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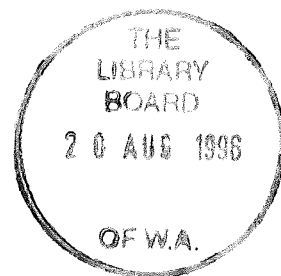
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PREFACE

The depth and variety of papers in this volume are a testament to the applicability of systems thinking to a wide range of problems. The complexity of modern management demands approaches that take into account not only difficult technical challenges, but also the various views and perceptions of those involved in the problem situation. The following papers are a small subset of the work being done to rise to this challenge. Systems methodologies and techniques will shape the future. They provide an avenue to attempt to solve the myriad of environmental, social, business, and technical problems that face us. Systems approaches help us to understand the basis of many present dilemmas. This understanding plus associated techniques make system "science" a discipline for the future.

ACKNOWLEDGMENTS

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Section 1

Keynote Addresses

SOLVING PROBLEM SOLVING: TSI -
A NEW PROBLEM SOLVING SYSTEM FOR MANAGEMENT

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SOLVING PROBLEM SOLVING: TSI -
A NEW PROBLEM SOLVING SYSTEM FOR MANAGEMENT

1. INTRODUCTION

For a number of years we have been developing a problem solving system that overcomes core unresolved theoretical and methodological problems, yet remains a practically useful tool (Flood and Jackson, 1991a,b; Flood, 1993a, 1993b, 1994, 1995a). In a sense we have been solving problem solving (1995b). Main problems in problem solving were tracked down and a number of critical success factors worked out from these. Success factors most relevant to this paper are given below.

- A problem solving system is needed that incorporates powerful tools to stimulate and provoke creative and perceptive thought about organisation and organisational problems.
- A problem solving system is needed that guides managers through the process of choosing methods relevant to the problems that they face.
- A problem solving system must include procedures that are critical of outcomes it generates and must include procedures which ensure that the system remains critical of itself.
- A problem solving system must not be shallow or gimmicky.
- Problem solving must be fun.

A brief account of the problem solving system that we have designed, called Total Systems Intervention (TSI) is given in this paper (a full account is given in Flood, 1995b). The title is explained below.

- It is called Total Systems Intervention.
  Total: It draws together and integrates methods for
  - *creativity* (to think creatively and perceptively about problems faced)
  - *choice* (to choose (a) method(s) relevant to those problems)
  - *implementation* (to apply chosen methods to tackle those problems).
  Systems: It guides managers toward a whole or systems view. It takes into account all relevant aspects of a problem solving situation. It deals with whole systems. It is a total problem solving system.
  Intervention: It is an activity that brings about progressive improvement where problems are found through intervention - Total Systems Intervention.

TSI has been used in a significant number of organisational contexts. Case studies in Flood (1995b) report on problem solving in Australia (by a finalist in Western Australia's Best New Exporter 1991), Hong Kong, Japan, Kenya, Singapore (by Singapore's Entrepreneur of the Year 1993), South Africa, Taiwan, United Kingdom, United States of America, and a country in the Middle East. The case studies cover problem solving in air transportation, bunker transfer, car sales, community projects, computer site preparation, the construction industry, consumer products, custody of offenders, entertainments, financial services, health care, hospital administration, management consultancy, mining, policing, search and recovery, and tourism. Unfortunately there is insufficient space in this paper to introduce these interventions. The main task of this paper is to introduce the problem solving system TSI. To start with, however, the need for a new problem solving system is discussed.

2. DO WE NEED A NEW PROBLEM SOLVING SYSTEM?

Well developed problem solving skills are vital possessions that all successful managers must hold. This is because managers essentially are problem solvers. Complementing, expanding and improving problem solving skills as recommended in this paper will help managers to cope even more effectively with organisational problems that they face and will broaden their perspective on how to face them (what is meant by 'organisation' and 'problem' is detailed later).

Making improvements to problem solving skills is important. Unfortunately several obstacles get in the way. There are perhaps three main obstacles.
- Time available for managers to make improvements is limited.
- Help given to managers seeking to make improvements is not good enough.
- Making improvements means change that may seem threatening to managers and not in their interests.
So, what can be done?

It is relatively straightforward to reason out what can be done and where to begin. Time available for managers can only be increased if they are able to do their work more efficiently and effectively. To do work efficiently means to work without any unnecessary waste in time or resources. To do work effectively means to achieve chosen tasks. Being more efficient and effective is only possible if managers' skills are improved. Improving the skills is only possible if the help given is good enough. The help given is not good enough. We need to begin, then, by substantially improving help given to managers and to convince them that it is in their interests, and the interests of those they work with, to make improvements. The help that we offer comes in the form of TSI.

The remainder of this paper is dedicated to introducing TSI in terms of its philosophy, principles, and process - the three Ps of TSI. Presentation begins with the philosophy.

3. A PHILOSOPHY FOR PROBLEM SOLVING

The main idea of TSI's philosophy is that we think about places in which we work as whole human organisations. It is only when a good understanding of organisation of as a whole is grasped, by taking into account the viewpoints of all concerned, that effective management can be achieved. If we fail to develop a whole understanding then unnecessary things will happen that foil otherwise well thought-out plans. When applied to the many forms of organisation, then, TSI insists that we assume an adaptable and negotiable stance so that we are able to develop and work with a whole view of them. (*Attention must be paid to my intended meaning of the term '(an) organisation(s)' in this text. TSI's understands '(an) organisation(s)' in terms of relationships between people that transcend the traditional appreciation set by a boundary being drawn between the internal organisation and its external clients. It is more realistic to appreciate '(an) organisation(s)' in terms of various forms of human relationships rather than separate organic social entities. Wherever and however employed in this text, the term '(an) organisation(s)' must be interpreted in the preferred way as just stated.*

With TSI, organisation is conceived of as a whole system that comprise parts which are continually interacting. Parts form a system (the horizontal dimension) that is a subsystem of a larger system and has subsystems itself (the vertical dimension). Organisation is therefore thought about as if it were a vertically and horizontally integrated series of systems.

The question remains how we can enrich our understanding of the whole organisation in these systemic terms. The following four key dimensions of organisation guide our thinking. We need to have a thorough understanding of *organisational processes*, the flows and controls from suppliers right through to consumers, including parties such as stakeholders with an interest in events. We need to understand *organisational design* within which the processes happen. This means identifying the possible functions of organisation, and how these functions (rather than lines of authority) are controlled and co-ordinated.

We must also appreciate *individual and cultural differences and similarities* that exist between people. People are different. People need different things, respond to things in different ways, and understand things differently. In this sense, there is no single organisation. There are as many forms of organisation as there are people thinking about the forms.

Despite this differentiation, cohesion can be attained. This is partly because of the possibility of corporate culture. A strong corporate culture with good cohesion comprises people who share a common history, hold a common understanding, and have a common sense of belonging. Corporate culture is where people who feel they belong to a corporation share many ideas, such as social rules and practices, although there will rarely be a total overlap. However, in a dynamic corporation differences of opinion or interest inevitably arise. A number of these will be expressed through organisational politics.

Having an appreciation of *political dynamics* helps to round things off, to complete the whole picture. It is important to know who holds power and how this power is used to serve certain interests. It leads us to explore who is in a position to bring resources or biases to bear to get their own way. The question is, 'Who in the scheme of things may be regarded as influential in determining strategy, policy, and what people do?'. It also allows us to examine how power may be spread in ways which indeed subvert official positions of power.

It is therefore the argument of TSI that we can only get to know about forms of whole organisation if we develop understanding in terms of 'control' in the following four key dimensions.
* *Organisational processes* - flows, and controls over flows.
* *Organisational design* - functions, their organisation, co-ordination and control.
* *Organisational culture* - mediation of behaviour in terms of people's relationship to social rules and practices.
* *Organisational politics* - power and potency to influence the flow of events.

Unless all four key dimensions of organisation are taken into account, i.e., a whole system view is developed, then problem solving is bound to be ineffective. It will be

ineffective because crucial influential factors will have been neglected. Leaving influential things hidden gives rise to a predominance of unexpected and usually unwanted changes. Allowing organisational activities to be run in this way leads to ineffective management.

The problem solving system TSI must therefore operate a system of methods that is able to deal with problems arising from each of the four key dimensions. There are methods available to do this. Methods can be grouped according to which key dimension they are best suited to, i.e., what types of problem they are judged by their users to be best at tackling. Each of the key dimensions of organisation is the source of a type of problem, which accordingly means that there must be four main types of problem solving method.

The image of organisation pieced together above builds a framework on which an ideal whole system view can be constructed. The ideal can be captured as a model of organisational dynamics that helps to achieve effective management. The model is an ideal because it represents the ideal dynamic of organisation from a TSI perspective. It is an ideal picture of organisational dynamics that we would like to achieve by employing TSI. Of course, ideals can never be achieved. The point is that we should try to approximate the ideal as best as possible. The ideal whole system view has six stages of construction as set out below.

- *Organisational forms comprise technical and human activities.* Organisational activities are represented by an interactive mixture of technical (organisational processes and organisational design) and human (organisational culture and organisational politics) activities. The whole system framework is, then, a horizontally and vertically integrated set of technical and human activities.
- *Organisational activities must be efficiently and effectively controlled (i.e., co-ordinated and mediated) whilst maintaining viability in-line with TSI's principles (see next section).* Activities are co-ordinated and mediated by technical procedures, and socio-cultural and socio-political rules and practices. Procedures, rules, and practices must attune, so that viability is achieved.
- *Organisational activities must be directed to achieve some purpose.* Human organisations normally have an officially declared mission to which activities are directed. Ideally this purpose will allow for interpretation and feedback between the declaration and implementation of purpose.
- *People appreciate organisational events in different ways.* Individuals and groups naturally make their own interpretations of events, the way they are controlled, as well as organisational purpose. They hold a view of their own role and purpose in organisational activities. It is this divergence that generates vital organisational dynamism. However, it can cause fruitless discord, a lack of cohesion, inefficiency, ineffectiveness, and ultimately non-viability. It can lead to polarisation with people rigidly adhering to their own position. Even shades of difference can lead to non-negotiable conflict in the long run. People's views therefore must be taken into account as a matter of course and conflict must be resolved or measures taken to accommodate differences fairly.
- *The previous two stages must be harmonised through organisational design and management style.* An organisational design and management style must be chosen that balance people's needs with organisational needs, remembering that organisational needs will also reflect the business or organisational context.

- *Managers and problem solvers must accept responsibility for the impact of their decisions and policies on the physical, biological, and social environment.*

When applied to organisational problem solving, TSI extends this systemic understanding of organisation. Of great importance here is TSI's awareness of the process of problem solving. For TSI, problem solving actually means getting to know about and then managing interacting issues as opposed to solving identifiable problems. (*Despite adoption of the term problem in this text - for readability - TSI's actual position is that there is no such thing as a problem, only interacting issues to be managed. 'Problem' must be read in this text to mean 'interacting issues'*). Problems arise from the interaction of technical and human activities, how they are co-ordinated and mediated, interaction of organisational activities with other factors, organisational mission, organisational design and management style, people's interpretations of these, and how people choose to exert power that they hold. Problem solving is a particular type of human activity that by definition is also a part of organisational activities. Organisation, then, can be understood as a complex of interacting activities and problem solving as a continuous process of managing them. Problem solving is a part of the problem to be dealt with.

Intervention accordingly will go something like this. Problems are surfaced through creative thinking. By undertaking careful and communicative reasoning, an approach most suitable to tackle the problems surfaced is chosen. Change proposals to deal with the problems are worked out using the chosen approach. Implementation of change proposals takes place. Some problems are dealt with purposefully and directly, some purposefully but indirectly, whilst others are surprisingly impacted on as a result of our never having an absolute understanding of the whole organisation. These surprises are counter-intuitive, i.e., things that occur counter to our intuitive understanding where formal analysis has not penetrated. New problems arise as a further consequence of implementation. Organisational dynamics, described in the form of problems, changes, and reformulated implementation directed at new problems takes place. TSI therefore is a continuous process of dealing with problems throughout whole organisations. This is the philosophy of TSI. Let us now move on to the next section and to the principles of TSI.

4.   PRINCIPLES TO ADHERE TO

Principles for problem solving are extremely important. They guide action and provide a mechanism to evaluate intervention. A TSI intervention must be evaluated against its own principles. If and only if intervention operates according to the principles established in this paper can the intervention be said to be a valid use of TSI. As a minimum, this means in practice endeavouring to achieve the principles.

There are four main principles - being systemic, achieving meaningful participation, being reflective, and the goal of enhancing human freedom.

The foundational principle tells us to study organisational forms as if they were *systemic.* This means 'take into account the whole'. It also means that there is a form of hierarchy. 'The system' under study is a part of a greater whole. It also comprises

interacting parts. For TSI the hierarchy comprises technical (organisational processes and organisational design) and human (organisational culture and organisational politics) activities at three hierarchical levels - 'the system', 'the subsystems', and 'the suprasystem'. 'The system' is always the hierarchical level that becomes the focus of attention, although the level focused on may change during analysis. All interactions between all parts, of technical and human sorts, at the three levels must be taken into account during the process of continuous management of problems. This principle helps to prevent undesirable counter-intuitive consequences from occurring. It therefore leads to more effective management.

The principle of *meaningful participation* follows the systemic principle. If we are to develop an adequate appreciation of all interactions between all parts, of technical and human sorts, at three levels at any one time, then the perceptions of all people involved and affected must be drawn into the picture. To a large extent organisational events are what people think they are. It is important therefore that we know what people think. If participation is not achieved then only a limited understanding of organisation can be developed. This is not a whole system perspective, meaning the systemic principle is violated. This will lead to less than effective management.

The principle of *reflection* follows the previous two principles. There are two reflective needs with TSI.
* To reflect upon the relationship between different organisational interests - demonstrating that people may be dominated who, as a result, cannot meaningfully participate.
* To reflect upon the dominance of favoured approaches to intervention - demonstrating where the use of one (or a few) method(s) prevails, restricting the capability of managers to tackle effectively the full range of technical and human issues that they face.

The first reflective need is to pinpoint where power is exerted and domination over people exists, throughout the organisation. Often a dominant view holds sway. Domination prevents meaningful participation of involved and affected people and the inclusion of their viewpoints in decision making. This in turn means that less than a whole system understanding is achieved during analysis and that fair practice in generating change proposals is hence compromised.

The second reflective need is to overcome a common mistake made by problem solvers. Normally they use a small number of methods with restricted problem solving capability. They do not know about the limitations in the methods they are using. Each method is limited, however, in the kinds of problem that it is best employed to tackle. A full range of approaches is required, sufficient to tackle all sorts of technical and human problems in the four key dimensions of organisation. This can be achieved through critical reflection on the strengths and weaknesses of each method, thus bringing these matters to the fore and so linking methods to the sort of problem they are best directed at. Alternatively, if methods are being used to deal with problems they were not originally designed to address, the consultant or manager should be made aware of this through critical reflection.

The reflective principle can be summarised neatly as follows. The first reflective need is to ensure that a whole system understanding is achieved - surfacing all problems to be dealt with. The second reflective need is to ensure that all problems are dealt with - employing methods as and when relevant. Achieving both needs promotes fair and effective management.

The fourth principle introduces TSI's ideology and indeed its moral justification. TSI argues that an explicit ideology of human freedom must enter management practice. This ideology is a personal commitment for some people, but I am also introducing it in TSI as a part of a coherent theory about effective management. It logically follows the preceding three principles. Freedom is enhanced through the process of reflection. Reflection helps to achieve meaningful participation, which in turn promotes being systemic and taking into account the whole. Taking into account the whole is an important step toward better informed management, effective problem solving, and minimising counter-intuitive consequences. Let us now turn to the process of TSI.

5.   PROCESS OF TOTAL SYSTEMS INTERVENTION

The process of Total Systems Intervention (TSI) has three modes of operation (which are operationalised in Flood, 1995b).
- Critical Review Mode.
- Problem Solving Mode.
- Critical Reflection Mode.

The Critical Review Mode reviews critically methods bidding to be incorporated in the Problem Solving Mode of TSI and helps to construct a system of methods. It does this by assessing the ways in which methods under review can be incorporated within and operated by the process of TSI. The Problem Solving Mode of TSI employs a system of methods for problem solving brought together through the Critical Review Mode. The Critical Reflection Mode uses the three phases of TSI to help problem solvers to reflect upon the adequacy of the output of the Problem Solving Mode. The three modes are discussed below.

6.   CRITICAL REVIEW MODE

The process of TSI guides the problem solving process by employing methods for creative thinking, choice of method(s) for implementation, and the use of those method(s) to develop and implement innovative change proposals. To do this TSI must incorporate problem solving methods in its schema. It must develop a system of methods. It does this by critically reviewing methods bidding to be incorporated in the system of methods operated through the Problem Solving Mode, using to structure the critique the three phases of TSI and the four key dimensions of organisation. The critical review has two starting assumptions that are tested out. The two starting assumptions enrich the process of TSI by encouraging variety in the methods employed in each of the three phases.

The first starting assumption is that each method undergoing review advocates forms of creativity, choice, and implementation. Procedures are given that help problem

solvers to learn about each method in terms of the three phases. Assessing a range of methods in this way provides a wide knowledge about what can be done within each phase of TSI. Procedures are given that then help problem solvers to choose the most suitable way of carrying out each phase taking into account the circumstances.

The second starting assumption is that each method asks four questions that respectively reflect the four key dimensions of organisation (process, organisation, culture, and politics): 'How can we efficiently design processes?', 'How can we realise effective organisational design?', 'What options should we debate and decide upon?', and 'Why should we accept a design or a decision, who is likely to benefit, and has fair practice operated in generating these change proposals?'. The questions help us to highlight which of the key dimensions each method addresses. Procedures are given that help problem solvers to understand exactly in what way the methods address the four questions. On the basis of this, problem solvers when using TSI in the Problem Solving Mode will be able to choose the most suitable method(s) for implementation in the circumstances.

7.   PROBLEM SOLVING MODE

7.1   Introduction

As already mentioned, the process of TSI has three phases in the Problem Solving Mode: Creativity, Choice, and Implementation. You will be very familiar with these by now. The activities are brought together in Figure 1. The cycle is a continuous process with no predetermined start nor finish point. It is a continuous process that promotes creative thinking about the organisational 'mess', surfaces and demonstrates the interacting nature of problems, and helps problem solvers to deal with them. The problems are an appreciation of organisational complexity arising from technical and human activities. The circular process operates in both clockwise and anti-clockwise directions. The clockwise direction is the Problem Solving Mode dealt with in this section. The anti-clockwise direction is the Critical Reflection Mode that is picked up in the next section.

The process (Creativity, Choice, and Implementation) in the Problem Solving Mode operates in the following way. Each phase has a task, methods, and expected outcome. The outcome is passed on to the next phase. That next phase uses the outcome from the previous phase to help achieve its given task drawing upon methods relevant to its task. The resulting outcome is passed on to the next phase, and so the process continues.

Starting with the Creativity phase, the process works as follows. The task of creative thinking is to surface problems to be dealt with, to demonstrate the interacting nature of the problems, and to identify the core ones. It does this by using methods for creative thinking that break-out of current assumptions and get to grips with core problems to be dealt with. A range of methods that promote creative analysis are employed here. The outcome is a set of interacting problems with the core ones highlighted. This appreciation is passed on to the Choice phase.

The task of the Choice phase is to choose (a) method(s) which has/have an immediate and given purpose for implementation that will deal with the problems surfaced by creative thinking, concentrating on the core problems that have been located. The need is to tackle the most pressing problems, the core ones, whilst managing as broad a spread of the interacting problems as possible. The trick is to remember that the problems are interacting and that each method will generate change proposals that cut across them in a different way, affecting many problems but dealing with them differently by concentrating on the most pressing ones to start with. The task then becomes a matter of choosing the most suitable method in the circumstances. The outcome, which is a choice of method(s) that will be used to come up with innovative change proposals, is passed on to the Implementation phase.

The term 'circumstances' is used above in a systemic sense, to mean the whole situation. The whole situation means everyone and everything. The notion of suitability therefore is subject to those circumstances. It is not the case that there is literally a right method independent of the problem solvers. If circumstances change such that there is a different mix of people, the decision on suitability may change too. It all depends on circumstances and the involved people are part of those circumstances. The Critical Reflection Mode helps to judge suitability in the circumstances - a point that must be remembered whenever problem solving.

The task of the Implementation phase is to employ the chosen method(s) from the Choice phase to deal with the problems surfaced by creative thinking. The chosen method(s) is/are used to develop and implement innovative change proposals that tackle the given problems. The outcome in the form of innovative change proposals is implemented and is also passed on to the Creativity phase.

The task of the Creativity phase is to continue to surface problems to be dealt with, to demonstrate the interacting nature of these problems, and to highlight the core ones. By this time problems will have changed because proposals will already have been implemented. The process continues from hereon in the manner described above, taking into account changes occurring as a consequence of implementation of proposals.

The process of TSI in the Problem Solving Mode is best thought of as a singularity, that is, it is one integrated whole. The purpose of separating out three activities, Creativity, Choice, and Implementation, is to explain the singularity and the process. Each one distinguishes and focuses on a type of activity that is carried out in the process of TSI, however, no phase exists independently as might be mistakenly assumed from the above presentation. At any one time each phase comes in to play, although one of the phases may be in sharper focus than the other two. A description of the process of each of the three phases in the Problem Solving Mode will now be given.

7.2   Creativity

Each of the three phases of TSI can be found actually within each of the three phases. That is, the three phases coexist in a recursive structure. Figure 2 illustrates this point. Creativity, the first phase to be covered, is best understood therefore as

the subactivities, creativity, choice, and implementation. However, each subactivity takes on its own meaning within the Creativity phase as seen later.

The aim of the Creativity phase is to surface problems to be dealt with using creative thinking. This involves both divergent and convergent thinking. These two forms of thinking are briefly discussed below.

Divergent thinking helps people to get unstuck by appreciating the situation from many different angles, and considering the viewpoints that others may have on the situation. Appreciating things in this way surfaces problems to be dealt with that are otherwise hidden or not previously thought of. Divergent thinking is therefore creative.

Convergent thinking works in co-operation with divergent thinking, converging on problems to be dealt with. Convergent thinking makes sense of the diversity of possible problems generated. It converges on core problems that must be dealt with.

So, in terms of the recursive structure, divergent thinking provides the *creative* input necessary to surface a wide range of problems to be dealt with. It does this by looking at organisational complexity from many angles, including the four key dimensions already mentioned, taking into account other people's viewpoints. Convergent thinking then *chooses* the core problems that must be dealt with. *Implementation* of the choice of core problems follows by passing them on to the Choice phase.

7.3   Choice

The aim of the Choice phase is to choose (a) method(s) which has/have an immediate and given purpose for implementation that will best deal with the problems surfaced by creative thinking, concentrating on the core problems that have been located. The process of Choice has choice of method as the main concern, although aspects of creativity and implementation are also found.

The process of choice of method for implementation is built upon the philosophy of TSI and its systemic view of organisation. Organisation, to be understood as a whole, must be analysed in terms of control in the four key dimensions introduced earlier.

Problem solving must take into account all four key dimensions to be effective. The problem solving system must therefore incorporate the following four types of problem solving method that each tackles problems from one of the four key dimensions of organisation.
- Methods that address the question 'How can we design the most efficient organisational processes and arrange their implementation?'.
- Methods that address the question 'How can we achieve effective organisation?'.
- Methods that ask 'What options should we decide upon, that debate technical and human issues that arise in organisational dynamics and lead to decisions on what to do about them?'.
- Methods that ask 'Why a design or a decision should be adopted that merely serve the interests of dominant groups, rather than balancing individual and

organisational needs, taking into account physical, biological, and social environments?'.

The four key dimensions of organisation can only be managed if problem solving methods are used in a complementary way. Methods are employed when they are most suitable in the circumstances to address core problems identified, but will be replaced by another method(s) when core problems change. Core problems change because all forms of organisation are dynamic, and part of that dynamic is intervention using problem solving methods.

The process of choice of method for implementation is in-line with the principles of TSI. The process of choice accords with the principle of human freedom which in turn provides support to the three other principles, reflection, participation, and being systemic (discussed in the previous section). The four main types of problem solving method necessary to deal with problems arising in the four key dimensions of organisation, address the need to guarantee as far as possible human freedom. This guarantee can be shown to exist for each one as summarised below.

Technical activities centre on the desire for some level of prediction and control. This is catered for by methods that *design freedom into organisational activities in the form of efficient organisational processes and effective organisational design.* For human activities methods have been established that encourage *freedom through open and meaningful debate.* Also focusing on human activities are methods that generate debate about individual and group *freedom, freeing people from dominating designs and decisions.* TSI's principle of human freedom is therefore supported by each of the four main types of problem solving method used in TSI's process, but interestingly, support comes in four different although mutually reinforcing ways.

Each type of method is reciprocal. We need to have efficient designs for processes and effective organisation that meaningfully involve people at all levels and across all functions so that activities operate well. The amount of efficiency and effectiveness realised from the designs depends upon there being an adequate understanding about how to operate the designs, roles to be played by people according to the designs (and their interpretation of the designs), how each role contributes and fits into the whole design, appreciation of the benefits and meaningfulness of the whole, etc. This means that people must learn about and understand these things, which requires open and free debate. Now, when designs or outcome of debate are subject to dominating forces a means of overcoming the forces is essential so that meaningful participation is achieved. Explicit questions about why designs or decisions should be adopted helps to achieve more genuine debate, enhancing learning and understanding, making fairer decisions, leading to more meaningful work and maximum effectiveness and efficiency from designs. This allows argument into the dynamics of organisation. Designs and decisions are therefore operated through the principle of human freedom - which all adds up to maximum freedom.

This leads on to the process of choosing (a) most suitable method(s) to tackle the interacting and core problems brought forward from the Creativity phase. This is relatively straight forward. There are two steps.
- *Choose type of method* by linking problems to be managed to one of the four key dimensions of organisation.
- *Choose actual method(s)* from the set of methods grouped according to the key dimension that it/they serve(s), by assessing which one most clearly tackles the problem(s) in detail.

If none of the methods incorporated in the problem solving system can tackle the problems surfaced by the Creativity phase, then it may be necessary to design a method most suitable to the circumstances. Whichever, this is a *creative* process. *Choice* of method is then *implemented*. The method(s) chosen is taken forward to the Implementation phase.

7.4 Implementation

The aim of Implementation is to employ the method(s) chosen for implementation to deal with the problems surfaced by creative thinking. The chosen method(s) is/are used *creatively* to develop, *choose,* and *implement* innovative change proposals that address the given problems. The process of Implementation employs method(s) for implementation as its main concern, although as just intimated, aspects of creativity and choice are also found. The process of implementation is carried out in-line with the immediate and given purpose, and guidelines of the chosen method(s).

Output of all three phases of TSI in the Problem Solving Mode are subject to further analysis through TSI's Critical Reflection Mode.

8. CRITICAL REFLECTION MODE

The process Creativity, Choice, and Implementation, in the Critical Reflection Mode, works as follows (see Figure 1). The Critical Reflection Mode operates in the anti-clockwise direction, raising questions about the outcome of the three phases. It does this by asking in the circumstances the following questions about the output of the phases.
- Is/are the method(s) used the most suitable one(s)?
- Is/are the output(s) of the method(s) appropriate?

This form of analysis is explained below for each of TSI's three phases.
- The Implementation phase receives (a) method(s) reasoned to be most suitable for managing the problems surfaced by the Creativity phase. It also generates innovative change proposals using the(se) method(s). Implementation's critically reflective position asks, 'Is/are this/these method(s) and the innovative change proposals it/they generate(s) most suitable given the circumstances?'.
- The Choice phase receives details of problems to be managed and on the basis of this chooses a method for implementation. Choice's critically reflective position asks, 'Is this an adequate appreciation of organisational events and is the method for choice capable of leading to the most suitable choice of method for implementation in the circumstances?'.

● The Creativity phase receives details of change proposals judged to be most adequate to manage problems surfaced by creative thinking. Creativity employs methods to continue the process of creative thinking. Creativity's critically reflective position asks, 'Were/are the change proposals most suitable to best deal with problems surfaced, and was/were/is/are the method(s) used for creative thinking the most suitable one(s) to surface core problems to be dealt with?'. It questions whether current practice needs to be altered.

Each phase, then, passes its outcome to the next phase in the clockwise Problem Solving Mode, but receives critical reflections on that outcome from the next phase in the anti-clockwise Critical Reflection Mode.

9.   CONCLUSION

The problem solving system TSI has been developed to provide managers with a practical and useful systems-based approach to problem solving. It offers procedures to integrate all methods for problem solving in a process which ensures that they are employed only to tackle the issues they are best suited to. TSI achieves this through three modes of its use: Critical Review Mode, Problem Solving Mode and Critical Reflection Mode. Ultimately this builds-up a system of methods for creative thinking, choice of method for implementation, and methods for implementation, within a reflective process that has three main phases. The phases are Creativity, Choice, and Implementation. Each of the three phases has three sub-phases, creativity, choice, and implementation, that follow in a recursive structure.

The process of TSI has matured over about eight years of practice and reflection upon this and its original theoretical foundations. TSI has been used by many consultants and managers in many countries. Its use has occurred in two ways: in consultancy, and in the process of management. The process of TSI arguably operates well in practice, although there is always scope for further evaluation such as checking across the board whether all organisational members agree about TSI's relevance. Research into this is and other problems of problem solving are currently in progress in the Centre for Systems Studies at Hull University.

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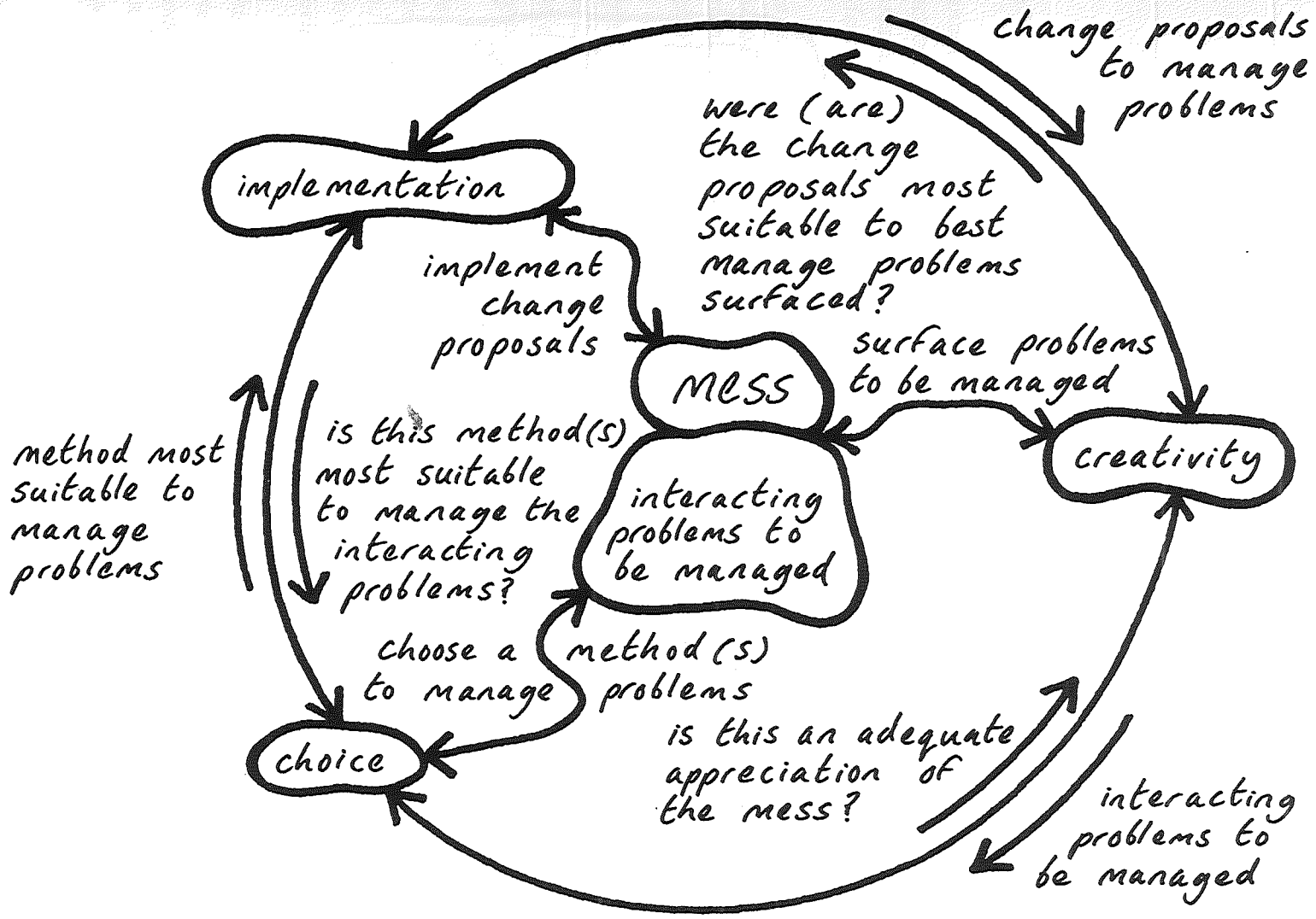
Figure 1.   The Problem Solving Cycle of Total Systems Intervention (TSI)
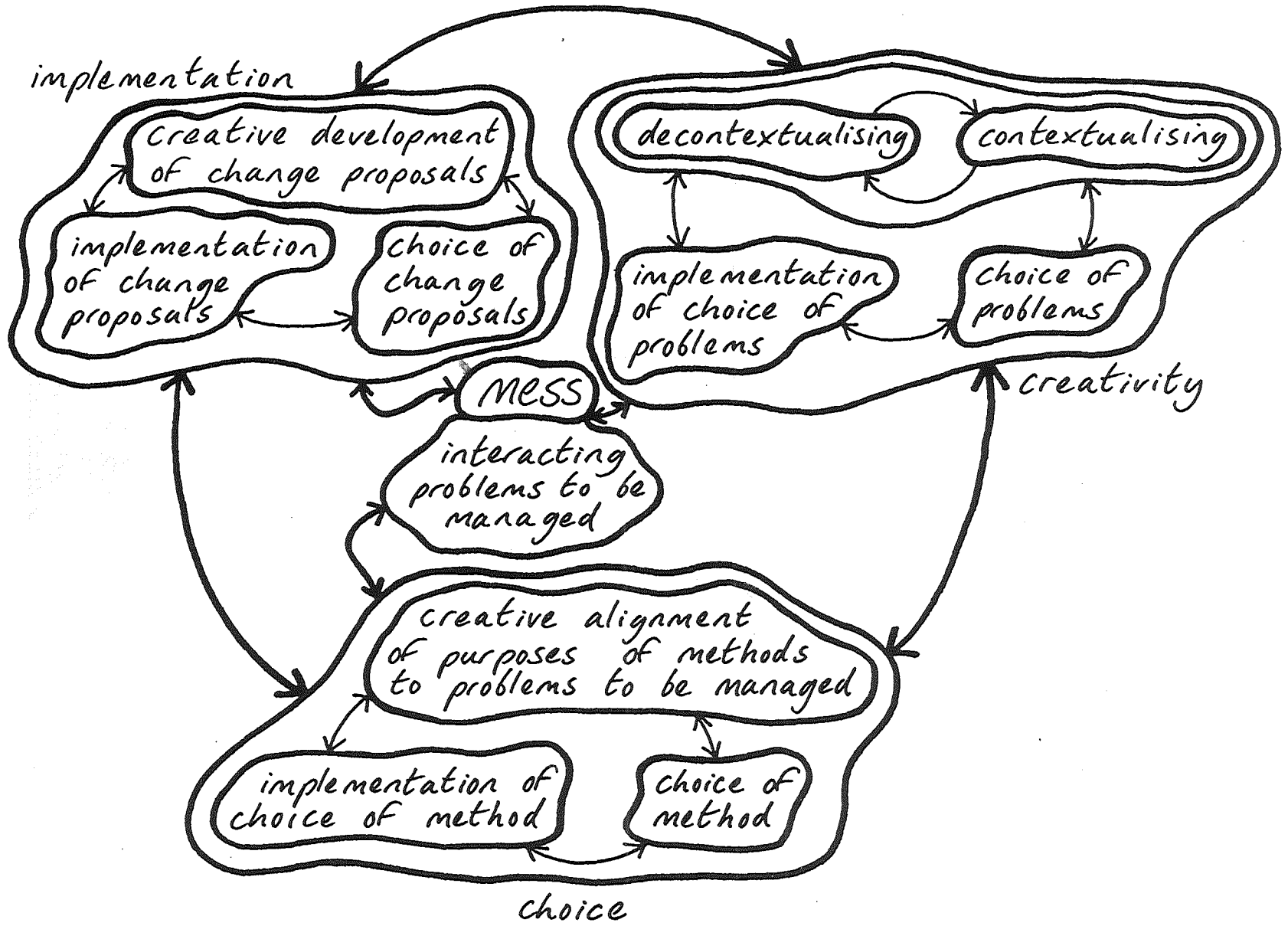
Figure 2.   Subactivities of the Three Phases of Total Systems Intervention (TSI)

THE ASSOCIATION OF SYSTEMS THINKING WITH THE PRACTICE OF MANAGEMENT

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Abstract

Managers work in systems known as organisations. These organisational systems are often functionally differentiated in order that the overall goals of the system may be achieved. In other words the model is that of a goal based system. This goal based model is readily accepted and understood by practising managers.

The goal based approach encourages 'straight line thinking' by managers in pursuit of efficient goal achievement. Problems demand rapid solutions and the straight line being the shortest distance between two points discourages the systemic thinking required to achieve a lasting rather than a satisficing solution to a problem.

Experience shows that many problems are of a recurrent nature in a host organisation, and that similar problems are felt across the organisational spectrum. Because of straight line thinking, the learning which should occur in problem solving is not being shared across the organisational spectrum and managers 'solve' the problem repeatedly.

Systems thinking has been associated with the development of methodological approaches for intervening in, and resolving, complex organisational problems. These approaches have not, by and large, found general acceptance in problem management by practising managers. They have been criticised as 'time consuming'; 'too academic'; 'not applicable in the pressurised world of real management'; etc.

This paper is an attempt to address this paradox. It will do so by reviewing some of the intervention methodologies which have been developed by the systems movement in a critical mode. It will then go on to discuss reasons why they are rejected by managers. This is a necessary debate for the Systems Movement if we are to make a real transition from the classroom to the world of business.

Introduction

Systems Thinking is an approach which involves:-
- The identification of a containing, or wider, system of which the system we are trying to understand is a part.
- An explanation of the behaviour of this wider, or containing, system.
- The explanation of the behaviour or properties of the system that interests us in terms of its roles or functions within the containing, or wider, system. (Ackoff; 1981).

For managers to manage anything they are having to cope with a constantly changing organisational scene over varying time scales from yesterday to five or more years from now. Modern day managers have to unravel and bring about improvements in situations that are problematical and complex. This need for improvement is a never ending task because the problem situations themselves evolve and change over time. We can assert that the solution for today's problem is the admission ticket to tomorrow's problem.

To manage effectively in such complex problem situations - which are the norm rather than the exception in today's business environment - then managers need to understand both their system of immediate concern (i.e. their own organisation) and the containing environment. This can be most effectively achieved through the use of the Systems Approach which involves the synthesis of the whole system in order to gain managerial understanding. This is sometimes referred to as the 'helicopter approach' which is the conceptual ability of managers to get above the 'nitty gritty' level of analytical detail and, through synthesis, look down on the whole system. Such an ability can be fostered through systems thinking and by managers taking a systems approach rather than the straight line thinking associated with the goal based approach.

Instead of thinking systemically, however, managers are being bombarded by the latest 'management fad'. The rate at which these fads appear is bewildering, and it has been found that managers can experience great difficulty in understanding the appropriate use and application of such fads. In recent times we have seen the emergence of Quality Circles; Total Quality Management; Just In Time; Material Requirements Planning; Planned Programme Budgeting; Benchmarking and Business Process Re-engineering amongst others. These have been promulgated as 'the way in which to improve organisational effectiveness. They are tools which can, and do, assist managers to answer 'how to do it' questions. However, all of these tools can only be really effective when 'what to do' has been properly specified by those who are capable of specifying that need.

'What to do' questions are inherently complex and need an approach which involves understanding the whole situation. Synthesis is a requirement and not an optional extra. Clearly a systems approach is needed to identify the 'what problem' prior to deciding which tool is required to address the 'how to do it' question. Managers, because of the adherence to the goal

driven approach, persist in deciding 'how' without understanding 'what' thus perpetuating the inability to learn through systems based problem solving.

Systems Based Intervention Methodologies

Space will not permit an in depth review of systems based intervention methodologies. Such a review can be found in Flood and Jackson (1991) and Jackson (1991). This treatment offered in this paper will be restricted to a brief statement of the main principles of the particular methodology being addressed. This will then be followed by criticisms that have been offered concerning why it has failed in terms of managerial acceptability.

Systems Engineering and Systems Analysis
These two methodologies are closely related in that they emerged from the application of scientific method to the military problems of the second world war. They are also examples of straight line thinking and are, therefore, accepted by managers in pursuit of organisational goals. Both methodologies assume a given and agreed objective and are concerned with the realisation of that objective through the optimisation of costs associated with alternative means of achieving the end. Such an approach assumes that all the participants in the problem situation will agree, not only with the problem definition, but also with the declared objectives and goals relative to the perceived solution. Neither systems engineering, nor systems analysis, are capable with dealing with multiple perceptions and therefore tend to fail in multi faceted managerial problem situations. Despite these shortcomings both methodologies have gained widespread acceptance in organisations largely due to their 'respectable' roots in scientific method. They both have 'rationality' as part of their pedigree.

Soft Systems Methodology
Soft Systems Methodology (SSM) (Checkland; 1981) emerged from the perceived failure of Systems Engineering and Systems Analysis to cope with ill defined problem situations. SSM claimed to be able to deal with multiple perspectives and the richness associated with problem situations involving human activity. Managerial reaction to SSM has varied from scepticism ('rich pictures' have been seen as too light-hearted), to taking too long, to 'nothing more than talking about action but doing nothing'.

Interactive Management
This is an approach rooted in the work of Ackoff (1981) and Warfield (1992), and is associated with achieving group consensus in complex problem situations through idea generation and model building. Some of the main criticisms levelled at this methodology include that it is time consuming - particularly for expensive executives; that decision making control is lost to a computer; that hidden agendas can still allow domination by a powerful few; that there is an over dependence on facilitator skills.

Viable System Model

Beer (1986) asserts that the Viable System Model (VSM), permits the diagnosis of the 'ills' of an organisation and the design of an organisation capable of dealing effectively with all operations. VSM has been criticised as far too academic; that it can only be used by those with relevant expertise; that it is not a methodology and will therefore produce inconsistent results.

Strategic Assumption Surface Testing

Mitroff and Mason (1981) developed Strategic Assumption Surface Testing (SAST), in order to address sets of interdependent problems in which the actual formulation of the problem is more important than arriving at a solution using traditional techniques. (Flood and Jackson; 1991). SAST has also been criticised for being difficult to use and, because of its adversarial nature, prone to causing rather than resolving conflict. It has also been accused of being very time consuming.

Total Systems Intervention

The 1970's and early 1980's were a time of great conflict in the Systems Movement, particularly in the UK. This conflict was associated with the 'soft' versus 'hard' debate with particular reference to methodology. The newly arrived 'soft' aficionados were super critical of the 'dinosaurial hard mob'. It appeared to many of us at that time that the only way forward was to hope for all out war in which one would emerge as the victor. However, a group of academics, critical of both 'soft' and 'hard' camps, emerged and produced Total Systems Intervention (TSI) (Flood and Jackson; 1991) which advocates Critical Systems Thinking as a basis for complementary use of all systems methodologies in problem management. The critics of TSI have argued that it is too dependent upon wide ranging expertise in all of the systems based intervention methodologies; that it has been designed for use within western culture and is not universally applicable; that it is complex in terms of its use of metaphor to understand and characterise organisations relative to problem situations; that it attempts to put the world of organisations into neatly packaged boxes which defies reality.

Commentary

The forgoing review was necessarily brief. To summarise, managers and major consultancy companies have failed to adopt systems based intervention methodologies on a general basis. These methodologies, which we in the systems movement claim to be effective in terms of problem management, still remain resident within the walls of academia, used largely by academics in their consulting activities. Some of the major reasons for this appear to be as follows:-

- Time consuming.
- Esoteric rather than practical.
- Concentration on 'what' needs doing rather than 'how' do we solve it.
- Academic toys.

- Non transferable in terms of expertise in application.
- Over concentration on theoretical development.
- Wishy washy sociological claptrap!
- Expensive, lock up too many expensive people for too long.
- We pay you to solve our problems not involve us in them.

The comments made above have been made by real managers working in real organisations. They are not figments of imagination. It is also necessary for us to note that many positive comments have been made with respect to the usefulness of systems based methodologies. However, it is the negative comments that we should be concerned and worried about.

The UK Systems Society 4th International Conference held in July 1995 (Ellis, et al (eds);1995) addressed Critical Issues in Systems Theory and Practice as the Conference Theme. One of these critical issues is the reason for this paper. It was a salutary statistic that less than 5% of those attending the UKSS conference were 'real world' practitioners. The UKSS has over 300 members, and yet less than 10% of the members are practitioners. The systems movement is dominated by academics and we need to ask ourselves - Why? Are the criticisms of our methodologies valid? If yes, what do we do about it? We could do nothing, or we could work out what strategy we wish to adopt to increase our penetration of the real world of organisations.

Earlier in this paper the topic of managerial fads was discussed. Managers appear to be able to identify with these approaches but appear to be either unwilling or unable to take on board the systems based intervention methodologies. The works of Tom Peters (1992) and Rosabeth Moss Kanter (1992) are routinely found in the 'airport bookshelves', but rarely do we see leading academic writers achieving this. Only Peter Senge (1990) seems to have achieved this transition of popularising academic work such that practising managers buy those books. The question is 'do they read and benefit from them?' If there is benefit then why do we seem to see a new fad every two or three years? Surely what we need to do is develop an approach which will not only be theoretically sound but also stand the test of time.

My personal view is that managers need to be systems thinkers in order to cope with, and manage, the complexity of modern organisational life. It is necessary for managers to be able to think and go beyond the latest managerial fad and understand their organisation as a system using both synthesis and analysis in the complementary manner advocated by Critical Systems Thinking. This means that we in the systems movement need to broaden our appeal through our teaching, research and consultancy work. We need to take our thinking out of academia and into the real world of organisations. We can do this through developing degree programmes at undergraduate and postgraduate levels which contain significant systems components; by developing our research programmes such that the output is applicable and useful to practising managers; by working with organisational managers on their problems to bring about effective

solutions. We must also develop Systems Societies which attract those practising managers to attend our conferences, workshops and seminars.

Such a vision will not be able to realise, but we need to make a start if we are going to convince our managerial colleagues of our worth.

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POSITIONING THE SYSTEMS MODEL TO CONTRIBUTE TO INNOVATIVE PROCESS IMPROVEMENT

Many process improvement approaches start by "mapping" existing processes and then examine the map to identify improvements. Inevitably this leads only to marginal and sometimes directionless change.

An alternative approach is to start from fundamental systemic thinking and then to develop, characterise and evaluate alternative system models as the basis for change. Choice can be exercised as to how innovative or visionary the models are.

The process then becomes the "who does what" implementation to make the chosen system work in practice. In addition, the same system model can be used to specify other attributes necessary for success - information, skills and other resources. Under a regime of continuous improvement the process implementation can be expected to change rapidly whereas the system model should remain robust.

Methods are reviewed and discussed using examples in the presentation which have been developed to keep the system model as the driver of change throughout the analysis and design and then to use it as a reference point for continuous improvement.

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POSITIONING THE SYSTEMS MODEL TO CONTRIBUTE
TO INNOVATIVE PROCESS IMPROVEMENT

This is a paper about some of the recent learning through practice that has occurred while working with consulting clients on innovative process improvement. The learning has taken place through working with clients in Europe and Australia from a background in system based approaches and in particular the Lancaster school.

The paper presents an alternative to mapping existing processes as a base for improvement. It suggests modelling the wider system, of which the process is a manifestation, as a basis for understanding behaviour and judging the extent of change. Choice can be exercised in positioning the model on a spectrum close to today's view or tomorrow's vision. The system model can be retained as a enduring point of reference throughout the analysis and design as focus for the change effort.

The starting point

A dilemma in process improvement work is whether to begin the analysis by mapping existing processes or to think afresh. Many approaches start with mapping the existing process in some detail. They then go on to examine opportunities for

> - elimination, sometimes of the process as a whole, more usually parts of the process where continuing to do it cannot be justified. Technology, such as EDI, is proving to be a way of eliminating activities such as invoice handling and can offer visionary approaches to process improvement.
>
> - streamlining, by removing players in the process where their involvement is of no real value.
>
> - substitution, where others such as contractors can perform activities more cost effectively and there are no overriding strategic reasons why they should not do so.
>
> - clarification of responsibilities where there is added value to the process from those who need to be involved in it.

Whilst this line of questioning may be sufficient, the changes stemming from

it may not be cohesive. The changes resulting from the approach could be in all directions - a scatter gun approach lacking direction and common vision.
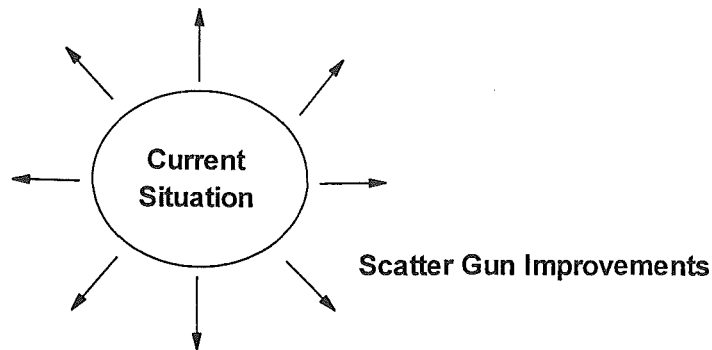
Alternative approach

The alternative approach is to spend some time on broader systemic thinking before any consideration of process. This takes the view that system is a wider and higher notion than process - a typical definition of system would include connectivity between processes and activities, elements of structure, resources and information that enables control and feedback.

In summary, the approach involves the following steps

> 1. Clarifying the desired future position by defining the wider system based on consideration of different stakeholder viewpoints and a "what for" challenge of current viewpoints.

> 2. Setting out the fundamental activities demanded by the system to form a basic system model.

> 3. Characterising and using the model to compare with the current manifestation of the process (or as the basis for immediate design if there is no process or it has been discarded).

> 4. Using the comparison to identify changes, not just to process but to the other elements of system as well.

> 5. Checking that the changes align and move the process as a whole towards the desired position and therefore give overall direction to the process improvement thrust.

The underlying idea behind the approach is not to work just from the current situation, but to use the desired position to drive the thinking and analysis.
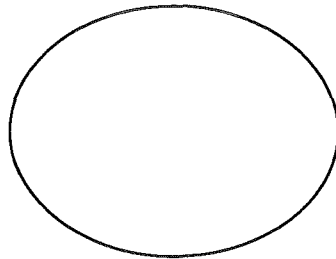
Current Situation   **Desired Position**

By clarifying the desired position as a system, changes can be determined which are aligned in reaching towards the future. The current situation can then be moved forwards as a whole.

Improved Situation
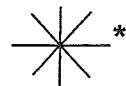
Clearer future (model)

Aligned changes
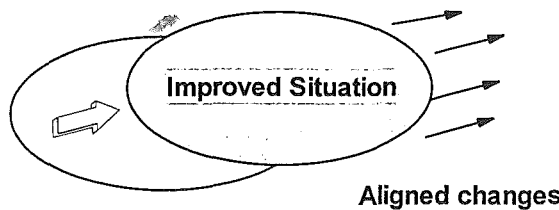
Note that the model itself is not implemented, but used to provide an overall direction for change. Use of the model throughout the analysis and design is discussed later in this paper.

Application

The approach is highly applicable to processes which are more difficult to define and which are inherently unclear. Generally, the more physical processes - Operating Processes - are easy to observe and often have many "givens" attached to them. They do not necessarily involve the operation of equipment, but do have a physical output such as a design or pre formatted analysis. Management Processes on the other hand are much more difficult to observe and define. This lack of clarity can mean that they can be particularly fruitful areas for improvement and can benefit from fresh thinking because they are not bound by physical constraints and have a wide scope for change. In addition, as the focus of management processes is on "doing the right things" rather than "doing things right", improvements to management process can have a spin off on the effectiveness of operating processes.
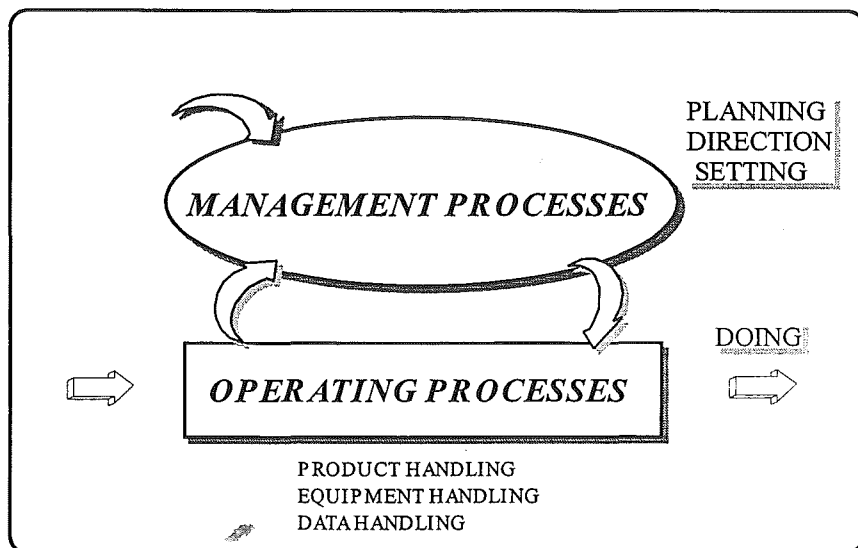
In addition, experience with several clients is showing that the system based approach is attractive to people who wish to enter the thinking and analysis from a fresh and wider perspective. However, some individuals do not find the uncertainty of outcome and conceptual thinking appealing and judge it to be time unduly time consuming in the more straightforward areas of the business.

In summary, mapping techniques seem to be of most value in the operational areas whereas a systemic modelling approach is likely to deliver results in the management arena. However, there is still the argument that in all cases time spent being a little clearer at the outset clarifying the desired position will always pay for itself in terms of subsequent improvement.

Practice

Having decided fresh thinking is appropriate where is the place to start from when confronted with a clean sheet of paper? What are the processes in a business? Which ones have the greatest potential for improvement? How to keep the systemic ideas alive as the thinking and analysis turns into design?

Identifying processes Before starting on process improvement it is necessary to identify the target processes. At the enterprise level, many organisations have built business models which set out all the processes within the scope of the business. These generally start with the overall process (often a physical one) and cascade this down, process to process, in greater levels of detail. A refinement is to clarify first the overall strategic management process, and then instead of process, to define the inherent structure of the business in creating value. Subsequent management and operating processes thus become much more specific. This specificity is won at the risk of changes to the business structure - but as that would only occur through some major acquisition or diversification it should be a rare event, and one which would warrant a reworking of the model.

CASCADING APPROACHES

CONVENTIONAL	STRUCTURAL
PROCESS	PROCESS
⇩	⇩
PROCESS	STRUCTURE
⇩	⇩
PROCESS	SPECIFIC PROCESS
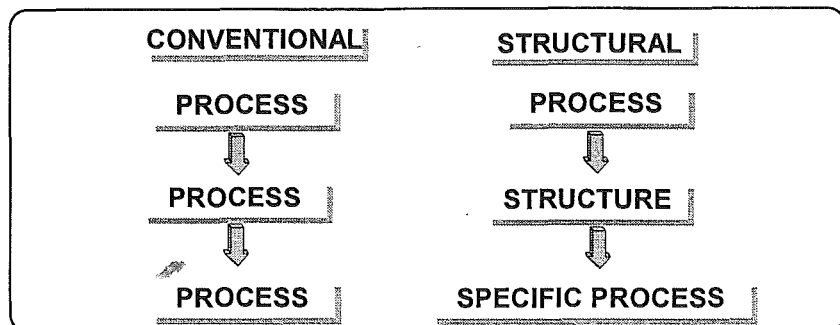
Clarifying the purpose At the individual process level, in Step 1 the approach uses stakeholder analysis to challenge the fundamental purpose (the "what for") of the wider system. This simple device can bring about some startling results - for example an offshore supply base that considered itself to be in the "materials" business came to see that it was in the "movements" business. As a result it eliminated the warehousing process except for transitory storage and produced dramatic savings. This would not have occurred with process mapping of "what is".

Positioning the modelling At both levels, there is a choice to make about positioning the modelling - this can be close to "today's view" of the business or "tomorrow's vision". Modelling close to today's view is effectively

nominating and mapping the existing situation and will provide clarity. Modelling closer to tomorrow's vision however can be used as the driver of change, having made a choice on how visionary the model should be, given the organisation's capacity to change.

Positioning the modelling:

TODAY'S VIEW

BUSINESS SYSTEM

Hierarchical
- highly structured
- long lines

PROCESS
- highly defined
- procedural

BUSINESS SYSTEM

Team based
- flat structure
- work groups

PROCESS
- aggregated plus sub processes

BUSINESS SYSTEM

Professional
- autonomy
- self management

PROCESS
- accommodating
- work flow

BUSINESS SYSTEM

Networked
- outside interactions
- responsive

PROCESS
- external roles
- accessible info.

TOMORROW'S VISION

Step 2, activity modelling, is described fully in the literature. Each resulting system model will have constituent elements of the system associated with it - the necessary processes, information, skills and so on. The model can be used to derive and align all these elements of system. This will ensure a match between the changes demanded by the model and each system element. A model which is too sophisticated or advanced cannot be supported by processes or information - implementation becomes impossible. Similarly, improvement

ideas that may have been stimulated by technology or information may demand an overall system implementation that is beyond reach of organisational capability.

Analysis and design In step 3 and beyond, the model can be used directly for process improvement and design. Rather than use it just for ideas and then put it to one side it has direct and continuing application. The activities from the model can be listed at the side of the process diagram. Then the process can be set out against it - either using the existing process or a new one that has to be designed. In both cases the process will show who in the organisation needs to be involved in each activity.

SYSTEM
ACTIVITIES
AS STABLE
REFERENCE

PROCESS STEPS
UNDERGOING
CONTINUING
IMPROVEMENT

	Functional Management	Process Owner Advisors	Man Dir Advisors	Centre of Expertise	B/Unit Manager	Customer
1. Create a Business Unit	Endorse	Review & Recommend	Assess Compliance to B/U Criteria	Advise & Assist	Apply for B/U Designation	
2. Agree Business Unit			Afford Special Considerations	Manage the Programme		
	Endorse		Agree & Approve Plan	Advise & Assist	Produce B/U Plan	Input
3. Enter Service Agreements						

By setting out the existing process against activities in the model the implementation gap will become obvious. Typically this reveals activities that would be expected to be in place as part of the system that are absent from the process. The process can then be realigned.

Role definitions In the case where the process has to be designed, the key question is "who needs to be involved in each activity and what is the nature of their contribution?"

Some role definitions help with this:

> - decision maker - it should be clear who is occupying the decision making role for each activity.

> - contributor - who is expected as a matter of course to contribute to the activity and has the right to be informed about the activity.

> - supporter - who may be asked for a contribution to the activity, say because of being able to provide a particular professional input.

> - doer - who performs the fundamental transformation of the activity.

Initially it may be sufficient to clarify roles within each activity and then to set out the process steps and tasks for each role as a following stage of design.

Conclusion

Developing a system model before any process analysis

> - allows choice in positioning the modelling target so that a future state can be selected which provides challenge but which nevertheless is within reach

> - enables alignment of all system elements, not just process. The same model can be used to derive and design requirements for information, skills, procedures and controls as well as process

> - provides an enduring reference point for all improvement work. On the process chart, the activity listing (derived from the model) can be used as a guide to continuous process improvement. Under a regime of continuous improvement, the activity list should be slowly changing in response only to major structural changes in the business, whereas the process design can be expected to change all the time. Without the model as a permanent reference, process changes would lose direction.

Experience in using these approaches has yielded some interesting points about Business Process Reengineering. There is an assumption that Information Technology is central to BPR. However, situations that have initially presented in terms of needing a redevelopment of a computing application have, after the modelling, turned into significant process improvement without significant investment in technology. In one case, concerning supply and procurement processes in a mining company, the process improvements were secured by developing a "user friendly front end" to an existing application and more extensive use of an application given to them by a supply partner.

Interest is now developing in using the models to get an understanding of the dynamic behaviour of the system before embarking on the process design. It is expected that the behaviour of the ultimate process should be reflected in the system and be available earlier in the thinking before committing to extensive analysis.

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SAFETY AND ACCIDENTS IN ANAESTHESIA:
The use of Teleonics

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Abstract

Anaesthesia consists of a complex network of processes, which have as their focus, the total management of the patient during an operation. However, in addition to the routine processes of anaesthesia, there are other processes which occur simultaneously. The most obvious are, of course, the corrective or eliminative processes of surgery and the routine processes in the hospital. In addition to these "official" roles, the participants in the hospital are involved in their own processes, some of which have their focus outside the operating theatre and indeed the walls and working hours of the hospital. All these processes interact with one another. The present paper suggests a method to deal with such a complex mesh of processes in order to predict some of the problems associated with them and to eliminate some of the unwanted complications. The method suggested is the TeleoniApproach, developed by Jaros and Cloete [1,2].

In the Teleonic Approach, processes are examined according to their "teleos" (viz, " purpose, end, aim, goal, force of attraction", according to the level and the circumstances of the inquiry). Once its teleos has been identified, the process is regarded as a system, referred to as a " teleon". Teleons can be examined regarding their governance, which ensures that their quest to reach their teleos is ensured. Teleons also form networks, which exhibit certain characteristics, which can provide useful information. These networks are examined, especially concentrating on the pathways of interaction between their different components. A central concept, in this regard is that of "telentropy", which is a measure of the likelihood of success within a teleon regarding the reaching of a teleos. When teleons interact, their telentropy can be transferred to other teleons. This transfer of telentropy can be advantageous or disadvantageous to the receiving teleon, depending on circumstances and attitudes. For example, a teleon can be completely distracted from its teleos or it can devise new, creative ways of dealing with the problem. In fact a lot of new ideas originate from systems of high telentropy.

The use of the Teleonic Approach is suggested here to deal with some of the complex interactions between the many processes taking place before, during and after an operation in which the anaesthetist is involved. By tracing the possible flow of telentropy in the system, potential problem areas may be highlighted and possibly eliminated and consequently, anaesthesia made safer.

Introduction

Although the word " anaesthesia" originally meant the " absence from sensation", the practice of anaesthesia, as we know it today, has come to involve a complex network of processes, which include the total management of the patient during and, to a certain extent, before and after an operation. In addition to the essential processes of anaesthesia, there are other more or less obvious processes which take place simultaneously with the former. The

obvious ones are, of course, the corrective or eliminative processes of surgery and the routine processes in the hospital. In addition to these, the personnel and patients in the hospital are involved in their own personal processes, most of which have their focus outside the operating theatre and indeed outside the walls and working hours of the hospital. No wonder that things can go wrong in the presence of such a complex system which generally operates in a stressful mode.

The profession of anaesthesia has placed a great emphasis on the safety of the patient for a long time. However, as recently as in 1985, it was reported that at least 2000 preventable occurrences of anaesthesia death or permanent brain damage occurred in the United States alone each year[3]However, since then there has been a steady improvement in the safety of anaesthetic procedures [4]. Serious injuries are now rare and anaesthesia seems to be , at least in medically advanced countries, safer than at any time in history [5]. Nevertheless, the battle for safety has not been completed. It is a never-ending struggle, which requires continued effort because of the many forces that have the potential to diminish whatever progress has been made. Three major groups of contributing factors to anaesthetic mortality have been identified [4]The first of these are environmental factors, such as noise, temperature, humidity, toxicity, ambient lighting and various workplace constraints. The next, and the most important were the human factors, such as human error, interpersonal and team problems, fatigue, sleep and rest deprivation, cicardian changes, boredom, workload and task characteristics, state of health, personality traits, training, experience, personal physical profile, time sharing and secondary tasks. The third group of factors relate to equipment and include system errors, vigilance, alarms, and automation.

Many efforts are believed to have contributed to improvements in the safety of anaesthesia: improved training of anaesthesia clinicians, new pharmaceuticals, new technologies for monitoring (especially pulse oximetry and capnography), standards for monitoring and other aspects of anaesthesia care, safety enhancements in anaesthesia equipment and the implementation of quality assurance and risk management programs[5]The creation of the Anaesthesia Patient Safety Foundation (APSF) in the United States [6] and the Australian Incident Monitoring Study (AIMS) in Australia[7] have helped to bring about awareness of safety issues and to support study of patient safety.

As one is dealing with a very complex system, it would be expected that an approach based on general systems theory would be appropriate for its analysis. The abundance of goal directed processes on the other hand, would suggest a process-based approach. Teleonics is a process- based systems approach ideally suitable for dealing with such a system.

Teleonics

The Teleonic Approach has been developed by Jaros and Cloete [1,2]and has been used in many complex situations[8-13] In this approach, processes are examined according to their " teleos", which can mean " purpose, end, aim, goal, force of attraction", according to the level and the circumstances of the inquiry. Once a teleos has been identified, the process can be regarded as a system, referred to as a " teleon". Teleons can be examined regarding their governance, which ensures that their quest to reach their teleos is ensured. Some teleons, such as those which maintain a state or function, utilise negative feedback to govern

themselves, while others, which have creative endeavours as their teleos, utilise positive feedback.

Teleons also form doublets and networks. Doublets exist within various levels of living systems and represent the material entities we find around us. For example, a human being would be a doublet. So would a cell, a family, a department in a hospital, a hospital itself and a country would be examples of doublets[1]. These doublets, which exist within different levels of the living hierarchy of systems[14] are in fact bundles of two kind of teleons, hence their name. These two kinds of teleons are those, which are directed in their teleos towards their suprasystems (exoteleons) and towards their subsystems (endoteleons), respectively. Exoteleons, therefore are directed from a system to its suprasystem. For example, teleons directed from a person towards a department in contributing to the functioning of that department. Endoteleons, on the other hand are directed in the other direction, viz, from system to subsystem. For example, teleons which reach from the department to the individual, such as looking after the professional development of the individual. These concepts are useful when considering the way teleons connect the different levels of the larger system under study.

Within doublets, teleons form networks. This is generally achieved through the same component forming part of two or more teleons. For example a single person performs many functions at work, at recreation and with his family and thus contributes to many teleons, which then through this involvement form networks.

With all the "vertical" connections between levels and the "horizontal" connections between teleons, one can actually visualise the formation of a net. The knots in the net are the doublets and the strands the teleons. If you pull the net at any point, a movement will spread over its entire area. The same happens to living networks, which are called the Biomatrix[1].

A concept, which can be used very fruitfully is that of "telentropy", which is a measure of the likelihood of success within a teleon regarding the reaching of a teleos. When teleons interact, their telentropy can be transferred to other teleons, which can have either beneficial, distractive or even destructive effects on the receiving teleons. A loss of teleos can destroy a system or it can lead it to creative heights.

The use of the Teleonic Approach to deal with some of the complex interactions between the many processes taking place before, during and after an operation in which the anaesthetist is involved. will be briefly illustrated in the rest of the paper. By tracing the possible flow of telentropy in the system, potential problem areas may be identified and modified, thus making anaesthesia safer for the patient.

The teleons of importance during anaesthetic procedures
For lack of space, the main teleons will simply be listed in the following table, without any discussion. The aim is to illustrate the extensive nature of the system. It must be remembered that each teleon has a force of its own. In some teleons the striving for the teleos is almost deterministic and very often subconscious, while in others it is much less rigorous. This flexibility and rigidity exist side by side, both with advantages and disadvantages, which vary with the circumstances.

Preoperative Teleons	Operative Anaesthetic Teleons
Establishing rapport (with patient and relatives)	Controlling awareness of patient
Obtaining relevant preoperative tests	Preventing pain
Preparation for the operation	Controlling contractions and muscle relaxation
Postoperative Anaesthetic Teleons	Maintaining oxygen supply
Controlling pain	Removing carbon dioxide
Maintaining fluid and electrolyte balance	Maintaining cardiovascular functioning
Surgical Teleons	Maintaining general functioning
Preopertative care	**Patient Teleons**
Operation	Physiological
Postoperative care	Therapeutic
Medication	Psychological
Assisted functions (such as heart-lung bypass)	Relationship to relatives
Ward Teleons	Financial
Nursing management	**Hospital Teleons**
Cleanliness and bodily functions	Hospital activities
Feeding	Financial management
Drug dispersal and administration	Pharmaceuticals
Monitoring of surgical wounds and general body functions	Equipment and tools management
University Teleons	Buildings and infrastructure
Teaching of students	Personnel management
Research	Hotel type management
Keeping up with the new developments	**Departmental Teleons**
Leading academic activities	Management of staff
Instructing students and staff	Management of finances
Personal Teleons	Handling interpersonal relations
Maintaining awareness	Developing prestige
Maintaining physical health	Management of specialised equipment
Maintaining psychological health	Ensuring pleasant working environment
Work satisfaction	**Professional Teleons**
Recreation and sport	Professional advancement
Family Teleons	Avoiding mistakes and litigation
Managing finances	Keeping up to date
Provision of health	Serving on committees
Provision of housing	Tackling challenges
Provision of education	Setting standards
Provision of entertainment	
Caring for the old	
Provision of mobility	
Maintaining interpersonal relationships	

Table 1 Teleons of importance in Anaesthesia

The structure of teleons

Teleons are identified by their teleos, viz, what they are supposed to achieve. The entire organisation and control of the teleon is directed at such a teleos. For example, to take the most relevant example from the practice of anaesthetics, the Controlling Awareness of Patient Teleon (CAPT) is supposed to regulate the awareness of the patient during and after an operation. He or she should not be aware of the events taking place during the operation but should regain consciousness soon thereafter. The following "components" play a direct role (coact) in this teleon:
1. Patient and Disease process.
2. Anaesthetist.
3. Anaesthetic machine and other equipment and parts.
4. Drugs and anaesthetic gases.
5. Electricity supply for all the equipment.

> (One could argue that the patient is simply a passive recepient of the anaesthetic manoeuvre. This is of course not the case. The patient is continously " talking" to the anaesthetist through his or her physiologial signals, such as breathing, heartbeat, pupil size, etc. Breathing can be spontaneous or be controlled using a mechanical ventillator.)

The above components, better called subsystems, are arranged in a well constructed system, the teleon, which is precisely controlled to achieve the aim of keeping the patient unconscious during the operation and allowing rapid return of consciousness afterwards. The anaesthetist plays an important role in the control loop of this teleon. By observing the patient's signs he regulates the machine and the amount of drugs and anaesthetic gases in order to achieve the teleos.

One can look at another teleon, say, the Maintaining the Oxygen Supply Teleon (MOST) , which is composed of the following:
1. Patient
2. Anaesthetist
3. Anaesthetic machine and other equipment and parts (mostly, different from those in CAPT above)
4. Oxygen
5. Electricity supply for all the equipment.

It is obvious that although the teleos of this teleon is different from the one above, it is composed of parts which are common to both teleons. These are the patient, the anaesthetist, the anaesthetic machine and the electricity supply for all the equipment.

A good example of interaction between the two teleons is through the patient at the end of the operation. As the patient is brought back to consciousness by the reduction of the anaesthetic agent in CAPT, the metabolic rate of the patient increases, which necessitates an increased oxygen supply. MOST has to respond by increasing oxygen delivcry. If the patient has not resumed to breathing spontaneously at this stage, it is the task of the anaesthetist to ensure that oxygen supply and ventilation are adequate to support the increased oxygen requirements. A temporary anoxia at this stage can be very serious and in case of a cardiac patient can even be fatal.

The interaction between teleons and the flow of telentropy

Similarly to the above interaction between the two teleons, many of the above listed teleons are connected to each other though the components they share. The patient is involved in quite a number, but obviously, the anaesthetist is involved in most. If one remembers that each of the teleons has a different teleos, this means that the anaesthetist is involved in a great number of different and often even contrasting tasks.

As we mentioned earlier telentropy, is the measure of uncertainty in a goal-directed system. The telentropy of a system which is sure in reaching its teleos, is low, while the telentropy of an uncertain system is high.

Telentropy can be transferred from one teleon to another through shared subsystems, especially if the couplings are tight [15.] If for example, there is a problem in one teleon, say, the MOST, and the patient is not getting enough oxygen, then the telentropy of the teleon is getting higher. By just increasing the oxygen flow to the patient, the amount of anaesthetic gas getting into his system may also get higher, putting the patient into a deeper level of anaesthesia, which might make it more difficult to regain consciousness after the operation. The telentropy, that has started in the MOST has now been transferred to the CAPT.

The surest way to operate teleons would be by keeping them completely separate. This would also be the most wasteful and in many cases not achievable. The patient cannot be divided up into separate parts and one cannot use a different anaesthetist for each of the tasks. By interconnecting the teleons economy is achieved at the expense of telentropy. However, it is possible to achieve separation in the above example of interaction between MOST and CAPT, eg. if one uses an injectable anaesthetic agent instead of one from a vaporiser, a change in the amount of inspired gas will not influence CAPT.

A similar potential problem exists with the interaction of MOST with the Pain Preventing Teleon (PPT), when nitrous oxide gas is used as an analgesic agent. The two gases use the same conduits to get to the patient. By increasing the nitrous oxide, the oxygen supply can be reduced, which means that by attempting to reduce telentropy in PPT, telentropy is transferred to MOST, a situation that could lead to serious complications in oxygen delivery and thus contribute to the incidents experienced in this area. It has been reported that the most common cause of intraoperative accidents (at least in the Harvard University area in a 12 year period ending in 1988) was that of unrecognised hypoventilation leading to insufficient oxygen delivery[16].

The potentially harmful increases in telentropy may be remedied by awareness of the role of transfer of telentropy and knowledge of which interconnections lead to increased telentropy in particularly dangerous telentropic connections. It is evident from the above examples that the direction in which telentropy is transferred is of great importance. By transferring it into a vital teleon, such as MOST, it can have serious consequences. On the other hand, by transferring telentropy away from vital teleons into teleons where time is of less importance, such as allowing the patient to breathe spontaneously rather than using muscular paralysis, which requires the use of artificial ventilation, one loosens the coupling and allows for creativity and for the generation of innovative solutions.

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SECTION 2

SYSTEM METHODOLOGIES

A SYSTEMS DYNAMICS APPROACH TO ENGINEERING DECISION ANALYSIS

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Abstract

Decision analysis is a well known systematic technique for tackling non-trivial problems with potentially uncertain outcomes. Traditional decision analysis methods, such as linear programming and decision trees, are limited in scope and flexibility. Decision problems have to be simplified before these methods can be used. This removes some of the inherent complexity of the problems.

This paper uses a System Dynamics approach to model and analyse decision problems. From a System Dynamics perspective all systems can be represented in terms of levels, rate variables and auxiliary variables. The approach is typically used for modelling dynamic and deterministic systems. However, decision problems which are static and stochastic can also be modelled using this approach. Obviously, flow rates which affect the rate of change with time in the levels do not exist in static systems. In this paper the static system is converted into a pseudo dynamic system in which flow rates simply represent the functions which define the relationships among levels.

Influence diagramming forms the basis of the method and is used as a tool to develop the different scenarios in the model. The software package "STELLA" is then used to convert the influence diagram into a graphical and mathematical model of the decision problem. Application of the method is demonstrated on a complex decision problem. A detailed sensitivity analysis is then undertaken to illustrate the usefulness of the method in evaluating alternative strategies.

The method presented allows the decision maker to investigate alternative strategies and to experiment with different probability distributions for uncertain events. This allows a flexible approach to decision problems.

Introduction

Construction managers regularly face crucial decisions concerning complex operations. A feature of decision making is that a choice needs to be made among a number of different alternatives in order to reach a goal. For example, one of the decisions that contractors have to make is on which of the following projects to bid, for example, project A or project B?

Decision analysis is a well known systematic technique for tackling non-trivial problems with potentially uncertain outcomes. Traditional decision analysis methods, such as linear programming and decision trees, are limited in scope and flexibility. Decision problems have to be simplified before these methods can be used. This removes some of the inherent complexity of the problems.

This paper uses a System Dynamics approach to model and analyse a traditional decision problems. Influence diagramming forms the basis of the method and is used as a tool to develop the different scenarios in the model. The software package "STELLA" [High Performance Systems, Inc., 1992] is then used to convert the influence diagram into a graphical and mathematical model of the decision problem. Application of the method is demonstrated on a decision problem. A detailed sensitivity analysis is then undertaken to illustrate the usefulness of the method in evaluating alternative strategies. The techniques demonstrated are then used to develop the influence diagrams that form the basis of a complex bidding simulator. The simulator could be used by contractors in preparing bids and deciding on a bidding strategy.

System Dynamics Approach

The approach of System Dynamics is centred on the ideas of Forrester. From a System Dynamics perspective all systems can be represented in terms of levels (state variables), rate variables and auxiliary variables. [Forrester, 1961; Wolstenholme, 1990].

The System Dynamics approach is typically used for modelling dynamic and deterministic systems. However, decision problems which are static and stochastic can also be modelled using this approach. Obviously, flow rates which affect the rate of change with time in the levels do not exist in static systems. In this paper the static system is converted into a pseudo dynamic system in which flow rates simply represent the functions which define the relationships among levels.

A Case Example

An example of the decision tree is given in Figure 1.
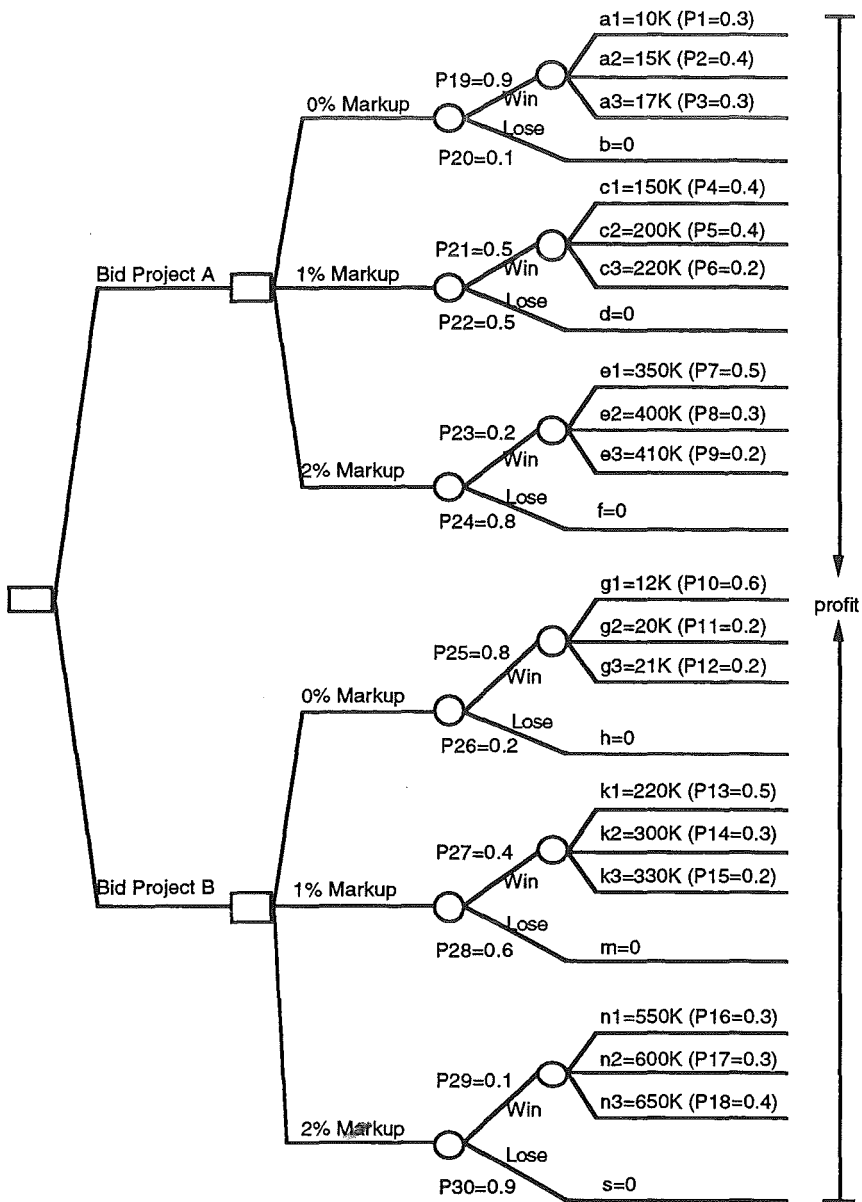
Figure 1 Contractor's Decision Tree [Halpin and Riggs, 1992]
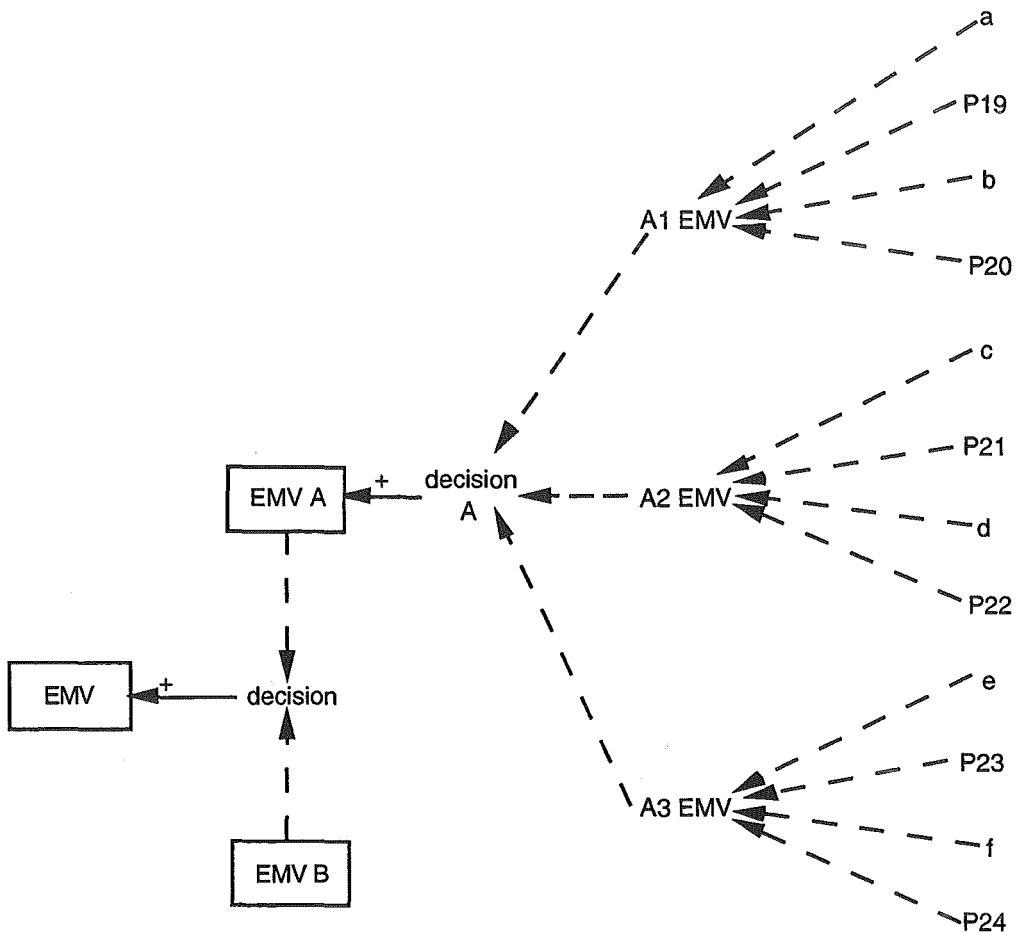
Figure 2 Decision Influence Diagram for the Contractor's Decision Model
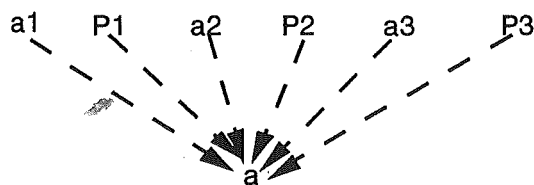
Figure 3 EMV of The Uppermost Chance Node

Figure 1 shows how a decision tree could be used to consider alternative strategies for bidding projects A and B. In Figure 1, squares represent decision nodes and circles represent chance nodes. At the right-hand tips of the various branches, the profit (or loss) for each is inserted. If this is multiplied by the combined route probability, the expected monetary value (EMV) for the individual route is obtained.

There are three decision points in the above example. The first two decision points concern the EMV for each project with different markup strategies. The third decision point is related to the EMV for the bid.

In the influence diagram, each decision point is a flow rate, while each EMV related to the decision point is described by a state variable.

Decision influence for the above example is shown in Figure 2 and Figure 3. The advantage of the model is that given the input, the end result (whether to bid project A or project B) can be obtained directly. It is also easy to adapt it for calculation.

The software package "STELLA" is then used to convert the influence diagram into a graphical and mathematical model of the decision problem (Figure 4 and Appendix).

It can be demonstrated that the results are the same for the decision tree and the STELLA model.
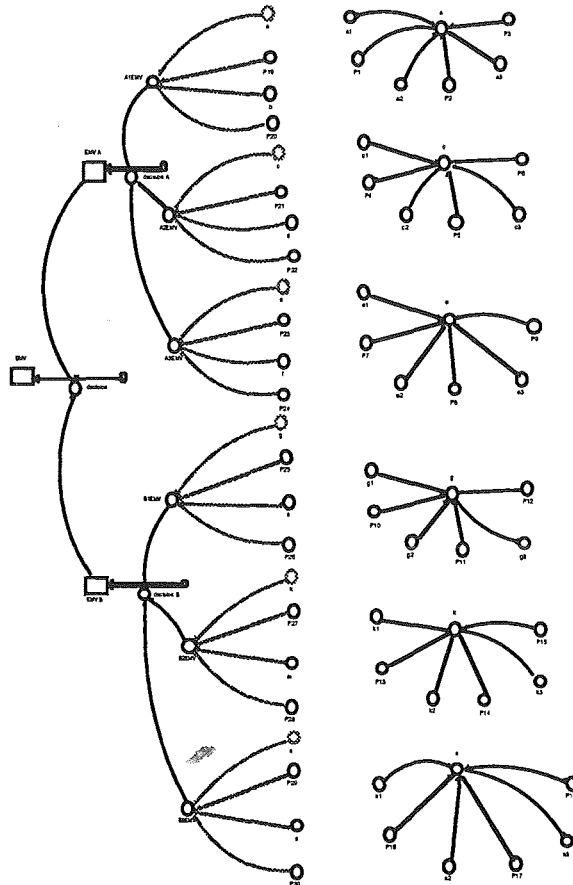
Figure 4 STELLA Model for the Contractor's Decision Model

Sensitivity Analysis

The results from the calculation of the expected values are based on the model in which single value estimates of various probability and profit values are used. A question should be asked as to whether the decision would change if different single estimates are used, particularly when the differences are only marginal. So the decision should always be subjected to an analysis of the predictions of the conditional outcomes and probabilities of the events [Buffa and Dyer, 1981].

Because of the individual nature of construction projects there is usually insufficient objective data to calculate the probability of occurrence of specific outcomes of risk events; some degree of subjective judgement is usually required. This weakness can be overcome by a sensitivity analysis [Perry and Hayes, 1985].

It is very difficult to assign a certain probability or a certain profit (or loss). Instead, it may be, for example, that the probability for profit of 10k is roughly 0.3, certainly no more than 0.4 and no less than 0.1, but it is difficult to give a more exact value. The same principle applies to the probabilities of winning or losing contracts and conditional outcomes.

Each probability must lie between 0 and 1. There will be other constraints on the values that these probabilities may take. The sum of probabilities at each chance node must equal to one.

A sensitivity analysis of the decision for a change in one parameter may be undertaken based on the STELLA model in Figure 4.. The selection of a parameter for a sensitivity analysis depends on the preferences of the decision makers and the parameter's possible impact on the final results. For example, P21 (that is the probability of winning project A with 1% markup) has been set at 0.5 in the previous decision calculation. In a sensitivity analysis, it is possible to compare the different results when probabilities of 0.4, 0.5, and 0.6 are used.

The results are listed in Table 1.

Table 1 Results of a Sensitivity Analysis

P21	EMV A	EMV B	Decision
0.4	75.4k	106.4k	bid project B
0.5	92k	106.4k	bid project B
0.6	110.4k	106.4k	bid project A

From the above sensitivity analysis results, it is concluded that with an increase of probability P21, the contractor's decision has been changed from bidding project B to bidding project A. So the contractor should be cautious in assigning the probability of a 1% markup.

It is also possible to carry out the sensitivity analysis for other parameters.

Complex Bidding Model - Work in Progress

In a decision problem without many branches (events), as in the above model, it is possible to carry out an exhaustive analysis. This means it is possible to consider each of the possible outcomes individually and test the implication each has on the decision to be made. However, not all decision situations are as simple as this example. Even this example is a simplified model because profit and its associated probability are selected very subjectively and a discrete probability distribution with very limited outcomes is used.

To submit a winning bid, the contractor must submit a bid that is less than the bids of his competitors, and it should be a bid which will yield a reasonable profit. This section of the paper sets out the basis for a simulator that contractors could use as an aid in developing bidding strategy.
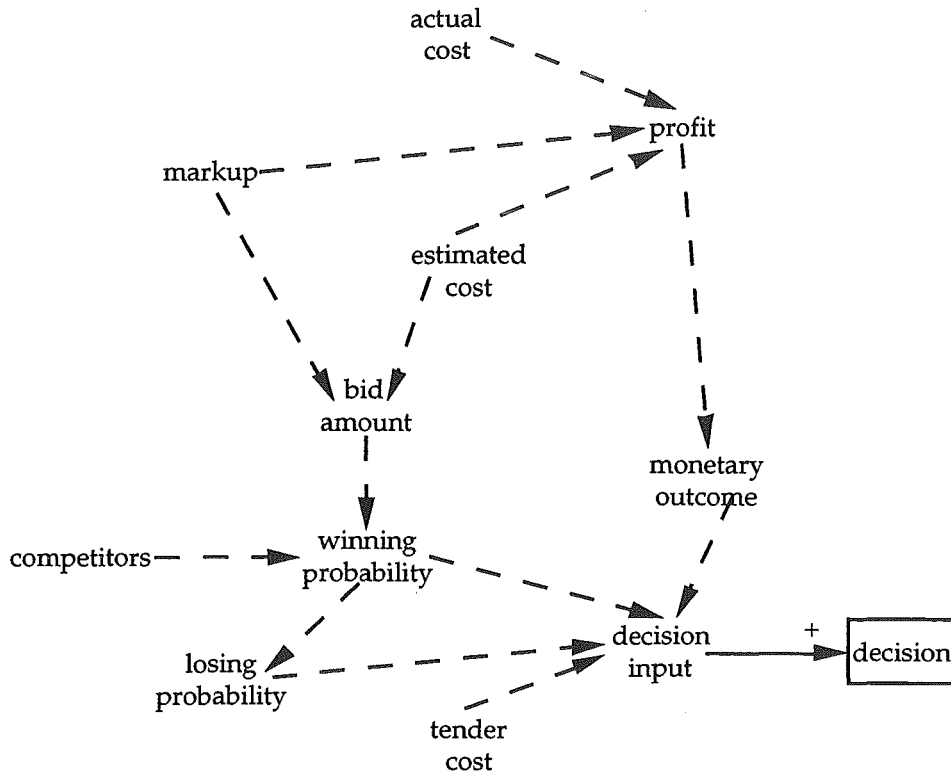
Figure 5 Influence Diagram for the Complex Decision Model

(a)

(b)
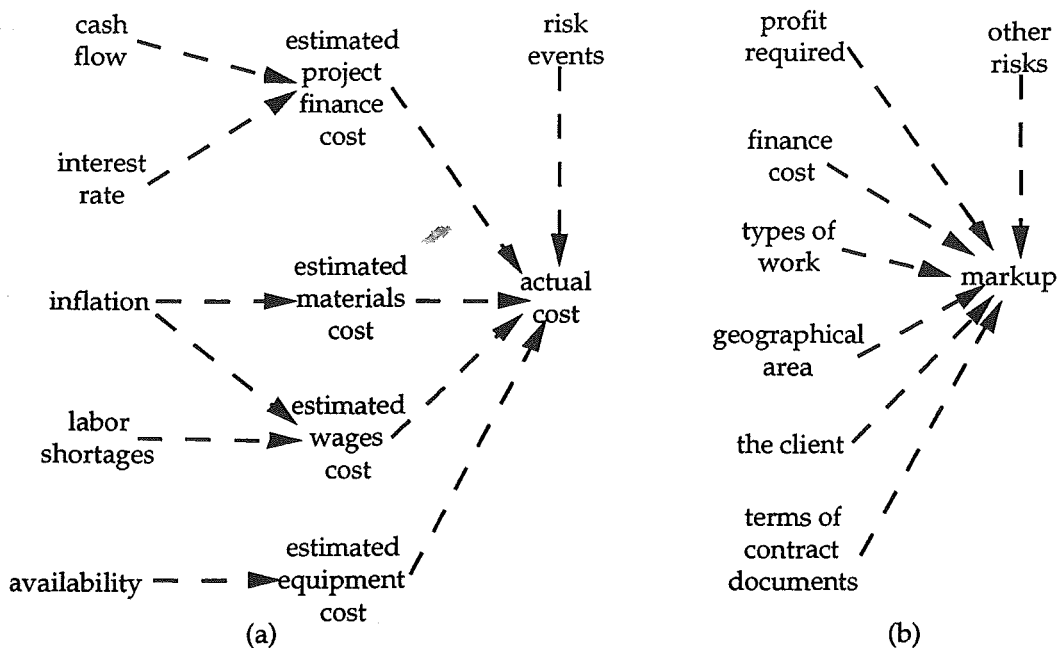
Figure 6 Influences to Actual Cost and Markup

Firstly, the influence diagram showing the influence on bidding outcome is shown in Figure 5. The profit in this Figure is made up of estimated cost plus markup minus actual cost. Actual costs incurred in a project may differ from the estimated costs due to the influence of a number of factors. These include interest rate fluctuations, inflation, labour shortages, equipment availability and the occurrence of certain risk events. These influences are shown in Figure 6(a). Depending on the requirements of the simulation, further subdivision

of influences could be undertaken. For example, risk events could be divided into routine weather risks, catastrophic risks, accidents and industrial problems, etc.

The markup on any bid is also dependent on a number of factors (see, for example, Antill and Farmer, 1991, Clough and Sears, 1994). One possible set of influences is given in Figure 6(b).

At present work is underway to develop an integrated project simulator based on these influence diagrams. The simulator will be of use to contractors in preparing bids and deciding on a bidding strategy.

Concluding Remarks

The method presented allows the decision maker to investigate alternative strategies and to experiment with different probability distributions for uncertain events. This allows a flexible approach to decision problems. Influence diagrams are also presented that form the core of a bidding simulator that is under development.

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Appendix: Equations for the Contractor's Decision Model

EMV(t) = EMV(t - dt) + (decision) * dt
EMV A(t) = EMV A(t - dt) + (decision A) * dt
EMV B(t) = EMV B(t - dt) + (decision B) * dt
decision = MAX(EMV A, EMV B)/dt
decision A = MAX(A1EMv, A2EMV, A3EMV)/dt
decision B = MAX(B1EMV, B2EMV, B3EMV)/dt
A1EMV = a*P19+b*P20
A2EMV = c*P21+d*P22
A3EMV = e*P23+f*P24
B1EMV = g*P25+h*P26

$$B2EMV = k*P27+m*P28$$
$$B3EMV = n*P29+s*P30$$
$$a = a1*P1+a2*P2+a3*P3$$
$$c = c1*P4+c2*P5+c3*P6$$
$$e = e1*P7+e2*P8+e3*P9$$
$$g = g1*P10+g2*P11+g3*P12$$
$$k = k1*P13+k2*P14+k3*P15$$
$$n = n1*P16+n2*P17+n3*P18$$

SYSTEMS THINKING FOR PUBLIC HEALTH IN THE 21ST CENTURY

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Abstract

Our major health hazards now originate in human decision making, and ultimately from impairments to reasoning processes. Prevention of such hazards may require intervention directed at reasons for such impairments to reasoning. This paper focuses on the role of usually non-conscious, (and possibly neglected), reasoning processes. The importance of Case-based reasoning processes (which are considered to have a Wittgensteinian basis) is emphasised, and examples given.

Introduction

We have always lived in interdependence with:
(a) our natural environment - for our physical needs, and
(b) other humans - for reasoning processes dependent on communication with others, (Churchman, 1971). Such communication will involve thinking and language that is derived from "forms of life" - human natural history of *action* with our world, as described by Wittgenstein (Malcolm, 1986). But words may have different meanings depending on their contexts ("language-games", "forms of life").

The world is infinitely complex, while our knowledge of the world is finite. Success in human adaptation has apparently been due to the capturing of distinctions that make an important difference, and the ignoring of others. This has been described as "qualitative reasoning", and is not well understood. (Kuipers, 1994).

We now live in a global village where our *major* health hazards *originate* in the escalating increase in power of human decision-making (and ultimately to impairments to human reasoning processes), rather than originating directly from the natural environment. Examples which have been described include galloping technology, environmental decline, pollution, biosphere disequilibrium, disappearing species, overpopulation, famine and nuclear threat. But we lack a global ethic for our "global village" and give insufficient attention to factors affecting knowledge and "values" (McMichael, 1993; Boyden, 1990; Higgins, 1980; Last, 1993). Streeten (1989) argues that our social and political arrangements have not caught up with our technological advance, and that we need an integrative system where there is a sense of community and obligation. Evolutionary *thinking* will be required by the formal health system to meet the demands of our evolving health problems. (Eckhardt, 1994).

I would argue that intervention in this situation will need to include prevention directed at events early in the causal network, viz. impairments to our reasoning processes. Can we utilise some "qualitative reasoning" here to capture a distinction that may have made an important difference in impairing our reasoning processes?

Our knowledge and reasoning processes appear to operate at:
(i) various levels of complexity, to deal with problems of varying structure (Churchman, 1971), where ill-structured social problems require the continuing sweeping in of differing perspectives for consideration,
(ii) conscious and non-conscious levels (e.g. as proposed by Harre et al, 1987).
It could be conjectured that:
(a) the *formal* study and description of our reasoning processes would have commenced with the simpler and more conscious levels, whilst the more complex and various *non*-conscious reasoning processes, may have been deferred or neglected, and

(b) that such *formal* study and description may have influenced the promotion and thereby our use of certain reasoning processes (Linstone 1982; and, for a present day example, Byerly and Pielke 1995).

This paper utilises Churchman's and Simmel's models of human reasoning (that focus on non-conscious knowledge and reasoning processes) to propose for consideration:
(a) the possible role of the formal education system in impairments to human reasoning,
(b) the importance of a Wittgensteinian component in our reasoning,
(c) the promotion of case-based reasoning - which is considered to have a Wittgensteinian foundation - (in interaction with model-based reasoning), and
(d) the importance for Public Health, of faculties of systems thinking, (e.g. at the Universities of Lancaster and Hull).

Churchman's philosophical model of systems thinking

I assume that most of you are familiar with this model of five levels of "inquiring systems" (IS), where there is recognition of the need, as we move to higher levels of IS, for increasing complexity of communication, (and hence of a Wittgensteinian component), in order to provide the guarantor of truth. (SeeAppendix for summary).

I wish to comment on only the following aspects of this model:
(a) its consideration of the *crucial role of higher order assumptions* in a purpose hierarchy, (because if these high level assumptions are incorrect, a program *cannot be rescued by lower level actions*. (Suchman, E.A. 1967).
(b) for people engaged in different contributing activities, the sharing of higher order purposes promotes a shared "form of life" This may well be lost where there is an inadequate consideration of the need for integration of knowledge. What enables agreement as to the varying uses of language is that we share needs and interests and the ways of going on in certain situations, i.e. the context. Ambiguous language obscures representational meaning or understanding (Langer, 1994). For example the word 'values' is

> "used in a confused and confusing but widespread way in our contemporary
> culture, and...because of the ambiguity and looseness that the terms engender, it
> would seem advisable to use (it) in narrower senses or not at all"... (Its) uses
> may vary from a narrower sense to cover only 'that to which such terms as
> 'good', 'desireable' 'worthwhile'. may be applied ... to what is valued .. to
> whatever they believe to be true." (Edwards, 1967).

An appreciation of the 'grammar of language' in situations of both (i) shared contexts and (ii) ambiguous language would seem to be important to achieve clarity of thinking. It would be appropriate therefore to include a Wittgensteinian component to Churchman's description of the conceptual structure of each IS.

Boudon's elaboration of Simmel's model of human reasoning processes

1. This model is concerned with the mobilisation of a priori which are *much more extensive than those proposed by Kant*, through which knowing subjects deal with the real world. Thus our reasoning processes, knowledge and theories are surrounded by a *halo of implicit and non-conscious* a priori, (e.g. logical, methodological, worldview, ideological, normative, epistemological, about reality, **Linguistic (Wittgensteinian)**, empirical and ethical (Boudon, 1994).
(I will be focussing on Wittgensteinian linguistic a priori in the latter part of the paper).
2. When we construct a theory, we always introduce:
      (a) explicit propositions and
      (b) implicit propositions (from implicit non-conscious a priori), on which we base   our reasoning
3. There is thus a discrepancy between:
      - our reasoning *as it appears to us*,
      - what our reasoning *is in reality*.

4. Therefore many false ideas arguably spring from correct ideas and reasoning, which have become *contaminated by non-conscious implicit a priori.*

5. The above situation raises the problem of the relativism of knowledge. This is dealt with by the identification and elimination of distortions, through *communication* with others (and so involving a Wittgensteinian component).

The Formal Education System

In recent times, the rise of powerful information systems, (e.g. the formal education system and the media), would appear to have the potential to considerably influence knowledge and reasoning processes (for good and/or harm), and would need to be considered as a factor that may have adversely affected human reasoning processes. We need to be aware of the "language-games" being played by these institutions. The influence of the media is fairly well recognised, and will not be considered in this paper. The following comments have been made about the formal education system:

1. Academia

It has been argued that academia is plagued by inadequate integration of knowledge, associated with loss of higher order purposes e.g.:

(i) Becher (1989) considers that academics have their own distinctive form of life,

(ii) Maxwell (1994) has argued that academia "though very successful at improving specialised knowledge and technological know-how, is an intellectual, social, and moral disaster when it comes to helping us realise what is of value in life - in particular, when it comes to helping us create a more civilised enlightened world",

(iii) Barnett (1994) considers that 'academic community' has dropped out of the lexicon.

2. Schools

(a) Linstone (1984, p.9) argues that schools promote the use of a Kantian level IS for *ill-structured social problems.*

(b) Explicit attempt to teach "values" that has resulted in values confusion.

The Values Clarification (VC) teaching strategy (Raths et al, 1966), is widely practiced in schools, and is touted as a strategy for moral education. Its rationale can be summarized as:

Values are situational, so what should concern us is the *process* of valuing, viz.:

(a) Choosing - freely, from alternatives, after thoughtful consideration of consequences

(b) Prizing - cherishing, affirming,

(c) Acting repeatedly.

If these criteria are satisfied, we will be "positive purposeful enthusiastic and proud".

VC has been widely criticised because of:

- the underlying conceptual framework,

- its practice, where students are pushed into making real life choices, *with very little time* to consider the consequences of complex and uncertain situations,

- the consequences - it leads to values *confusion,* and to environmental decline.

-Hitler followed the 'valuing process' and was "positive purposeful enthusiastic proud".

I wish to add the criticism of confusion from the various meanings of the word "values", which may lead to pursuit of individual preferences and desires, with loss of community spirit.

Implications of a Wittgensteinian Component to Human Reasoning

I have proposed that:

(a) appropriate reasoning processes are significantly dependent on our interdependence with others in communication, involving thinking and language that is derived from shared "forms of life" - human natural history of *action* in our world, as described by Wittgenstein, and

(b) in today's world, the formal education system is involved in some promotion of impairment to communication and reasoning processes through different "forms of life", associated with lack of integration of knowledge and loss of higher order purposes, resulting in the loss of community spirit. This suggests the need for the recovery of community through shared pursuit of higher order purposes.

But the understanding of, and the dealing with, these impairments to reasoning processes would itself require an adequate Wittgensteinian component. I propose that this dilemma be dealt with by the promotion of Case-based reasoning, (whose roots are Wittgensteinian) at all levels of dealing with problems. I suggest that this style of reasoning has been down-played in academia.

Case-based Reasoning (C-br)

Two interacting knowledge bases and modes of reasoning, have been described, viz. - model based and case based. (Kolodner, 1993, Deardon and Bridge, 1993, The Knowledge Engineering Review, whole issue Dec. 1994,).

Model-based Reasoning <----> Case-based Reasoning

Case based reasoning (C-br) seems to operate at a largely non-conscious level, it is said to have a Wittgensteinian foundation (Aamodt 1994, Shrader-Frachette 1993), and is used extensively in education for occupations, e.g. medicine. "It is a safe rule", wrote Sir William Osler in 1904, "to have no teaching without a patient for a text, and the best teaching is that taught by the patient himself" (quoted in Hunter, 1989).

Knowledge engineers, with inputs from cognitive psychologists, try to *emulate* human reasoning and natural knowledge representation in their artificial systems of C-br. They use indexing and complex forms of abstraction to generalise from particular cases. These generalisations *can involve the reasoning process itself*. (Kolodner, 1993). We appear to be in our infancy in understanding this form of reasoning.

The importance for a Singerian IS of a Wittgensteinian component to thinking and language has been mentioned. Descriptions of the use of such inquiring systems (that include a C-br component) appear to be given by:
(a) Shrader-Frechette (1994) in dealing with problems of applied ecology,
(b) Hunter, (1989) from clinical medicine.

I will now briefly describe what I perceive as the use of a *Singerian IS involving C-br* used by the Igbo of Nigeria in their everyday living and informal education processes.

These people have been described as an ultra-democratic society, (a Singerian IS), where their children learn, *by practice*, participatory democracy, together with:
(i) the need for group-oriented values and identity,
(ii) the need to recognize the context of words or parcels of words used by another,
(iii) and where this context is inappropriate (e.g. for group functioning), to assist the speaker to perceive this inappropriate form of life, by the use of proverb quoting behaviour in such a manner that it protects the author and the speaker from embarrassment, and
(iii) promotion of *prevention* through feed forward of information.

Penfield (1983) studied the Igbo's *extensive* use of proverb quoting, and has described this situation as follows.

> "identity is achieved through groups ... because meaning in life is based on communal or group-oriented values, members of Igbo society have a collective rather than an individual-oriented conscience ... group identity puts forth heavy pressures on

the members of the culture to conform to the ideal cultural mores and penalizes those who fail to do so" ...

Intelligence in Igbo society is a matter of prevention, since it takes intelligence to foresee what   can lead to trouble and to stop such actions ... (it) is also a matter of controlling upset forces which is only achieved through skilful performance in the *manipulation of the culture and the language* (emphasis added). ... Depersonalization is one of the essential qualities of the quote in that this process allows the message conveyed to be done indirectly and impersonally ... depersonalization allows the speaker to bring out a very sensitive matter in a non-definite and abstract manner ... igbo proverbs have impersonal verbal forms and other liguistic devices which also add to the impersonal nature.

Conclusion

It is suggested therefore that:

(a) there may be a need for an appropriate emphasis on case-based reasoning *throughout* the formal education system,

(b) faculties of systems thinking that are concerned with the integration of knowledge and utilise case-based reasoning (as at the Universities of Lancaster and Hull), could make a significant contribution to our understanding and dealing with current major Public Health problems arising from impairments to human reasoning processes described above.

I would also conjecture that case-based reasoning will make contributions to our understanding of qualitative reasoning, and also clear some confusions associated with the important concept of 'metaphysics'.

Appendix

The underlying spiritof each of Churchman's "inquiring systems" (IS)

Linstone and Turoff have described how the underlying philosophical system (or spirit) of each inquiring system can be simply differentiated from one another in terms of the kind of characteristic question(s) that each would address to the individual or group making a statement or assertion in order to *guarantee its truth*:

"Leibnizian IS. How can one independently of any empirical considerations give a *purely rational justification* of the assertion? What is the model you are using? How was the result deduced?

Lockean IS. Since data is always prior to the development of theory, how can one independently of any formal model justify the assertion by means of some objective data or the consensus of some group of expert judges that bears on the subject matter of the assertions?

Kantian IS. Since data and theory (models) always exist side by side, does there exist some combination of data or expert judgment plus underlying theoretical justification for the data that would justify the propositions? What alternative sets of propositions exist and offer the strongest combination.

Hegelian IS. Since every set of propositions is a reflection of a more general theory or plan about the nature of the world as a whole system, i.e. a world-view, does there exist some alternative sharply differing worldview that would admit the serious consideration of a completely opposite set of propositions? Why is this opposing view not true or more desirable? Further, does this conflict between the plan and the counterplan allow a third plan or world-view to emerge?

Singerian IS Have we taken a broad enough perspective of the basic problem? Have we from the very beginning asked the right question? Have we focused on the right objectives? To what extent are the questions and models of each inquirer a reflection of the unique personality of each inquirer as much as they are felt to be a "natural" characteristic or property of the "real" world?"

(We note that the communication process for each guarantor of truth becomes more complex as we move to higher level inquiring systems).

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FUZZY LOGIC AND SOFT SYSTEMS METHODOLOGY
- A COMPLEX CONNECTION

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Abstract

Fuzzy logic allows the diagnosis of complex systems by drawing logical inferences from imprecise relationships. It is a knowledge-based approach that formalises thinking in terms of linguistic rules. The fuzzy logic approach begins with an understanding of the basic structure, control logic, and flow pattern of the problem. The problem is then partitioned into the parts that are precise and deterministic, and those that have fuzzy properties. Systems developed with this approach can accommodate approximate reasoning, poorly defined parameters, and human error.

Soft Systems Methodology is a heuristic and subjective approach for knowledge elicitation in complex and poorly defined areas. This methodology is designed to allow the human element of complex managerial systems to be incorporated into system design work. This is achieved by a holistic process of inquiry within a framework that compares the complex real-world problem situations with conceptual systems models.

This speculative paper explores the proposition that Soft Systems Methodology can assist in the knowledge elicitation stage of fuzzy logic systems development. It examines the two approaches in the context of developing a framework for problem solving and system development in situations where there is poorly defined complexity.

Key words: Soft Systems Methodology, fuzzy logic, complex systems

Introduction

It is not uncommon at a conference for the author of a paper on the application of Soft Systems Methodology (SSM) to be asked the question "Just what is this Soft Systems all about?"

In the ensuing explanation, a number of key concepts are generally used which include; heuristic and subjective approach; a learning system; an alternative methodology for modelling complex, poorly defined systems; a holist, systemic approach; and a non-reductionist approach to model situational complexity in human activity systems. However, when a response based on the above is given to someone with a background in the computer sciences, on several occasions the reply has been "Oh, you are talking about fuzzy logic systems!"

The immediate answer to this assertion has been "No! Soft Systems Methodology and fuzzy logic are totally different things." However, a seed has now been sown that begs the question "Is there a link or relationship between Soft Systems Methodology and fuzzy logic?"

Investigating Fuzzy Logic And Soft Systems Methodology

An immediate response to the above question is to undertake searches of various electronic data bases to ascertain if any material has been indexed with <u>both</u> the terms fuzzy logic and Soft Systems Methodology.

However, extensive searches on CD-ROM databases and the InterNet have failed to locate any evidence of work or publications that have investigated possible links between these two system approaches. The closest "semantic" match is found in Zadeh (1994) who discusses fuzzy logic in terms of "soft computing" - computing which tolerates the imprecision of human behaviour. Similarly, studies by Gaines and Shaw (1984, 1985) examine fuzzy logic in the context of expert systems and the systemic principles of knowledge representation. In subsequent publications, Shaw and Gaines (1986, 1987) propose that soft systems methodology provides a systemic framework for knowledge engineering that can be operationalized using repertory grid elicitation and analysis. Fuzzy logic is identified as an important component of the repertory grids analysis, but the relationship between fuzzy logic and Soft Systems Methodology is not discussed.

Lacking any evidence in the literature of relevant joint discussion of the two methodologies, this study will attempt a comparative analysis. However, first it is important to provide an overview of each of the methodologies.

Fuzzy Logic - the basics

Fuzzy logic is based on the idea of membership sets where values exist in a set of range [0.0, 1.0], where 0.0 represents absolute Falseness, and 1.0 represents absolute Truth (Elkan, 1994). This allows the diagnosis of complex systems by drawing logical inferences from imprecise relationships. It is a knowledge-based approach that uses linguistic rules to express what needs to be accomplished.

The fuzzy logic approach begins with an understanding of the basic structure, control logic, and flow pattern of the problem. The problem is then partitioned into the parts that are precise and deterministic, and those that have fuzzy properties. Systems developed with this approach can accommodate approximate reasoning, poorly defined parameters, and human error. Therefore the human solution, common sense reasoning, uncertainty, and rules of thumb, are able to be used to define a process. Fuzzy logic systems can exploit the tolerance for imprecision and uncertainty, learn from experience, and adapt to changes in the operating conditions (Zadeh, 1994).

It is important to note that fuzzy logic has been successfully used in human activity systems. Systems of interest include database information retrieval systems (Armstrong, 1992), investment portfolio management systems (Stevens, 1993), and at a mundane level, washing machine control (Zadeh, 1994). A model of a Fuzzy Decision Support Expert System that successfully integrates the judgement of a number of experts, and outputs an overall group decision, has been described by Satyadas and Chen (1992). The value of using fuzzy logic in expert systems to link linguistic rules of thumb to formal analytical systems, thereby adding realism, is illustrated by Jablonowski (1992, 1993) in studies of the design of insurance underwriting and loss management systems. Jablonowski (1993) emphasises that the incorporation of the ability to learn is the major challenge facing expert system designers. However, Elkan (1994) observes that, in a review of fuzzy logic applications in knowledge-based systems, there is no evidence of the use of fuzzy logic operators for reasoning about uncertainty. This suggests that there is some contention about the adequacy of using fuzzy logic for knowledge representation in expert systems.

Soft Systems Methodology - a brief review

The traditional systems approach to problem solving is based on the technique of reductionism, which solves a problem by fragmentation, one stage at a time (Checkland, 1981: pp. 757-767; Flood and Carson, 1988: pp.2-6). This technique is appropriate for complex and highly structured problems that are able to be well defined. The problems associated with the "people dimension", however, are complex, unstructured and poorly defined (Flood, 1988). In these situations, a holistic rather than a reductionist approach is recommended (Checkland, 1981, 1992; Checkland and Scholes, 1990).

A holistic approach to problem solving is provided by the Soft Systems Methodology (SSM) which was developed by Peter Checkland, Professor of Systems at Lancaster University (Checkland, 1981). The concepts are based on practical application and experience in a wide variety of complex managerial systems. The methodology is designed to allow the human element of such systems, which is typically unstructured and poorly defined, to be incorporated into system design work. It may be used to analyse any problem or situation, but it is most appropriate where the problem "cannot be formulated as a search for an efficient means of achieving a defined end; a problem in which ends, goals, purposes are themselves problematic" (Checkland, 1981, p.316).

Soft Systems Methodology, in its idealised form, is described as a logical sequence of seven steps (Checkland, 1981, pp. 162-183). These are:

- **Stages 1 and 2 - Expression of the problem**
- **Stage 3 - Selection of a Root Definition**
- **Stage 4 - Model Building - the Conceptual Model.**
- **Stage 5 - Comparison**
- **Stage 6 and 7 - Recommendations for Change, and Taking Action.**

It is most important to note that the sequence is not imposed upon the practitioner, a study can commence at any stage, with iteration and backtracking as essential components.

Checkland (1981, p.163) observes that "... in fact the most effective users of the methodology have been able to use it as a framework into which to place purposeful activity during a systems study, rather than as a cookery book recipe". This is expressed as an iterative cycle of action research (Figure 1).
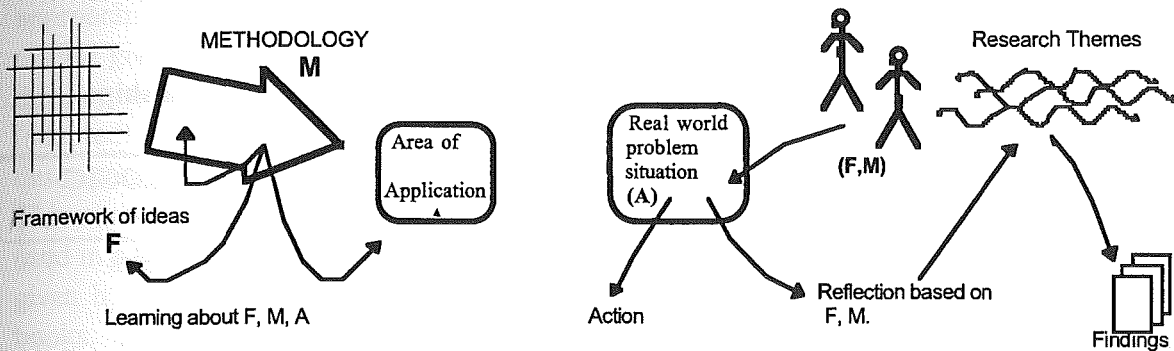
Figure 1: The Elements of Research, and the Cycle of Action Research
(Adapted from Checkland, 1992: pp. 4-5)

Soft Systems Methodology has been applied to many situations in business as a practical and successful general purpose methodology. Mingers and Taylor (1992) list organisational structuring, performance evaluation, and information systems work as common uses of Soft Systems Methodology. It has also been identified by Shaw and Gaines (1986, 1987) as a suitable inquiry process for specifying the function of an expert system. This application has been further investigated by Rodger and Edwards (1989), who conclude that Soft Systems Methodology can contribute significantly to a problem-driven approach for expert system development. Discussing expert system design, Stowell and West (1990) also recommend that Soft Systems Methodology has potential as a knowledge elicitation tool.

Is there a linkage?

In order to test for a relationship between the two methodologies, a comparative analysis has been undertaken based on the examination of methodological descriptions by the foremost researchers in each area, Professor Peter Checkland and Professor Lotfi A. Zadeh.

Checkland (1989) uses the following keywords to characterise the features of Soft Systems methodology: learning system; complex problematical human situation; purposeful activity; process of inquiry; problem situation; learning process or cycle; process for managing; whole system; emergent properties; purposeful whole; human activity system; real world action; Weltanschauung (unquestioned points of view which we use to make sense of the world); models; real world problem situations; participative process.

The keywords used by Zadeh (1994) to describe the application of fuzzy logic are: approximate reasoning; tolerance for imprecision; uncertainty; human mind as a role model; formalisation of the cognitive processes; rule based systems for learning and adaptation; real world problems, fuzzy sets; linguistic variables; human interpretation; models for approximate modes of reasoning.

In Table 1, an attempt has been made to identify possible relationships between the key concepts of the two methodologies. Each arrow is annotated to help clarify nature of the relationship.

Table 1: Fuzzy Logic and Soft Systems Methodology - Keyword relationships

SOFT SYSTEMS METHODOLOGY	RELATIONSHIPS	FUZZY LOGIC
Real world problem situations, problem situation	same domain as ⟵———⟶	Real world problems
Learning system, learning process or cycle, process of inquiry	can provide input ___into___⟶	Rule based systems for learning and adaptation, formalisation of the cognitive processes
Complex problematical human situation	same domain as ⟵———⟶	Human mind as a role model, approximate reasoning, tolerance for imprecision, uncertainty
Participative process	helps to achieve ———⟶	Human interpretation
Weltanschauung (unquestioned points of view which we use to make sense of the world)	same domain as ⟵———⟶	Linguistic variables; human interpretation
Emergent properties	can be expressed as ———⟶	Fuzzy sets
Human activity system	can provide input ___into___⟶	Models for approximate modes of reasoning
Purposeful activity	can control what is ⟵———	Human interpretation
Real world action, purposeful activity, process for managing	can be used to ⟵_achieve_	Rule based systems for learning and adaptation

The above interpretation can be used to argue that there are useful relationships between the qualities and functions of the two methodologies. Furthermore, it suggests that features of Soft Systems Methodology can provide inputs into fuzzy logic systems. This is consistent with Soft Systems Methodology as a methodology for learning and acquiring knowledge,

whereas fuzzy logic may provide a methodology for implementing imprecise knowledge into an expert system. It can be also argued that a fuzzy logic rule-based system for learning and adaptation is entirely consistent with, and can achieve, the objectives of Soft Systems Methodology - purposeful real world activity that provides a process for managing complex, poorly defined situations.

Expert systems development has been identified as a suitable candidate for both methodologies, therefore comparisons can be drawn between the application of each approach. The dynamic nature of expert knowledge is the reason that Chuk and Sattar (1994) give for adopting the Soft Systems Methodology as the basis of an expert system development system. The conceptual models that are developed (learning) and refined (adapted) by the methodology form the basis of the expert system. A very detailed description of the development of a fuzzy logic expert system is provided by Sun (1995). This shows clearly how both rules and concepts in vague and continuous domains can be used in a two-level structure for knowledge representation in an expert system. The example given by Sun (1995) uses highly descriptive qualitative knowledge derived from source books. This strongly suggests that a similar approach could be used to structure the "purposeful activity" of Soft Systems Methodology.

Conclusion - What To Do Next

This speculative study proposes that there is sufficient evidence to suggest that the Soft Systems Methodology is potentially a tool of inquiry, analysis and knowledge elicitation to be used in the development of a fuzzy logic based decision support system. The next step in this inquiry will be to use the knowledge base derived from a Soft Systems study in the implementation of a fuzzy logic rule-based system. The challenge, of course, is to bring this to fruition.

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THE CRITICAL REVIEW MODE OF TOTAL SYSTEMS INTERVENTION

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Abstract

Total systems intervention is a meta-methodology which interprets and brings into action a range of problem solving methodologies, viewing problem solving as a process of intervention where practitioners can learn about and manage complex interacting issues. TSI was a framework that evolved from one of many possible operationalisations of critical systems thinking. For further reading on the early development of CST, and earlier iterations of TSI, the reader is directed to Flood (1990), Flood and Jackson (1991a,b), Flood and Ulrich (1990), Jackson (1985, 1990; 1991a,b), Jackson and Keys (1984), Oliga (1988), and Ulrich (1983). For further reading on more recent developments in CST the reader is directed to Payne (1992), Gregory (1995), Midgley (1992a,b; 1995), and Flood and Romm (1995). From these beginnings, TSI (as one practical implementation of the principles of CST) now continues its development into a methodology for use by problem solvers in all situations, not just the organisational-enterprise setting. This paper presents an outline of a detailed operationalisation of the critical review mode, one of the three modes in TSI.

An Introduction to TSI

TSI begins with the perception of the "mess." In problem-solving situations the majority of methodologies simply present an implementation strategy for analyzing and dealing with this perceived "mess." TSI adds the dimension of creativity (thinking creatively about surfacing the issues inherent in the "mess") and choice (choosing the best methodology(s) for tackling the "mess") in a recursive structure and process which more fully addresses the complexity of the problem-solving situation or "mess." This cycle is shown in Figure 1 which is taken from, and explained in greater detail in, *Solving Problem Solving* (Flood, 1995c).
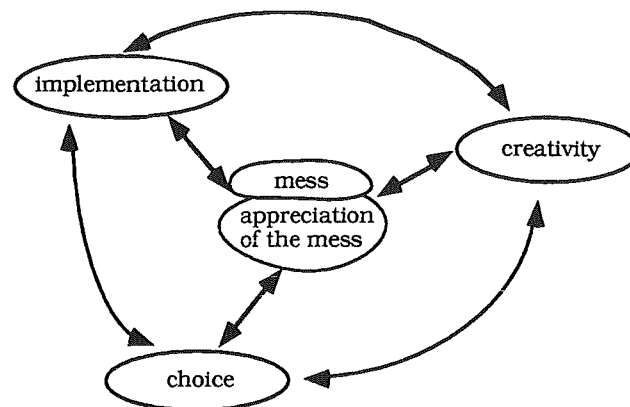
Fig. 1. The 3-Phase Process of TSI

More recent developments in TSI have expanded this basic structure to include three modes (the critical review mode, the problem solving mode, and the critical reflection mode) which all involve the same recursive structure. However, while the problem solving mode, as shown in Figure 1, deals with solving the "mess", the central concern of the prior critical review mode is the critique of a candidate methodology, and the central concern of the subsequent critical reflection mode is the review of the implementation of one or more of the previously critiqued methodologies which have been implemented in the problem solving mode. These interconnections are shown in Figure 2 which also shows how the entire process of TSI's three modes of operation can be viewed as being nested recursively within TSI's creativity, choice, and implementation cycle at a meta-methodological level.
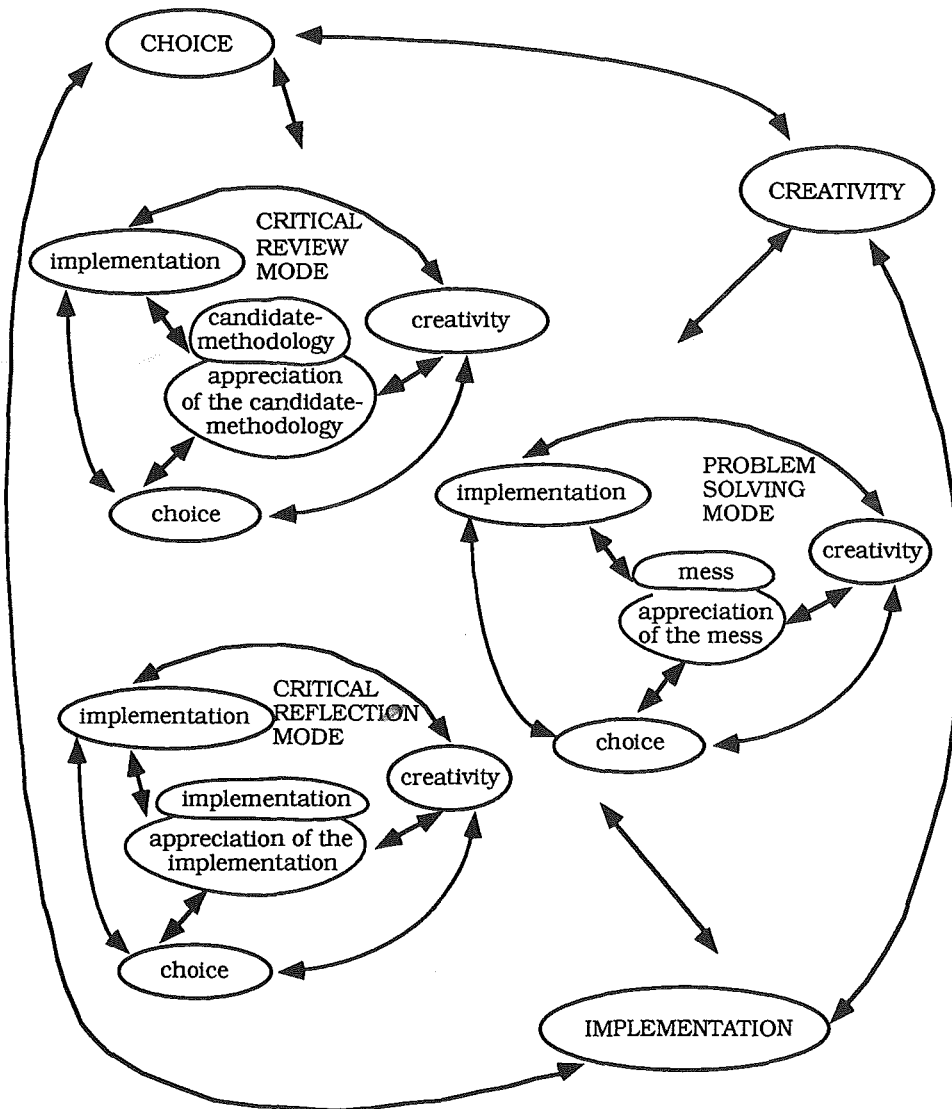
Fig. 2. Overview of the 3 Modes and 3 Phases in TSI

The Three Modes of TSI

The critical review mode, as it currently stands, critically assesses methods that may be used in the problem solving mode of TSI. This critical assessment is done by drawing upon

the three-phase "creativity-choice-implementation" cycle (Flood, 1995c). In the *problem solving mode* the phases of creativity, choice, and implementation are used to creatively surface core issues about the problem situation, choose the methodology(s) best suited for managing those issues, and offer and implement innovative change proposals for managing those issues. Methodologies are placed in TSI's system of methods following their review in the critical review mode.

The third mode is the *critical reflection mode*, which reflects on the outcome and the adequacy of the implementation made in the problem solving mode. Creativity is used to surface information about the issues arising from the implementation of a methodology, choice is used to decide the use of this information and implementation in the critical reflection mode causes changes to be made according to the decisions made in the choice phase of the critical reflection mode. At each phase, the critical reflection mode asks whether or not the most appropriate method was chosen for implementation, and asks whether or not the outcome was of benefit to the individuals involved in the situation.

The Three Phases of TSI

Within each of the three modes of TSI are the three phases of creativity, choice, and implementation. The first phase is *creativity*, facilitating an environment where participants can creatively think about their prior assumptions of the problem situation. Their problem situation can then be explored and addressed using divergent and convergent thinking, and the resulting information surfaced about core problems and issues in the problem situation can be recorded. The second phase is *choice*, evaluating and choosing methods with reference firstly to the issues and assumptions surfaced, and secondly, to the given purpose of available methodologies, so as to use the most appropriate methods for the situation. The third phase is *implementation*, implementing the methods chosen in the choice phase, so as manage the issues which were originally surfaced in the creativity phase.

In summary, the three modes are the critical review mode, the problem solving mode, and the critical reflection mode; and the three phases (creativity, choice, and implementation) operate within each of these three modes.

The Recent Changes in TSI

Much of the recent development of TSI reflects its use within the organisation-enterprise setting. However, the principles, practice, utility, and ideology underlying TSI are equally applicable in other types of systems interventions. The modelling and operationalising of the critical review mode presented in this paper is a recent addition to TSI, however the intellectual descriptive content of the steps within the operationalisation process and the naming of the three phases of creativity, choice, and implementation which underpin this model have already been introduced in previous iterations of TSI (Flood and Jackson, 1991a,b, and Flood, 1995a,b,c).

The Proposed Critical Review Mode

The critical review mode begins with two starting assumptions about any candidate methodology. The first assumption is that any candidate methodology advocates certain forms of creativity, choice, and implementation. The second assumption is that each candidate methodology may be defined in terms of four questions which are in turn linked with the four key dimensions of an organisation. The first and second questions (of these four questions) are "how" questions which address the first two key dimensions of an organisation, i.e. how is the efficient and effective design of a system (the design phase) to be achieved?. The next question, "what", addresses the third key dimension, the cultural issues, and questions the options available for the design (the debate phase). The final question, "why", addresses the fourth key dimension, the political issues, as to why a design should be accepted for implementation, who benefits from its implementation, and was this process the result of fair practice? (Flood, 1995c). These two assumptions underpin the use and operationalisation of the critical review mode.

The Generic Step Model for the Critical Review Mode

A generic outline of the six-step operationalisation of the critical review mode is shown in Figure 3. The generic diagram shows the possible recursive structure and process in the steps within the critical review mode, which is also central to the structure of the overall critical review mode and the TSI meta-methodology.

The content of the model shows the three phases, creativity, choice, and implementation underpinning the content of each step. The descriptive content of each step lies in the central rectangle and this is detailed later in this paper in Table 1 which shows the written detail of each step in the critical review mode.

The first phase, *creativity*, attempts to generate the possibilities, assumptions, and core issues which are inherent in the internal operation of the principles or the external practice of the candidate methodology.

The second phase, *choice*, is to make choices about the information gathered from the creativity phase and choices about the usefulness of this knowledge. This requires direct reference to the underpinning principles of TSI which are the principles/commitments of critical systems thinking. CST has three commitments: critical awareness, emancipation, and complementarism. In more recent writings, these commitments have been addressed and described as critical reflection (rather than critical awareness), pluralism (rather than complementarism), and improvement (rather than emancipation). For the reasoning underpinning these different wordings the reader is referred to Midgley (1992a,b; 1995).
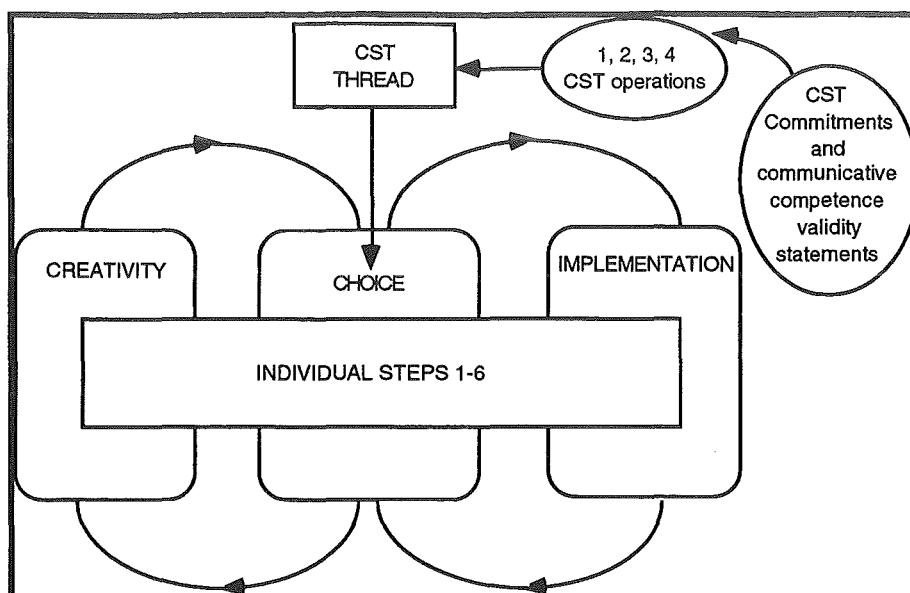
Fig. 3. Generic step model within the critical review mode

Some of these later writings about CST explore the use of Habermas's theory of communicative competence as the replacement for the underpinning theory of critical systems thinking (Habermas, 1976; 1984a,b). In this chapter, both the three commitments (critical awareness, emancipation, and complementarism) and the validity statements (truth, rightness, and internal subjectivity) will be utilised in this process of critique, rather than only one or the other sets of these principles.

The external, natural, objective world relates to the truth of the information gathered, which in turn relates to the theoretical underpinnings of hard systems methodologies, questioning the correctness of the information gathered. The social, normative, world relates to ideas of the rightness and justifications for the gathered information. Such rightness issues relate most closely to the underpinnings of soft systems and emancipatory systems methodologies. The final internal, subjective, world relates to the ideas about the sincerity of the gathered information and asks questions regarding the internal subjectivity of the people doing the communicating of the gathered information. These latter ideas may find expression in such methodologies as personal construct theory and cognitive mapping but this remains an area for further research (Midgley, 1992b; 1995).

These validity statements can be integrated into the choice phase of TSI (in the form of additional interrogative questioning) to operate in tandem with the previous three commitments. In this way, the combination of both the commitments and the validity statements, rather than just the use of one or the other, provides additional dialogue and input to the critical review mode for a candidate methodology. The integration of the commitments and the validity statements may be addressed in the choice phase by the operations in the CST-Thread which runs through the choice phase within all steps of the critical review mode and TSI.

In each of the step diagrams the CST-Thread feeds into the choice phase of the step. Each of the four operations detailed below are used to answer the requirements raised by the three commitments and the validity statements in each of the steps of the critical review

mode. These CST-operations are 1) **categorisation** of the information generated in the creativity phase, 2) **comparison** of that information both against the candidate methodology's own stated internal principles and with the knowledge accumulated in the system of methods, 3) **evaluation** of that comparison in terms of its enhancement of the candidate methodology, TSI, the system of methods, and how the candidate methodology fits into and adds to TSI's system of methods, and 4) **critical reflection** on the choice process just undertaken before the information from the choice phase moves into use in the implementation phase. Each of these operations use the information generated in the creativity phase and specifically work to answer the question content of the step.

The four CST-operations apply the "how" (comparison), "what" (categorisation), and "why" (evaluation and critical self-reflection) questions to the information creatively surfaced in the first phase. In addition, the validity statements can also be changed into interrogative questions regarding the truth, rightness, and internal subjectivity of the information communicated to the critical review mode by the researcher's critique of the candidate methodology. By applying these CST-operations at each step, an attempt is made at every stage to address the principles of CST, both the commitments (critical awareness, complementarism, and emancipation) and the validity statements (truth, rightness, and internal subjectivity), as the critique builds to the final picture of the candidate methodology which emerges at the end of step six in the critical review mode.

The third phase, *implementation*, implements this synthesis of information by either passing the information to the creativity phase of the next step or passing the information back to a previous phase in the critical review mode for further review. The reverse-recursive cycle shown in the generic diagram illustrates the possibility of passing the content of the critique back through the phases of the present and previous steps in the critical review mode. It's goal is to facilitate a critically-reflective feedback channel for further possible improvements to the evaluation of the candidate methodology.

The Creativity, Choice, and Implementation Subgroups

The critical review mode may be further grouped into the three subgroups, understanding/creativity (steps 1 and 2), categorizing/choice (steps 3, 4, and 5), and analysis/implementation (step 6). These subgroups explain the creativity, choice, and implementation phase requirements at the level of the overall model of the critical review mode.

The first subgroup of steps 1 and 2, understanding/creativity, involves surfacing the basic underpinnings of the candidate methodology being critiqued. The information from these two steps are the building blocks required for further critique and evaluation of the candidate methodology. Steps 1 and 2 together fulfill the creativity phase of the critical review mode.

The second subgroup of steps 3, 4, and 5, categorizing/choice, uses the information from the first two steps to further review the candidate methodology in terms of its contribution to knowledge about methodologies and their purpose for the problem solving mode. This subgroup of steps 3, 4, and 5 makes choices in terms of the categorization, comparison,

evaluation, and critical self-reflection of that information and fulfills the requirements of the choice phase and the principles of TSI within the overall critical review mode.

The third subgroup of step 6, analysis/implementation, sorts, evaluates, and implements the information gathered in the previous five steps of the critical review mode. This last subgroup reflects on the overall process and has the choice of either passing the information forward for use in the problem solving mode, or cycling back into the critical review mode at any point for further evaluation of the candidate methodology.

This step is the culmination of the previous five steps and it uses the four operations of the CST-Thread at a higher conceptual level to determine 1) the cumulative critique of the candidate methodology, 2) the enhancement to TSI from this cumulative critique, 3) the benefit to the system of methods, and 4) the increase to our understanding of the system of methods. The system of methods for TSI is a collection of critiqued methodologies which are placed within the creativity, choice, and implementation framework depending on their ascertained purpose and their assumed contribution to the TSI meta-methodology.

This last subgroup reflects on the overall process and has the choice of either passing the information forward for use in the problem solving mode, or cycling back into the critical review mode at any point in the step structure for further evaluation of the candidate methodology. The step 6 subgroup fulfills the requirements of the implementation phase within the overall critical review mode.

The last change in this iteration of the critical review mode is the addition of the CST-Thread which runs through every step of the process and culminates in the final step of the critique in step six. As described previously this CST-Thread holds the intentions and asks the questions required by the principles of CST.

Table I. The Subgroups and Steps of the Critical Review Mode

Subgroup One: Creativity/Understanding	
Step One	Details the candidate methodology's philosophy, principles, methodological practice, and process.
Step Two	Critiques the candidate methodology in terms of how its theory, methodology, utility, and ideology address the technical, practical, and emancipatory knowledge-constitutive interests (Habermas, 1972) of the situation and its participants.
Subgroup Two: Choice/Categorizing	
Step Three	Evaluates which of the three phases, creativity, choice, and/or implementation, the candidate methodology contributes to using the three phases themselves as the process for evaluation.
Step Four	Asks how the candidate methodology creates a vision of the organisational-enterprise ideal (as described later in this chapter) while also tackling the four key dimensions of organisation: efficient design, effective organisation, culture, and politics (the "How?", "What?", and "Why?" questions.)
Step Five	What meaning, if any, does this candidate methodology give to these four key principles of TSI: being systemic, being reflective, enhancing emancipation, and encouraging meaningful participation. (Realizing that each candidate methodology will answer these questions in different ways and using their own terms of reference.)
Subgroup Three: Implementation/Analysis	
Step Six	Asks how does the information gathered in Steps 1 to 5 combine to present a critique of the candidate methodology? How does this analysis enhance TSI and how does the information gathered enhance the candidate methodology itself? Finally, how does this critique enhance our understanding of the system of methods and how is the system of methods itself enhanced by this critique?
	In step 6 there is an accumulation of knowledge about a candidate methodology which is used to answer the questions detailed in this step. In addition, at this step there are also final questions about the methodology's ability to work instead of, or with, other methodologies which are already a part of the system of methods. This is discussed in greater detail in the explanation of step six presented in Wilby (1995).

Discussion

This chapter has focused on the operationalisation of the critical review mode but there are further possible insights. It may be that the structure of the critical review mode shown in Figure 3 can also enhance the other modes of TSI (of problem solving and critical reflection). The arrows between stages demonstrate the recursive structure of TSI, not only within the critical review mode, but also in the problem solving and critical reflection modes.

The end result of the critical review mode is a body of information that is more than a simple addition of he information generated in the individual steps of the mode. The enlightenment from this review process comes from the complete review, and the quality and benefits of this enlightenment are directly tied to the quality of the critical review of a candidate methodology. That is why the principle of critical awareness and self-reflection is so important in the critical review mode because a mechanical, objective, assessment of a candidate methodology will overlook any possible subjective insights and the recognition of

internal and external forces and biases in the review process. At step six the information can no longer be unthreaded to a particular source in the process but has instead become a synthesis of the gathered information. In this way, the critical review mode presents a review of the candidate methodology that is greater than simply summing the information from steps one through six.

In the choice phase, decisions (choices) must be made between the differing outputs from the information generated in the creativity phase and choices must also be made about the use and interpretation of the resulting information about the candidate methodology. The result of this work is dependent on the need to be critically reflective about the underlying biases, values, aims, and philosophy both of the method, and of the researcher(s) involved in the critique process. One researcher's use of the critical review mode will produce a critical review that is different from the critical review of any other researcher.

There is also a choice to be made as to where the critiqued candidate methodology will be placed in any theoretical framework which classifies systems or non-systems methodologies, a choice to be made in determining the role of participants in the intervention process, and a choice to be made in defining the relationship between the practitioner, the participants, and any others affected in the managing of complex situations. All of these concerns about choice and the practitioner's role call for a careful working of the choice process in all of the steps of the critical review mode.

In using the third phase of implementation, two levels of implementation are apparent. On one level there is the practice of actually implementing the critical review of the candidate methodology which is almost, but not quite, a nuts-and-bolts type of operation; simply working through the six steps of the review. However, on another level, this process also reveals where the candidate methodology being critiqued fits into the overall framework of TSI for possible use in the problem solving and critical reflection modes. So one level of implementation is somewhat routine (surfacing core issues and evaluating the candidate methodology) but the other level is a more complex evaluation which places the candidate methodology into the overall framework of TSI. This benefits and improves both the individual candidate methodology and the TSI meta-methodology.

The choice phase of the critical review mode presented in this chapter also attempts to answer questions concerning the roles, limitations, and responsibilities of individual participants and expert practitioners in each of the three modes of TSI. It is probable that the people involved in the process of critique will not be the same people involved in the implementation of the problem solving or the critical reflection modes.

The critical review mode can and should also be turned inward and be applied to the meta-methodology of TSI itself. This would provide further enhancement and understanding of TSI at all levels, and provide an evaluation of the utility of the meta-methodology and its system of methods in the management of complex situations. Such an evaluation would provide an internal critique of the TSI model and its principles which could then be further critiqued by other researchers. It would also facilitate a critical self-reflection on the part of TSI practitioners. At this time it is also important to comment that other non-systems methodologies may also be critiqued using this process in the hope that they will add a greater diversity to the present and future forms of TSI.

Finally, the language used to explain the recent changes and improvements to the framework of the critical review mode in TSI has been developed through research in the organisational-enterprise setting. This has arisen partly from the interests of the researchers involved in developing the philosophy, principles, and process of TSI, but also because the managing of complex situations is an enormous area of concern which will require much more time and effort in order to move TSI into these other areas of research. Attempts to define TSI's use in other contexts will ensure that the meta-methodology of TSI continues to evolve and widen its applicability and utility.

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THE ADOPTION AND USE OF SOFT SYSTEMS METHODOLOGY IN PRACTICE

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Abstract

The research reported in this paper is concerned with the adoption, adaptation, and use of Soft Systems Methodology (SSM) (Checkland 1981, Checkland & Scholes 1990, Davies & Ledington 1991) within management practice. The paper concentrates upon the extent to which SSM has been adopted and integrated into the management practice of 349 members of the Systems Study Group (SSG) of the Queensland Department of Primary Industry (QDPI). The study builds upon and complements the work of Mingers & Taylor (1992) who surveyed the use of Soft Systems Methodology in the United Kingdom.

Introduction

The undecidability of systems methodology (Checkland 1972, 1981, 1989) is the central, intellectual problem that confronts researchers in the field of applied systems analysis. Checkland goes on to suggest that the appropriate criteria for evaluating systems methodology are use, transferability, and teachability (Checkland, 1989). It is our contention that Checkland's position only represents the developer's perspective and that the user's perspective is equally as relevant. We suggest that, from the user perspective, the appropriate criteria are adoption, adaptation, and use. This paper reports the initial results of the survey of the members of an Australian-based interest group concerning their adoption, adaptation, and use of Soft Systems Methodology (SSM).

The rest of this paper is structured into sections discussing the background to the study, prior research, the background to the Systems Study Group, the research questions addressed by the study, research methodology, results, and, finally, discussion and conclusions.

Background

The discipline of management science is concerned with the development, evaluation, and use of formal methods of analysis for the enhancement of managerial decisionmaking and problem-solving. Since the early 1970's, a critique of the dominant, well-established, paradigm framework of the discipline has emerged and continues as a focus of research concern (Rosenhead 1989). One of the motivations for the debate about the nature of management science is a concern with the relevance of its theories, tools, and techniques to the real-world practice of management. It is a realisation that OR/Management Science has not developed as an extensive professional occupation in its own right and that often the results of management science studies are not seen to have value by real-world managers.

The critique of management science has been extended by a range of research programs that have established non-traditional formal approaches for the support of managerial problem-management activities (Rosenhead 1989). One of the major non-traditional systems analysis/management science approaches is Soft Systems Methodology (SSM), developed by Checkland and his colleagues at Lancaster University. SSM is considered an appropriate focus for this research because:

a) it is well-established in the research literature of management science
b) it is distinctly non-traditional in philosophy and operation
c) it has a recognisable degree of formal structure
d) it has had a clear profile in the literature for over a dozen years which suggests that there has been sufficient time for some impact upon practice to have taken place
e) the use of SSM outside the research community has been established in a previous study
(Mingers & Taylor 1992).

A substantial research literature concerned with this approach has developed. Yet, still very little is known about the impact of SSM upon the practice of problem-solving outside the research community. In this paper, the primary focus is the impact of SSM upon management practice.

Prior Research

Mingers & Taylor (1992, p. 321) set out to
" ..establish the use of SSM by people with no reason for choosing SSM other than its efficacy."

Recognising the impossibility of defining such a population, they chose instead to concentrate upon
" .. those who have been exposed to SSM in some way, for example by a course."

They established a sample population of 294 and attracted 137 respondents to a postal questionnaire. The responses established that 90 respondents were users of SSM; 47 non-users, and 90 (66% of respondents) had used the approach more than once. Of the 126 reported projects using SSM, respondents rated the level of success in using SSM as good or very good in 67 (53%) of the cases. Overall, the study establishes that adoption, use, and adaptation of Soft Systems Methodology has occurred within the United Kingdom, outside the originating community of researchers who developed the approach.

The study, however, raises the following three concerns when considered from the perspective of the impact of formal methods upon management practice:

• the study is (or at least appears to be as no mention is made to the contrary) limited to the situation within the U.K. As SSM was initiated at Lancaster University and much of the

research conducted in the U.K., the question becomes, "is SSM transferable to other situations?" This concern questions the generalisability of the Mingers & Taylor study to other countries.

• it is difficult to establish the relationship of the sample population to the intended reference population; a point which Mingers & Taylor recognise. Again, this concern raises the question of generalisability of results to other situations.

• the sample population, and apparently the population of survey respondents, is heavily biased towards people who became aware of SSM through postgraduate study. Of the chosen sample population in the Mingers & Taylor study, 57 (41.6% of respondents) became aware through postgraduate study [44 (32.1%) were graduates of the MA/MSc. courses in systems from Lancaster University and 13 (9.5%) were from the MSc. course at East London Polytechnic]. This situation is highly unlikely to occur in any other population.

The Mingers & Taylor study focusses upon a group with very high exposure to Soft Systems Methodology. In addition to the postgraduates mentioned, 51.8% of the sample is drawn from lists of U.K. Operational Research/Management services groups and 48% from members of the United Kingdom Systems Society. Within this population, adoption rates vary with the degree of exposure to the approach. The results lead Mingers & Taylor (1992, p. 323) to suggest that " .. SSM cannot be successfully assimilated without a significant period of study." Clearly, the level of exposure to SSM appears to be an important variable influencing its adoption and successful use.

In summary, Soft Systems Methodology can be regarded as a significant non-traditional, general, formal method that has had an impact upon management practice in the sense that a user community separate from its originators has been identified. What is far less clear is the Mingers & Taylor results regarding the processes of adopting and using SSM in management practice. The level of exposure to the ideas emerges as a possible influence. The focus of the study presented in the rest of this paper is the investigation of a population with a lower level of exposure to Soft Systems methodology - a population drawn from the Systems Study Group (SSG) of the Queensland Department of Primary Industry (QDPI).

Background to the Systems Study Group

Agriculture (Primary Industry) is a major sector of the Queensland and Australian economy. It is an economic sector with enterprises ranging in size from the small family farm to large multinational corporations. It operates on a vast geographic scale with many types of climatic conditions and land types. It is a highly competitive economic sector with extensive local, national, and international markets. Agricultural activity is heavily dependent upon science and technology, as well as being influenced by economic and environmental factors. It impacts upon all aspects of the state, its population and government and requires communication and transport infrastructure to support its operations. Financial, medical, education and other services are also needed to support its human communities. It has an impact on upon land use,

land care, the management of water, and the natural environment. Yet, in human terms, agriculture has a small, widely spread, and relatively isolated community with a lifestyle very different to that of the predominantly urban majority. The dichotomy between the bush and the city is part of the psyche of Queensland, part of its heritage and culture, and a major part of its economic, political, and social dynamic. In short, primary industry is a large, complex, and very important part of Queensland.

The Queensland Department of Primary Industry (QDPI) is the department of the state government that seeks to monitor, regulate, and enhance the operation of the primary industry sector of the state economy. To pursue its mission, the QDPI undertakes a wide range of activities including the conduct and support of research in agricultural science and technology, and, through its extension officers, seeks to provide the best advice possible to those engaged in primary industry activity. It is in this context that the Systems Study Group was established and developed.

The Systems Study Group (SSG) is the formal name for a semi-formal interest group. It was initiated in the late 1980's by a handful of people in the QDPI who recognised that they were facing, in the course of their work, ill-structured problems that ranged well beyond the conventionally accepted boundaries of agricultural science and that required new (to them) approaches to problem management. Systems ideas were regarded as relevant to this area as they overlapped the domains of conventional agricultural science and the new problem areas that were being faced. The ideas had a champion and activist within the QDPI and, through his efforts, the SSG emerged as an interest group.

The group has little formal structure and, although recognised and encouraged by the QDPI, it is not formally supported as a program activity within the department. The main activities of the SSG are the circulation of a newsletter and the organisation of occasional meetings. There is no membership requirement, qualification, or fees. The group has members Australia-wide.

There is some evidence that Soft Systems Methodology is a topic that has entered the discourse of the group. Soft Systems Methodology has been mentioned within the newsletter, a 2-day course on SSM was initiated in 1990 and similar short courses have been continued since. In addition, two informal conferences, focussed upon complex problems in agriculture, were organised - one in 1991 and the other in 1993. Each conference attracted about 40 participants and some mention was made of SSM during the proceedings.

The SSG is an informal community in apparently that some exposure to SSM has occurred, but the population of the group is not dependent upon an interest in, or knowledge of SSM. It is a population constituted quite differently to that of the Mingers & Taylor study, ie. not determined by formal exposure to SSM, and one in which the nature and form of exposure to the ideas should be substantially different to that of the U.K. sample population. The extent, level, and nature, of the exposure to SSM, and the extent, level, and nature of the use of SSM amongst the membership of the group have not been investigated prior to this study.

Research Questions

The primary research question in this paper is the extent and nature of the impact of Soft Systems Methodology upon the membership of the Systems Study Group. The basis for the group is some (undefined) level of interest in ideas and experiences relevant to tackling complex real-world problems. The group, therefore, is not predicated upon any a priori relationship with Soft Systems Methodology. It is a professional grouping that, in principle at least, is founded on the basis of concerns with management practice rather than with formal methods. The group is also based outside the U.K., has had some exposure to SSM, but should have had lower levels of exposure as a formal method than the U.K. group surveyed by Mingers & Taylor because of the distance from the primary source of research and teaching in the area of SSM. The group is appropriate for this study because it should be qualitatively different from that used in the previous study and relevant to the overall concern with management practice.

The research situation, outlined above, leads to the following aims for this research project:
  a) to establish the extent and level of exposure to SSM within the SSG;
  b) to establish the nature of the exposure to SSM within the SSG;
  c) to establish the extent and level of usage of SSM within the SSG;
  d) to establish the level of success in the use of SSM within the SSG.

Further, based upon Mingers & Taylor's conclusion that "a reasonable amount of training is necessary - certainly more than a one-day short course" for SSM to be adopted, and the presumption that the SSG will have lower levels of exposure to SSM than the U.K. group, the following propositions can be made:

P1:   **That the levels of use of SSM within the SSG will be significantly lower than those observed within the U.K. study.**

P2:   **That the level of success in adopting SSM will be significantly lower in the SSG group than those observed with the U.K. study.**

Research Methodology

The research approach adopted is exploratory, cross-sectional, and SSM specific. A questionnaire containing 10 questions was developed by adopting the key elements of the Mingers & Taylor study. It contains a mixture of specific and open-ended questions. One question asks specifically about whether the respondent is aware of SSM, and if the response is "No" then no further questions need be answered. The covering letter urged those not aware of SSM to complete and return the questionnaire.

The intended sample population was all members of the SSG. The mailing list for the SSG was obtained from its co-ordinator. However, upon examination two members were removed from the membership list - Dr. Paul Ledington (co-author) and Prof. Peter Checkland, on the basis that they are strongly associated with the research program that developed SSM at Lancaster University and, therefore, they could not be considered either typical or unbiased respondents.

Survey Results

Summary statistics of the survey are presented in Figure 1. The response rate of 55.9% is slightly higher than the Mingers and Taylor response rate of 47%. While all respondents in the Mingers & Taylor study are aware of SSM, some 40 (20.4% of respondents) in this study had not heard of SSM.

Nature of the Exposure to SSM

The mode by which respondents became aware of SSM is shown in Figure 1. The respondents coded their level of awareness as: (1) through contact with knowledgeable individuals, (2) through books and articles, (3) through training courses, (4) through undergraduate courses, and (5) through post-graduate training, with level (1) providing the least exposure to SSM and level (5) being the most extensive exposure. Their responses were categorised into three exposure levels: low, medium, and high exposure. The low category corresponds to level (1) - contact only; the medium category to levels (2) and (3) - exposure by books, articles, and training courses; and the high category comprises levels (4) and (5), university undergraduate and postgraduate courses.

Extent and Level of Exposure to SSM

The extent and level of exposure are summarised in Figure 1. Of the 156 respondents who are aware of SSM, 56 (35.9%) have exposure by contact with knowledgeable individuals, 30 (19.2%) became aware through books and articles, 34 (21.8%) became aware through 1-2 day training courses, 5 (3.2%) through an undergraduate course, and 29 (18.6%) have had the most extensive exposure through post-graduate training courses. The percentages of the aware group for each category are: low - 35.9%, medium - 41%, and high - 21.8%. Two respondents (1.3%) did not provide an explanation of how they became aware of SSM. This result substantiates the assumption in this study that the group has a lower level of exposure to SSM.

Extent and Level of Usage of SSM

Of the 156 (79.6%) respondents who are aware of SSM, 102 (65.4%) claim to use the methodology. This proportion is similar to the Mingers & Taylor result where 90 (65.6%) were users and 47(34.4%) were non-users of SSM. **This result does not support the proposition, P1, that the level of use will be significantly lower in the SSG group.**

Nature of Adoption of SSM

Adoption of SSM is coded into three levels: (1) use SSM core elements, (2) partially use core elements, and (3) don't use core elements. Checkland [1981], identifies the core elements of

SSM as (a) the development of conceptual models and (b) the comparison stage. SSM users who use the two core elements are coded in level (1), those who only use one of these elements are coded in level (2), and users who claim to use SSM but do not use these core elements are coded in level (3). Level (3) users use other aspects of SSM such as Rich Pictures and CATWOE analysis.

Extent and Level of Adoption of SSM

Of the 102 users, 46 (45.1%) state they user the core elements, 40 (39.2%) don't use the core elements, and 10 (9.8%) partially use these elements. These findings are substantially different from the Mingers & Taylor result. Mingers & Taylor do not clearly specify how many users adopt the core elements; however, they do specify that these aspects were nearly always used.

Relationship of Level of Exposure to Level of Adoption

Expectations are that the level of exposure to SSM would affect how users adopted SSM. The greater the exposure to SSM, the more likely they would understand and use all aspects of the methodology while less exposure would result in only partial adoption of SSM. The results of the X^2 test showing the relationship between level of exposure and level of adoption are summarised in Table 1.

Table 1. X^2 Results - Level of Exposure vs Level of Adoption

	Level of Exposure			
	Low	**Medium**	**High**	
Level of Adoption	Observed Frequency			$\dfrac{(f_o - f_e)^2}{f_e}$
Use Core Elements	7	16	23	9.476
Partially Use Core	6	6	4	0.948
Don't Use Core	14	22	3	9.064
Total	27	44	30	

$df = (3 - 1)(3-1) = 4, X^2_e$ at .001 level = 18.465 $X^2 = 19.488$ ** $p < .001$

The analysis shows a highly significant relationship ($p < .001$) between level of exposure and level of adoption. The results indicate that the greater the level of exposure to SSM, the greater the adoption of core elements of SSM. One user did not respond to the adoption question.

Nature and Level of Success in Using SSM

As shown in Figure 1, 70 (68.7% of users) state they have used the methodology successfully, partially successfully, or sometimes successfully. Only 8 (7.8% of users) claim unsuccessful use. 18 (17.6% of users) did not comment on the success of SSM use and 6 (5.9%) could not

comment because the project was not completed. Comparison with the Mingers & Taylor result for success proved difficult because the base on which the % success is calculated is not clear. They do report that 63% replied good or very good success. **It appears, therefore, that proposition, P2, is not supported. The level of success in adopting SSM is not significantly lower in the SSG group.**

Relationship of Level of Adoption to Level of Success

Table 2 depicts the relationship between level of adoption and level of success. Some cell frequencies are not large enough to conduct a X^2 test. The results, however, indicate that there is no difference in reporting successful use of SSM between non-core and core users. 29 core users and 29 non-core or part-core users report successful use. The core-element users tend to be more hesitant about committing to complete success. 11 of the 12 who report partial success are core users. 75% of unsuccessful users do not use core elements although the frequencies in these cells are too low to draw any conclusions.

In response to why the use of SSM was successful, the majority of non-core users (13 of the 18 respondents to the question) believed it facilitated learning and understanding, created a breadth of ideas, or increased communication and enthusiasm. Only 5 of the 18 mentioned achieving objectives or outcomes as success factors. The main focus, therefore, of the non-core users is on sense-making in the situation. The core users believed sense-making is important (12 of the 29 respondents to the question). These users, however, placed a greater emphasis on outcomes as 22 of the 29 mentioned improved situations, changed practices, problem improvement, problem solution, or better outcomes as success factors.

It, therefore, appears SSM can be adopted successfully in two ways - as a sense-making methodology or it can be fully utilised to facilitate action and improvement in the situation.

Table 2. Level of Adoption vs Level of Success

Level of Adoption	Level of Success			
	Successful	Partially Successful	Unsuccessful	Total
	Observed Frequency			
Use Core Elements	29	11	2	42
Partially Use Core	7	0	3	10
Don't Use Core	22	1	3	26
Total	58	12	8	78

Discussion and Conclusions

These are early results from our study and, therefore, need to be treated with some caution. Further data collection is underway in an effort to address some of the issues that arise from this study. Bearing in mind this caveat, we see a number of issues arising from this survey.

- Although the exposure to SSM in the SSG is qualitatively very different to that in the U.K. study, the overall level use is not significantly different.

- The nature of the adoption does, however, seem to be at a considerable variance with the U.K. study. Discrimination into the three groups - core users, partial users, and non-core users seems to readily fall out of the data and correlates significantly with the three exposure levels.

- The success rate is similar to the U.K. study but qualitatively the idea of two frames of reference (sense-making and change management) emerges clearly.

- Two other features stand out to us. First, the importance of personal contact in facilitating the diffusion of the ideas. Second, the ineffectiveness of the short training course in producing core users.

We conclude that there is evidence of substantial adoption, adaptation, and use of Soft Systems Methodology with the Systems Study Group. The extent of the proliferation of the approach is, however, unexpectedly large, the variation in adaptation is more complex than anticipated, yet, given the extent to which users see the approach as successful, we conclude that a positive impact upon management practice has been demonstrated.

Number of Surveys - 349

Number of Responses - 196   Non - Responses - 153

Number not Aware of SSM - 40   Number Aware of SSM - 156

Became Aware by Contact   Aware by   Aware by Training   Aware by   Aware by   No Response - 2

Number of   Non -Users -

Used SSM Successfully   Partially Successful Use 12 (11.8% of Users)   Unsuccessful Use   Project Continuing   No Answer

Use SSM Core   Don't Use   Partially   Use SSM Core   Don't Use   Partially   Use SSM Core   Don't Use   Partially

Figure 1 - Summary Statistics of SSM Survey

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SECTION 3

INFORMATION SYSTEMS

A SYSTEMS PERSPECTIVE ON USING A STRUCTURED INFORMATION SYSTEMS DEVELOPMENT METHODOLOGY

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Abstract

The process by which systems development staff develop computer-based information systems has changed significantly over the last fifteen to twenty years. During the early 1970s, ad-hoc methods were used to analyse and design computer based information systems. In the nineties structured systems development methodologies are frequently used. This study looks at the role of a structured systems development methodology in a large service organisation. In particular, it looks at the satisfaction with the method in terms of the strengths and weaknesses of the approach and what the significant factors are in the methodology being deemed to be a success within the organisation.

The study, through a series of in-depth interviews, examines the 'life' of a methodology from both a technical and non-technical perspective. The work proposes that the success of the methodology depends on political and social factors as much as the technical. Whether the method has strong support from key personnel, the standards that are enforced, and the reward system for technical competence are all significant aspects of successfully using a structured methodology. A systems approach in the case study was the only way that these factors could be uncovered and tends to confirm the growing body of research in IS that developing 'technical' systems is as much a political and social process as a technical one.

Introduction

The process by which systems development staff develop computer-based information systems has changed significantly over the last fifteen to twenty years. During the early 1970s, ad-hoc methods were used to analyse and design computer based information systems. According to Hawryszkiewycz (1988) during the 1970s:

> many new ideas were introduced to overcome problems associated with ad-hoc methods. One of these ideas was the use of modelling techniques instead of natural language for describing systems. Another idea was the distinction which was made between logical and physical analysis and design. A third idea was the introduction of a structured way of moving from a description of user needs to a working system. (p. xi)

With increased emphasis being placed by management and owners of computer systems on productivity and performance in the marketplace, use of and satisfaction with, systems analysis and design tools becomes increasingly important. During the period spanning the last twenty years many different methodologies and tools have been used to develop computer-based information systems. While the magnitude of improvement in hardware technology has resulted in lower cost and increased capabilities, Necco, Gordon, and Tsai

(1987) found that this has highlighted the need to improve the software development process.

SSADM over the last ten years has become the standard systems development methodology used by central government bodies in the United Kingdom. Over that time it has experienced a number of revisions with version 4 being released in 1990. The reason behind its development was to have a standard systems development methodology which could be used across all government departments and by external organisations that were developing computer systems for the various departments. Ashworth (1988, p. 153) found that "SSADM has also been adopted as a standard by public utilities, local government, health authorities, foreign governments and several large private sector organisations".

The study will identify the satisfaction with the methodology and how the culture and the politics of the organisation effect the development and success of the methodology? The methodology under examination is SSADM (Structured Systems Analysis and Design Methodology) in a large service organisation. The overall intention is to take a systems perspective of the methodology to uncover the factors that infulence its success or failure and associated degrees of satisfaction. It is important therefore to take a wide perspective in analysing the methodology, to determine if the technical, or the social and political factors are of paramount significance. We argue that if the benefits of using a structured information systems methodology are to be accrued then there needs to be a systems or holistic systems appraisal (Checkland (1981). As Checkland and Scholes (1990, p.312) say "Where perceptions and meanings, and hence tasks, are more problematical, the project approach needs to be complemented by a process for the continual rethinking of organisational tasks and processes." The first section of the paper will examine other work on structured methodologies. The second section will explain the research approach taken in this study. The third section will present the research findings and the final section will at the implication for organisations using structured information systems methodologies.

Research on Structured Information Systems Development Methodologies

During the 1970s structured methodologies emerged to provide an organised approach to software development. These methodologies consisted of sets of rules, methods, and assumptions used to organise the problem solving approach by listing, documenting all steps, and diagramming. They helped standardise and systemise software development and maintenance by approaching it using an engineering discipline rather than by whatever individual software developers fancied.

While some conventional systems development techniques have recognised the importance of the social and political components of Information Systems Development, a greater concentration is still given to the technical process of systems development. A number of books, Hawryszkiewycz (1988), Hodge and Clements (1986), Whitten, Bentley and Barlow (1994) have concentrated on the technical aspects of systems development. Generally, they present developing an information systems as a structured process which models the data and processes and where the people or users are one component of the existing or proposed system along with the hardware and software. Research into SSADM in particular was conducted by Edwards, Thompson and Smith (1989a, 1989b). Through a series of case studies they looked at how SSADM was used. Again though there studies

were technical examinations of the methodology and did not to any great extent examine the human-technical interface.

Mowshowitz (1976) is quoted by Hirschheim et al. (1991, p. 29) as saying that "many, if not most, information systems are failures in one sense or another." Gladden (1982) is also quoted by Hirschheim et al. (1991, p. 30), reported some worrisome figures, saying that "75% of all the cases of systems development he surveyed, either the development is never completed or the product of completed development is not used". It is believed that a major part of the problem has been the lack of recognition that Information Systems development is largely a social process. This was recognised by researchers such as Checkland (1981), Keen (1981) and others. It should come as no surprise to systems developers that social interaction such as : prototyping, obtaining requirements, conducting structured walkthroughs, discussing design options, are all intensely social activities, important in the process of building systems. These activities on their own however are not considered to be sufficient to guarantee success. Boland (1985) is quoted by Hirschheim et al. (1991, p. 30) as claiming that "Systems development proceeds through the social interplay of multiple actors who attempt to interpret or "make sense" of their and others' actions, largely through the medium of language."

Those that recognise the importance of the social and political factors are growing in number. According to Grover et al. (1988, P. 145) "user resistance to management information systems is common." While there a number of different reasons why systems either succeed or fail an important part to understanding user resistance to management information systems is to recognise the role politics has to play. In some circumstances user resistance may take the form of obstruction due in part to a perceived threat to their parochial interests by reducing their autonomy, increasing their workload or invading their territory. The tactics they may use range from disingenuousness to downright dissimulation. To view user resistance to a project Keen (1981) applied the concept of "games". The games metaphor and the typology developed by Bardach (1977) and cited by Grover et al. (1988) may serve as the basis for a discussion on the existence of political activities during MIS development and implementation. Keen (1981) believed that the typology might assist MIS professionals, users, user management, and MIS managers recognise political maneuverings as they try to develop high quality systems and with substantial contribution to their organisation.

Hirschheim et al. (1991) examined the influence of myth, metaphor, and magic as a means to facilitate a much richer understanding of systems development. The work of Kendall and Kendall (1993) has an interesting contribution to make in that they linked the concept of the metaphor with development methodologies. During interviews nine metaphors were identified. These metaphors were then linked to various development methodologies that are currently used. Kendall et al. (1993) attempted to link these metaphors to the development methodologies currently used in the Information Systems development industry (see table 2).

For many people careers and career progression is an important part of a persons working life. Ginzberg and Baroudi (1988) found that there were very few MIS directors that had moved beyond Vice President for MIS to a corporate General Management position.

According to Ginzberg et al. (1988, p. 587) " Career DP managers do not typically possess the requisite communication and general managerial skills to move into general management of the organisation". Ginzberg (1988) points out that while the reported results from various empirical studies are not all consistent, the recommendations for managing DP personnel found in the literature is. DP managers need to:

1. Pay closer attention to formal career planning maybe by adopting such tools as skills inventory, career ladders, training programs and skill matrixes; and
2. Provide both a technical and managerial career options for IS personnel by implementing a dual career ladder.

Research Method

The research methodology is an ethnographic, genealogical study. As many of the objectives of the research relate to the behaviour, world views and values of individuals and the culture and politics of the organisation, a qualitative approach was most suitable. The study has drawn upon informal communication as a participant, personal observation over the period of the study, interviews conducted with staff and a range of formal interactions and communication. Field notes were made to document information, thoughts, and impressions, while an on-line diary was used to record appointment times with the interviewees. A tape recorder was used to record the interview only if the interviewees granted their permission. The researchers have had a long association with the organisation.

The organisation under study is a large organisation which will be referred to as Information System Development (ISD), with offices throughout the state of Western Australia providing a number of vital services to the public. The section within this organisation that is the focus is the Systems Development Section. The Systems Development Section is responsible for building customised software applications for clients throughout the organisation. These applications vary greatly. They include personal, work management, asset registering, customer information, payroll, and stores systems. The software developed by Systems Development typically consists of large, Mainframe CICS / COBOL / DB2 based transaction - processing application systems that the organisations clients use to support their major administrative activities. Some Personal Computer systems are also developed but there are fewer PC system developments.

The study adresses three main areas:

1).The reasons for choosing the methodology.
2).The extent to which the methodology was used and the perceived satisfaction with it.
3).The factors that influence the development, usage and success/failure of the methodology.

The organisation that was targeted for this case study is one that develops computer systems that vary from small PC based systems to large corporate wide mainframe systems. This enabled the researcher to compare the responses from developers of both small and large systems. The main employees that were targeted within this organisation were computer systems development staff employed as Programmer / Analysts (8), Project Leaders (3), Programmers (9), Information Technology Officer (1), Project Manager (1), and

development review and consulting personal such as the Chief Analyst (1), Quality Assurance Administrator (1), Data Administrator (1) and Chief Programmer (1). There were 26 participants involved in this research case study. Staff who have not had any experience or very little experience in using SSADM were still selected for an interview so they could express their opinions and the reasons for them.

Comments

Below are a series of comments made by the employees. Due to the brevity of the paper I have just put these in to represent a range of views.

we attempted to use SDM70 in its complete form. The methodology was so verbose that it became very difficult to use so we rationalised its use and used selected parts of the forms and used that for some years with considerably more success. There appeared to be some initial use of SDM70 but that waned very quickly. There were training courses conducted but very little follow up and very little enforcement.

Preferably a prototype to me seems the best way of absorbing a users requirements. Users mainly associate with screens and identify processes via screens. This gives them an added advantage because they see a system which is related to there initial idea therefore it allows change without major implication. I.E. cost, it can be thrown away, and minimal effort. I have developed one or two systems using a prototyping technique and the results have been encouraging. Users tend to provide more information and the analyst are able to communicate in better terms, thus delivering a product which is more useable by the user.

There is no career path down the technical way because you have the Chief programmer sitting up there and no body in between but the analyst types and that really is ridiculous, I don't know how that evolved. Probably because management types believe that if your not a good manager then you are not a good worker and management types tend to believe that if you cant manage then you are not worth more than $30,000 a year.

You need to be versatile, a sound technical knowledge, in some cases you need to be conniving and not entirely truthful. The interviews that are conducted require you to have strong technical knowledge in areas such as the programming environment, data modelling, SSADM.

Unfortunately political involvement of who likes you and who does not rather than on merit. Its obvious from the way people get promoted and the way people get allocated analysis tasks according to favouritism, prejudice, political expediency. There is no career path except people who want to specialise in analysis. Analysis is the only way up. My main experience of this is due to not towing the political line. I don't play the political game and I don't expect to be promoted.

Discussion

The above has described a number of key experiences of Systems Development staff within ISD before the deployment of SSADM to seven years later, and examined the influence of factors both inside and outside the control of the Systems Development section. The results indicate that, contrary to certain expectations in the literature, a structured methodology such as SSADM, which is receiving widespread use in the United Kingdom's government departments, is not the single most important part of building successful systems. Instead, we see the emergence of factors such as myths, metaphors, magic, politics, interpersonal skills, culture, resistance, group dynamics, symbols and world views. Keen (1981) found that

> There have been few studies of the political aspects of information systems development. The topic is rarely discussed in textbooks and even the literature on tactical implementation deals with it only peripherally. Yet when one tries to reconstruct or observe the progress of any major project, this is an obvious and important feature. It is absurd to ignore it or treat it as somehow an unsuitable subject for study or for training MIS specialists. (p. 31)

These results, albeit from only one organisation, highlight, yet again, the fallacy of believing a methodology alone could bring about the development of successful systems. Technologies are built to achieve certain goals at a given time. The productivity tool's particular form and functioning reflect the interpretation of ISD Systems Development (SD) management strategic intentions in the late eighties. Within ISD, the SSADM methodology was introduced into the development process to augment and automate newly developed work practices.

Implications For Methodology Selection

The findings on how ISD selected the SSADM methodology provide a basis by which other organisations considering the selection of a development methodology may approach this difficult task. With any decisions there may be people for and against the outcome using an approach which involves people who may be considered as independent with an objective evaluation procedure may reduce the likely hood of disputes between parties with opposing views. The decision to select SSADM occurred during a time of change initially in the structure of the SD section and then a potential change to the work practices of SD from an external management consulting firm named IMC who had plans to jointly develop software using their own in house developed methodology. The methodology was one of the three selected for evaluation.

One of a number of weaknesses with this approach to methodology selection though is that depending on the circumstances that may exist in an organisation an apparently objective approach such as selection through the use of weightings can easily be altered to suit the desired option. For example if the situation that exists in an organisation is one where the external organisation involved in the joint software development contract plans to take over the software development through an out sourcing process then those performing the

evaluation, who may not be in favour of out sourcing, could weight the criteria in such a way as to favour one of the alternate methodologies which would reduce the likelihood of out sourcing. In this case SSADM. The situation that has just been described does not appear to be the case as far as ISD is concerned as there was research carried out on training and support available, referees for the methodology and feedback from Project Leaders way sought.

Implications For Satisfaction With SSADM

The ISD results, indicate that SD personnel are divided as to whether they should be using SSADM or some other methodology. This division exists throughout the SD hierarchy. Even though officially SSADM is the standard development methodology some of the senior staff who need to support it to guarantee its future use are not support it to guarantee its future use are not supporting it. This has left some SD personnel frustrated by the lack of commitment to SSADM. While others are hoping that they can influence the decision so that it can be changed.

With the onset of Client / Server development at ISD, further evaluations may need to be carried out to determine whether a structured approach to developing systems or an alternate approach such as Object Oriented Development, Rapid Application Development (RAD), or prototyping is most suitable. The belief that using one standard methodology for all systems developed is now beginning to be rejected. Senior staff in SD are starting to recognise the need for a standard family of methodologies. At the start of a project a decision will then be made to determine which methodology is best suited for the development.

Implications For Employee Career Paths

The ISD findings show that there is considerable dissatisfaction among IS personnel in regards to the career paths available to them. The majority of IS personnel felt that there should be more than one career path available to them. Preferably a technical path which helped them progress up towards a Chief Programmer position.

Of the twenty six SD personnel interviewed for this research six have left ISD to obtain promotions with other organisations in the last year. A seventh employee has joined another computing section of ISD. Four of the seven have gained promotions following a more technical career path.

SD personnel have shown the same concerns about their career paths as Ginzberg et al. (1988). The ISD results show that staff feel that they have to go down the analysis path towards Project Leading and management because they believe that this is the only way they can earn a higher pay rate and promotions.

Implication For Career Progression

The results of the interviews with SD personnel working for ISD show an alarming trend for management and one that needs to be addressed quickly to maintain the integrity of the interview, selection and promotion process. SD personnel believe that the problem started by the allocation of higher duties to certain employees. The higher duties resulted in certain selected staff receiving additional pay for doing duties above their present level. An employee could be given the opportunity to perform duties (at most usually tow levels above their existing level) at a higher level, receive extra pay and gain experiences that would assist them when promotions were advertised. The decision to allocate higher duties being largely a subjective decision based on the comments of an employees supervisor or on a decision by the managers based on the difficulty level of the work to be completed.

Not all staff have received the opportunity to perform higher duties. The reasons for the discrepancy very depending on the employee interviewed. The main concern for management was that negative comments were given from employees from differing level in the SD hierarchy, and from employees performing the higher duties. Due to a fixed hierarchy structure with low turnover because of the recession and the lack of promotion opportunities in other organisations, promotion opportunities within the SD section have been few and far between. So the main opportunities for staff to gain more challenging duties was by performing higher duties. An example follows: A programmer is allocated to perform some system enhancements to a system. While performing these duties they received an higher duties allowance and were given an opportunity to act as a Programmer / Analyst. To assist them to make all the program changes an additional programmer was allocated to the project. The acting Programmer Analyst was then given an additional temporary pay rise and there position was upgraded to Analyst / Programmer for the duration of the changes. This left the allocated Programmer feeling that they were being unfairly treated as there was only a years difference in experience between them.

Implications For SSADM and Future Careers

The findings show that SD personnel at ISD don't see SSADM as being a vital part of their future careers. To them SSADM was a methodology which they would use only if it was the standard methodology they were meant to be using. Only one of the SD employees say it being a methodology that they would look for if they joined another organisation. Since the experience level in other development methodologies were low, some found it difficult to say if that would be the methodology they would want to use in their future careers.

Most employees had differing opinions as to whether it would be the methodology they would see themselves using in their future careers. SSADM as a methodology, while extensively used in the United Kingdom's government departments has not received as widespread use outside the UK or Europe. At present there are only a few local sites which actually use the methodology. So the likely hood of staff who leave ISD using SSADM in another organisation is very low. With SSADM's use under long term doubt employees need to be adaptive and support the current organisational standard rather than become too attached to using only SSADM in their future careers.

Implications Of The Role Of SSADM In Career Progression

SD personnel were divided on the issue in regards to whether SSADM does have a major role in career progression at ISD. Other personal qualities such as analytical abilities, interpersonal, communication, group dynamic and leadership skills were considered more important than being an expert in a methodology by some employees. The views are partly consistent with the views of text books and research on systems analysis, such as Hawryszkiewycz (1988), and Hodge and Clements (1986).

Some staff in SD were very cynical in their views on the role of SSADM. They believed it was being used as a political tool to convince, in combination with friendship with senior staff as a means of progressing by stealth. In the opinions of these employees, SSADM was being used as a tool which made the documentation of a system pretty and bulky. As these systems were not continued through to completion the personnel who produced these big reports were not expected to produce these systems using these documents as other staff were given these roles. SD personnel who believed this, used this reason as a means of explaining why some staff of equal experience and perceived ability were given opportunities to perform higher duties and be paid more in comparison to those who had not.

Implication Of SSADM and Its Influences On Opportunity

SD personnel felt that while knowing the organisations standard methodology, there is still no substitute for good analysis skills. A lot of the time it is very much dependent on making the most of the opportunities that you are presented with.

Being good at SSADM does not have any major influence in an employee gaining any additional opportunities. Other factors such as interpersonal skills, demonstrating leadership ability whether this be by leading a project team or organising a social lunch or morning cakes, sharing good relations with senior staff, having a mentor who is able to influence the people who could give you better opportunities, all help.

Its one thing to be good at analysis but people need to market themselves a lot more and at the same time be able to support there marketing message with personal ability otherwise they will loose credibility and their career will suffer.

One of the more important skills that systems analysts need to have is interpersonal skills. Analysts frequently find themselves attending meeting with senior management from end user department and from SD to discuss project issues, gather data or just explain project progress. With systems sometimes crossing departmental boundaries the Systems Analyst needs to be able to negotiate, influence the decision making process or control / chair meetings. A Systems Analyst lacking these skills may end up facing an implementation failure if the games as described by Keen (1981) are played, and they are unable to negotiate, persuade, present their ideas or resolve the issues.

A significantly large number of staff felt that they would lack the confidence or would be nervous if they were in a meeting in which they were required to carry out negotiations or influence the decision makers. The interpersonal skill levels of staff varied from one

employee to another. The more experienced staff showed a higher level of interpersonal skills than the less experienced staff. The important point however is that staff believed there interpersonal skills were improving with experience.

Implications Regarding Problems With Using SSADM

The findings suggest that SSADM is a reasonably difficult methodology to use without adequate support from a CASE tool which supports the methodology. A number of areas that SSADM was particularly weak on included, the missing link to the business planning and IS planning, lack of good CASE tool support. The number of cross checking products created additional work for the Systems Analysts and some felt that there was little benefit in them. SSADM has a number of review points and some SD staff felt there were too many reviews. The larger number of acronyms meant that those who were not regular users of the methodology would need to continuously refer to the glossary to find their meaning.

SSADM is a large methodology with many steps, methods and products most of which had to be produced by hand or by some other means due to lack of support from CASE. Some staff found it difficult to see how the products could be of any benefit to them.

Implications For Education and Training

The ISD results, however, do indicate a need to:
- continuously improve the general IS knowledge of all employees,
- improve the IS personnel's organisational knowledge,
- end - users and IS personnel's need to be educated so that each can be made more sensitive to the other's problems,
- end - users need to improve their IS product - related and technical skills, and
- regular periodic needs assessments need to be conducted.

The fact that only one employee within ISD's SD section has completed a higher degree ie Masters, may highlight the need for universities to better promote the value of completing a higher qualification in the Information Systems field.

Based on the findings of this study, it appears that the organisation needs to pay more attention to IS - related education for all employees, whatever the functional area may be. It appears that IS and end - user personnel need to know more about issues such as how to use information technology (IT) and IS for competitive advantage, the potential for IS / IT within the organisation and the fit between IS and organisation. With the onset of increased competition both in the business and IS services sector, organisations need to pay closer attention on how they can work together better to continue being competitive against similar external service providers.

The findings also suggest that there is a lack of organisational knowledge in IS personnel. IS personnel need to know more than just the objectives and goals of the organisation. IS personnel need to know about the environmental constraints that the organisation operates in. These may include competition, government regulations, relationships with customers and suppliers. IS personnel also need to know about the organisations business processes

and business rules. "The notion that it is useless to bother putting more than minimal training dollars into IS employees because they may leave often becomes a self - fulfilling prophecy." (Bartol and Martin, 1982, p. 55)

The search for skill enhancement and knowledge is also motivated by a desire to reduce the communications gap. Steps are currently under way at ISD to help the SD section become more sensitive to understanding the business through the use of external consultants.

Conclusion

The results reported here, while bounded by their scope, strike a balance between what SD personnel believe and what happens in reality. While controversial in nature the key factors to progressing on ones career according to the findings has more to do with an employees interpersonal skills than there technical ability in building information systems. While new, inexperienced graduates may believe that it will be there qualifications or there technical knowledge and ability that will earn them the promotions in a highly competitive IT environment, these findings show that this might not be the case. If we are to believe previous literature on factors affecting the successful implementations of information systems then IS professionals need to pay closer attention to building up skills in communicating, negotiating, presenting, handling culture clashes, myths, metaphors and politics in addition to their technical skills.

Most of the current discussions do not discuss the tremendous difficulties associated with successfully implementing information systems.

Hedberg, Nystrom and Starbuck (1977) are quoted by Orlikowski (1991, p. 39) as claiming that "Organisations typically display inertia through their established routines, institutionalised practices, and taken - for - granted assumptions that inform and reinforce the status quo."

There was no evidence in the findings to suggest that an employee educational or work experience background or there knowledge of SSADM played nay role in an employees career progression.

The SSADM methodology while considered as the SD standard is usually tailored to a point where the steps of the methodology are treated more as a check list. The products that are produced are those that form the bare essentials of most structured methodologies. SSADM has been in use for five years but still lacks the support of some senior staff who would prefer to see it replaced. The main reasons for its lack of support stems from the difficulty in end users confirming that the products produced meet their requirements. Personnel believed that the methodology does not produce business deliverables which any user can understand and confirm.

The lack of a CASE tool that supports SSADM counted as a further disadvantage. Since, the CASE tool that was available did not fully support the methodology and was not as accessible as some staff would have liked. The fact that only one copy of the methodology exists adds further doubt about SSADM's long term future at ISD. While it may remain as

one of a family of methodologies based on current trends and the move towards business process modelling and corporate data modelling SSADM's long term future is doubtful.

The selection of the SSADM methodology took place during a controversial period in the history of the SD section. Since its selection most of the staff who participated in its selection have moved on to other organisations. The documentation produced, such as the evaluation criteria, weightings and final report with its recommendations have been lost in time which prevented any in depth documentation reviews. The only information that could be gathered were received during in depth interviews with the three remaining members of the selection panel. Besides the selection team only the Project Leaders at the time had the opportunity to have any input into the methodologies selection. Based on the results this has resulted in a lack of ownership or commitment to SSADM. Some staff cant fully identify with the methodology and feel more like its been thrust onto them rather than being a tool to help them develop successful systems.

The selection and eventual use of a methodology usually effects both developers and users at various parts of the organisation hierarchy. With joint software development contracts involving external software developers who were using their own methodology, the selection of SSADM may well have resulted in political involvements at a senior management level in the selection process. Unfortunately since the senior management who were performing these roles have left the organisation this may never be known for sure.

This paper has described a study which examined the experiences that SD staff have had with the selection and implementation of a structured development methodology named SSADM. The results indicate that while methodologies and systems development is largely regarded as technical in nature the major parts are actually non technical. We see the historical development of an information systems methodology and the levels of satisfaction that exist in using it. This study highlights the impact of other factors such as the behaviour, world views and values of individuals and the culture and politics of the organisation and its relationship with SSADM. Finally, it reaffirms the notion that for changes to take place with the introduction of a new methodology, requires considerable negotiation among all players effected by the change.

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TOWARDS A GRAPHICAL TRANSACTIONAL WORKFLOW SPECIFICATION LANGUAGE

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Abstract
Most of today's business requirements can only be accomplished through integration of various autonomous systems which were initially designed to serve the needs of particular applications. In the literature[1,2,4,5,7 & 8], workflows are proposed to design these kinds of applications. Workflows can also be regarded as a complex business transaction which is different from the traditional ACID transaction. By incorporating some ACID properties into workflows one can provide workflows with some safeguards, such as correctness of computation and recovery. Workflows with such properties are referred to as Transactional Workflows. In [6] we have described a Framework in which Transactional Workflows can be specified and implemented in an orderly manner. The core tool proposed for use in the framework is a Graphical Workflow Specification Language. We support a graphical language rather than a textual language in this regard since part of the Framework deals with the conceptual level. It is accepted that graphical conceptual tools are more effective than textual. Such a language should be capable of capturing the transactional properties of workflows among others. These other properties include ordering execution, task attributes and dataflows between tasks. In this paper we present the way these features could represent as a mixture of graphical and textual constructs of a graphical language. While we are not presenting a complete graphical language at this stage this paper describes some major constructs such language should have.

Introduction

Information systems integration may be considered a key theme for the 1990s since it is a very serious business problem which has to be solved in order to run a business cost-effectively. Most of today's business requirements can only be accomplished through the integration of various autonomous systems which were initially designed to serve the needs of particular applications. In designing such integrated systems we use pre-existing systems as components of the new system. We call these pre-existing autonomous systems Traditional Application Systems (TAS). As a result, we now see some complex applications which span across several TASs. Workflows have been identified as a good candidate for designing such applications. In a workflow, a set of operations performed on one TAS is usually described as a task. A set of tasks constitute a workflow where these tasks may be interrelated in some way reflecting business application needs. The tasks are either existing information processes in a TAS or they may be implemented on request by the workflow designer. Workflows can also be regarded as complex business transactions which are different from the traditional ACID transaction. However, workflows may have some ACID properties. By incorporating some ACID properties into workflows one can provide them with some safeguards, such as correctness of computation and recovery. Such applications are referred to as Transactional Workflows. Various extended transaction models [3] have been proposed to implement such relaxed versions of traditional ACID transactions. These are mostly application specific. In contrast, workflows should be user defined and are characterized by four main components: tasks, TASs, the constraints, and

correctness criteria that are enforced by appropriate coordination of the task execution [7]. Thus specification of Transactional Workflows demands a set of new constructs to specify these transactional properties which are not included in the individual TAS design process.

In this paper we describe a set of such constructs which is capable of specifying transactional properties of workflows among others. The objective of designing a graphical language with such constructs is to provide a universal tool which begins from end-user level and goes down to the semi-executable level gradually articulating information which can be used in the Transactional Workflow Management process.

The rest of the paper is organised as follows. In the next section, we briefly describe the related work in this area. Section 3, very briefly discusses the proposed Framework. Section 4 presents the graphical constructs with help from an example while Section 5 concludes the paper.

Related Work

Workflow management research has received much attention in recent years [1,2,5]. [4] provides an up-to-date high-level overview of the current workflow management methodologies and software products. Research prototypes are concentrated at the concurrency, correctness and recovery of workflows while commercial products pay more attention to user friendly workflow specification tools leaving aspects like recovery and correctness to designers. As identified in [4], workflow management needs a complete framework starting from the conceptual level. Our current work is trying to provide such a complete framework for workflow management up to the semi-executable level incorporating transactional properties: concurrency, correctness and recovery. Since the Framework starts from conceptual level it is vital to use a graphical language as the backbone of the entire Framework.

As far as we know there is no graphical workflow specification language which is capable of capturing transactional properties of workflows either in research or in the commercial world. Hence, in this paper, as a part of our ongoing work, we have designed a set of graphical constructs to capture transactional properties which will eventually lead to a complete language.

The Framework

The Framework [6] is constructed from four different stages and is built around a graphical language. The constructs of the language include ordering execution, task attributes and transactional properties such as failure atomicity and execution atomicity. The workflow specification is built stage by stage. The first stage, which provides business level abstraction, uses a very primitive set of constructs since the objective of this stage is to document user requirements at the conceptual level necessary for understanding, evaluating and re-engineering. The second stage, which provides information systems level abstraction in terms of tasks, uses more constructs since this stage includes some lower-level details of tasks necessary for workflow implementation and transactional properties. In both stages the structure of the specification is sequential. The third stage generates some possible optional workflow diagrams (maintaining the overall semantics correctness) from the previous stage's output.

The fourth stage is the boundary between conceptual design and physical design. In this stage conceptual specification is converted to the underlying semi-executable language (textual). We call this stage Semi-Executable since the underlying language is not executable directly. The final implementation should translate this programme into system specific execution code. This transformation can be defined as a set of interfaces to different systems and we have decided to handle the implementation stage separately from this work. An outline of the Framework is depicted in Figure 1.

Graphical Constructs

In this section graphical constructs are described in terms of an example given in [8]. The example shows the way workflows embed more information in each stage gradually and precise meanings of the constructs. Only stages 1 and 2 are involved with manual workflow specification, while stages 3 and 4 are automated to generate final semi-executable workflow specifications. Therefore, the example covers the constructs only necessary for stages 1 and 2.

Example

In the travel agent information system [8], a travel plan consists of three tasks: purchasing an air ticket, renting a car, and reserving a hotel room. We assume two choices for purchasing an air ticket: Continental or Delta airlines. We assume that the flight and car rental reservations can be cancelled by issuing another (compensating) task. In contrast, hotel reservations cannot be cancelled. If any of the main tasks fail then the workflow has to be terminated. Another assumption is that compensating tasks always succeed. Additionally, we accept the ordering of tasks as specified by the travel agent's customer.
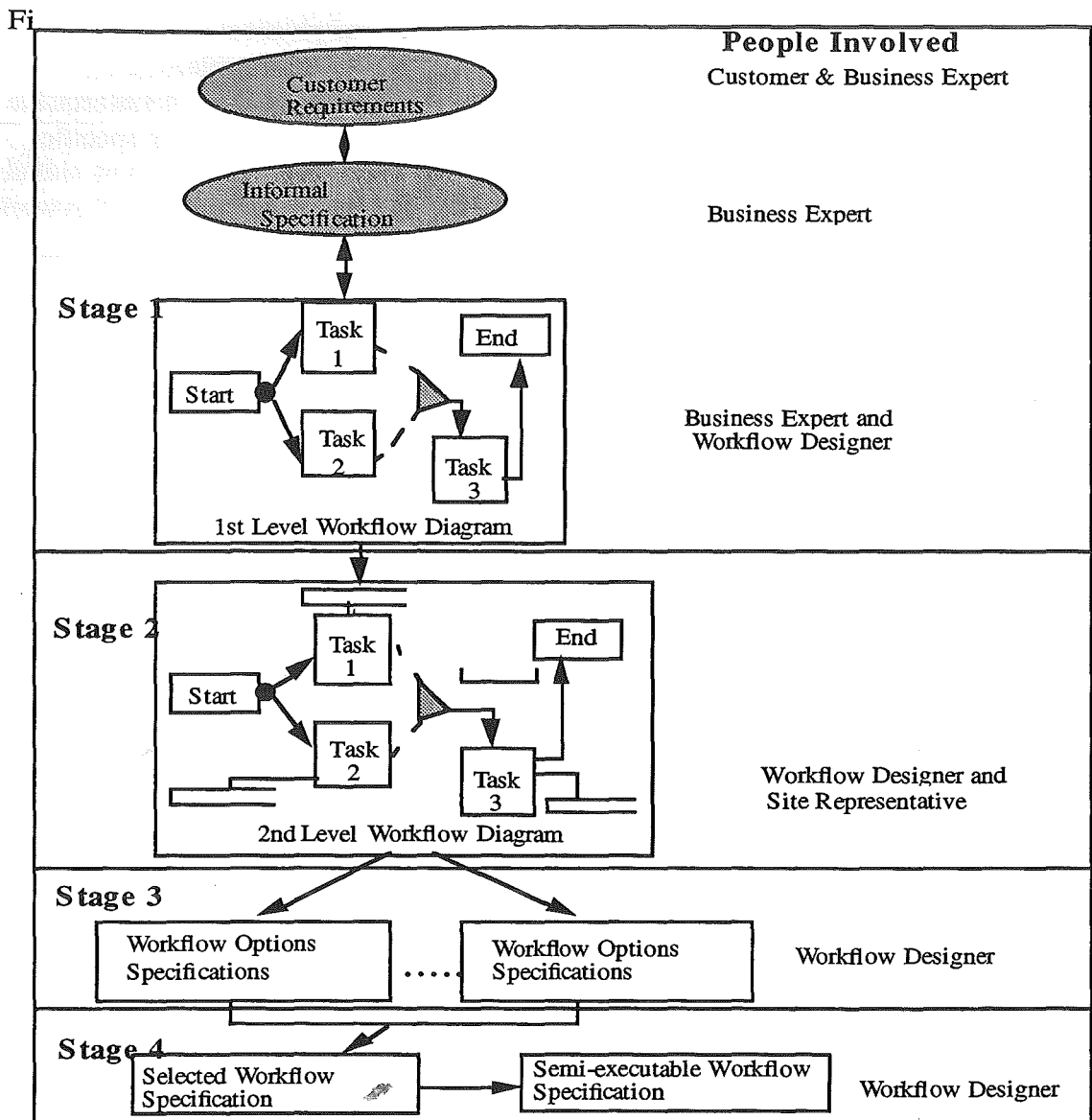
Figure 1: Outline of the Framework

Application to Stage 1

Figure 2 shows the symbols used in this stage. The 1st Level Workflow Diagrams (1LWD) [6] are very similar to 1st Level Dataflow Diagrams (DFD). However, 1LWDs capture only process details, merely showing a sequence of processes (tasks). The ordering of the task is agreed upon between the user and the designer beforehand. Obviously, in some cases, different ordering may be possible to achieve the same overall goal. Initially, we support an arbitrary order which confirms the workflow requirements. A subsequent example consolidates the meanings of these constructs.
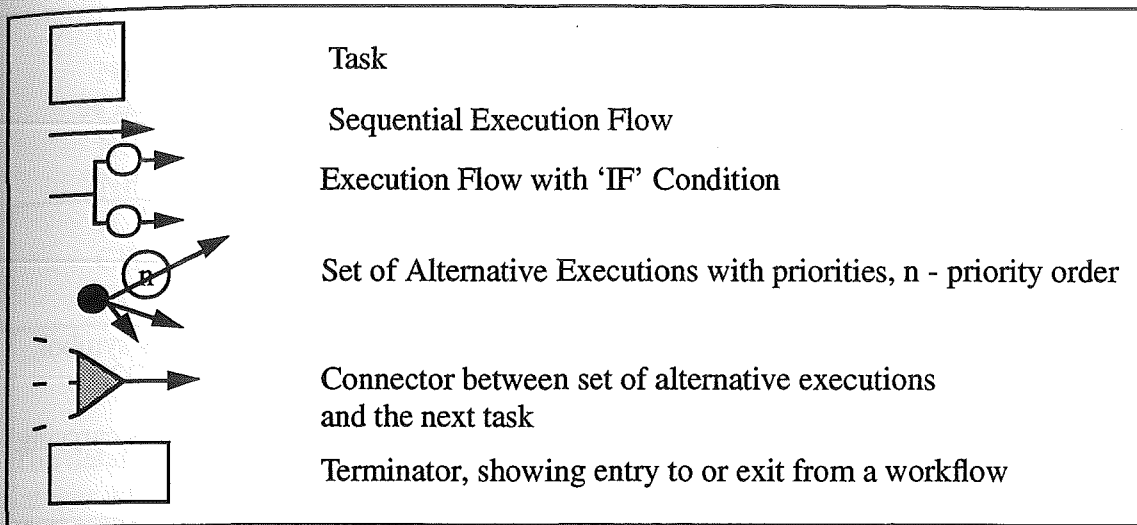
Task

Sequential Execution Flow

Execution Flow with 'IF' Condition

Set of Alternative Executions with priorities, n - priority order

Connector between set of alternative executions
and the next task

Terminator, showing entry to or exit from a workflow

Figure 2: Symbols Used in Stage 1

Figure 3 displays the 1LWD for our example. Each of the tasks are information processes within TASs. This example involves four TASs: Continental Airline's TAS, Delta Airline's TAS, Avis Company's TAS, and Hilton Hotel's TAS. In this example the travel agent can reserve a flight from either Continental or Delta airlines but priority is for Continental. This priority is marked on the execution flow. Following this, a car and a room are reserved. As mentioned above, this ordering of tasks is agreed upon beforehand. Pre-conditions, not applicable to this example, can be displayed with the execution flow by means of a circle marked with a condition number (eg. c1, c2, ...) on the execution flow. Conditions are then specified outside the diagram.
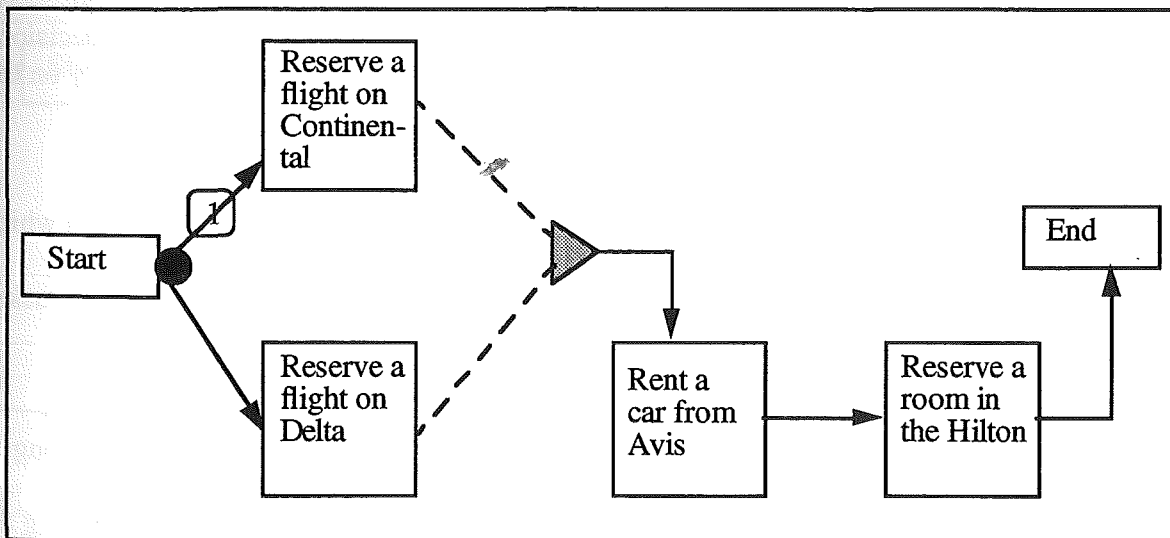

Figure 3: 1st Level Workflow Diagram

Application to Stage 2

In stage 2, the 2nd Level Workflow Diagram (2LWD) [6] is produced. Each task is accompanied by a set of attributes and the execution flow may have some dataflow and pre-conditions. Dataflow contains data elements (eg. customer name, address, flight number, etc.) similar to dataflows in DFDs. Task attributes specify information like, whether the task is compensable, appear to be atomic for other concurrent tasks, critical (failure of a

critical task leads to failure of the entire workflow) or not, etc. These attributes are predefined (given in Figure 5). The third construct in Figure 3 shows the atomicity requirement over two or more tasks (multi-task), i.e., part of the workflow should be executed as an atomic unit. Figure 4 shows the symbols used in this stage.
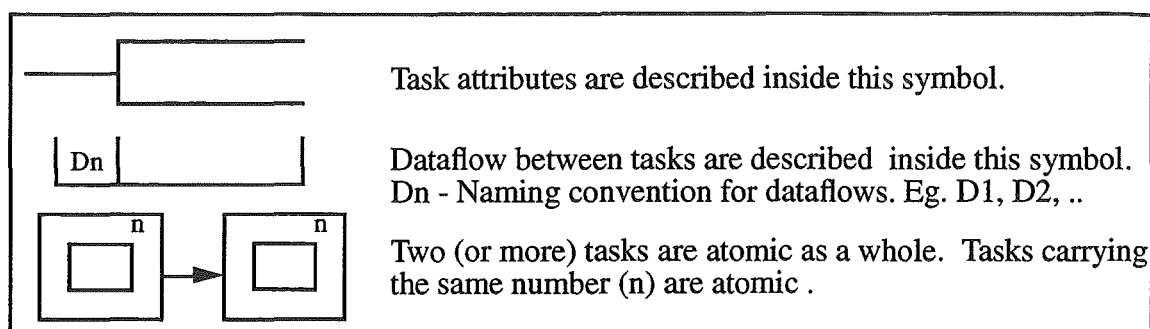

Task attributes are described inside this symbol.

Dn — Dataflow between tasks are described inside this symbol. Dn - Naming convention for dataflows. Eg. D1, D2, ..

Two (or more) tasks are atomic as a whole. Tasks carrying the same number (n) are atomic .

Figure 4: Additional Constructs Used in Stage 2

2LWD is much richer in terms of information than 1LWD since it serves a different purpose: information systems level abstraction in terms of tasks. In the point of recovery some tasks are compensable while some are not. A compensable (C) task can always commit independently (CI) whereas non-compensable (NC) tasks have to wait for Workflow commitment as a whole. Thus, attribute C implies attribute CI and attribute NC implies the attribute "Commit When Workflow Commits" (CWWC). Therefore, an attribute list of a task does not explicitly contain these implied attributes. We do not consider compensating tasks, which are supposed to remove the effects of the relevant original task, as tasks since their existence purely depends on the original transaction. Instead, it is shown as an attribute of a task which can later be compensated. This decision has two advantages: reduced number of tasks in the specification, and emphasis only on the original tasks which constitute workflows.

In the case of Critical (Cr) task failures the entire workflow has to be recovered. The Atomic (A) task must appear atomic for other concurrent tasks.There are some tasks which cannot be failed (NF) logically such as printing an invoice. The underlying TAS should guarantee the successful execution of tasks with attribute NF. Hence, failures of such tasks have no effect on the workflow execution.

Attributes which show critical feature and compensable features support the workflow recovery. The Atomic (A) attribute (single task) and multi-task atomicity construct along with the compatibility matrices described in [1], will be used in preserving the correct concurrent execution of tasks.Since we have taken an evolutionary approach in designing the language at this moment we do not claim that the predefined attribute list (as well as graphical constructs) are complete. However, the list does capture the intuitive requirements. Thus, future work might expand these areas.

Cr	- Critical
NCr	- Non Critical
C	- Compensable
NC	- Non Compensable
NF	- Not Fail by Itself
A	- Atomic
CWWC	- Commit When Workflow Commits
CI	- Commit Independently

Figure 5: Task Attributes

The dataflow naming convention has two parts: the first is prefix D, and the second is an integer which increases from left to right and top to bottom along the workflow execution path (eg. D1 , D2, ...). It helps to concatanate dataflows along the execution path without repeating the same data elements within different dataflows. Dataflow also can be referenced outside the 2LWD like pre-conditions. However, it is desirable to have it on the diagram itself whenever possible.
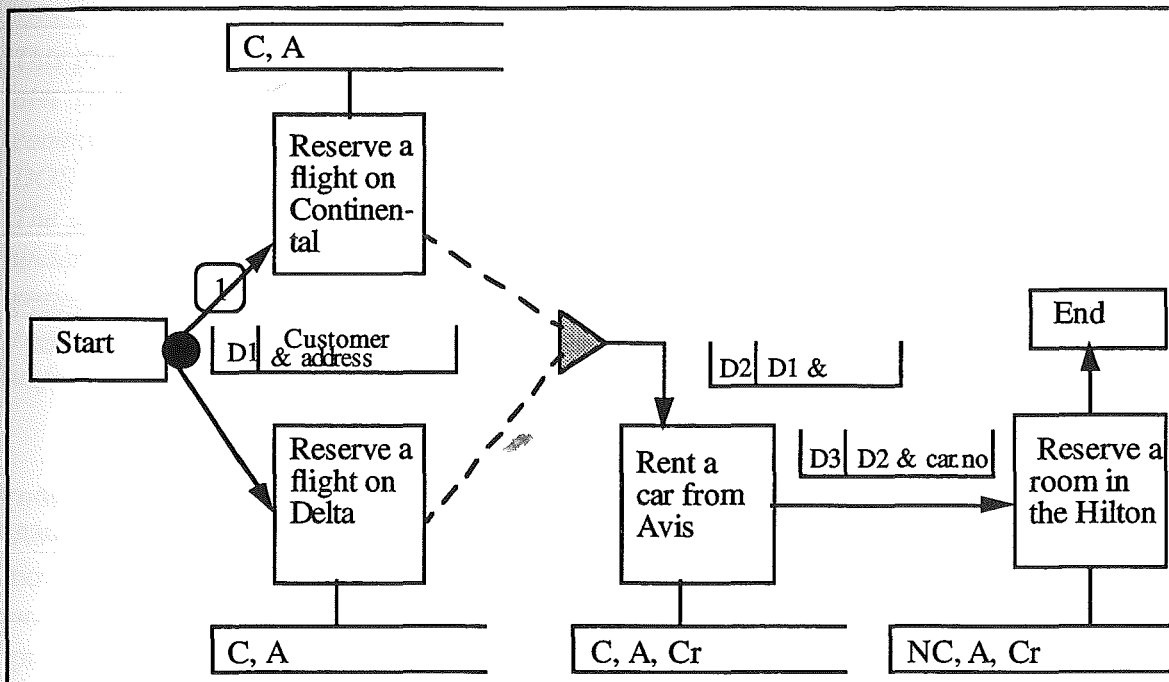

Figure 6: 2nd Level Workflow Diagram

Figure 6 depicts the 2LWD of the example. All the tasks in the example are atomic i.e. TASs are either databases or capable of providing atomicity for tasks. "Rent a car "and "Reserve a room" are Critical tasks. Therefore, if they fail, all the previous tasks have to be compensated. However, some might not be compensable. Therefore non compensable tasks are not allowed to commit independently. Since flight reservation tasks are not Critical, failures of such tasks do not require any recovery. Once a task fails it looks for the attribute to decide about the recovery actions. The simple scenario of actions described above indicates that not all specifications may be executable. This leads to a discussion of workflow specification correctness. However, it is not the intention of this presentation.

Conclusion

In this paper we have presented a set of graphical constructs which can be used in specifying Transactional Workflows. The presented constructs are the elements of the graphical language designed as the core technique to be used throughout the Workflow Management Framework described in [6]. A Transactional Workflow is described as a complex transaction with some ACID properties. The proposed constructs help to embed these transactional properties at the conceptual level in terms of task attributes and execution dependencies.

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