able to 'improve' the structure of the problematic situation or not. If some of them do not contribute to, it will be necessary to return to SSDM's Stage 5 and iterate among Stages 5–7, until a culturally feasible and systemically desirable problem-solving diagram context and system dynamics model can arise.

Thus, doing Stage 7 means building up a context diagram on the solving –oriented approach to be implemented in the real world. This means also that it is possible to go further to next modelling details (next resolution levels of the system dynamics models), doing sensitivity analysis to observe the outcomes according to the variations of the causes and/or their relationships (desirable and feasible changes). This again gives to the observers, important insights about the diverse consequences and sequels of the 'solutions' provided by them.

8.3. Stage 8: Solving Situation-Oriented Root Definitions

Once the problem-solving model has been achieved, Stage 8 is carried out. We have to remember that this stage is placed in the second SSDM systems world, that is in the 'Solving-Situation-Oriented Systems Thinking World' (World 3). Stage 8: 'Solving Situation Root Definition,' in SSDM terms, aims to express the transformation process needed to make 'improvements' of the problematic situation. After doing all the linguistic corrections, it is important to do its CATWOE analysis in order to elucidate, clearly, what is the 'solving-oriented' transformation process that the computerized model proposed in Stage 7 is promoting to undertake in the real world, as the basis to build up this solving-oriented root definition.

Once all the adjustment are done, a comparison between the 'solving'-oriented root definition and the real world problematic situation is made (i.e. a comparison between Stages 8 and 2 must be performed). If it is noticed that although the 'solving'-oriented root definition can be literally interesting, but the comparison with the real world problem situation could show that the transformation process proposed by it has some difficulties to be implemented due to systemically undesirable factors or be culturally unfeasible, then some adjustments have to be made among Stages 2, 8 and 7, as well as in the loop composed by Stages 5–7, until some 'good' transformation processes have to be find among them, which can make the change proposals culturally feasible and systemically desirables ones.

9. REAL WORLD

9.1. Stage 9: Implementation of Feasible and Desirable Changes in the Real World

Once a good balance has been found among Stages 2, 8 and 7, then it is the time to return to Stage 6 where the ultimate culturally feasible and systemically desirable changes have been reached. Done this, changes are ready to be implemented in Stage 9: implementation of feasible and desirable changes in the real world.

9.2. Stage 10: Learning Points

The last activity of SSDM is Stage 10, where all learning points have been collected and compiled for study and reflection from time to time and future interventions. The learning points came from the sensitivity analysis of modelling the 'problematic situation' (Stage 4) as well as the 'solving situation' (Stage 7) and the proper implementation action in the real world (Stage 9). The aim is to orient to people involved in the analysis and design of social systems (i.e. Problem Solving System) to the learning paradigm, since a self analysis, synthesis and reflection of real world concrete interventions.

10. SOFT SYSTEM DYNAMICS METHODOLOGY: A SYNTHESISING METHODOLOGICAL SYSTEMIC TOOL

We have argued, that SSDM synthesizes the diverse philosophical frameworks, paradigms and intellectual tools from SD and SSM, which working together allow it to be a powerful intellectual framework for the analysis and design of social systems. The following points emphasizes the synthesizing role that SSDM brings to the methodological arena in the systems community.

Essentially, it draws and combines the following stages from SSM and SD:

- From SSM the phenomenological way of describing real world complexity (Stages 1 and 2) is taken. To these first two stages, several new mental tools and concepts have been added and using in structuring messy problems and soft situations, in order to build suitable rich pictures, all of this coming from the experience of using SSM in Peru and other Latin American countries in the last 15 years. Thus, some of the concepts that have contributed to center the study of a problematical situation are those like system of reference, supra-system, hetero-system, infra-system, iso-system and sub-system. Also the use of diverse colours and intensities in graphing the rich picture, the use of the Mind Mapping technique (Buzan, 1996; the Nominal Group Technique and Delphi Technique, Delbecq *et al*., 1975), the De Bono (1986) creativity techniques, added to the use of causal links, the clear distinction between the Problem-Solving System and the Problem–Content System (Checkland, 1981; Rodriguez-Ulloa, 1988), the consideration of the power and cultural issues as important part of analysis to be considered in any rich picture in order to detect the Owners, Clients and Actors in a problematical situation and their world views (i.e. weltanschauungen); all of this being view under an phenomenological and holistic view, have contributed to enrich the process of building rich pictures, seen for us as the basis for a good systemic understanding and intervention, being this way how we use Stages 1 and 2 in SSDM.
- From SD it takes the functionalistic and causal rationality, that being treated in a positivistic way in the 'austere SD' (Lane, 1999; 2001a,b), here causal rationality is used under a phenomenological umbrella, coming from the influence of SSM over SD. Thus, from each problematic 'solutionatic' root definition, a causal diagram can be generated; but in this case, this causal diagram is based on a particular world view (i.e. weltanschauung) clearly identified in the root definition, which defines the context diagram and the subsequent qualitative and quantitative system dynamics model. This aspect is very important if we take into account the way how system dynamicits usually do the process of building system dynamics models, where they start from scratch or with a pre-conditioned first idea of how the system dynamics model will be (i.e. which should be at least the main variables to be considered) in a process of for example group model building (Vennix, 1996, 1999; Vennix *et al*., 1996; Wolstenholme, 1990), but where the help of a root definition, which could define the main problematic or solutionatic transformation process could help to center the analysis in the root cause of the study.

SSDM overcomes the limitations of SSM by bringing SD to its framework; from SD the support of ad-hoc computer software to simulate in the laboratory diverse social behaviors is borrowed, making it possible to probe if the suggested 'culturally feasible' and 'systemically desirable' changes are really as we think they can be or they are just a chimera because they will not work in the real world as it was expected. The contribution of phenomenological SD models (i.e. SD models coming from diverse weltanschaunngen) is regarded of crucial importance to assess the possibilities of the changes the analysts can propose to be implemented in the real world, before wasting time and other resources.

A main contribution that SSDM does to the field of SD, with the support of SSM, is that in any SD process, it is still nowadays not clear the path on how decision takers should follow in order to do a changes implementation process proposed in any SD study, knowing besides, that without a changes implantation process, no changes will exist in the real world. If we take the work of Vennix for example (1996, pp. 111–115), he states, summarizing, that in order to define and detect changes in a SD project, a group of stakeholders must be meet frequently and applying for example a 'Reference Approach' (Randes, 1977) or the 'Strategy Forum' approach (Richmond, 2001), the group can reach a model to be implemented in the real world. The field where Vennix and Richmond are working on within SD is what is called Interactive SD and Group Model Building, considering the learning process in parallel. But the problem not yet resolved is on how the implementation process of the proposed changes being considered in the model has to be done, assumedly that the model is culturally feasible and systemically desirable, aspect that, besides, is not analyzed in any SD current working field. However, as it has been explained before, following Stages 6 and 9 (Stages 5, 7 and 8 are needed to be done before), it is possible to have a logically and systemically way of implanting the decisions and changes proposed in the solutionatic system dynamics models encountered in the study (SSDM's World 3). So that, the process in SSDM, concerning the changes affair, ends not only in conceiving and proposing changes for their implantation, as the SD strand does (but where there is not any clear path of how to do it) but it ends in implanting them in the real world (Stage 9). Another important contribution that SSDM does is that its overall process finishes with a learning attitude expressed at Stage 10, where all learning points are accumulated for next experiences. These learning points come from the sensitivity analysis of the first system dynamics models loop (SSDM's World 2), from the sensitivity analysis of the second system dynamics loop (SSDM's World 3) and also from the implementation stage (Stage 9), thus in this way, SSDM is walking the path of what is called Modelling for Radical Learning (Lane, 1999, 2001a,b) within a similar point of view of Wolstenholme (1990) concerning the ends of SD. Aspect that could be linked in the near future with the knowledge management issue (Nonaka and Takeuchi, 1999).

11. AN APPLICATION OF SSDM IN A SMALL PERUVIAN ENTERPRISE: THE TUBOS S.A. CASE STUDY

An application of SSDM in a specific problem situation is described in the following section.

11.1. Stage 1: Unstructured Situation

Tubos S.A., is a small Peruvian company dedicated to commercialize national and imported steel products. Its clients are from the construction, mining, petrol, fishing and industry sectors, among others. It is managed by a directory composed by four persons: two partners and directors (Mr. Martinelli (D1) and Mr. Ampuero (D2) and two directors and managers (Mr. Zapata and Mr. Merino). Outside information is managed and processed by director D2, who, as well, does the strategic decisions of the enterprise. This attitude provokes conflicts with director D1, generating personal resentments between them, blockading the formal communication channels of the company. This situation also re-feeds the domination willing of director D2 creating the conditions for the conflictive relationship with director D1. The informal communication (originated by the poor relationships between the directors), generates, as well, the lack of strategic plans and a low degree of organization in the company.

The external environment is characterised by scarcity of foreign currency, credit restrictions and a deficient legislation generating negative effects in the market conditions, as well as, in the strategic plans of Tubos S.A., with the exception of the last variable (legislation) which can produce positive or negative effects in the strategic plans (more or less market regulation, rigid or flexible labour legislation or a mixture, deficient juridical codes which provoke delay in the administration of justice processes where the firm is involved, etc.).

To break up the dominating power position of director D2 over director D1 something needs to be done, otherwise the internal situation of Tubos S.A. could collapse. One way could be the implementation of participative planning. This could allow to unite efforts between both partners, reducing the resentments in between them. Re-establishing the communication channels and the formal procedures (structure and functions manual) within the company would allow to improve the coordination of activities and the information flows, impacting in the development of management, the productivity, efficiency, competitiveness and net profits. Increment in earnings reinforces the participative planning as well. Finally, an increasing in the formal communication channels generates more competitiveness due to the formalization of the strategic plans.

11.2. Stage 2: Structured Situation

Figure 3 shows a consolidated rich picture of the problem situation at Tubos S.A. based on the information obtained at Stage 1 of the SSDM.

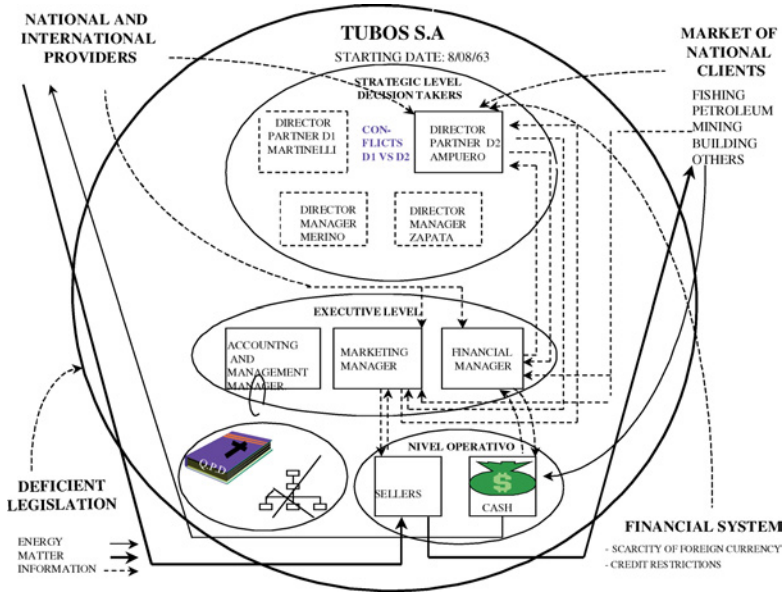

Fig. 3. SSDM's Stage 2: Rich Picture of the problem situation (after Rodríguez-Ulloa, 1999, 2002a,b, in press; Montbrun *et al*., 1998).

11.4. Stage 3: Problem-Oriented Root Definitions

Among diverse problem-oriented root definitions that can be generated, it has been chosen the following as an example:

> A human activity system owned by a private company, *which sells steel products to the construction, mining, petrol, fishing and industry sectors of the internal Peruvian market with competitive disadvantages not satisfying its clients' needs,* due to internal problems in the company's general management, motivated by personal interests and conflicts between the owners and the lack of a good communication among them and the other directors and managers of the company. This situation leads to the implementation of an informal management and culture at different hierarchical levels of the company, affecting the good management as well as the marketing and financial results of the enterprise as a whole. This HAS is being done under diverse external constraints, product of the environment existing in the country, like credit restrictions, scarcity of foreign currency and deficient legislation

11.5. Stage 4: Building System Dynamics Models of the "Problematic Situation"

Figure 4 shows the problematic context diagram and Fig. 5 the problematic causal diagram of the particular interpretation of the problem situation based on the problematic root definition presented at Stage 3.

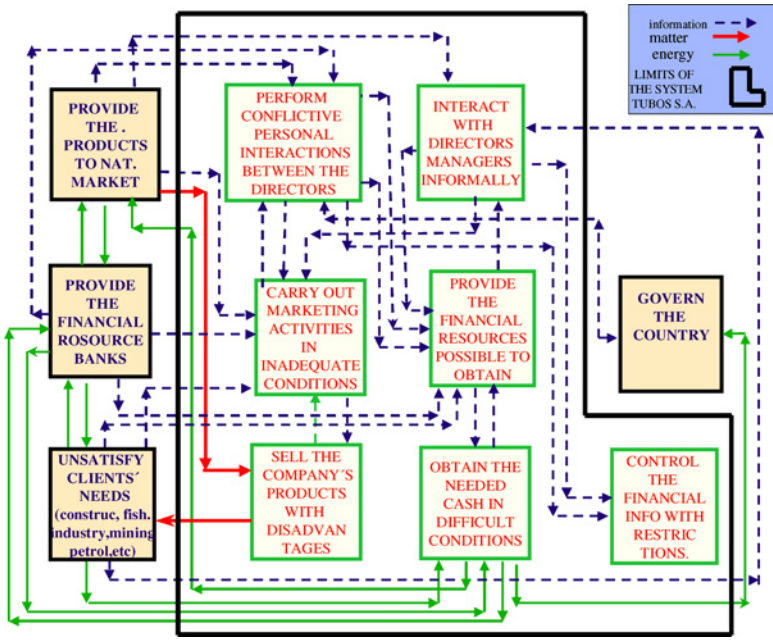

Fig. 4. SSDM's Stage 4: An example of a problem oriented context diagram of the problem situation which comes from a problem oriented root definition (after Rodríguez-Ulloa, 1999, 2002a,b,c, in press; Montbrun *et al*., 1998).

11.6. Stage 5: Compare Stage 4 ('Problematic' Situation System Dynamics Model(s)) or Stage 7 ('Solving' Situation System Dynamic Model(s)) against Stage 2 (Rich Picture)

In the first iteration of SSDM (World 2), a comparison is made between Stage 4 (Problem-Oriented System Dynamics Model(s) vs. Stage 2 (Rich Picture). From that comparison some findings can be detected, the aim being to validate the "problematic" system dynamics models. The criteria of validation are the same of SSM (in this case the validation is concerned to probe that the inadequate behaviour of the system is culturally feasible and systemically desirable by the people involved in the problem situation). The validation process here is made to the problematic context diagram as well as to the problematic system dynamics model (nouns, verbs, adverbs and causal relationships).

In the second iteration of SSDM (World 3), a comparison is made between Stage 7 (Solving-Oriented System Dynamics Model(s) vs. Stage 2 (Rich Picture) after Stages 6 and 7 are done.

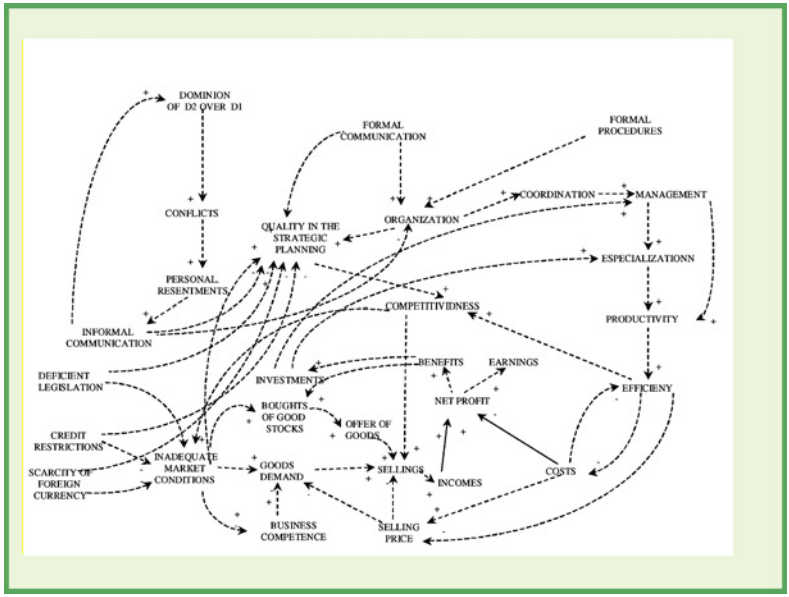

Fig. 5. SSDM's Stage 4: Problem-Oriented causal diagram based on the problem-oriented context diagram which comes from a problem-oriented root definition (Fig. 4) (after Rodríguez-Ulloa, 1999, 2002a,b,c, 2004; Montbrun *et al*., 1998).

11.7. Stage 6: Determine Culturally Feasible and Systemically Desirable Changes

From the work done in the previous stage (first iteration), a list of culturally feasible and desirable "solving" changes can be obtained, leading this to see the way they can be implemented in the real world in order to "improve" the problem situation. The changes could be a new "noun" (level), a new verb in gerund (flux) or adverb (auxiliary variable) (i.e. a SD's variable) or one or some causal relationships that need to be aggregated to the problematic system dynamics model, or, on the contrary, the elimination of a noun, a verb or an adverb (i.e. a SD's variable) or one or some causal relationships which allows to change the behaviour from a problematic to what we call a solution oriented or 'solutionatic.' This can be tested using the sensitivity analysis of the 'solving-oriented' system dynamics model(s).

11.8. Stage 7: Building System Dynamics Models of the "Solving Situation"

In this stage, both the solving context diagram and the solving causal diagram are shown. Figures 6 and 7 show the 'solving' context diagram and the 'solving' causal diagram with several culturally feasible and systemically desirable changes

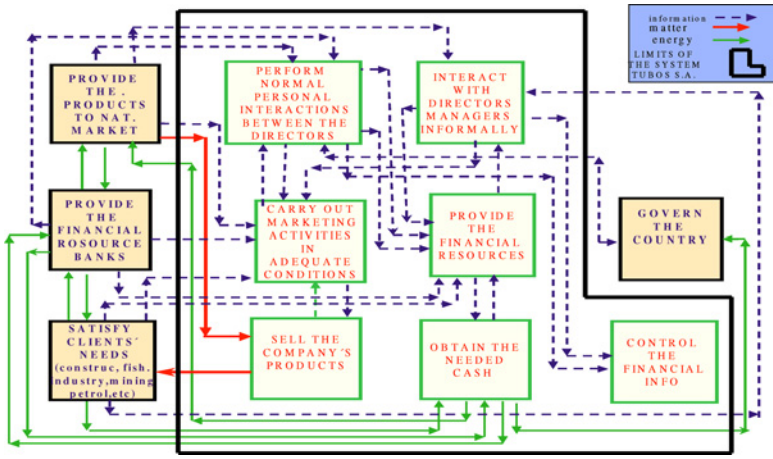

Fig. 6. SSDM's Stage 7: Solutionatic context diagram of the problem situation which comes from a solution oriented root definition (after Rodríguez-Ulloa, 1999, 2002a,b,c, in press; Montbrun *et al*., 1998).

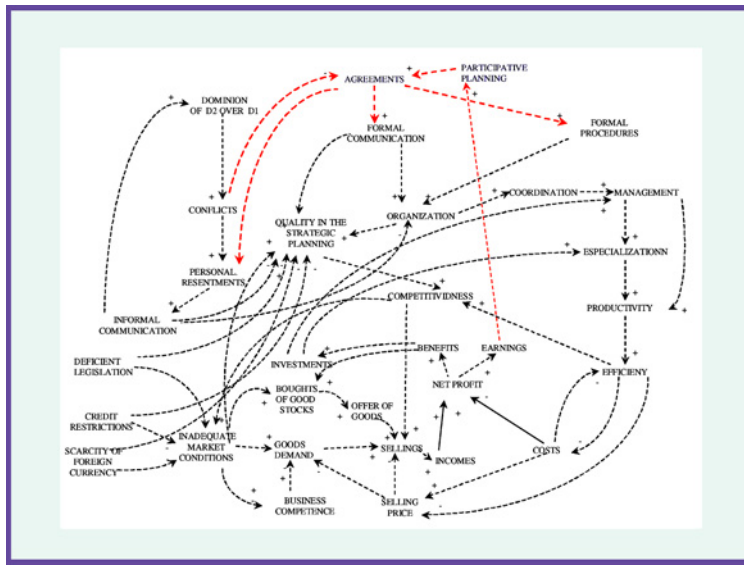

Fig. 7. SSDM's Stage 7: Solutionatic causal diagram of the problem situation based on the solutionatic context diagram (Fig. 6) (after Rodríguez-Ulloa, 1999, 2002a,b,c, in press; Montbrun *et al*., 1998).

11.9. Stage 8: Solving-Oriented Root Definitions of the Problem Situation

At this stage, those root definitions which being culturally desirables and systemically feasible are elaborated to express the transformation processes that 'improves,' 'finish,' 'solve' or 'alleviates' the problem situation encountered in the problematic analysis so taking into account the problematic root definition (Stage 3) then the corresponding 'solution-oriented' (i.e. 'solutionatic') root definition will be:

> A human activity system (HAS) owned by a private company, *which sells steel products to the construction, mining, petrol, fishing and industry sectors of the internal Peruvian market, with competitive advantages in order to satisfy its clients' needs*. To get the adequate competitiveness, this process is done under the implementation of a formal management and culture at different hierarchical levels of the company, aiming to have good human relations, good communication, adequate organization, high quality strategic planning processes and performance for the enterprise as a whole, as measured in marketing and financial results and achievements along time. This 'HAS' is being done under diverse external constraints, as a result of the unclear environmental situation existing in the country, like credit restrictions, scarcity of foreign currency and deficient legislation

11.10. Stage 9: Implement Culturally Feasible and Systemically Desirable Changes in the Real World

Once the adjustments have been done among Stages 8, 2 and 7 as well as among Stages 5–7, then the culturally feasible and systemically desirable changes selected are ready to be implemented in the real world. At this stage, it has been seen, according to our experience using SSM, that the process of implementing changes can be also the arena where several situations could happen, which maybe could not be considered for any reasons in all the previous stages (the real world is very different from the ideal one), then some last time adjustments could be needed to implement in the selected changes, in the real world.

11.11. Stage 10: Learning Points

Here the learning points from the sensitivity analysis of the problematic and solving system dynamics models computer simulation (Stages 4 and 7 in SSDM) can bring some insights to learn about the 'pathological' and the 'healthy' behaviour of the system being studied. For example, the concentration of power made by director D1 brought many and diverse kind of problems to Tubos S.A. and only the cultural acceptation of participative planning by the directors, allowed to improve the communication between D1 and D2 and from this, to reshape the strategic behaviour of Tubos S.A.

On the other hand, the implementation process Stage 9, can also bring about some insights from the experience of implementing what is proposed at Stage 6, for learning purposes. The way how to do participate planning for example, or how to improve the communication between de directors, can have special issues to treat that only can be seen at this stage. Both learning experiences, one theoretical and the other from the real world will help very much in the adjustments and learning process of the analysts for tackling future problematic situations using SSDM in the same problematic situation (i.e. Tubos S.A) or in a new one.

12. CONCLUSIONS

- In this paper, the framework of SSDM, a type of multi-paradigm and multi-methodology systemic practice that have been used extensively in LA has been revisited and its 10 steps outlined in some detail. The emergence of SSDM can be seen as part of the recent developments that have occurred in the system dynamics community.
- The ontological, epistemological and methodological premises underpinning SSDM and its constituents, SSM and SD have been discussed and the rationality for combining some stages of SD and SSM in an integrated framework have been presented and discussed. SSDM as a methodological tool can be located alongside the recent developments in of SD community; these fields include: Holon Dynamics, Interactive Dynamics (Group Model Building) and Modelling Radical Learning (Lane, 1999, 2001a,b).
- The methodology described includes 10 stages and 2 systemic loops which forces the practitioner to visit SSDM 'three worlds': (i) Real World (SSDM's World 1); (ii) Problem–Situation-Oriented Systems Thinking World (SSDM's World 2); and (iii) Solving–Situation-Oriented Systems Thinking World (SSDM's World 3). By traveling through its two loops the methodology becomes a useful framework and arena for debating both the 'whats' and 'hows' concerning a particular 'Problematical Situation' in a dialectical way. And we say that it is a dialectical approach as well, due to the fact that in the first loop, it is seen one face of the coin (the problematic view of the Problematical Situation) and in the second loop it is seen the other face of same coin (the 'solutionatic' view of the mentioned Problematical Situation).
- An important distinction in SSDM as regards SSM is the way how Root Definitions are built and used. SSDM adheres to a dialectical approach; Root Definitions here are built in two different ways: When we are in the first loop (SSDM's World 2) then Root Definitions described the problematic transformation process which is culturally feasible and systemically desirable in that situation. When we are at the second loop (SSDM's World 3), then Root Definitions describe what we call the

'solutionatic' transformation process which should be culturally feasible and systemically desirable, to be implemented in the real world. This fashion of building and using Root Definitions differs significantly in the way that SSM constructs and uses Root Definitions.

- Additionally, the paper highlights the advantages of the combined use of SD and SSM under the SSDM framework, the main being: (i) It introduces explicitly the observer's weltanschauung and the observer's role in SSD studies; (ii) It proposes and allows to implement desirable and feasible changes in the real world; (iii) It allows, through the computer simulation over time, to measure and asses the kind and intensity of impacts, due to the behaviour of the variables studied in the problem situation (Stage 4) as well as in the solving situation (Stage 7); and (iv) It allows to analyse *n* different possible interpretations on the 'problematic' and 'solving' behaviour of a situation in the real world.
- The use of SSDM has been briefly illustrated by an application to a small Peruvian company: 'Tubos S.A.'; here SSDM can be seen as a learning process from both, the problematic situation which is being analysed, if we do iterate in an attempt to gain more understanding of it, as well as proposing 'solutions' for it, from diverse weltanschauungen, getting then, more insight into the situation and adding richness to the systemic intervention.
- Although SSDM has been in use for some time, known and properly tested in various scenarios, the authors do not claim that the methodology is free of possible adjustments and it is not in any way a finished work, thus comments and criticisms are welcome.

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