

2001

## **Systems in management 7th annual ANZSYS conference 2001: the relevance of systems thinking in the contemporary world**

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SYSTEMS IN MANAGEMENT 7TH ANNUAL ANZSYS CONFERENCE 2001

PERTH, WESTERN AUSTRALIA 27 & 28 NOVEMBER, 2001

the relevance of systems thinking  
in the contemporary world

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# SYSTEMS IN MANAGEMENT 7TH ANNUAL ANZSYS CONFERENCE 2001

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**"the relevance of systems thinking  
in the contemporary world"**

## P R O C E E D I N G S

EDITORS:

Dr William Hutchinson

Dr Matthew Warren



seventh

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All papers that appear in these Proceedings have been subjected to a blind, peer review by least two anonymous reviewers.

# FORWARD

Welcome to Perth, Western Australia, and to the Systems in Management 7th Annual ANZSYS Conference 2001 "the relevance of systems thinking in the contemporary world" hosted by the We-B Centre, School of Management Information Systems at Edith Cowan University.

The conference provides an opportunity for sharing and networking among academics and industry specialists in systems and related fields. The conference has drawn participants from national and international organizations.

All submitted papers were subjected to an anonymous peer review process managed by the Conference Committee. Stringent review criteria resulted in an unprecedented number of papers declined this year. Based on these reviews, the final programme was determined. A total of 54 papers were submitted for consideration and 39 were accepted for presentation.

The Conference Committee would like to recognise the efforts of many people who have contributed to the success and support in the organising of this conference and without their efforts the conference could not have occurred. The authors are thanked for their continued support to the Systems in Management 7th Annual ANZSYS Conference 2001 and we hope that the conference will receive similar support into the future.

The reviewers deserve a special vote of thanks for their commitment and dedication in having their reviews conducted professionally.

This year saw the launch of our Best Paper and Paper of Distinction award program. Papers nominated for this honour received particularly rigorous reviews. The winners will be announced at the conference.

Thank you and enjoy the conference.

DR WILLIAM HUTCHINSON  
Chairman

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# Systems Thinking And Industry Innovation

Dr Karen Manley

*CMP, Queensland University of Technology*

## ABSTRACT

*The academic literature, and business practice, reveals a shift in the way analysts understand innovation processes. This shift is not revealed as a cohesive trend, rather it comprises contributions from a wide range of academic disciplines and empirical evidence. Building on Edquist (1997) this paper ties together the diverse new ideas which stress a systems approach to successful innovation. The paper presents an up-to-date overview of this fast moving field, with a view to assisting public policy makers and business managers in designing more effective innovation processes.*

*Keywords: innovation systems, business networking, literature review*

## INTRODUCTION

Defined simply, innovation can be regarded as new creations of economic significance. Innovation is widely regarded as critical to economic growth processes. The academic literature contains considerable evidence of the value of innovation in driving growth. In commenting on such evidence, Edquist (1997: 1) notes that: '[i]t is almost universally accepted that technological change and other kinds of innovations are the most important sources of productivity growth and increased material welfare...'<sup>1</sup> Yet despite the value of innovation, it is only over the past decade or so that considerable progress has been made in understanding the key features of successful innovation. Such progress has hinged on taking a *systems* perspective. This new perspective has the potential to improve innovation outcomes for firms, industries, regions and nations, through better informed public-policy and business initiatives.

This shift to systems thinking is not revealed as a cohesive trend in the academic literature, nor in business practice, rather it comprises contributions from a wide range of academic disciplines and empirical evidence. It is the aim of this paper to bring together the diverse ideas on innovation systems, building on the substantial contribution of Edquist (1997). This paper presents an up-to-date overview of this fast moving field, with a view to it assisting public policy makers and business managers in designing more effective innovation systems.

## FROM LINEAR INNOVATION PROCESSES TO INNOVATION SYSTEMS

During the 1950s, 1960s and 1970s, most innovation analysts viewed innovation processes as predominantly linear. The first linear model developed to explain innovation was the science-push approach where innovation was seen to begin with 'scientific discovery, passing through invention, engineering and manufacturing activities and ending with the marketing of a new product or process' (Dodgson 2000: 17). The second linear model developed, the demand-pull model, portrayed innovation as being stimulated by demand. The figure below summarises the two models.

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<sup>1</sup> Readers interested in the evidence are referred to OECD (2000) in the first instance.

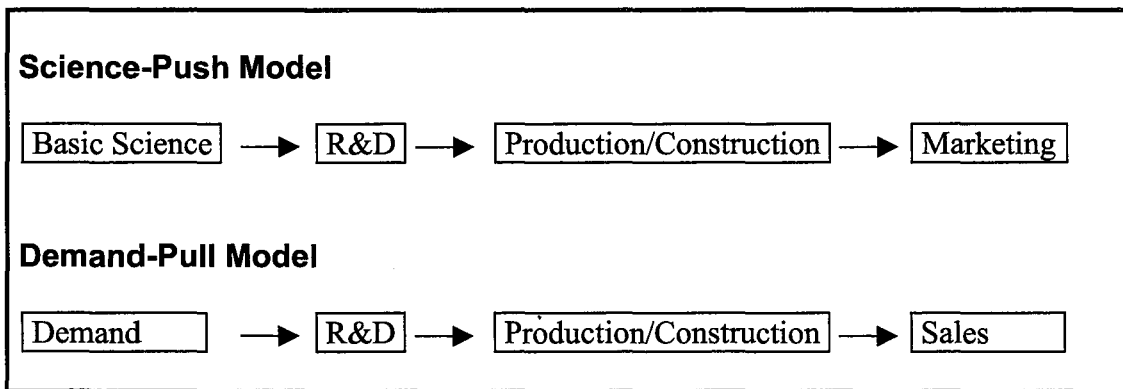


Figure 1: Linear Models of the Innovation Process

Note that neither model incorporates any feed-back mechanisms, failing to account for multi-directional information flows – such as input into R&D by manufacturers or marketers.

During the 1980s, more interactive models were developed so that by the 1990s, systems approaches had appeared, representing more complex views of innovation processes. Such ‘interactive’ models are strongly supported by empirical evidence and are also intuitively appealing. A general form of this model may be represented as follows.

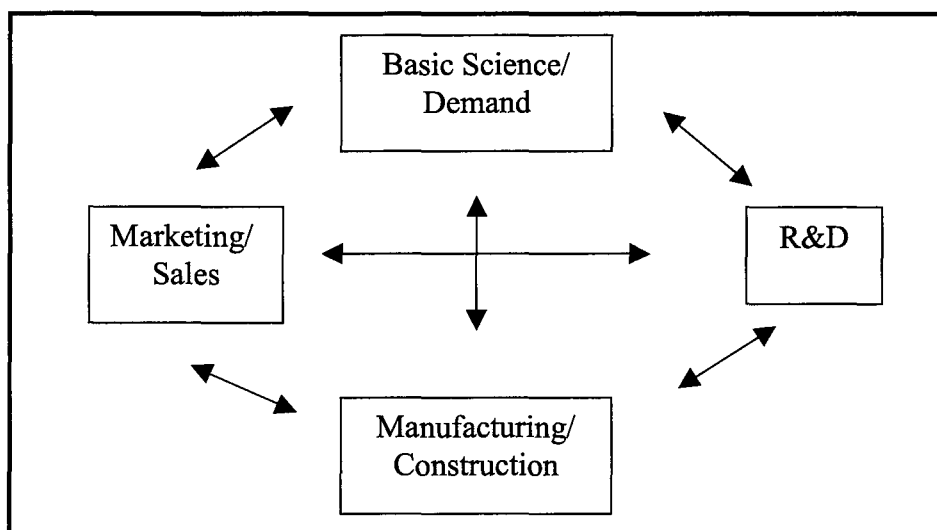


Figure 2: Interactive Model of the Innovation Process

This model highlights the existence of feedback loops between all stages in the innovation process. Innovation is now understood as the result of interaction between various economic and social processes. These processes are rapidly increasing in complexity, through forces such as the IT revolution, privatisation trends and globalisation. To manage this complexity in the pursuit of innovation and growth, individual organisations need the capabilities of others. Hence, the dominant unit of analysis in innovation studies has shifted from individual organisations, to groups of organisations in innovation systems, their interaction and potential for learning. Indeed, ‘learning has become the central core of the new canonical thinking about the source of wealth of nations’ (de la Mothe and Paquet 1998: 328).

This new 'systems' way of thinking has been gaining momentum from the 1970s to the present day, during which time a number of highly influential studies have emerged, including Dosi et al (1998), Porter (1990), Lundvall (1992), Nelson (1993), Carlsson (1995) and OECD (1999b; 1999c) These studies all point to innovation processes driven by knowledge, relationships and learning, in the context of collaborations with external parties. These collaborations may be informal or formal; they often involve clients, customers, research organisation, regulators, finance providers and related organisations. A wide range of system configurations are replacing solo innovation efforts as firms adjust to their more complex surroundings.

*Interactive* innovation processes lie at the heart of success in the new economic circumstances. As the BIE (1991:7) notes:

'For some time, studies of the innovation process have stressed the importance of networks to successful innovation, over-turning the traditional model which characterises innovation as a linear sequence running from basic research, through product development, to production and marketing. Innovation is now seen as an interactive process requiring intense traffic in facts, ideas and reputational information within and beyond the firm'.

The interactive view of innovation shown in Figure 2 is the basis for a number of useful elaborations of the innovation process, all of which emphasise the increasing complexity of successful innovation and the importance of external knowledge sources. These approaches include: networks (Freeman 1991); value-chains (Walters and Lancaster 2000), clusters (Porter 1990; OECD 1999c), development blocks (Dahmen 1988), complexes (Glatz and van Tulder 1989; Marceau 1995), innovation milieux (Camagni 1991; Ratti et al 1997), complex products and systems (*Research Policy*, 29 2000) and competence blocs (Eliasson 1997). Many of the ideas contained in these approaches are captured in contributions which fall broadly into an *innovation systems* perspective, which is the subject of this paper as it currently receives the most attention from policy-makers and business people. Readers interested in a broader review of associated literature are referred to Manley (2001).

## **INNOVATION SYSTEMS**

Although the innovation system approach emerged only a decade or so ago, Edquist and McKelvey (2000: xi) note it has:

... diffused surprisingly fast in the academic world as well as in the realms of public innovation policy making and firm innovation strategy formulation. The OECD has been particularly influential in using and further developing empirical analyses and research using this approach. 'Systems of innovation' is at the centre of modern thinking about innovation and the relations of innovation to economic growth, competitiveness and employment.

The *systems* perspective recognises that innovation is a collective undertaking where innovating organisations interact with others in particular institutional settings. Innovations are developed in *systems* where organisations and institutional rules are key elements. System approaches to innovation focus on the nature and impact of the collective character of innovation. System features will have a 'decisive impact on the extent to which firms can make innovation decisions, and on the modes of innovation which are undertaken' (Edquist 1999: 7-8).

The innovation system approach is 'holistic and interdisciplinary' and has the potential to encompass all the determinants of innovation. It differs from earlier analytical approaches in assuming that innovation relies primarily on interactions between institutions and people (Landry and Amara 1998: 261).

All the features of innovation systems stem from the collective nature of successful innovation efforts. For any organisation, success relies on relationships with *external* parties. This view is supported by numerous empirical studies, an example of which is a rigorous examination of an innovation system by Landry and Amara (1998: 274). Their case-study work indicates that 'innovative firms develop more interactions with outside sources of ideas, information and technology than non-innovative firms do'. In many respects, an innovation system is a social system in which innovations emerge partly as a result of social interaction between economic actors from different organisations (Cooke 1998: 11).

The OECD has played a major role in the mobilisation of this approach to understanding economic growth. According to the OECD, innovation is the result of a complex set of linkages between actors creating, applying and distributing various kinds of knowledge. Innovation performance depends critically on 'the way these actors relate to each other as elements of a collective system of knowledge creation and use ...' (1997a: 9).

The following sections highlight four key drivers of innovation in contemporary innovation systems – knowledge flows, institutions, economic competence and interactive learning. These are the main innovation inputs discussed in the literature.

### **Knowledge Flows**

The current popularity of the innovation system approach reflects the increasing knowledge intensity of economic activity. A key variable of interest is the 'knowledge distribution power' of a particular system, which involves the system's ability to facilitate effective knowledge flows. Analysis of a particular system will involve tracking the linkages between industry, government and academia in the development of technological and organisational innovations. A key policy aim is to identify the main channels of knowledge flow, to evaluate bottlenecks and to suggest approaches to improve the effectiveness of knowledge diffusion (OECD 1997a: 11).

The OECD (1997a) has developed a model to guide empirical studies of knowledge flows in innovation systems, as shown in Table 4 overleaf.

**Table 4: Assessing Innovation Systems**

---

<b>Four Basic Flows of Knowledge:</b>	<b>Five Key Research Methods:</b>
<ol style="list-style-type: none"><li>1. Joint Activities between Firms<ul style="list-style-type: none"><li>• technical collaboration</li><li>• informal interactions (tacit knowledge transfer)</li></ul></li><li>2. Joint Activities between Firms and Public-Sector R&amp;D Providers<ul style="list-style-type: none"><li>• technical collaboration</li><li>• informal interactions (tacit knowledge transfer)</li></ul></li><li>3. Innovation Diffusion<ul style="list-style-type: none"><li>• adoption of new processes, equipment and machinery developed elsewhere</li></ul></li><li>4. Personnel Mobility<ul style="list-style-type: none"><li>• flows of tacit knowledge</li></ul></li></ol>	<ol style="list-style-type: none"><li>1. firm surveys</li><li>2. literature-based alliance counting</li><li>3. value of research contracts</li><li>4. co-patents and co-publications</li><li>5. citation analysis</li></ol>

---

In this model, four key types of knowledge flows are highlighted – joint firm collaboration, joint private-sector/public-sector collaboration, innovation diffusion and personnel mobility.

Joint activities between firms often take the form of collaboration between producers to pool technical resources, gain economies of scale and achieve synergies from complementary technical and human assets. User-producer interaction is also important in stimulating innovation. In both cases – producer/producer and user/producer interaction – formal and informal relations are important.

Joint activity between firms and public-sector R&D providers typically takes the form of contracts for R&D. The value of these linkages is determined by the quality of the research infrastructure and its accessibility to firms. Private/public-sector interaction is particularly valuable within innovation systems, as the public-sector is often a key performer of R&D and resultant knowledge needs to be transferred to users in order to promote innovation and growth.

Innovation diffusion – the adoption of advanced methods and technologies by new users – is the most traditional form of knowledge flow in innovation systems (OECD 1997a). The innovation performance of a particular system depends critically on the *rate* of such adoption and investment in appropriate adaption to ensure successful implementation.

The movement of personnel and their knowledge capital is considered another key flow in innovation systems (OECD 1997a). Personnel mobility reflects the movement of tacit knowledge – knowledge which cannot be written down – which is often critical in the successful integration of innovations produced by external parties.

As noted in Table 4, there are five basic methods available for gathering data on knowledge flows:

1. *Firm surveys* involve the use of questionnaires and personal interviews to elicit information on collaborative behaviour and the sources of knowledge for innovation, particularly with regard to tacit knowledge flows.
2. *Literature-based alliance counting* gives a rough idea of the nature and extent of different types of alliances, within which knowledge is exchanged. It involves reviews of newspapers, journal articles, specialised books and journals, together with corporate annual reports and industry directories.
3. Analysis of *research contracts* indicates the extent to which the private-sector is linked to public-sector R&D capabilities. Information about the value of such contracts can be obtained from government funding sources, universities, private-sector research bodies and/or private-sector users.
4. The number of *co-patents and co-publications*, indicating inter-firm collaboration and private-public sector collaboration, can be ascertained from patent records and publication indices.
5. Users of R&D cite patents and publications in their literature on new developments. These *citations* can be counted and analysed to reveal collaboration patterns, particularly between the private and public sectors.

This OECD approach focuses on the role of knowledge in innovation systems. Statistics Canada (Anderson and Manseau 1999: 3) also focuses on the role of knowledge, and its movement from the site of generation to the site of use, which requires:

- a means of transmitting knowledge between sites;
- the capacity of knowledge generators to transmit knowledge; and
- the capacity of knowledge users to search for and absorb knowledge.

From an individual firm's perspective, *knowledge sites* include those internal to the firm and those found in the external environment, for example (Landry and Amara 1998: 265):

*Market sources*

- clients
- competitors
- suppliers
- consultants

*Education and R&D providers*

- universities
- public and private R&D organisations

*Local, state and national framework providers*

- regulators
- finance providers
- trainers
- unions
- professional associations

### *Generally available information*

- fairs/exhibitions
- conferences/workshops/seminars
- journals
- patent disclosure

Institutions play an important role in determining the efficacy of knowledge flows between sources such as those described above.

### **Institutions**

Institutions are the 'rules of the game' which govern *how* knowledge moves between system participants and the way in which subsequent learning and innovation takes place. Nooteboom (2000: 916) suggests that firm-level innovation outcomes are, *to a large extent*, dependent on the institutional context.

The following key institutions affect the performance of innovation systems (based on Amable and Petit 1999: 12):

- the finance system;
- the taxation system;
- the intellectual property rights system;
- the training system;
- the education system;
- the industrial relations system;
- labour markets;
- the internal structure of corporate firms and government bodies;
- conceptions of fairness and justice held by capital and labour;
- the structure of the state and its policies; and
- idiosyncratic customs, traditions, norms, moral principles, rules, laws, standards and routines.

The innovation performance of organisations is strongly influenced by these institutions. For example, if the education and training systems are under-resourced by government, firms may find it difficult to access suitably skilled employees to support their innovation efforts. Another example is the Australian federal government cutting back of the 150% R&D Tax Concession in 1996 which had a significant impact on R&D expenditure in Australia (see Marceau and Manley 1999). On a more positive note, Australian culture tends to support early adoption of new innovations, which can help tie Australia into global innovation systems.

### **Interactive learning**

Another key feature of innovation systems is *interactive learning*. The term *interactive learning* implies a reliance on multiple sources of tacit knowledge in the learning process. In turn, learning has been shown to be a key input in the innovation process (eg. Dodgson 1996). Dosi (1988: 222-223) observes that there are five problematic features of innovation processes that require interactive learning in order to promote positive outcomes, these are:

*Uncertainty*: including the lack of full information about the occurrence of known events, the existence of techno-economic problems whose solution procedures are unknown, and the inability to predict precisely the consequences of one's actions. The involvement of multiple players in interactive learning increases the stock of knowledge and the breadth of experience that can be drawn on to reduce uncertainty in the innovation process.



*Scientific Knowledge*: the increasing reliance of major new technological opportunities on advances in scientific knowledge highlights the importance of linkages between R&D users and major R&D organisations in interactive learning.

*Complexity*: the increasing complexity of R&D activity means that multiple players are needed in order to access multiple knowledge sources, rather than just relying on the skills of individual innovators.

*Experimentation*: the increasing role of experimentation in the form of *learning-by-doing* and *learning-by-using* requires access to appropriate partners to maximise the value of experimentation.

*Cumulativeness*: the cumulative character of innovative activity means that past decisions shape future opportunities. Hence, it is important to keep options open by maintaining a broad array of innovation interests through multiple relationships.

In summarising the importance of interactive learning, Lundvall (1999: 3) notes that ‘the last decade has witnessed a change in the mode of competition that implies that interactive learning, and forgetting, has become the most important process for determining the position of individuals, firms, regions and countries in competition’.

In a practical sense, the key methods of interaction undertaken by system participants in response to the above drivers include the following (Huggins 2001: 449):

- written contact (letters, fax, email);
- social/recreational contact;
- one-to-one meetings; and
- group meetings.

Such contacts may take place in the context of user-producer interaction, formal R&D agreements, professional association activities, consultations with regulators/training organisations/fiance providers, production agreements, licencing, joint ventures, sub-contracting, conference/workshop/forum attendance and related activities.

## **Economic Competence**

The final feature of innovation systems reviewed here is the *economic competence* of a system’s participants. The outcomes of interactive innovation process are ‘a function of the level and content of economic competence on the part of various agents within the system’ (Carlsson and Stankiewicz 1991: 113). This quality, or economic competence, is the microfoundation upon which the success of the innovation system will rest. Economic competence involves the ability to initiate and exploit new business opportunities. It is a ‘scarce and unequally distributed resource ... not all economic agents ... are equally adept at generating new ideas or absorbing new ideas from outside’ (Carlsson and Stankiewicz 1991: 94). Carlsson et al. (1999: 5) identify four crucial types of firm-level competence in innovation systems:

*1. Selective/strategic ability*: the ability to: make innovative choices between markets, products, technologies and organisation structures; engage in entrepreneurial activity; select key personnel; and acquire other key resources, including new competencies. An important part of strategic capability is the notion of *receiver competence* or *absorptive capacity*, which involves the ability to scan and monitor relevant technological and economic information; identify technical and market opportunities; and acquire knowledge, information and skills needed to exploit opportunities.

2. *Organisational/integrative/coordinating ability*: the ability to organise and coordinate resources and economic activities within the organisation so that overall objectives are met. This includes the ability to generate and improve technologies through new combinations of existing knowledge and skills. It is the main function of middle management in an organisation.

3. *Technical/functional ability*: the efficient execution of various functions within the firm to implement technologies and utilise them effectively in chosen markets. The key issue here is one of efficiency.

4. *Learning/adaptive ability*: the ability to learn from success as well as failure, to identify and correct mistakes, to read and interpret market signals and take appropriate actions, and to diffuse technology throughout the organisation. This ability is essential for long-term survival. A firm that is both effective and efficient at a point in time eventually becomes neither unless it can adapt to changing circumstances (especially changing technology).

Later research by Nooteboom et al. (2000: 120) suggests that a fifth *relational ability* is required.

5. *Relational ability*: the ability to focus on core competencies and utilise complementary resources from other firms. This ability has increased in importance in recent years due to the pressures of globalisation, the increasing complexity of input and output markets and the increasing speed of technical change.

The presence of these five abilities in the organisations which make up an innovation system will greatly assist the system's performance, particularly by improving the value of interactive learning opportunities.

## CONCLUSIONS

This paper has touched on four key drivers of innovation in innovation systems – knowledge flows, institutions, interactive learning and economic competence. These drivers are the main ones to emerge from analysis of a wide range of contributions to the academic literature. Compared to earlier linear approaches to understanding innovation processes, systems thinking has contributed a great deal to our understanding of effective innovation processes.

Although the literature acknowledges that an ideal system is not possible to specify (Edquist 1997: 20), the following guidelines concerning the nature of a well-performing innovation system can be put forward:

- **Organisations**: An innovation system is more likely to be effective if it includes a diverse range of organisations with different types, and high levels of, economic competence. The system is likely to operate more effectively if it includes firm and non-firm organisations, demanding customers, and new industry players.
- **Institutions**: Innovation system performance is critically affected by institutional arrangements. Critical institutions, such as those related to training, education, finance and intellectual property need to incorporate arrangements that are supportive of innovation.
- **Linkages with external parties**: Maximum advantage will be gained if external linkages are dense, multistranded, long-term, knowledge-intensive, vertical *and* horizontal, market *and* non-market oriented, and inclusive of innovation, production and distribution relationships. Such factors support the development of effective dynamics within innovation systems.

- **Outcomes:** Innovation system outcomes will be maximised if individual participants perceive benefits beyond what they could achieve in isolation. The system is then more likely to be stable and productive.

In the rapidly changing environment of the 21<sup>st</sup> century, the ability of businesses and governments to generate growth and jobs will rest critically on their innovation performance. The systems framework represents a new and increasingly popular approach to understanding and improving that performance.

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# The organisational impacts of Knowledge management systems

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## ABSTRACT

*This proposal paper aims to outline an in-depth, interpretive case study investigating the organisational impacts of a knowledge management and groupware information system named "Web-based Legacy EDI Groupware", abbreviated as "WebLegacy". In particular, the way in which WebLegacy operates as an agent in converting tacit knowledge to explicit knowledge, its organisational impact, success factors, and success indicators will be explored. This study is based on the framework and analysis used by Daniel and Graeme (1999) to examine knowledge management in the Australian health industry. The paper will examine one organisation in Western Australia using WebLegacy:*

*an automotive company who contracted a local external website design consultant to implement WebLegacy on their sites; In addition to interviews with the companies, interviews with the website design Consultant Company will be conducted in order to gain an alternate perspective of topics and issues raised in the research.*

*Keywords: Knowledge Management Systems, Web-based Legacy EDI, Organisational Impacts, and Information Systems.*

## INTRODUCTION

Knowledge management research has increasingly become an important concern in decision support that create value for organisational strategy and structure in meeting the challenges of the information age. Knowledge is information combined with experience, context, interpretation, and reflection. Knowledge is a high value form of information that is ready to apply to decisions and actions (Davenport, 1998). This research study will explore the practical reality of the subject of knowledge management system by focusing on a tangible, pragmatic entity, the knowledge management project. Hence, it is significance for the need of a successful knowledge management project to be in place as one of the indicators of the success of the firm is its increasing pool of knowledge.

Knowledge management may also be seen as an extension of information system management whereby the organisation benefits from the more effective use of information/knowledge. This may or may not have a strategic dimension (Remenyi, D. 1999). According to Remenyi, D. (1999) knowledge management may also been seen as tool by which the organisations core competencies may be focus and developed. This provides knowledge management with a strategic focus. As an extension of information system management, knowledge management is concerned with decision support systems, data warehousing, data mining and groupware systems. Knowledge management is also closely associated with Intranet applications.

Groupware application is also been seen as an application that can facilitate organisation-wide knowledge management. It is also able to provide human with an unprecedented global many-to-many medium to exchange information. According to Hauben & Hauben, (1997), individuals around the world are now able to broadcast their isolated opinions and gain feedback from a diversified population (Hauben & Hauben, 1997). They also suggest that knowledge management may be seen as an extension of information system management, which utilises the exchange of business information through an IT network. This entails the exchange of information electronically between separate organisations, or between an organisation and its customer, business to business or business to customer. Such a network of exchanging information is crucial to support successful business partnerships.

However, in order to achieve knowledge superiority, an organisation must first understand its knowledge asset, ie the value of its knowledge, how well that knowledge is being applied, and the true cost of its IT. This means the organisation needs to establish a proper knowledge management project that provides strategy for managing and exploiting such knowledge.

## **LITERATURE REVIEW**

### **Groupware application and knowledge management**

In the paper by Gunther, L (1994), the author says that WebLegacy is about 'better business practices', both in the way an organisation manages its internal operations and more directly in the way it manages its relationships with customers and suppliers. He also mentions that such WebLegacy encourages, or more often forces companies to re-examine business processes and trading relationships. As a result, WebLegacy is seen as a tool used to transmit standard structured messages electronically from the computer application in one location to another computer application in another location. Thus WebLegacy is an 'enabling technology' that allows organisation to meet its business goal

### **Previous empirical research**

In this section, a framework for analysing a knowledge management project that involved the WebLegacy, based on previous empirical research is discussed.

The framework for the knowledge management project referred to above incorporates four stages: the objectives, the strategies, the success indicators and the success factors (adapted from Daniel, L and Graeme, G, 1999).

First stage, the objectives of knowledge management project.

Objectives define what a knowledge management project is trying to achieve.

According to Davenport (1998), knowledge management projects can provide four types of objectives that allow organisation to achieve knowledge superiority. They are as follows:

- "Creating knowledge repositories; WebLegacy focuses on creating structured repositories to store explicit knowledge;
- Improving knowledge access; WebLegacy focuses on providing access to tacit knowledge and facilitating its transfer between the individuals;
- Enhancing the knowledge environment; WebLegacy focuses on the establishing an environment conducive to knowledge creation, transfer and use;
- Managing knowledge as an asset; WebLegacy involves in measuring the value of the knowledge assets" (adapted from Daniel,L and Graeme, G, 1999).



## Second stage, the strategies of knowledge management

Strategies define the methods for achieving the objectives.

According to Hansen et al (1999), there are two broad types of strategy for implementing knowledge management (Hansen reference in Daniel, L and Graeme, G, 1999). They are as follows:

- “Codification strategy: codification is about turning tacit knowledge into explicit knowledge.
- Personalisation strategy: personalisation focuses on tacit knowledge and involves the sharing of knowledge directly between people” (adapted from Daniel, L and Graeme, G, 1999)”.

Hansen et al (1999) found that “all companies use elements drawn from each strategy, either focus on one type or focus on both together. The choice of strategy was dependent on the competitive strategy of the organisation” (Hansen reference in Daniel, L and Graeme, G, 1999).

## Third stage, the success indicators for knowledge management project

Success indicators measure the effectiveness of a knowledge management project, which includes the dependent variables or the outcome measures.

According to davenport et al (1999), he identified four success indicators for knowledge management projects (Davenport reference in Daniel, L and Graeme, G, 1999). These are as follows:

- “growth in resources attached to the project. This refers to the increases in number of people or the size of the budget assigned to the project over its lifetime;
- growth in knowledge content and usage. This is measured by increase in the volume of knowledge stored in repositories;
- organisational initiative. This means that if the projects are the initiatives of one or two individuals they are less likely to succeed than projects that originate in organisation-wide initiatives;
- financial returns. This refers to the financial return either for the project itself or for the organisation as a whole” (adapted from Daniel, L and Graeme, G, 1999).

## Stage four, the success factors for knowledge management projects

Success factors define the conditions that lead to success in knowledge management projects.

According to Davenport et al (1998), there are eight types of success factor for implementing knowledge management project (Davenport, (1998) reference in Daniel, L and Graeme, G, 1999). They are as follows:

- “ the link to economic performance. This involves money saved or earned.
- technical and organisational infrastructure. This refers to the level of involvement through technology and organisational infrastructure for the success of knowledge management project;
- flexible knowledge structure: finding the right balance of knowledge repositories to a project;
- knowledge-friendly culture: finding the aspects of a knowledge friendly culture;
- clear purpose and language: clearly defined communication and objectives are important for success;
- change in motivational practices: incentives and rewards are important to motivate people;
- multiple channels for knowledge transfer. This means providing opportunities for face to face contact as well as electronic forms of communication;
- senior management support. This implies providing funding and other resources for the success of the organisation” (adapted from Daniel, L and Graeme, G, 1999).

In summary, the literature review above has attempted to provide an overview of the empirical studies by Daniel, L and Graeme, G (1999) pertaining to knowledge management projects. It explored the success factors, the success indicators, the strategies and the objectives. It was then synthesised into an analysis framework, and was used as the basis for analysis of the case study data.

## Research objectives

Specifically, the research objectives are to determine the followings:

- To what extent can the adoption of a knowledge management project, which involves WebLegacy, serve as a mean to support knowledge management in providing value creation to the organisation?
- If so, how and why does the adoption of WebLegacy act as a vehicle to support knowledge management in providing value creation to the organisation?

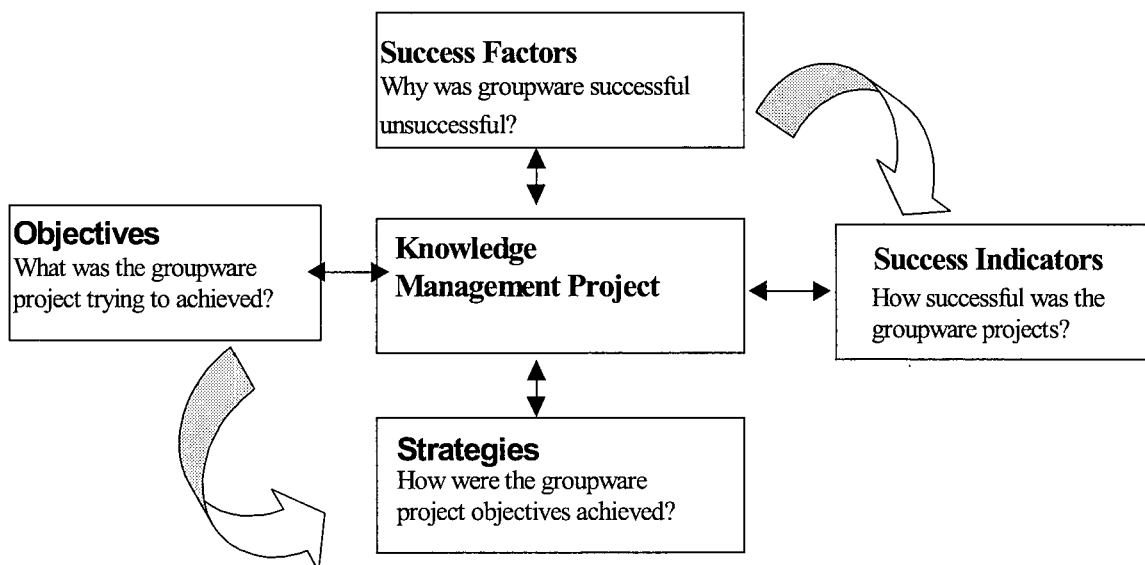
## Discussion of Case Scenario

Organisation #A is a family owned automotive group. The company was established to offer Western Australia car buyers an innovative option to serving vehicle needs, and has been in business since the mid 1980's.

To research the question raised above, the author held preliminary discussions with organisation #A's knowledge manager and its external website design consultant's staff. Key players were identified from organisation #A and consultant company and these individuals (the Technical Supervisor, Operations Director and knowledge manager) were interviewed.

## Analysis Framework

According to Yin (1994), it is important to ensure adequate rigour in research design when utilising case research. It is proposed that the analysis framework (adapted from Daniel, L and Graeme, G, 1999) shown in Figure 1, which incorporates the objectives, success indicators and success factors of Davenport et al (1998) and the knowledge management strategies identified by Hansen et al (1999) will be applied to this study.



**Figure 1: Proposed Analysis Framework**  
(Adopted from Daniel, L and Graeme, G, 1999)

## PRELIMINARY FINDINGS AND CASE STUDY ANALYSIS.

### Stage One: Objectives

What was WebLegacy project trying to achieve?

Objectives KM project	Knowledge from internal, external source		
	Operations staff	Existing Customers	Marketing staff
Create knowledge repositories	Provide 24hrs accessibility/ accurate information provided	Provide quick response on request/queries	Information easily accessible to public
Improve knowledge access	Facilitate transfer of tacit knowledge between individual	Increase in Satisfaction	Facilitate transfer of tacit knowledge between individual
Manage knowledge as an asset	Moderate	Not sure	Moderate
Enhance knowledge environment	Improve conducive environment for sharing knowledge	Increase in Satisfaction	Improve conducive environment for sharing knowledge

**Table 2: Matrix showing the relationship of objectives of Knowledge Management and WebLegacy**  
(Adapted from Daniel, L and Graeme, G, 1999)

The above indicator provides the finding for WebLegacy in trying to achieve. These are as follows:-

- In the scope of creating knowledge repositories, it created a virtual ‘information library’ accessible 24 hours a day to staff across all branches. The significant improvement observed was due to the external knowledge (knowledge from an external source). This means that improved information exchange can lead to intangible benefits, cost reduction and quality improvement efforts.
- In the scope of improving knowledge access, it has helped to facilitate the transfer of tacit knowledge between the individuals.
- In the scope of enhancing the knowledge environment, it has helped to induce conducive environment for sharing knowledge.

In summary, WebLegacy has successfully created a knowledge repository for knowledge transformation, sharing, and knowledge creating processes for organisation #A. The WebLegacy entails staff of organisation’s # A tacit knowledge, which resides in many heads can now be codified into formulated knowledge resides on electronic form. In addition, WebLegacy has also proven to be successful in allowing information sharing and collaboration across departments, and functions.

## Stage Two: Strategies for WebLegacy project

How were WebLegacy objectives achieved?

	Knowledge management project components		
Strategies for the KM project	Functionality databases, eg. operational & administration	External network, eg. supplier and customer focus	Listservers eg endusers
Codification strategies	Not codifying because providing access to already codified knowledge	Not codifying because providing access to already codified knowledge	Not ascendable
Personalisation strategies	Not ascendable	Not ascendable	Involves exchange of ideas and experiences between individual endusers.

**Table 3: Matrix showing the relationship of strategies of Knowledge Management and WebLegacy Groupware**

(Adapted from Daniel, L and Graeme, G, 1999)

To answer the question of how WebLegacy objectives were achieved. It is necessary to explore the three major of components of WebLegacy. These are as follows: functionality databases, eg. operational and administration; external network, eg. suppliers and customers; and listservers, eg. endusers. The list server component fits into the personalisation strategy because it involves the exchange of ideas and experiences between individuals ie. endusers. However, the other two components do not fit into either of the strategies, ie. The codification strategy or the personalisation strategy. This means that both the functionality databases and external networks focus on explicit knowledge, and are not concerned with codifying knowledge. However, the functionality data bases and external network components provide only access to already codified knowledge resides in the electronic form.

### Stage Three: Success indicators for WebLegacy

How successful was WebLegacy project to organisation # A?

<b>Table 4: Success Indicators for WebLegacy project to organisation # A</b>			
<b>With respect to organisation #A:</b>	<b>Pre- adoption of groupware</b>	<b>Post- adoption of groupware</b>	<b>One years from post- adoption of groupware</b>
Growth in resources attached to the project	Low	Improved	High
Growth in knowledge content and usage	No online discussion	Increase online discussion	Exponential increase online discussion/ request /Business Improved
Organisational initiative	Not Appealing	Satisfaction	Increasingly Appealing/ satisfaction
Financial return	Stagnant	Indications of cost reduction	Business Improved/profit increased

**Table 4: Matrix showing the relationship of success indicators of Knowledge Management and WebLegacy**

(Adapted from Daniel, L and Graeme, G, 1999)

The above indicator provides findings on the level of success for WebLegacy in organisation # A.

- In regards to the scope of growth in resources attached to the project, the estimated total costs of ownership for implementing the project was \$98,400. However, it was estimated that the annual budget of recurring or operational costs would be \$24,000 per annum.
- In regards to the increase in the growth in knowledge content and usage, there was an exponential increase in information usage since the post adoption of WebLegacy.
- In regards to the extent of organisational initiative, there seems to be greater levels of satisfaction on the part of end user. Customers' complaints have dropped significantly since the adoption of WebLegacy in the organisation.
- In the regards to the size of the financial return, there seems to have been some reduction in cost, as WebLegacy is able to integrate web EDI with their inventory, accounting and order entry system. This means that the integration brings about an increase because it greatly decreases human involvement in information flow, thus making business processes simpler, faster, cheaper and less error prone.

In summary, the success indicators have indicated that a significant impact to organisation # A has occurred. They have improved the quality of their management decision making and thereby improved the quality of service provided to their customers.

## Stage Four: Success Factors for WebLegacy.

Why was WebLegacy successful or unsuccessful to organisation # A?

<b>Table 5: Success Factors for WebLegacy to organisation # A</b>			
<b>With respect to organisation #A:</b>	<b>Pre- adoption of WebLegacy</b>	<b>Post- adoption of WebLegacy</b>	<b>One years from post- adoption of WebLegacy</b>
Link to economic performance	Normal	Indication of Improvement in financial savings	Strong Indication of Improvement in financial savings
Technical and organisational infrastructure	Normal	Increased involvement in both Intranet & Internet technology & WWW infrastructure	Exponential increased involvement in both Internet & Intranet technology and WWW infrastructure
Flexible knowledge structure	Not Appealing	Satisfaction	Increasingly Appealing/ satisfaction
Knowledge-friendly culture	Negative attitude to knowledge, organisation learning low, innovation low	Towards positive attitude to knowledge, organisation learning increase, innovation increasing	Positive attitude to knowledge, organisation learning increase, innovation increasing
Clear purpose and language	Not ascertainable	Objectives being defined in company mission statement	Objectives being defined in company mission statement
Change in motivational practices	No incentives and rewards system	Staff are motivated by incentives and rewards system	Staff are motivated by incentives and rewards system
Multiple channels for knowledge transfer	Confined to face to face	Internet access for customer request	Face to face , electronic forms of communication
Senior management support	Management participation low	Indications of management support increases	Indications of management support increases

**Table 5: Matrix showing the relationship of success factors of Knowledge Management and WebLegacy**  
(Adapted from Daniel, L and Graeme, G, 1999).

For organisation # A, the findings of the success factors are as follows:-

- In regard to the extent of linking to economic performance, this project has saved significant amounts of money for organisation # A. However, the estimated total costs to the owner for implementing the legacy EDI groupware project was \$98,400. It was anticipated to produce an increase of annual sale of Aus \$ 30 million (from Aus \$100 million to Aus \$ 130 million) a year after implemented WebLegacy.
- In regard to the scope of technical and organisational infrastructure, this project used Internet and Intranet technical infrastructure, and the World Wide Web.
- Concerning the degree of flexible knowledge structure, the project involved different levels of structure of knowledge content. Some have sophisticated indexing structures, eg. information generated from the integration with the internal accounting and inventory system or information transformed through search engines.
- In the scope of knowledge friendly culture, there was an indication of positive attitude to knowledge sharing particularly from suppliers and among other staff. For example, supplier coordination, including smooth flows of information provides greater information linkage, and able to gain a competitive advantage over their rivals.
- In the scope of clear purpose and language, the project has provided staff and suppliers with access to on-line inventory request to support in inventory turnover. It also provided speedy information sharing with customers.
- In the scope of motivation to share knowledge, the project has successfully proven that staffs were motivated to share knowledge through an incentives or rewards system.
- In the scope of multiple channels for knowledge transfer, the project has provided two channels for knowledge transfer, both electronic: through the Internet for customers to access to the latest product information and through the listservers for staff to share knowledge and experiences amongst individuals.
- Assessing the extent of senior management support, the project has promoted and secured active participation among management.

In summary, WebLegacy has satisfied most of the eight success factors defined in the framework. WebLegacy has also successfully offered cost savings to organisation # A, which flow from improved information exchanges between its customers and its suppliers.

## CONCLUSIONS

### Summary of findings

In this study it has been demonstrated that WebLegacy has successfully offered infrastructure to organisation # A, which has supported the acquisition of knowledge and enhance the environment in which knowledge artifacts are created and managed. Several reasons are associated with the significant of WebLegacy particularly to organisation # A.

- WebLegacy is identified as the most popular application used by staffs of organisation # A. It is widely noted as being helpful in its virtual office environment as its geographically dispersed branches can collaborate and exchange information.
- WebLegacy is able to provide network tools such as shared, indexed and replicated document databases and discussion threads, as well as shared white boards, joint document editing capabilities and full duplex, multimedia communication features. These tools serve to mitigate collaborative losses.
- Substantial cost savings result because of improved information exchanges between organisation # A, its suppliers, and its customers. These tools serve to add value to organisation # A products and the services to its customers. They also help organisation # A to gain a competitive advantage over its rival.
- Using WebLegacy to do business in the long run, may enable organisation # A to relinquish its control over its suppliers.

WebLegacy was chosen as a mean of supporting knowledge management in providing value creation for organisation # A, because it was believed that this project was able to provide a strategy for managing and exploiting knowledge. This project also serves to help organisation # A in understanding its knowledge asset, ie the value of its knowledge, in assessing how well that knowledge is being applied, and the true cost of its IT.

### Limitations and directions for further research

The approach used in this paper is geared to address factors affecting WebLegacy by using an analysis framework (proposed by Daniel, L and Graeme, G, 1999). It does not propose to build a new model that provides a new way of looking at IT investments that will help to identify its benefits. This refers to a model that is able to address a new focus of responsibility for the identification and delivery of IT investment benefits. However, the factors that have been combined into Daniel and Graeme's model that describe and explain the drivers and critical success factors for knowledge management project implementations, requires further testing for thorough empirical validation.

The work outlined in this paper may encourage other IS scholar to formulate a model that can capture the information reflecting the perception and practice of the Adoption Electronic Commerce Knowledge Management Project. In particular, it would be useful to identify the internal or external environment factors affecting the adoption of them and their degree of influence. (Length of paper is 3630 words)



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# A systems-based approach to policy making. Is there synergy between natural resource management and the Kyoto Protocol?

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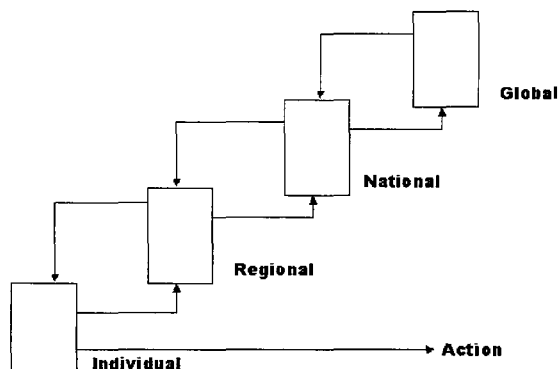
## ABSTRACT

The management of environmental issues, such as climate change and land use change, involves complex dynamics in ecology, economics and social systems. Developing integrated frameworks for these complex problems presents a challenge at all policy-making levels. Market-based policies for ecosystem services are examined with a focus on carbon sequestration, as an emerging synergy between land-use change and emissions trading of forestry-based carbon sinks, under the Kyoto Protocol. A systems-based approach offers the potential to increase our understanding of the complexity surrounding policy development for the management of multiple objectives of natural resources, within a holistic policy framework.

*Key words:* Global environmental problems; Systems-based approach; Natural resource management; Policy; Multiple objectives; Market-based approaches; Kyoto Protocol.

## INTRODUCTION

The degree of seriousness and complexity of the impacts of human use of the environment is increasing, potentially reaching crises in the 21<sup>st</sup> century (Capra 1996, Daily 2000, De Greene 2000). Land degradation and climate change are two examples of these complex problems. Recognition of the number of interacting agents and the interrelatedness in time and space, and across hierarchies, all serve to increase the perceived complexity as knowledge increases (Figure 1). The characteristics of complex systems (non-equilibrium, non-linearity, emergence etc.) are a major challenge for policy design. It is the synergy between the mitigation strategies for climate change and natural resource degradation that is the subject of this research.



**Figure 1:** Hierarchy of individual, regional, national and global relationships involved with climate change and natural resource management.

## **Dilemma for policy-makers**

The dilemma for natural resource policy-makers is how to increase the understanding of the complexity of the interrelated ecological, social and economic systems, particularly to achieve multiple natural resources objectives across sub-systems at the individual, regional, national and global scales. De Greene (2000) proposes that new systems-based theories and concepts will provide the necessary building blocks for policy-making in these complex systems. However, a large gap exists between the theory and concepts in systems thinking, and the praxis and translation into implementable policy and actions.

## **CLIMATE CHANGE**

Recently, the Intergovernmental Panel on Climate Change (2001) accepted, beyond doubt, that human actions are responsible for the rapidity of climate change. International policy designed to combat climate change, by reducing greenhouse gas emissions, is coordinated by the United Nations Framework Convention on Climate Change through the ad hoc Kyoto Protocol (United Nations 1997). In Australia, The National Greenhouse Strategy (Commonwealth of Australia 1998b) pursues the Kyoto Protocol objectives through four actions: (1) limiting greenhouse gas emissions, particularly from fossil fuels; (2) sequestering carbon dioxide, through carbon sinks on agricultural land; (3) increasing understanding of climate change issues; and (4) provision for adapting to potential environmental effects of global warming.

In 1996 the energy sector, utilising mainly fossil fuels, accounted for 79% of Australia's emissions; and emissions from agriculture, including land clearing, accounted for 20% (Commonwealth of Australia 1999). If the projected increases in economic growth are to be realised it will require significant changes in current practices to meet Australia's Kyoto Protocol (if ratified) emissions target of 108% of 1990 levels by 2008 - 2012. Changing land use practice and increasing carbon sequestration in woody perennial plants on agricultural lands will help to meet the Kyoto Protocol targets and may produce multiple benefits for both climate change and natural resource management.

## **NATURAL RESOURCE MANAGEMENT APPROACHES**

Natural resource degradation is due to multiple causes in our social and economic systems and inadequate understanding of ecological systems and institutional structures (Chisholm and Dumsday 1987, Sala and Conacher 1998, Cortner et al. 1998). None-the-less, extensive land clearing of deep-rooted native vegetation is considered to be the single most important cause of land degrading processes causing flooding and dryland salinity (Commonwealth of Australia 1998a). Moreover, this activity has transformed the biotic carbon store into atmospheric carbon dioxide.

Traditional natural resource management policies in agriculture have been based on obsolete ecological theory, assumptions of social behaviour (Brown and MacLeod 1996) and in isolation from social and economic policy frameworks (Bellamy and Johnson 2000). In comparison, recent rhetoric in the literature in natural resources management recognises the interrelatedness of social, environmental and economic systems. One major outcome has been the development of integrated, process-driven, community-based approaches (Holling 1978, Carpenter et al. 1999, Bellamy and Johnson 2000). However, such community-based integrated approaches have proven to be difficult to implement (Bellamy and Johnson 2000). The difficulties correspond with the identified inherent systems characteristic of complex problems.

Natural resource management issues have been identified and described in the literature, in such terms as 'wicked' problems in integrated resource management (Bellamy and Johnson 2000) and planning (Rittel and Webber 1973, Karacapilidis 2000), and 'messy' problems (Checkland 1984) in soft systems thinking. The 'wicked' and 'messy' nature of these problems relates largely to the complex sets of attitudes, beliefs, values, opinions and perceptions that humans introduce into a system (Waring 1996). Similarly complex problems in economics are described as 'flighty' (Goldstein 2001). Other causes for the complexity in natural resource management has been stated to arise from the variability of the resource-base and their continually evolving nature (Lynam 1999); through interactions with ecological and economic sub-systems (Rosser 2001); from cause and effect not being closely linked in time or space, and that the services they provide are intangible (Bellamy et al. 1999); and from market failure, property-right failure, institutional inefficiency, political deficiency and lack of information (Young et al. 1996).

## **Future directions of natural resource policy in Australia**

Two future policy directions in natural resource management in Australia have been identified as critical: (1) adopting a regional approach; and (2) achieving fundamental change through a wider mix of policy instruments, including enhancing the role of economic and market-based mechanisms. For example, creating market-based mechanisms to realise the intangible benefits of ecosystem services is proposed as one of a mix of policy instruments

### **Market-based mechanisms for ecosystem services**

Although ecosystem services are essential for human existence they are typically undervalued, especially when the value to future generations is taken into account (Daily 2000). Ecosystem services have usually been considered to be 'free' goods. They are subject to open access, and assuming economic rational behaviour, they are ultimately degraded (Hardin 1968). Methods to value ecosystem services are emerging, for example, avoidance costs of building and maintaining water treatment plants by maintaining a healthy catchment that purifies the water (Daily 2000). As another example, emissions trading of carbon sinks is being developed under the Kyoto Protocol.

Daily (2000) describes an ecosystem services framework that attempts to integrate biophysical, economic and social systems of natural resource protection. However, Rosser (2001) cautions that the coupling of ecological and economic systems may produce non-linear dynamic outcomes at multiple levels and in multiple ways. A supporting proposition is that complications will arise from the coupling of equilibrium economic market-based approaches within a non-equilibrium ecological system (De Greene, pers. comm.).

## **POTENTIAL POLICY SYNERGY**

On the one hand concern over the impact of human induced climate change through increased atmospheric carbon dioxide has driven international policy to search for flexible mechanisms to reduce carbon dioxide concentrations in the atmosphere. One of these mechanisms, emissions trading using forestry-based carbon sinks, has emerged as one of the market-based initiatives to mitigate the increased atmospheric carbon dioxide concentrations. On the other hand concern over the continuing trend in the declining condition of natural resources and biodiversity in agro-ecosystems, partly due to the loss of deep-rooted vegetation, poses a dilemma for rural land management in Australia.

Agriculture and forestry are reliant upon natural resources for the production of food, fibre and timber. However, they also provide ecosystem services, such as the removal of carbon dioxide from the atmosphere through photosynthesis, biodiversity maintenance and flood mitigation etc. These two rural enterprises are being considered as suppliers of increased ecosystem services through the potential to sequester carbon from atmospheric carbon dioxide. Carbon, biodiversity, and salinity are being proposed as ecosystem services that could be traded. Some investigators believe that it will be

necessary to package a number of ecosystems services together to drive the necessary landuse change required in many agricultural areas in southern Australia (Thompson and Heffer 2000). Consequently, synergy arises from the need in Australia for reforestation of degraded agricultural land and the potential to offset carbon emissions to meet our potential international commitments under the Kyoto Protocol.

The current policy framework for natural resources is developed within individual portfolio areas and is neither integrated across all natural resources nor across social and economic government portfolios. The integration of policies for sustainable land management and climate change policies is one prescription to achieve multiple objectives in environmental, social and economic systems. Increasing carbon sequestration through plantation development can be coupled with the Kyoto Protocol flexibility mechanisms of emissions trading.

Systems thinking provides the conceptual understanding and principles that are necessary (De Greene 2000) to understand the interrelatedness of issues in natural resource policy making.

If this market-based approach is adopted within the current institutional arrangements this raises a number of questions. How can systems thinking aid decision-making to achieve multiple objectives in natural resource management and climate change? What complications will arise from the coupling of equilibrium economic market-based approaches within a non-equilibrium ecological system?

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# Teaching Project Management: A systems challenge

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## ABSTRACT

*Systems thinking action research and experiential learning are used to help understand, to help make relevant and to help manage a complex system. The system is Business students' learning in the project management subject. The monitored system outcome is students' competency as expressed in their final grade in the subject. Action research and experiential learning interventions will be used three times during the semester to increase the desired outcomes. There is a constraint on resources as currently defined. This paper is mainly about the description of the system and the conceptual model of the system.*

*Keywords: Teaching, Learning, Students, Project management*

## INTRODUCTION

Systems thinking and action research and experiential learning have long been used to help understand, to help make relevant to the current world of Business and to help manage systems. One recent example is in the analysis and design of complex work systems at the Australian Taxation Office (Bruce-Smith, 2000). This paper attempts to use a very similar approach with second year Business students' learning in the project management subject in the School of Business at James Cook University in Townsville, Australia.

Within teaching, one of the current technologies is 'Pick a textbook and then teach the text'. There are a number of attempts to move beyond this teaching technology, see for example: Bryant and Nunez (1997), Cowen (1998), Fox (1997), Lancaster (1999) and Salner (1986). This paper uses systems thinking to help understand the system and then to move beyond this technology to a more holistic view of students' learning in the project management subject. Specifically by:

- Taking more account of the sub-system 'individuals' journey'.
- Paying more attention to factors that decrease and increase students' learning.
- Taking more account of weekly and semester dynamics within the subject.

The paper continues with a brief review of systems thinking. The main part of the paper is the description of the system and the conceptual model of the system. This is divided into the following parts:

- The three sub-systems.
- The factors that, within the system, decrease and increase students' learning.
- The weekly and semester dynamics of the system.
- The stakeholders, the competency outcomes and the resources outcomes.



The paper ends with a brief outline of the action research and experiential learning interventions that will be used at the beginning, during and at the end of second semester 2002 to increase the desired outcomes from the system.

### **A brief review of systems thinking**

Systems thinking has a long, abundant and very diversified literature. The publications by the early authors like Ackoff, Bertalanffy, Boulding, Churchman, Emery, Forrester, and Meadows were largely driven by a strong concern for our ability to understand and manage the complex systems upon which we collectively depend for our very survival. Even though considerable progress has been made to date, many of their original concerns are still with us today.

Since those early authors the literature has virtually exploded. Thus the current literature has a large wealth of material from which to draw a clearer vision of what is currently possible and what is still beyond our grasp. Also our benefit of hindsight gives us an appreciation of the significant effort that has already gone into systems research and practice. This accumulated effort has provided us with the luxury of having a wide range of methodologies from which to choose in order to approach current problems. For example Checkland and Scholes (1990), Flood (1990), Senge (1990).

For the purpose of this paper a system: Is a collection of parts that interact with one another to function as a whole. Is more than the sum of its parts. Is a product of the interactions between its parts. Subsumes its parts and can itself be part of a larger system (Maani and Cavana 2000 p6). Thus systems thinking is any matter related to systems without holding bias to any position, rationality and so on. (Flood 1990 p217).

This paper draws specifically on the systems literature for: General concepts and practice (Maani and Cavana 2000 chapters 2,3,4 and 7 and Gaynor 1998 chapter 10). A conceptual framework that through collaboration the stakeholders (in the system) can develop a critical heuristic that could lead to a transformation in the way that they go about making sense of the system (Bawden and Packham 1998). Facilitation to conceptualise the learning about the system and to help stakeholders' interests to emerge rather than to be determined in advance (Callo and Packham 1999). Methodological pluralism to integrate understanding in a complex work situation (Bruce-Smith 2000) and to connect the system's dynamics into the overall learning heuristic (Linard and McLucas 1999).

### **DESCRIPTION OF THE SYSTEM AND THE CONCEPTUAL MODEL OF THE SYSTEM**

The system is the second semester second year Business students' learning in the project management subject. It can be described as the ongoing interaction and evolution of the content, the relevance to the current world of Business and of the relationships between the stakeholders. The system has one special attribute in that one of the stakeholders (the students) is in fact multi-generational. That is, it is made up of current students who have not taken the subject, students enrolled in the subject and current students that have already passed the subject. The dynamics between this stakeholder and the others is very interesting, to say the least.

The conceptual model of the system is presented in Figure 1. The system has three sub-systems plus a number of parts:

- The sub-system the concepts and practice of systems thinking.
- The sub-system the concepts, tools and practice of project management.
- The sub-system the individual's journey (of each stakeholder).
- The factors that, within the system, decrease and increase students' learning.
- The weekly and semester dynamics of the system.
- The stakeholders, the competency outcomes and the resources outcomes.

The system (That is: Students' learning in the project management subject) has typically seen the three sub-systems as being independent, non-dynamic and largely generic (rather than context specific) sub-systems. This paper treats the sub-systems as interrelated and the system as a whole as dynamic and largely context specific. The paper continues with a description of the three sub-systems, the factors that, within the system, decrease and increase student's learning, the weekly and semester dynamics of the system, and of the stakeholders, the competency outcomes and the resources outcomes.

### **The sub-system: Systems thinking**

The sub-system: The concepts and practice of systems thinking, is those parts of systems thinking that are relevant to or can help understand the system. In both general and specific terms, it includes the brief review section above. Thus the sub-system: The concepts and practice of systems thinking, is relatively well described but the relationships with the other two sub-systems needs further work.

### **The sub-system: Project management**

The sub-system: The concepts, tools and practice of project management is the extensive literature on project management. Specifically the most significant are the following that are used in the subject: Texts: Gido (1997), Gray and Larson (2000), Keeling (2000), and Kerzner (2000). Software manuals: Courter and Marquis (2000), Friedrichsen and Bunin (2000) and Quinn (2000). Extension material: Bean (1996), Bender (1997), Capper (1998), Gaynor (1998), Hawken, Lovins and Lovins (1999), Savage (1996), Vaill (1996a). Before arriving at this material to describe the sub-system an extensive review, including their relevance to the current world of business, was undertaken of project management texts, of manuals and texts for the software called Project 2000, and of texts and material for students requiring extension, that were available to deliver the project management subject.

The sub-system has a very large amount of material from which to choose what to use in the subject and what depth to give to the material covered in the subject. There is far too much content for any reasonable one-semester subject. The sub-system has two very different orientations: An engineering orientation and a business orientation. Only the business orientation is used in the subject. From a content point of view the available material can be divided into:

- Creating, tracking and closing a project.
- Managerial oversight of a project.
- Technical aspects of using Project 2000 in project management.
- Context specific material.

From, a depth to give to the material covered in the subject, point of view the available material can be divided into:

- A school leaver student planning to work in a large project management team.
- A mature age employed student studying project management with their current employer's support.
- A student who just wants to keep their employment options open.
- All of the above or none of the above.

From a systems thinking point of view this abundance raises the following two issues that are as yet to be resolved:

- Where to draw the boundary to what is offered in the subject.
- How to represent, in the conceptual model, this additional feature of the system that is this abundance of choice.

Thus the sub-system: The concepts, tools and practice of project management is relatively well described but the relationships with the other two sub-systems need further work.

### **The sub-system: The individual's journey**

The sub-system: The individual's journey (of each stakeholder), is the very real component of learning that is each individual's personal journey of life and of independent lifelong learning. The system (That is: Students' learning in the project management subject) has typically only acknowledged the important contribution of this sub-system in smaller size classes; but has largely ignored the impact (often very negative impact) of this sub-system in normal size classes. It is often expressed as being too difficult in normal size classes. This paper takes more account of the sub-system individual's journey. It treats this sub-system as interrelated with the system and treats the system as a whole as dynamic and largely context specific. Though related to this sub-system, but not directly related to this systems paper, see for example: Cowen (1998), Dillenbourg (1999), and Goodwin (1997). Thus the sub-system: The individual's journey (of each stakeholder) is relatively well described but the relationships with the other two sub-systems need further work.

Describing the system and the conceptual model as three sub-systems and some parts, allows the focus for this paper to be on the three sub-systems. The content of each of these three sub-systems is relatively well established in isolation. The challenge lies in improving our understanding of the system and in achieving improved monitored system outcomes. The paper continues with the description of the factors that, within the system, decrease and increase students' learning.

Factors that, within the system, decrease learning

The factors that decrease students' learning fall into the following six categories: Student factors, subject factors, engagement factors and institutional factors. These four will be described in their positive form below as factors that increase students' learning. However there are two categories of factors that decrease students' learning that rarely have a positive side. These are work for money and life's crises.

Work for money is currently a significant factor that decreases students' learning. It has, as yet not formally been quantified, but it is clearly evident from the day to day contact that Academic Advisers have with students. The logic goes something like this: I, the student, need to work for money more than about 10 hours per week because I have lifestyle expenses like new car registration and insurance. Because I have these expenses I need to go to University so that I can get a better paying job. I do not want to give up my lifestyle expenses so I do not have the time to study and I make little progress with my degree.

Life's crises are deaths of close ones, sick minors, accidents etc.

Factors that, within the system, increase learning

The factors that increase students' learning fall into the following four categories: Student factors, subject factors, engagement factors and institutional factors. There is also the interaction between these factors. However, for the purpose of this paper, all aspects of each factor, including all interactions, have been allocated to one category. All these factors have the common characteristic that removing limitations in one or more of these factors will increase students' learning.

The factors that increase students' learning have typically only been acknowledged as being important in increasing the monitored system outcome in paperwork but have largely been ignored in practice. It is often expressed as being too difficult in normal size classes. This paper pays more attention to factors that decrease and increase students' learning. The assumption here is that these factors are a very effective way of increasing the monitored system outcome. The assumption is based on the fact that the system is relatively complex and that the students' needs and thus their positive response are very heterogeneous.

Student factors are those associated with each individual student. Student factors include student motivation to study, student dedication or commitment to learning, student has a life (outside university), grade expectation of credit or better, semester planning, weekly planning, preferred learning style, and participation in class.

Subject factors are those associated with the design, implementation and delivery of the project management subject. Subject factors include peer support, remedial support, choice in their learning, choice in their assessment, control over their learning, control over their assessment, non content skills, skills of better graduates, and attendance to class.

Engagement factors are those associated with each individual student's reason for and experience with engaging in a learning process. Engagement factors include prior positive learning experience, congruence of expectations between main stakeholders, and communication about learning tasks between students and staff.

Institutional factors are those associated with the School of Business, the University, and the staff. Institutional factors include student policies, rules and regulations, DETYA requirements, and staff assigned to the project management subject. Though related to the factors that increase students' learning, but not directly related to this systems paper, see for example: Cowen (1998), Cranton (1996), Fox (1997), Vaill (1996b) and Welton (1995). Thus the factors that, within the system, decrease and increase students' learning is relatively well described as a whole but both the

interactions between these factors and the heuristic with which to manage the action research and experiential learning interventions to achieve increases in the monitored system outcome need further work.

#### The weekly and semester dynamics of the system

The weekly and semester dynamics of the system are rarely formally acknowledged in the design and implementation of a project management subject. This paper takes more account of weekly and semester dynamics within the subject because of its fundamental conceptual link with learning project management. Learning project management relevant to the current world of Business and appropriate for the current employment realities has a lot to do with taking account of foreseeable disruptions to and considering consequences for the project in question. That is, in terms of dynamics, there are considerable similarities between a student's learning in a project management subject and a graduate doing project management at work. Though related to the weekly and semester dynamics, but not directly related to this systems paper, see for example: Cowen (1998), Cranton (1996), Emery (1981), Jacques (2000), Lancaster (1999) and Vaill (1996b). Thus the weekly and semester dynamics of the system is relatively well described as a whole at the conceptual level but the understanding of both the students' priority learning requirements and the heuristic with which to manage the action research and experiential learning interventions to achieve increases in the monitored system outcome need further work.

#### The stakeholders, the competency outcomes and the resources outcomes

For this paper this heading includes the balance of the system. For this systems paper they are of minor importance. The stakeholders are the students, the lecturer, the School of Business (as a part of the University) and the students' future employers. From a systems point of view the listing of the stakeholders both specifies the system boundary and helps highlight the interest in the monitored system outcome. The monitored system outcome is students' competency in project management, as expressed in their final grade in the project management subject. The resources outcome is expressed as a constraint imposed on the system set at existing available money and non-money School of Business resources. But this constraint is not restricted to resources as currently defined. That is, in a systems context the challenge is to extend the definition of resources and to identify and to capture them so that they can be used to help achieve increases in the desired outcomes from the system. Thus the headings that form the balance of the system are relatively well defined as such and of little importance for the description of the system and for the conceptual model of the system. However, they are highly significant for the implementation of the action research and experiential learning interventions to achieve increases in the monitored system outcome.

#### The action research and experiential learning interventions

There are three aspects to implementing the action research and experiential learning interventions aimed at achieving increases in the monitored system outcome: (a) How to most effectively monitor the system. (b) How to prioritise the interventions. And (c) What heuristic to use to manage unplanned events and occurrences. For all three aspects there is a significant literature and experience available. The third aspect, unplanned events, is of special interest because they provide, based on experience, a significant opportunity for achieving significant improvements. Unplanned events are significant largely because of the intense focussing of stakeholders' attention and energy. They can relatively easily be made into real 'teachable moments'. Interventions will be early (week 2) mid and late (next to last week) in the semester. Thus the action research and experiential learning interventions are the mechanism used to achieve increases in the monitored system outcome. The desired outcome is clear and the process is acknowledged as likely to be highly dynamic. This is in part contextual to the system but also due to the real opportunity for improvement even at the expense of a tidy process.

## CONCLUSION

This paper is mainly about the description of the system and the conceptual model of the system thus the conclusion is mainly about the description of the system and the conceptual model of the system.

The description of the system and the conceptual model of the system are by design, exhaustive. However, they are not always mutually exclusive. This is specially the case with the relationships and interactions within the system. This should not be a significant limitation as long as the rules both for allocating content to parts to avoid duplication and the rules to make duplication explicit are covered by careful design and are made relatively transparent.

The fact that the description of the system and the conceptual model of the system are exhaustive is important because the increased understanding about the system will actually be used to manage the system. The description of the system and the conceptual model of the system have identified the following as important aspects for the implementation:

- The three sub-systems and the other parts of the system are relatively well described and their content relatively well established in isolation but the relationships between them need further work.
- The interactions between the factors that increase students' learning need further work.
- The students' priority learning requirements need further work.
- The heuristic with which to manage the action research and experiential learning interventions to achieve increases in the monitored system outcome needs further work.
- A few of the headings are of little importance for the description of the system and for the conceptual model of the system. However they are highly significant for the implementation of the action research and experiential learning interventions to achieve increases in the monitored system outcome.
- The desired outcome is clear and the process is acknowledged as likely to be highly dynamic. This is in part contextual to the system but also due to the real opportunity for improvement even at the expense of a tidy process.

In summary, systems thinking has helped develop a conceptual model of the system and it has helped sort out what is more and what is less important for the implementation. It has also helped sort through the complexities of the system. Together they will make the implementation relatively easy.

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# Using Soft Systems Methodology to address Supply Chain Management Problems – Proof of Concept

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## ABSTRACT

*This paper reports an investigation of if, and how, Soft Systems Methodology (SSM) might be used to facilitate better management of industry supply chains. In two workshops involving supply chain managers from the Textile Clothing and Footwear (TCF) industry and industry facilitators, ways in which SSM techniques might supplement existing Supply Chain Management (SCM) workshop approaches have been explored. Specifically, the placement of SSM techniques within a workshop setting, reactions to the techniques, perceived reasons for using SSM, together with strengths and difficulties encountered, have been examined.*

*Keywords: Soft Systems Methodology (SSM), Supply Chain Management (SCM)*

## INTRODUCTION

In the world of eCommerce, Supply Chain Management (SCM) is now mission critical; get it right and a business prospers, get it wrong and it can threaten the very survival of the organisation. SCM involves both optimisation of the delivery of goods and services, and optimisation of information flows. To the customer, optimisation means that the supplier knows what the customer needs and understands the timing of the delivery of goods and/or services. To the supplier, optimisation means that the right goods and/or services are available in the right quantities at the right time, when the customer needs them, without requiring the supplier to carry excess inventory or maintain excessive production capacity.

Interest in SCM has grown steadily since the 1980's, as firms have come to recognise the benefits to be gained from collaborative relationships within and beyond their own organisations. It has been realised that it is not possible for companies to effectively compete in a climate of isolation from their suppliers and other key stakeholders; cooperation brings success for all (Lummus and Vokurka 1999).

The role of technology as an enabler of SCM has facilitated the initial development of relationships between organisations, however technology alone is not sufficient. Businesses are volatile and their operation is dependent upon a chain of cooperating people. Researchers are really now only in the early stages of understanding and modeling the social, cultural and political dimensions of the supply chain, and in particular, understanding how the people focused challenges of managing the supply chain might best be addressed. It remains an open question how supply chain managers might accommodate various stakeholder perspectives of supply chain problems, the cultural, social and political forces at play, the diversity of individual skill and knowledge bases, and diverse individual value systems.

In this paper we report an investigation of if, and how, an existing systems-based problem solving approach, Soft Systems Methodology (SSM), might be used to facilitate better management of industry supply chains. In two workshops involving supply chain managers from the Textile Clothing and Footwear (TCF) industry and industry facilitators, ways in which SSM techniques might supplement existing Supply Chain Management (SCM) workshop approaches have been explored. Specifically, the placement of SSM techniques within a workshop setting, reactions to the techniques, perceived reasons for using SSM, together with strengths and difficulties encountered, have been examined.

Initially in this paper, the scene is set with a brief review of some areas of SCM concern, and recent trends. SSM is then briefly introduced, and the objective of the present research program is established. The research approach is then outlined, including a brief background to the workshop participants and their situation. Some of the key results are then outlined, including insights into the way in which SSM might be integrated with an existing SCM workshop technique used for some years now by the Quick Response (QR) Group within Business Victoria. Some of the perceived strengths of the use of select SSM techniques in this context are reported. Finally, some possible future paths for this research are discussed.

## **SUPPLY CHAIN MANAGEMENT— AREAS OF CONCERN AND TRENDS**

Areas of current SCM concern have been highlighted by Hakanson (1999), and include:

- Improving customer service - having the right product at the right place at the right time to reduce the number of people purchasing elsewhere;
- Saving money and reducing costs; and
- Achieving better cash utilisation - the time it takes to be paid for products delivered.

According to Li (2000), recent trends in supply chain management are now pushing companies to more diverse products, shorter product life cycles, increased competition and ever-increasing globalisation. These trends challenge companies seeking to achieve supply chain efficiencies. Li argues that in order to address such challenges stakeholders in the supply chain must convene regularly to discuss matters of mutual concern.

One might observe that the above concerns and trends are but symptoms of a fundamental SCM principle. Forger (2000) has suggested that what makes one supply chain better than another is *collaboration*. Collaboration allows companies to predict supply chain events, as well as permitting suppliers and customers to plan around potential glitches while maximizing their return on supply chain opportunities. Further, the impact of collaboration is not limited to improvements in the inter-organisational chain, but can have profound effects within the four walls of each company making up that chain.

In summary, examination of the SCM literature reveals difficulties with the lack of communication between supply chain partners, cultural inconsistencies, and difficulties with the integration of systems between key stakeholders in the supply chain. In short, if one is to take collaboration seriously, to achieve the full potential of a supply chain, one must be able to analyse the social, cultural, and political dimensions of a SCM situation.

## SOFT SYSTEMS METHODOLOGY

It is beyond the scope of the present paper to review Soft Systems Methodology (SSM) (see Checkland and Scholes (1990) and papers therein). Suffice to say that SSM has been widely used as a general systems-based problem-solving framework but little has been written on its application to SCM problems, although Rigby et al. (2000) makes oblique reference to some perceived shortcomings of SSM when describing research undertaken in the field of agile supply chains (see also Day (1999)).

Developed in the UK and used around the world, SSM provides a set of procedures and notations for investigating organisational problem situations and taking action to improve those situations. SSM has a well-documented set of processes, supported by a rich set of techniques for finding out about problems and generating systems-based models that can be used to generate systemically desirable and culturally feasible organisational change.

Even though SSM has not been widely applied to addressing problems in supply chain management, the very nature of SSM appears to make it a suitable vehicle to address the social, cultural, and political issues commonly associated with SCM problems. What is evident from a search of the SCM literature is that SCM problems of a human nature are overwhelmingly more common than problems of a technical nature. In this sense, organisations are social systems, as well as business systems - thus the social construction of problematic situations in organisations are complex to understand and manage.

## RESEARCH OBJECTIVES

Reflecting the above observations based upon the extant literature, the aim of this study is to address the research question:

*Can SSM be used to complement an existing workshop-based approach for thinking about supply chain management problems by conceptualizing and modeling the key activities of suppliers, retailers and other stakeholders?*

As such, can SSM techniques such as rich pictures, CATWOE analysis, root definitions and conceptual models be used to reveal issues that were previously unrecognized by those involved in the management of supply chains?

## RESEARCH APPROACH

Given the exploratory nature of the present research, a case study approach has been used to address the research question. Yin (1985, cited by Rubin and Babbie (1997)) defines a case study as an empirical inquiry that: *'Investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used'*.

Participants in the present case study were a senior supply chain manager, a production planner, a SCM facilitator and two SSM facilitators. Two half-day workshops were used to collect the data. The SCM facilitator was from Business Victoria, a Victorian Government initiative for improving supply chain management processes within the Textile Clothing and Footwear industry (TCF) industry. The facilitator had extensive experience in running SCM workshops but had no knowledge of SSM. The senior supply chain manager and the production planner were from a large Australian company in the TCF industry, specifically a producer of socks and hosiery.

As a producer of socks and hosiery, the organisation manufactures locally as well as importing products that can no longer be cost effectively produced within Australia. The company purchases yarn from local producers and imports yarns. The company sells to the major retail discount stores such as Woolworths, Coles Myer and Big W. They also concentrate on selling their own brands in smaller boutique stores around Australia and are looking at the prospect of exporting niche products, particularly by using Merino wool because it can be marketed as a unique Australian fiber.

The company had been previously involved in meetings initiated and facilitated by a Victorian government SCM facilitator who had spent a considerable amount of time working with TCF companies, forming cluster groups. Those that made up the cluster groups were typically a major retailer, a TCF manufacturer and one or two suppliers to the manufacturer. The aim of convening the cluster groups was to achieve mutual gain by improving their total effectiveness in servicing each other and the end consumer. The format of these earlier meetings was an approach outlined below (see the next section of this paper). It was against the experience of participants in those previous workshops that select SSM concepts and techniques were introduced in the two half-day workshops conducted as part of the present research.

Data collection from the two SSM-based workshops took the form of:

- Some pre and post workshop semi-structured interviews with some of the workshop participants;
- Drawings and written responses to questions asked in the workshop situation; and
- Audio recordings (each workshop was audio recorded with the permission of participants).

Data from the above collected sources were analysed to:

- Document supply chain management processes currently employed by workshop participants;
- Identify SCM issues and problems;
- Identify initial reactions to the SSM techniques introduced in the sessions; and
- Collect reactions to the experience of using SSM techniques in the workshops.

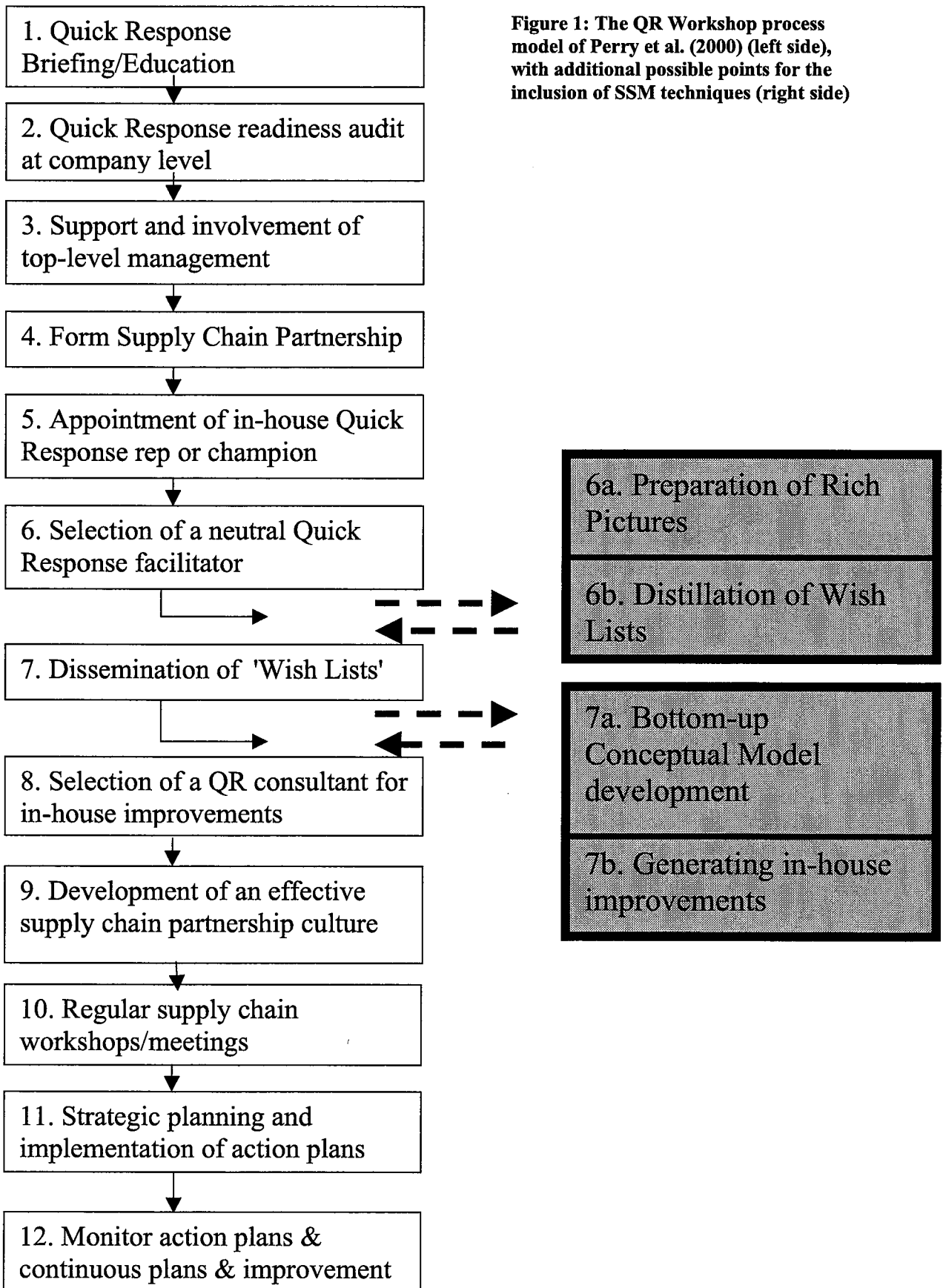
## **THE INTEGRATION OF SSM WITH EXISTING SCM WORKSHOP APPROACHES**

As indicated above, the workshops discussed in this paper built on previous workshops that had been run over several years by the Quick Response (QR) Group within Business Victoria. This QR program has been documented by Perry et al. (2000) and is summarised on the left-hand side of Figure 1. Specifically, in these workshops senior managers meet regularly in newly formed cluster groups consisting of one or two representatives of major retailers, manufacturers and suppliers. The processes involved in the QR workshops can be summarised, as shown on the left-hand side of Figure 1, as involving four key features:

1. The generation and circulation of company SCM 'wish lists' within each cluster group;
2. Discussion of the wish lists and the development of group and company action plans;
3. The injection into each group of a consultant selected by the various companies to provide assistance with in-house Quick Response implementation activities; and
4. Follow-up strategic and tactical planning amongst each cluster group.

Results from these QR workshops (Perry et al. 2000) reveal that improved communication and information flow result, as well as improved performance within the supply chains involved.

Prior to the workshops discussed in this paper the present authors speculated on points at which SSM techniques might be injected into the QR workshop process model of Perry et al. (2000). The initial view that was formed is represented by the additional Steps 6a,b and 7a,b shown on the right of Figure 1.



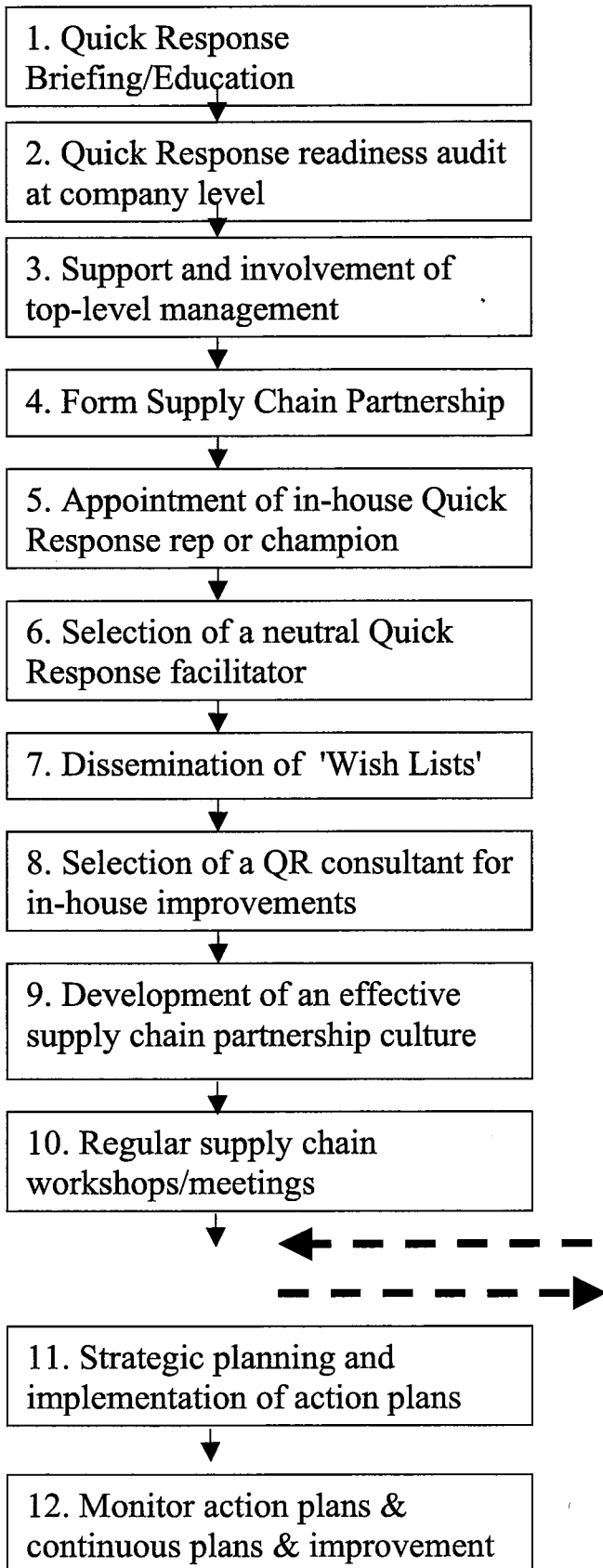
Specifically, it was felt that the SSM technique of Rich Picture Building and reflection upon those Rich Pictures might facilitate the preparation of the SCM 'wish list' (ie. Steps 6a,b). Further it was felt that the use of CATWOE analysis, SSM Root Definitions and Conceptual Modeling of each node in the supply chain (ie. a "bottom up" development of conceptual models of each node in the supply chain) might provide a useful means of facilitating the identification and specification of in-house improvements (ie. Steps 7a,b).

This possible use of SSM in conjunction with the established QR workshop process model described by Perry et al. (2000) was introduced to workshop participants, and reactions were collected. Results and findings from these workshops follow.

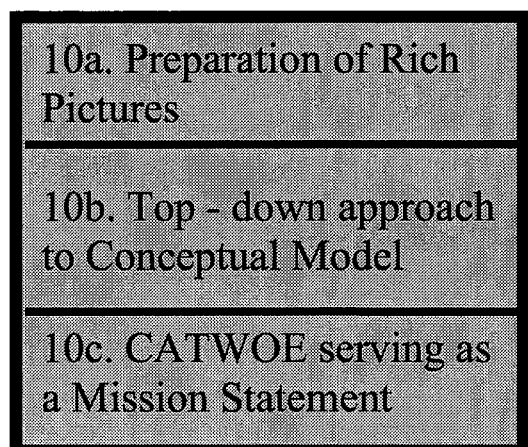
## **RESULTS**

### **The placement of SSM Techniques within the Workshop**

Before looking at the reactions of participants to the individual SSM techniques, it is worth reporting the reactions of those participants to the suggested placement of those techniques within the workshop process. In summary, significant doubt emerged from the participants concerning the suggested placement outlined in Figure 1. Instead, a preferred sequencing, outlined in Figure 2, emerged.



**Figure 2: The QR Workshop process model of Perry et al. (2000) (left side), with the placement of additional SSM techniques preferred by workshop participants (right side)**



In summary, the participants argued that:

- The SCM 'wish list' generation step did not require support from SSM Rich Picture building (see further discussion under 'Workshop Techniques' below). Instead, the wish list approach had the advantage of yielding quickly high value insights that build important enthusiasm for the workshops within participants. Use of graphic SSM Rich Picture building and reflection at this very early stage in the life of the workshop group was seen as unnecessarily delaying the realisation of these quick returns. Instead the workshop participants argued that the Rich Picture techniques would be best introduced subsequently, as part of the cycle of regular supply chain workshops/meetings, where it might be used as a technique to identify some of the less readily apparent SCM issues and concerns (Figure 2, Step 10a).
- SSM CATWOE analysis and Conceptual Model Building was seen also as best introduced as part of the subsequent cycle of regular supply chain workshops/meetings (Figure 2, Step 10b). Further, it was believed that the value of the conceptual models came from examining the supply chain from a top-down perspective, rather than the bottom-up approach proposed in Figure 1. The CATWOE technique was seen also as a useful means of reviewing/reasoning about the mission of supply chain participants (Figure 2, Step 10c).

## Workshop Techniques

As noted above, the workshop participants strongly supported the retention of the use of wish lists, a central component of the previous QR workshops. These were seen as a fast way of focussing workshop participants thinking on the main supply chain issues and problems, yielding quick returns to the participants. The wish lists typically contain requests for improved working relationships between partners, improved response to customer orders and reduced pipeline waste and delay. In a sense, the wish lists were simply lists of things participants would ideally like to happen in the supply chain in order to improve their own performance and profitability. It was observed that using wish lists seemed to 'break the ice' with participants.

In the course of the workshop, when the SCM facilitator asked the senior supply chain manager to come up with a wish list, as many as 15 'problems' were produced in a manner of minutes. The QR facilitator stated reasons as to the usefulness of the wish list approach. They were:

- It gives people ownership, therefore it's not just the facilitator coming in and stating that he is going to rework the supply chain;
- It is the day-to-day things that people are anxious to fix;
- The senior supply chain managers know intimately all the details, thus the solutions are usually fairly readily achieved; and
- It leads the people in the workshop to realise that problems can often be solved by a simple alteration to a requirement or a procedure in another cell.

This is not to say that the SSM techniques, when introduced to the workshop participants, were not appreciated. Indeed, the SCM facilitator commented on the fact that the use of SSM substantially added to the wish list approach:

*'After deriving wish lists you end up with informal results. What you want to do then is to add structure, ...now SSM techniques can be used to add that structure.'*

What did emerge was that it was felt that the SSM techniques were better introduced after the quick gains achieved by using the wish list approach had been realised. In this regard it is worth noting that the participants observed that it was not a matter of whether it would be useful to apply SSM to SCM, - rather, where and how SSM could be applied.



The collected observations of participants on their exposure to the SSM Rich Picture Building, CATWOE and Conceptual Modeling techniques are recorded as reasons for using SSM (Table 1), identified strengths (Table 2) and difficulties raised (Table 3). It is beyond the scope of the present paper to discuss each of these in detail. Suffice to say that they provide support for the use of SSM in this context, and some insight into potential difficulties that may need to be addressed in future SSM-enabled SCM workshop sessions.

<b>Reason</b>
Acknowledges different ideas and perspectives
Promotes understanding of SCM concepts
Prompts questioning, thinking, and critical analysis
Encourages formal consideration of political and social environment
Provides a disciplined, formal way to proceed in an unstructured situation
Iterative nature of the approach

**Table 1: Reasons cited by participants for using SSM in the SCM context**

<b>Strength</b>
Conceptual nature of the approach
Adds structure to wish lists
Focuses on the purpose of the chain, systems, needs, outputs ...
Practical
Promotes creativity and builds confidence
Provides discipline and a formal structure
Systematic nature of the approach
Able to deal with unstructured situations
Participative and collaborative in nature
Prompts thinking
Allows for questioning of the current supply chain arrangements
Takes account of social, political and cultural issues

**Table 2: Strengths of SSM in the SCM context cited by participants**

<b>Difficulty</b>
Learning how to begin to draw Rich Pictures
Problems in reaching group consensus
Learning how to represent human activities using SSM conceptual models

**Table 3: Difficulties encountered in the use SSM in the SCM context cited by participants**

## DISCUSSION AND CONCLUSIONS

Drawing upon the results reported above, four central themes related specifically to the introduction of SSM techniques and associated concepts have emerged from the research to date:

- It appears that SSM allowed participants to achieve a better understanding of supply chain management processes because it introduces techniques that allow them to quickly see the views and perspectives of other stakeholders. Participants easily take to the use of rich pictures to visually show supply chain processes. Rich pictures accommodate different peoples' image of the chain, and therefore eliminate pressures on the manager to come up with verbal descriptions of systems and processes.
- When an approach involving using CATWOE analysis as a tool for the development of root definitions or SCM 'mission statements' was canvassed, participants felt that by incorporating the elements of customers, actors, transformation, worldview, ownership and environment, they could see and reanalyze the cooperative role of the supply chain.
- Participants saw that the value of conceptual models in the SCM context comes from examining the supply chain from a top-down perspective. Rather than beginning with each participant in a supply chain developing their own activity model and capturing their perceptions of the current sequence of events, it was argued that it was better to start at the top-level and develop *fresh views* in order to overcome the danger of locking oneself into current practices.
- SSM techniques were seen as generally useful in identifying shared and conflicting views. By having the parties come together in a workshop situation they are able to discuss key processes through the use of universal icons and remove those icons that are not appropriate. This allows inhibitors to a smooth functioning supply chain to be identified so that they can be removed.

It should be noted, however, that the experience reported in this paper is limited to two workshop sessions and associated interactions with the workshop participants. It is therefore important that the findings reported be confirmed by the conduct of a future, richer series of such sessions, with participants drawn across all tiers in supply chains, operating in a number of industrial settings. Results to date, however, are promising.

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# The SoSM Revisited - the Importance of Social Structures

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## ABSTRACT

*The article revisits the System of System Methodologies (SoSM) and suggests that use of the SoSM as a framework for defining methodological assumptions is difficult when the concerned methodologies have significantly different meanings for one axis of the framework - "system" complexity. It is suggested that the **purpose** of the underlying system can provide a more appropriate frame for defining system approaches – such purpose being defined as interaction or transformation (Mathiassen and Nielsen 2000).*

*The article also uses aspects of critical realism to provide insights into the SSM (as suggested by Mingers 2000b). A critical realist critique of SSM suggests that SSM would benefit from a greater acknowledgement of the role of underlying social structures. The paper proposes that stakeholder analysis may provide a useful technique for incorporating such recognition of social structures. It is suggested that stakeholder analysis is particularly important where the primary function of the system is aimed at interaction. This suggestion is highlighted by placing SSM within the new framework which includes consideration of the system purpose (interaction or transformation).*

*Keywords: Soft Systems Methodology, Critical Realism*

## INTRODUCTION

In the systems area, probably the best-known model for structuring thinking with respect to systems methodologies is Jackson and Keys Systems of System Methodologies (1984) (SoSM). This framework suggested that a mapping of system complexity against the decision makers environment allowed a useful means of categorising systems methodologies to provide an indication as to their underlying assumptions concerning systems complexity (simple or complex) and participant situation (unitary, pluralist or coercive). Banathy (1988) and Keys (1988) both used the SoSM to argue that an examination of problem contexts can suggest suitable methodological approaches. According to Jackson (1990) this use of the SoSM was seen to be a functionalist interpretation of the framework and such a use for the SoSM was invalid as problem context and system's characteristics are "in the eye of the beholder".

The framework was developed as a practical tool to encourage methodological pluralism by suggesting a critical approach to the use of systems methodologies. The framework encompasses such diverse "systems approaches" as Beer's Viable System Model, Forrester's System Dynamic Modelling, Ackoff's Interactive Planning and Checkland's Soft Systems Methodology. This paper argues that given the multiplicity of systems approaches the practicality of such a framework is doubtful. The various "systems approaches" differ so fundamentally in their underlying assumptions regarding, for example, what "system" in fact means that it does not seem sensible to present a framework that has system complexity as one of its major axis.

This paper suggests that the *purpose* of the underlying system provides a more appropriate frame for defining system approaches – such purpose being defined as interaction or transformation (Mathiassen and Nielsen 2000). The concepts behind this argument are introduced and the article suggests that the application of the framework to a limited number of methodologies is more sensible. The final section of the paper considers how the framework can be modified to incorporate a critical realist perspective and considers how SSM should be placed in the new framework.

## CRITICAL REALISM

Mingers (2000a) points out Checkland's SSM regards the concept of a "system" as being purely an epistemological device having no ontological foundation. According to Checkland systems thinking is a "particular way of describing the world" (Checkland, 1983, p. 671). A theory such as Forrester's System Dynamic Modelling, however, provides a far greater solidity to the concept of "system". Forrester's concept of systems as real objects with important cybernetic interactions can provide an ontological foundation for systems examination and would allow a far deeper explanatory analysis of systems and their components.

The SSM concept of a system as being entirely conceptual places systems entirely in what a critical realist would argue as the "transitive" world. Mingers (2000a) suggests that the lack of solidity within SSM towards the concept of a system is one of the major shortcomings of SSM. "With a single blow Checkland reduces the force of systems thinking" (p. 749) by its placement of SSM solely within the conceptual world. Such a placement does not allow for any explanatory focus for the methodology. Each investigated system is seen as being a unique study, open to differing perceptions and conclusions - the possibility of deriving deep explanatory concepts that are loosely generalisable is denied. SSM

Bhaskar's (1978, 1979, 1986, 1991) brand of realism (referred to by Searle (1995) as external realism) argues that there exists a reality totally independent of our representations of it; the reality and the "representation of reality" operating in different domains - roughly a transitive epistemological dimension and an intransitive ontological dimension. For the realist the most important driver for decisions on methodological approach will always be the intransitive dimension - the target being to unearth the real mechanisms and structures underlying perceived events. Critical realism acknowledges that observation is value laden as Bhaskar points out in a recent interview:

...there is no conflict between seeing our scientific views as being about objectively given real worlds, and understanding our beliefs about them as subject to all kinds of historical and other determinations. (Norris, 1999)

The critical realist agrees that our knowledge of reality is a result of social conditioning and thus cannot be understood independently of the social actors involved in the knowledge derivation process. However it takes issue with the belief that the reality itself is a product of this knowledge derivation process. The critical realist asserts that "real objects are subject to value laden observation"; the *reality* and the value laden *observation of reality* operating in 2 different dimensions, one intransitive and relatively enduring; the other transitive and changing.

Critical realism places a strong emphasis on the unearthing of the deep structures and mechanisms that make up the world. It is interesting to examine the SoSM in general and SSM in particular from a perspective which specifically emphasises the importance of social structures.

		<b>Problem Context</b>		
		Unitary	Pluralist	Coercive
<b>Problem Type</b>	Simple	<b>Operations Research</b>  <b>Systems Dynamics</b>	<b>SAST</b>	<b>Critical Systems Heuristics</b>
	Complex	<b>Viable Systems Model</b>	<b>Interactive Planning</b>  <b>SSM</b>	<b>??</b>

**Figure 1: The System of System Methodologies with example approaches**  
 (Adapted from Flood and Jackson 1991, p. 42)

## **A CRITICAL REALIST PERSPECTIVE ON THE SOSM**

The SoSM maps the relationship between the problem context (unitary, pluralist or coercive) and the problem type (simple, complex). The problem context is seen to be definable dependent on the relationship between the main actors. Critical realism would view such relationships as social "structures".

For the critical realist the SoSM framework has a limited conception of structure with the SoSM equating organisational context with organisational "structure" (unitary, pluralist or coercive). A critical realist perspective would suggest that the organisational context reflects a complex interplay of multiple interacting structures and mechanisms (both internal to the organization and external to the organization) that affect the agency action of "IS development and deployment" in various ways. Every organisational situation necessarily involves a plurality of structures - a structure being seen as "an internal network of social relations" (Brown 1999). For the critical realist a coercive situation may indicate the presence of a dominating inequitable structure that needs to be addressed. The emancipatory focus of critical realism would suggest that this inequitable structure would need to be made explicit as the first step in emancipatory action.

Given the categorisation evident within the SOSM, it can be concluded that that in general the systems approaches considered are each placed firmly within a unitary, pluralist or coercive "structure" - structure is therefore not considered to be a variable and thus does not play a pivotal role within the various approaches. This is in conflict with a critical realist perspective which sees social structures as all important.

## **SSM AND SOCIAL STRUCTURES**

SSM is a practical methodology - its focus is on achieving systemically desirable and culturally feasible change. This focus on accommodation has opened the methodology to the criticism that it is ultimately overly conservative and does not encourage radical change. Tsoukas (1992) suggests that systems perspectives derivable from within an interpretivist paradigm suffer the common shortcoming of all such interpretive approaches - a neglect of wider impacting social structures and power relationships:

... [the systems perspective] rightly stresses the importance of open debate among actors in order to explore different points of view and arrive at a rational consensus. However, it barely addresses the societal conditions under which debate among actors is (or ought to be) conducted. In particular, the omission to deal with cases where "there is conflict between interest groups, each of which is able to mobilize different power resources" (Jackson 1990, p. 663) results in ISP [Interpretive Systems Perspective] being unable to generate a "genuine consensus" among actors, and thus failing to realise its true potential. (p. 640)

Systems approaches founded on both the interpretivist or functionalist paradigm have been criticised for "favouring regulation and the status quo rather than advocating radical social change" (Tsoukas 1992 p. 639). Jackson (1982) makes a similar claim as does Mingers (2000a) - "SSM, in focusing exclusively on the espoused beliefs and values of individual people, thereby lost connection to the wider social and political structure that shaped such beliefs". (p. 743).

Rose (2000, p. 78) highlights the importance of interpretation within Checkland's SSM: The epistemological, or learning premise of his work involves the conscious movement between unstructured perceptions of the world and perceptions structured by systems principles, in order to foster debate.

He argues that Checkland's SSM does not provide a specific model on organisational change nor does it provide a mechanism for explaining the reproduction of social structure between people:

Though Checkland clearly adheres to the notion of a socially constructed world, the mechanisms of that social construction are less clearly specified. The closest his writings come to these understandings are in his commentary on Vickers. (p. 77)

In line with Vickers (1965) Checkland and Holwell (1998, p. 48) argue the "soft" systems movement sees organizations as "social entities which seek to manage relationships". This so-called "tribal" view sees organizations as relationship managing entities, yet the SSM in practice does not particularly emphasise such relationships - perhaps the only recognition being in the development of a rich picture to reflect such relationships and their interaction. Once this interaction has been identified however, there is little further reference to the rich picture and identified structures.

Mathiassen and Nielsen (2000) argue traditional use of SSM within the IS field has tended to neglect the interactive or relational aspect of Information Systems and has tended to focus more on the transformative purpose behind Information Systems use as exemplified in the root definition of the system which requires the inclusion of a transformation. They suggest that SSM would gain a wider application if it concentrated on the interaction aspect of IS as well as the traditional systemic concept of transformation. As a part of this change in focus they suggest that depending on the system purpose the root definition may include a definition of the interaction process rather than the transformation process.

In line with Mathiassen and Nielsen (2000), Rose (2000, p. 102) argues that the two primary metaphors reflected within Checkland's SSM are transformation and interaction. He suggests that traditionally transformation has been the primary focus of SSM and action research in general. For the action researcher the primary aim of research intervention is transformation with the emphasis on systematically desirable and culturally feasible *change*. This concentration on action and process has tended to result in a neglect of underlying structures such as power relationships and external impacting structures.

Rose (2000) argues that later versions of SSM have concentrated more on the idea of the organization as a human activity system with the primary focus on relationship maintenance. This move towards an interaction metaphor may be seen as an attempt to address criticisms of SSM that it does not adequately reflect pre-existing structural relationships. Rich pictures have always provided a mechanism for recognising such relationships, yet the structures identified through these rich pictures are not used to any great extent in the later formal modelling process. The rich picture is primarily used to define the root activity of the system - this reflects a move back to process thinking and the transformative metaphor rather than towards social structures and interaction.

From a critical realist perspective the concentration within SSM on transformation and process misses much of the story. As Reed (1997) argues, approaches that concentrate solely on processual issues and situated social action can tend to ignore important wider impacting structural impositions which can "constrain actors' capacities to make a difference" (p. 25). Approaches which 'work with "flat" or "horizontal" social ontologies in which the processual character of social reality totally occupies the analytical and explanatory space available' (p. 24) face the danger of ignoring important structural constraints.

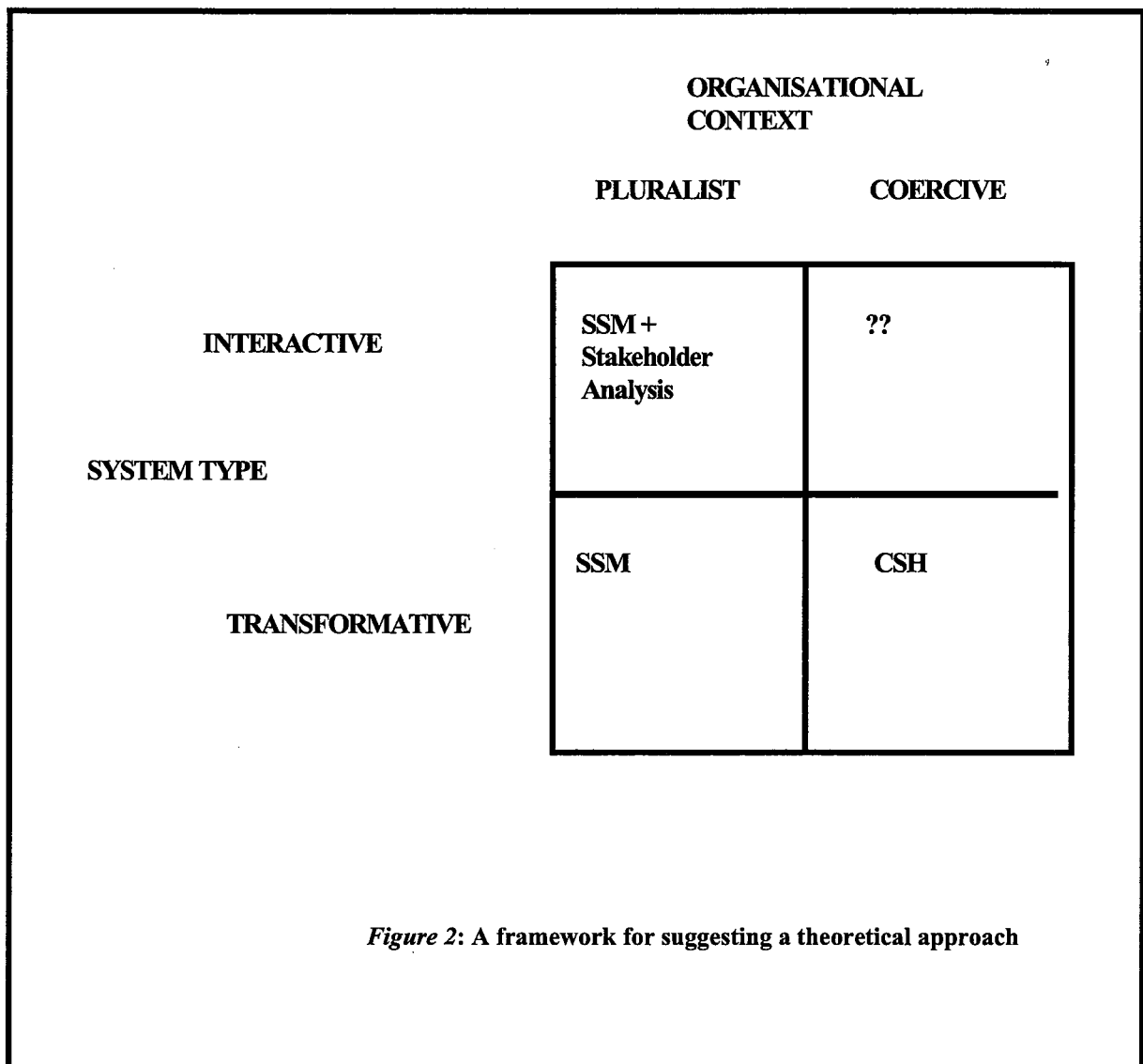
The incorporation of techniques such as stakeholder analysis within SSM seems a sensible means to address this neglect of social structures. As an example of this approach Vidgen (1997) proposes an extension of Multiview 2 to include stakeholder analysis. He proposes that firstly a rich picture be developed to reflect the complex and messy situation under investigation. Once completed the rich picture is then used along with a stakeholder map to identify the concerned stakeholders. Once the concerned stakeholders are identified it is then possible to consider how the new system might impact each of their situations. The identification of such possible stakeholder effects allows for their



inclusion in the ultimate new system. Stakeholder analysis provides an opportunity to more clearly reflect the pluralism Vidgen sees as evident in all systems development situations - he feels that a pluralist perspective is invariably the norm in systems projects and rejects the "simple" category reflected within the SoSM.

It is interesting to note the close relationship between the definition of stakeholders and the critical realist conception of social structures. Vidgen (1997) quotes Mitroff and Linstone (1993, p. 141) who see stakeholders as "any individual, group, organization or institution that can affect as well as be affected by an individual's, group's, organization's or institution's policy or policies". Similarly, the Stanford Research Institute of 1963 is quoted as defining stakeholders as "those groups without whose support the organization would cease to exist". Vidgen suggests the organization be seen as a web of stakeholder relationships rather than a single entity. This perception is similar to the critical realist perception of structure as defined by Brown (1999) - "For critical realism an internal network of social relations essentially constitutes a social structure".

Adopting a simplistic support to this argument derives Figure 2 which suggests that when examining interactive systems social structure is particularly important. In this case the use of a tool such as stakeholder analysis can be most useful. When examining transformative systems structural analysis is perhaps less important and SSM can be used in the traditional manner.



## CONCLUSION

Historically it can be argued that one of the most powerful components of SSM is its interpretive stance. As Holwell (2000) suggests "Checkland's work is recognised for adding interpretive thinking to the fields of systems, problem-solving and IS; so much so, that his argument and language have become part of the general discourse" (p. 778). Checkland's (1981) emphasis on the problem situation rather than the problem itself provided a fresh way of looking at organisational problem-solving and allowed a deeper recognition of the problem context. Checkland readily admits that the SSM resides within the so-called transitive dimension - the name systems "thinking" highlights this emphasis and has been one of its major strengths.

Interpretivism, however, has its weaknesses, not the least of which is its concentration on individual perceptions and its neglect of wider impacting social structures. This paper suggests that given the underlying interpretivist perspective of SSM, SSM must suffer the same weakness. This article suggests that SSM can grow further through a clearer recognition of social structures and their impact on problem situations. The inclusion of stakeholder analysis within a soft systems investigation would appear to be one way of addressing this issue, particularly in the examination of interaction systems which depend more heavily on existing and potentially important social structures. As detailed in Figure 2 if the primary focus of the system is interaction then a more detailed investigation of stakeholders and their concerns is essential; for a transformative system a traditional use of SSM with its strong focus on process and transformation would be sufficient. The recognition of social structures provided by a combination of SSM and Stakeholder Analysis can provide a solidity or reality that traditional uses of SSM do not supply.

Despite the clear successes of SSM the approach has been criticised for its isolationist approach. Mingers (2000a) suggests that in all of Checkland's writing he cannot find a single example where another methodology apart from SSM is used - this representing a great lost opportunity. The adoption of stakeholder analysis would help to address such criticism.

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# Higher Education Policy, Quality Assurance and Academic Standards: A Systemic Mapping of Change

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## ABSTRACT

*The paper selects key policies that have implications for university teaching and applies a Qualitative Systems Dynamics approach to demonstrate that the combination of policies produces some unintended counter-intuitive outcomes. The author argues that the quality assurance procedures, intended to maintain academic quality, have become unintended contributory factors in a systemic pressure towards lower academic standards. This pressure, in turn, becomes a contributor to increased stress levels amongst academic staff.*

*Key words: University management, quality assurance, Qualitative Systems Dynamics*

## INTRODUCTION

Academic standards need to be maintained by universities to maintain the credibility of university education in developing high levels of skill in critical analysis, and in providing students with mastery of specific bodies of knowledge. This is especially so if the Australian government is serious about promoting Australia as a 'knowledge economy' (Chubb, 2001), (Kemp, 1999).

In the last 10 years there have been changes in higher education. The Government's objectives for Higher Education (DETYA, 1999a) are to:

- Expand opportunity
- Assure quality
- Improve universities' responsiveness to varying student needs and industry requirements
- Advance the knowledge base and contribute to national and global innovation
- Ensure public accountability

The Government has responded to concern from many quarters, (for example, AV-CC, 2000a; DETYA, 1999b) about the quality of university education by requiring universities to implement quality assurance process and tying DETYA funding to this requirement (Australian Vice-Chancellors' Committee, 1999; DETYA, 1999b). DETYA and other stakeholders recognise the scepticism of academic staff towards this quality assurance process (DETYA, 1998).

This paper explores the relationships between quality assurance processes and educational quality by using a Systems Dynamics approach to analyse how the systemic forces of quality assurance and efficiency strategies impinge upon academic standards. The intention is to analyse whether in systemic terms, the scepticism of academic staff has plausible justification. Qualitative Systems Dynamics was chosen because its diagrammatic basis illustrates clearly how disparate management strategies affect teaching and learning processes. According to Wolstenholme (1990, p2), Qualitative Systems Dynamics methodology is well suited to this task as it, *'facilitate(s) understanding of the relationship between the behaviour of the system over time and its underlying structure and*

*strategies/ policies/ decision rules*'. He defines it as "A rigorous method for qualitative description, exploration and analysis of complex systems in term of their processes, information, organisational boundaries and strategies; which facilitates quantitative simulation modelling and analysis for the design of system structure and control."

Two other important characteristics are 'Its ability to generate structures which can be transferred to create insights into other systems.... Its ability to help in identifying the counter-intuitive behaviour of systems.' These attributes are used here to build a model of system behaviour consistent with available data to analyse whether quality assurance processes are contributing to counter-intuitive outcomes.

The three stages in the System Dynamics process are:

1. Qualitative diagrammatic representation of the system
2. Quantitative Simulation
3. Designing of Changes

This paper focuses on the first stage, the qualitative diagrammatic representation.

## **BACKGROUND: FORCES AND FACTORS**

DETYA, (1999b, p 15), has chosen to define the quality for Australia Higher Education in terms of measures that assume that education is similar to commercial activities, as demonstrated by the following choice of indicators:

- Percentage of staff with a PhD
- Percentage of students from overseas
- Percentage of students satisfied with their course overall
- Percentage of students satisfied with their acquisition of generic skills
- Percentage of students satisfied with the quality of their teaching

This view of quality expounded by DETYA has been influential in informing policies and strategies of university management. The AVCC and DETYA have documented and monitored changes in the sources and types of government funding for universities. According to the figures (AV-CC, 2000b), p5, public funding per student place has been declining since 1984 and declined most sharply between 1996 and 1999. During the same period student contributions to fees have risen, rising most sharply between 1996 and 1999. The total proportion of revenue from public funds and student payments has declined slowly between 1984 and 1996 and more steeply since 1996, despite a steep increase in the rate of student payments. The consequences for the teaching and learning processes have been an increase in the staff student ratio. In 2001 there was one member of academic staff for every 18 student whereas in 1987, there was one member of academic staff for every 12.7 students, (Megalogenis, 2001). These figures show that the cost cutting processes forced upon university management by changes in government funding have had a direct impact on staff student ratios, and therefore need to be factored into any consideration of university policy and educational quality.

It has sometimes been suggested that a reduction in public funding may not be harmful provided universities can access replacing funds from other sources. The AVCC (2000b) note the overall rise in university income from diversification of activities does not indicate that universities are in a financially strong position, because income from these sources cannot be diverted to cross subsidise Australian students or support infrastructure requirements. There is a slight decline in the ratio between universities operating grant and research monies granted through commonwealth research programs (Andrews, Aungles, Baker, & Sarris, 2000), but the biggest change is the diversification of sources of funding, especially research funds from industry and fees from overseas students. Andrews (2000, p 19) reports DETYA figures that show access to alternative sources of funding varies

substantially between Universities, (e.g. eight 'Cluster 1' research Universities share 70% of total research income, while the 25 universities in the third and fourth clusters share 10%).

## **ORGANISATIONAL BOUNDARIES**

Four different organisational boundaries are relevant to this problem:

- University management,
- University teaching staff,
- Professional institutions,
- Students.

The rationale for dividing universities into two discrete units is that the locus of control and responsibility for teaching is divided. Universities as organisations are anisotropic because there are different organisational cultures within university management at different levels. (Cooper, 1998).

Students are a separate stakeholder group, because they have been identified within the quality assurance framework as 'customers' of the universities whose feedback on satisfaction is part of the quality assurance process. Student behaviour is influenced by separate policies and considerations, and therefore, they form a separate constituent group in organisational terms.

The professional institutions are included because they have been identified in the Quality Assurance Framework as having a role in auditing standards for professional courses.

## **Resources**

Several key resources are directly relevant to this problem, the key resources being students, teaching staff, aptitude of students, aptitude of staff, time available to staff for teaching related activities, and time available to students for study.

## **Processes**

The main process of interest to this problem is how academic and professional standards are maintained within universities' teaching and learning processes. Relevant to this are formal university quality assurance processes, university processes for adjusting to reduced per capita student income, university perception management processes, other processes that significantly influence the balance of time available for teaching or teaching related activities, and processes that change the nature of the teaching and learning relationship.

## **Policy objectives and associated strategies**

On the basis of the information presented earlier, five policy interventions have been selected that have direct bearing on teaching processes within universities, when viewed systemically. The rationale for choosing these policies is they are related to common university quality assurance / performance measures (derived from the DETYA quality indicators outlined above) or are based upon the forced need to diversify funding sources and reduce costs due to a progressive reduction in the real value of the combined public subsidy and fees per student place, or have been included because they change the nature of the teaching and learning relationship.

- Improve staff qualifications
- Improve staff research output
- Improve efficiency
- Increase student numbers
- Monitor staff teaching performance

Each of the five policy objectives is pursued through strategies. The table below outlines some of the typical strategies employed to achieve the desired policy outcome.

Policy objective	Strategy
Improve staff qualifications	Reward through tenure and promotions Support with study leave
Improve staff research output	Reward through tenure and promotions Reward staff by giving them and a share of the RAI point value they generate
Improve efficiency	Increase student: staff ratio Increase student numbers
Increase student numbers	Recruit local and overseas full fee paying students
Monitor staff teaching performance	Monitor student satisfaction with study Monitor student attrition

Table 1: Policy objectives and strategies

### INFORMATION SYSTEMS

From these policy objectives and strategies, the relevant information systems can be identified as formal monitoring systems: e.g., student satisfaction surveys, attrition data, and the informal information channels that influence decision making about academic and professional standards (see Figure 1).

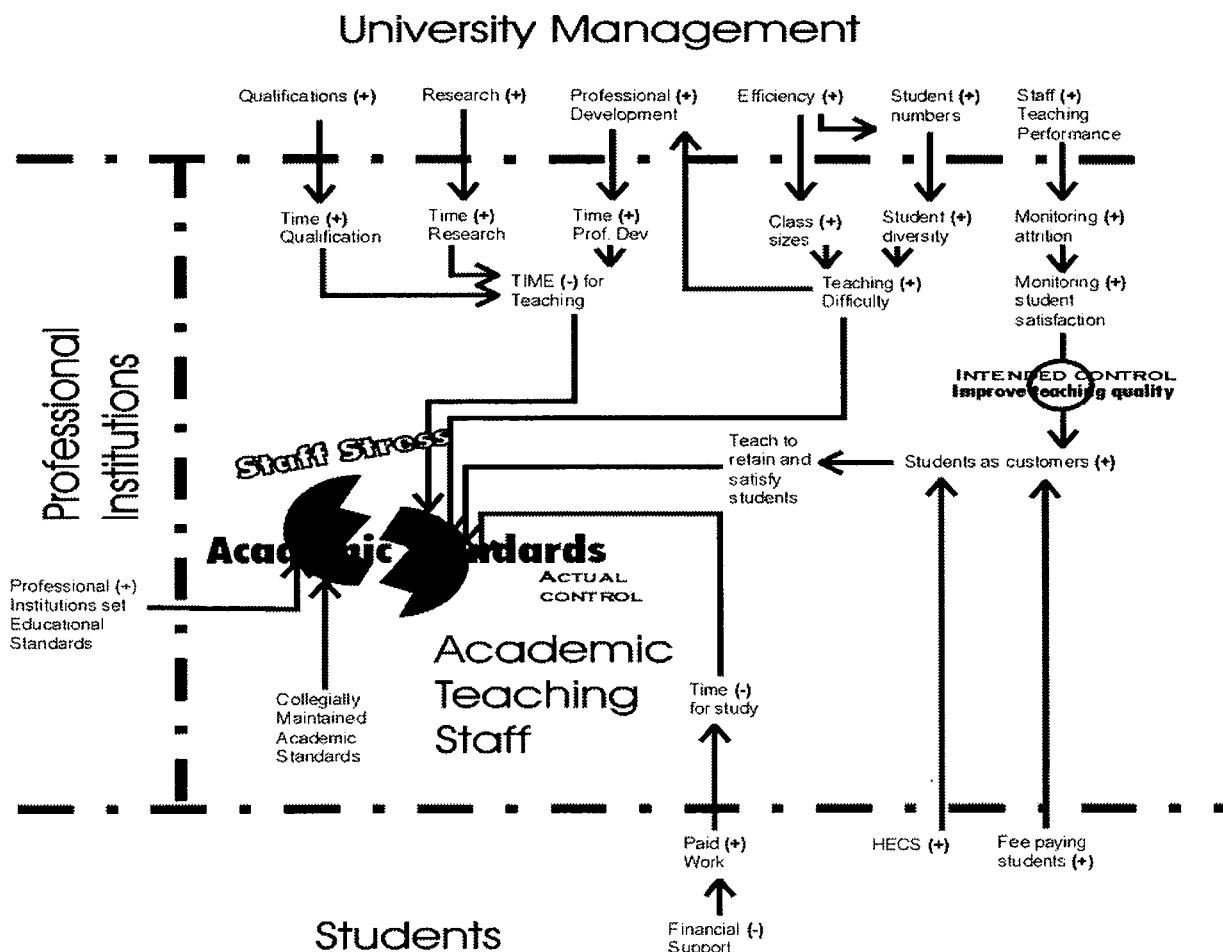


Figure 1: A Systems Dynamics Model of Intended and Actual Control Systems



## DESCRIPTION

**Qualifications policy strand:** The use of the measurement of 'the proportion of staff with PhD's' as a measure of university quality leads to pressure on academic staff to upgrade qualifications. Staff study time reduces the time available for teaching related activities and has no demonstrable relationship to teaching quality.

**Research policy strand:** Research output has become more important to universities. Staff are encouraged to spend more time in research related activities. Once again, there is no demonstrable relationship between research output and teaching quality and research activities reduce the time available for teaching related activities.

**Efficiency policy strand:** This strand has two distinct strategies. The first is average class sizes have become larger: an effect is found most strongly in first year courses. Whilst larger class sizes do not necessarily imply the quality of teaching and learning processes is reduced, class size contributes to the difficulty of teaching. In other words, it is a more difficult task to effectively teach larger groups of students in ways that engage all members of the class in teaching and learning activities. This has been recognised to some extent, and universities offer professional development courses to help staff refine and develop their teaching skills to improve learning outcomes for large classes. Whilst this is laudable from some perspectives, these courses represent another call on the time of the staff member detracting from time they have available for teaching related activities, for research, or for improvement of qualifications.

**Efficiency policy strand (student numbers):** The second strategy within this strand represents attempts by universities to increase their student numbers. Two principle strategies are used to address this policy objective. Firstly universities have devised alternative entry pathways and secondly they have sought ways of increasing their numbers of fee-paying students. In the USA where trends towards open enrolment are more advanced, the diversity is such that in some universities almost 40% of students have not achieved Year 6 standards in literacy and numeracy when they enter college, (Tinto & Riemer, 1998). Both these strategies have increased the diversity of the student group. (Meek & Wood, 1998). A more diverse group requires greater teaching skills to keep all members effectively engaged in learning and increases the difficulty of the overall teaching task.

**Monitoring staff teaching performance policy strand:** The policy objectives of this strand are concerned with the strategies universities use to monitor staff teaching performance within the institution. This strand represents what university management chooses to measure for internal management purposes. Measurements include surveys of student satisfaction with individual units, with their courses and a collection of data on student completions. Staff are aware that their future employment may depend upon being able to demonstrate a good performance on these measures and are therefore under pressure to teach in ways that prioritise satisfying and retaining students, even where this may be at odds with sound educational principles and practices.

**Students as 'customers':** Increases in HECS and the acceptance of full fee paying students means that students have now become 'customers' of the university and this almost certainly changes their expectations of university education. The change in status is supported in the recent overview of quality in higher education, (DETYA, 1999b), p14. The customer buys a 'product', but whether students believe they are buying an educational process or a final qualification is a moot point and has implications for perceptions of responsibility for failure and of what constitutes an appropriate level of study effort. (For a discussion of why student should not be considered as customers see, (Scrabec, 2000).)

The world has changed for students since the 1980's and this is reflected in their changing relationship with university education. Although university education still appears to offer advantages to graduates in higher median wages and lower unemployment than other sectors of the community, these differences are smaller than previously. (DETYA, 1999a), p20)

**Students and paid work:** Student poverty has been recognised as a growing concern (Turale, 2001). There is evidence that students are under increasing pressure to work substantial hours whilst studying fulltime (McInnis, James, & Hartley, 2000). If these perceptions are accurate, then other things being equal, the consequences are that students without independent financial support have less time available for study because of work commitments.

**Professional institutions and professional standards:** The professional institutions are a formal part of the proposed quality assurance process that links universities with industry and commerce, (DETYA, 1999b). The professional institutions accredit university courses by granting recognition of their qualifications and admitting graduates of specific courses to the professional institution. Some institutions stipulate specific professional learning outcomes and learning processes (for example, Australian Association of Social Workers and the Institute of Engineers Australia) others make more general judgements about standards, (for example, the Australian Computer Society).

**Academic standards:** Academic teaching staff have responsibility for delivering courses that are approved by the university. In practice, this means that they are required to make autonomous judgements about the standards of student work. Unlike the UK, there is no system of external moderation of student work in Australia, (Harman & Meek, 2000).

In practice, academic staff, rather than university academic boards, have the responsibility for ensuring that teaching standards satisfy the requirements of the professional institution. In many instances teaching staff are also members of the professional institutions that accredit professional courses and by virtue of their professional membership, they have a responsibility to maintain the standards required by the institution.

## DISCUSSION

Figure 1, above illustrates that, from a systemic perspective, the various strategic responses to government policies combine to produce a *prima facie* systemic pressure that tends to erode academic standards. The diagram shows three distinct aspects to this problem, a structural component, a strategic control component, and an expectation component. The structural component of the problem occurs because there is a dislocation of control and responsibility. The strategic control component occurs because there is a counter-intuitive effect, whereby measures intended to increase educational quality, contribute to pressures that tend to decrease academic standards. The expectation component occurs because there is an unrealistic expectation, that per capita costs can be dramatically cut at the same time as student intake is broadened, without any effect on quality.

The structural problem: forces potentially resisting the pressure to reduce academic standards are located with academic staff but institutionally academic staff are poorly supported to undertake this role. Academic teaching staff have no direct influence over the flow of key resources within universities, but they have responsibility for maintaining standards. There is a dislocation of responsibility and control. In an institution context, there are two possible consequences of this dislocation between control and responsibility. The first possible consequence is that academic standards will indeed fall. The second alternative consequence is that academic teaching staff will suffer unreasonable work related stress as they attempt to maintain academic standards without either the necessary institutional support or the necessary control of the resources. Although there is no clear data about whether academic standards have fallen, a recent study undertaken for the NTEU found that stress experienced by academic staff had increased, (Winefield, Stough, Jagdish, & Gillespie, 2001).

The strategic control problem appears in the diagram in the monitoring processes chosen for teaching performance management purposes. The quality assurance procedures intended to improve academic quality in practice act counter intuitively as demonstrated in the diagram. This has occurred firstly because the measures chosen do not have any direct relationship academic standards and

secondly because some of the measures chosen directly contribute to reducing the proportion of time academic staff spend on teaching. Most universities are choosing to include measures of student attrition and measures of student satisfaction in their quality assurance statistics rather than direct measures of academic quality. (See individual university quality management plans in (DETYA, 1999b).) Data on student attrition or even student satisfaction does not have any simple relationship to course quality. Recent research (McInnis, Hartley, Polesel, & Teese, 2000) indicates that while teaching quality is significantly related to attrition in the TAFE sector, there is no evidence of a relationship between teaching quality and attrition in higher education. The focus on student satisfaction instead of academic standards is also misplaced (Scrabec, 2000). Measures of graduate attributes potentially provide a more direct measure of student learning outcomes but the current ACER testing procedure is expensive, time consuming for students and according to some staff involved in the trial, deeply unpopular with students. If there is difficulty in achieving a high level of student compliance, then quality management based upon testing based upon graduate attributes may prove impractical even though, in principle, graduate attributes testing offers a means of finding out whether student skills are enhanced by university. More importantly, testing graduate attributes does not address the fundamental problems of the dislocation of control and responsibility, the falling per capita spending on university teaching and the increasing student diversity.

Where university management collects student attrition data on a course-by-course basis for quality assurance purposes it may have counter-intuitive effects on the system as a whole. The use of student attrition data as a measure of course quality is intended to demonstrate a commitment to educational quality, but it may in fact, act to reduce course quality. This is most likely to occur if academic staff choose to teach in ways that retain and satisfy students by reducing the minimum acceptable standard. In such an instance low attrition data may actually indicate low academic standards. This is especially likely if the initial entry requirements for a course are relatively academically uncompetitive.

The diagram highlights that government policy is providing universities with less public money per capita whilst expecting universities to increase their research output, make themselves more relevant to industry, and maintain the standard of education offered to students. In the long-term, it is not realistic to expect that universities can achieve all this whilst per capita teaching budgets are shrinking. It is argued elsewhere, (Cooper, 1998), that it is in the interests of university management to better support collegially management arrangements for academic teaching. As this is not occurring, the author now argues, that bureaucratic management principles should be applied throughout the university so that control and management are clearly co-located. This would permit workloads to be honestly assessed and realistic decisions could be made about how each university wished to use its more limited resources.

## **SUMMARY**

A major structural weakness in the management processes within universities allows the separation of responsibility for academic standards from the control of resources necessary to maintain those standards. This dislocation has masked the unrealistic expectation that it is possible to maintain quality whilst cutting costs. This myth is further bolstered by the choice of 'quality indicators' that do not have any demonstrated relevance to academic standards. The diagram presented in this paper demonstrates the interactions between different policy strategies and their possible effects on academic standards. It illustrates that the combination of policies intended to maintain educational quality and to promote university efficiency tends to act systemically to erode academic standards. The main countervailing force depends upon academic staff collegially acting to maintain standards. Such actions, however, have little institutional support, are contrary to the career interests of staff members, can only succeed in the short-term, and may contribute to the stress that academic staff experience in their work.

## CONCLUSIONS

It is concluded therefore, that improvement in this situation can only occur if: quality assurance measures directly relate to educational outcomes; if the fundamental structural problems are addressed; if universities receive sufficient resources to maintain high quality teaching; and if priority is given to the strategies that enhance educational outcomes for students rather than supporting strategies that address students' expressions of satisfaction.

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# A Case Study on Factors Influencing Accounting Information Quality

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## ABSTRACT

*Quality information is one of the competitive advantages for an organisation. In accounting information system, the quality of the information provided is imperative to the success of the systems. This paper reviews the current literature, and uses a case study to address the important factors that influencing the accounting information quality.*

*Keywords: information quality, data quality, accounting information systems*

## INTRODUCTION

The management of the organisations in today's contemporary world has much more focus on systematical issues. Accounting Information System (AIS) as one of the most critical systems in the organisation has also changed its way of capturing, processing, storing and distributing information. More and more digital and on-line information are utilized in the accounting information systems nowadays. Organisations need to take the system thinking approach, and consider both the system and the human related factors while managing their accounting information systems. They must focus on critical factors if they are to attain high-quality accounting information. Failure to do so has negative impacts on the organisations' financial process. Poor information quality may have adverse effects on decision-making (Huang, Lee and Wang 1999, Clikeman 1999). This paper first reviews the literature in relevant areas and then uses a case study to discuss the factors that influencing accounting information quality. Finally, it draws some tentative conclusions from the analysis of the case interviews.

## BACKGROUND

Although the factors for high data quality (DQ) in AIS have not been addressed, there have been many studies of critical success factors in quality management such as Total Quality Management and Just-In-Time (Saraph et al 1989; Porter and Parker 1993; Black and Porter 1996; Badri, Davis and Davis 1995; Yusof and Aspinwall 1999). Some of the data quality literature has addressed the critical points and steps for DQ (Firth 1996; Segev 1996; Huang et al 1999; English 1999).

Table 1 indicates the related research efforts and reflects whether these research efforts addressed certain issues or elements of critical success factors of quality or data quality management.

Factor	Saraph (1989)	English (1999)	Firth (1996)	Wang (1998) Huang et al (1999)	Segev (1996)	Zhu (1995)	Birkett (1986)	Yu (1973) Cushing (1974) Fields (1986) Nichols (1987)	Johnson (1981) Groomer (1989)	Bowen (1993)
Role of top management	✓	✓	✓	✓	✓	✓				
(Data) quality polices and standards			✓	✓	✓					
Role of (data) quality and (data) quality manager	✓	✓	✓	✓	✓	✓				
Training	✓	✓		✓		✓				
Organisational structure		✓				✓				
Nature of the system Product/service design	✓				✓					
Approaches (control and improvement) Process management	✓	✓		✓	✓					
Employee/ personnel relations	✓		✓			✓				
Supplier quality management	✓			✓		✓				
Performance evaluation and rewards (responsibility for DQ)		✓		✓			✓			
Manage change		✓								
External factors							✓			
Evaluate cost/benefit tradeoffs					✓	✓				
Audits									✓	
Internal control (systems, process)								✓		
Input control										✓
Customer focus				✓						
Continuous improvement		✓								

**Table 1: Summary of literature review identifying factors influencing data quality**  
(Source: Developed by the author)

In data quality studies, four types of stakeholders have been identified; they are data producers, data custodians, data consumers, and data managers (Strong et al 1997, Wang 1998). In AIS, these stakeholders were identified as follows:

- (1) Data producers are those who create or collect data for the AIS;
- (2) Data custodians are those who design, develop and operate the AIS;
- (3) Data consumers are those who use the accounting information in their work activities;
- (4) Data managers are those who responsible for managing the entire data quality in AIS.

## CASE STUDY

In this section, a case study is used to discuss the factors that impact on accounting information quality. It briefly describes the case study organization, includes an overview of the company, its AIS, and then analyzes the case interviews.

The current research project includes 7 case studies, in this paper, however; only one case will be discussed. In this case study, there is no data manager position; therefore, three other stakeholders are interviewed, and they are:

- Data producers: CFO and accounting officer
- Data custodian: IT manager
- Data consumer: General user

Case study organisation E is an education and training infrastructure company that partners with universities and professional education providers to market and deliver their courses over the Internet to students and organizations. It's a medium size organisation with approximately a hundred staff. They use a package called Quikbooks and that basically does the group's accounting information through it. They use it to report against budgets. The organizations business units throughout the world have different entities with their own local budget and they run a division in the software package for each of those divisions.

Data quality is a priority in their AIS and high quality accounting information aids the decision-making. As the CFO states:

*'We have to monitor our cash balances fairly closely and it (DQ) is definitely one of the highest priorities. We have forecasts we need to met so we need to give ourselves early warning signals if part of the business looks like it is not performing, the numbers will tell us that hopefully so we can address the issue.'*

E transfers a lot of its funds electronically, and that seems easier to control than traditional method. Typically any transfer requires two approvals from two senior people. *Input controls* have been addressed as the most important controls.

As opposite to the traditional data entry, E captures most of the information online. For most of the circumstances the *raw data supplier* is the data entry person, and they input raw data into the system. In order to manage the quality of data from suppliers, they established position called 'account relationship manager'. They are the ones have all the details they need to know about the systems and information requirements; and do all the communication back and forth between the technical staffs and clients.'

Therefore, the *input controls* divided into two main parts, the systems' controls and the human controls:

*'When we set the system up as easy to use as possible for our clients to use to input their data. Now it of course has all the edit checks and balances for the data that they actually enter. But you can't always put 100% controls that is just impossible... the 'account relationship managers' that is their job is to oversee the information to make sure that what they are doing is what they are meant to be doing so it is a manual look over the quality. (IT manager)*



There is no formal *performance evaluation or rewards* for employees' data quality control activities. Instead, they try to employ the well-trained and experienced personnel to prevent the possible DQ problems. They put the DQ requirement as part of the job descriptions. It works as a negative incentive: "You do it right or you get sacked." Management tries to keep good *personnel relations*.

On the other hand, because it is a young company and is expanding very rapidly, the people that do a good job normally are getting promoted. So if they are doing a good job and high quality control, then that is recognised. As commented by the IT manager:

*'There are three rewards, there is the bonus level; there is promotion possibilities; and there is the reward of being recognised.'*

There is usually a *timing pressure* from each of the *information customers*, both internal and external customers. Timing is the major influence. Although, sometimes to make the deadline might *suffer the accuracy* of the information, realistic timing deadlines are the main focus in E.

In relation to responsibility for data quality, *top management commitment* to data quality has been seen as most important:

*'It is management commitment to it and management review of how things are going. At the end of the day they should be the ones who have to ensure it works properly.'*

Because it is a medium size organisation, E doesn't have the middle layer of the management. Therefore, to set up a data quality manager position is seen as not necessary for the company at the moment. As it is believed would help to have such an individual or a team, but they could not afford it as a growing medium company. Therefore, duty to ensure the data quality has been assigned to the individuals who is doing the relevant work.

*'I think each person has to actually be their own data quality manager for that part of their job that requires high quality data.'*

Furthermore, whether to have DQ manager position wouldn't cause the significant difference.

*'The people at the front end who are responsible whether they are answering to someone called data quality manager or someone doing the data quality manager function, I don't think it makes any difference.'*

## CONCLUSION

As one of the seven cases of the ongoing research project, the conclusion drawn from this case is tentative, detailed analysis of all seven cases is conducting by the author and will be discussed in further papers. However, there are some important points could be drawn from the case analysis, they are:

- *Competent personnel* is as important as the *suitable system*
- *Input control* is the most important controls, and in the online transaction environment, it should be incorporated with *data suppliers' quality management*
- It is hard to have *DQ manger* position in the small and medium organisations; however, should incorporate DQ manager functions into those relevant people's work, which should responsible for DQ in AIS.

The on-going research project includes the across case analysis of all case studies, and the large-scale survey of those factors identified by the case studies, in order to discover which of the factors are most critical, and have a ranking order of the critical success factors. In addition, future studies could look into the relationship between the critical factors' implementation with the data quality outcomes in organization's AIS. Cross cultures and cross-countries research in this topic may also needed.

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# Strategic Management and a Systemic Approach

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## ABSTRACT

*This paper seeks to demonstrate the prime purpose of the strategic management process as a learning process, with the application of learnings to achieve desired change and to build organisational capabilities. A discussion of the alignment of a systemic approach to strategic management and the power of inculcating such an approach to the strategic management process then follows.*

*Keywords: strategic management, systems thinking, TSI, learning, change, capabilities*

## INTRODUCTION

This paper represents the initial stages in a much broader study whose working title is *A Systemic Architecture Supporting the Transition from Strategic Planning to Strategic Fulfilment*. The study involves the examination of: the strategic management process within a business unit of a large Australian based financial services company, and a model of the strategic management process that will be tested by Action Research. Early observations of those engaged in the strategic management process point to an emphasis on strategy formulation. Anecdotal evidence would suggest that the plan is viewed as a discrete event occurring in a flurry of activity in a two-month window during the financial year rather than as an ongoing process. Additionally there appears to be a significant disconnect between the formulation and implementation phases of the strategic management process, which is compromising strategic success. Once again, anecdotally, there appears to be limited understanding of the strategic management process itself or indeed its purpose – as a learning process for all those engaged in the strategic management process and the application of learnings to achieve desired change and to build organisational capabilities. Hence a significant shift in thinking and behaviours will be required.

The purpose of this paper is to overview the strategic management process and to then determine, at least in principle, whether the use of metaphors and the adoption of a systemic approach can provide theoretical guidance to aid the understanding of the strategic management process, thereby creating a paradigm shift.

## STRATEGIC MANAGEMENT PROCESS – THE THEORY

### Strategic Management Process – what is it?

Strategic management brings together each of the elements of strategic planning, implementation and performance management in an ongoing and cyclic process. Essentially it seeks to address the questions “where are we now, where do we want to be, how do we get there and how do we measure progress?” Strickland (1995) refines this identifying five tasks namely: ‘1. Developing a strategic vision and business mission; 2. setting objectives; 3. crafting a strategy to achieve objectives; 4. implementing and executing the strategy; and 5. evaluating performance; reviewing new developments and initiating corrective adjustments.’ (1995,p4) These five tasks build a process, which is continuous.

The benefits of engaging the strategic management process include organisational focus, the identification of priorities and goals, clarity and communication amongst stakeholders, managing for results, and a mechanism for anticipating and planning for change while dealing with possible consequences. Unfortunately the full benefit of the strategic management process is often not realised possibly because of a failure to adopt a holistic view of the process. This appears to be the situation in the organisation under study, with a failure to recognise the process in its entirety concentrating more on the discrete event of the strategic plan. Traditionally, corporations have focussed heavily on the techniques and procedures for long term planning (tasks 1 to 3) and have focussed less on developing the learning capabilities implicit in task 5. There may be many reasons for this, among them: degree of difficulty – it’s much easier to articulate the way forward as opposed to doing it and then following through with implementation; organisational ‘behavioural’ comfort zones – repeating behaviours (in this case planning). The reason for this is that often the organization knows what it is doing and is good at it; and a perception that strategy is sexy because it usually has an organisational profile involving the organization’s thought leaders unlike implementation which is often viewed as very ‘back office’ and operational.

A long term planning focus, disconnected from execution and evaluation, serves to reinforce the widely held view that such an approach will maximise future certainty, increase predictability and in doing so secure organisational performance. Subconsciously practitioners begin to act as if operating in a ‘known’, and a steady state environment –and accordingly what has been planned for will eventuate. This thinking has supported what Kotter terms the ‘decide and implement model’ where organizations study something, it gets the go-ahead and then is implemented with the assignment of responsibilities and resourcing. According to Kotter this ‘doesn’t set the stage well enough (or) follow through well enough. It’s a mechanism designed for small changes in a steady state’. (Emerald Now 2000)

Unfortunately, organizations operate in dynamic, rapidly changing environments filled with ambiguities and uncertainties, and where new information, – generated internally or externally, can create a different perspective on original strategies. Hence a process is needed to deal with these dynamics. Action Research as an operating model allows for these dynamics. Essentially, action research revolves around diagnosis, agreeing a course of action, the application of plans and reflections on outcomes. These reflections then serve as inputs to the next cycle of ongoing change. This ongoing and cyclical process is fundamental to strategic management. Cycling the strategic management process in its entirety - from strategic planning through implementation and ongoing performance management, provides a mechanism for ensuring that new information is fed back into the decision making process. This lifts the quality and relevance of the plan itself (the plan now reflects the changed conditions) and provided these changes flow through to implementation plans, ensures that the desired strategic outcomes are realised. These outcomes, whether they be in terms of market share, process efficiencies or profit growth, can only occur if there is a tight nexus between each task within the strategic management process. It is interesting to note that according to Brews ‘in unstable environments planning capabilities are far better developed and formal plans more amenable to change.’(1999,p889)

Hence feedback is a fundamental component to the strategic management process. Feedback loops are 'processes through which an organization interacts or *discovers* information, then makes decisions or *chooses* an action, and takes *action* to develop the organisation' Stacey (1993, p3).

### **Strategic Management Process Purpose**

From the preceding discussion, it can be concluded that the strategic management process encapsulates a number of aspects, among them: planning, analysis, collaboration and change. Mintzberg (2001) has identified these aspects in the emergence of ten schools of strategic thought namely: 'Design school: strategy formulation as a process of conceptualisation; Planning school strategy formulation as a formal process; Positioning school: strategy formulation as analytical process; Entrepreneurial School: formulation as a visionary process; Cognitive school: formulation as a mental process; Power school: process of negotiation; Cultural school: strategy as a collective process; Environmental school: strategy as a reactive process; Configuration school: process of transformation.' (onepine,2001,p1) Fundamentally however, Mintzberg argues that formalising a strategy implies a sequence from analysis through procedure to action. To Mintzberg, 'the essence of strategy making is the process of learning as we act.' Horizon, (2001, p1) As a strategic management practitioner, this is the fundamental purpose of the strategic management process and it is the application of learnings to achieve desired change and to build organisational capabilities.

### **Learning, Change and Capabilities**

At its heart, strategic management represents a learning process, where information is gathered through a searching process of an organization's internal and external environments, and synthesised to generate knowledge. Knowledge is key to providing a competitive edge and its successful application helps organizations deliver creative products and services. However it is not merely the generation of knowledge it is the sharing (and implementation) of it, which contributes to product development performance. Hoopes, (1999,p837). Hence the cycles of thinking and the presence of feedback loops in the strategic management process is critical to the generation and application of learnings.

Importantly they provide the opportunity for participants in the process to reflect on their own decisions and behaviours and identify ways in which they may have contributed to outcomes and where necessary make appropriate changes. Argyris (1976) has termed this process double-loop learning. Double-loop learning differs from single loop. Single loop learning is about developing solutions within the current context, whereas double loop learning involves the continuous experimentation and feedback of how organizations define and solve problems. It requires the questioning of assumptions underpinning decisions, which in turn create shifts in mental models. Senge (1992,p13) captured this in his definition of learning as 'a fundamental shift or movement of mind'. Thus such a shift occurs within the strategic management process when the information output of strategy is monitored back as information input, resulting in the regulation of behaviour.

Learning is important for organisational well-being and is the key to achieving a desired change. Both are fundamental to the strategic management process and both are particularly important in a dynamic and competitive environment. Both significantly contribute to the enablement of a competitive advantage. 'The origins of competitive advantage then rest in the ability to identify and respond to environmental cues well in advance of observing performance-oriented pay-offs.' Cockburn, (2000,p1123) Thus, an output of the strategic management process is the identification, development and deployment of an organization's capabilities in the form of an intelligence system, thereby securing competitive advantage. A firm's capabilities exist in several spheres: business and operational processes, technology, financial and management capabilities and human resources. When evaluating the source of competitive advantage however, it is important for firms to integrate their internal analysis (assessment of their own capabilities) with that of an external environmental analysis. As Barney (1995) states 'Firm resources are not valuable in a vacuum, but rather are

valuable only when they exploit opportunities or neutralise threats.’ Hence the strategic management process provides an architecture or system of knowledge and learning, and as Helfat (2000,p961) attests it is the co-evolution of organisational knowledge and capabilities that can result in competitive advantage.

## METAPHORS

To view strategic management as an ongoing, cyclic process, whose threefold purpose is built on learning, change and capabilities, involves a fundamental mindset shift for many strategic managers. To help invoke such a shift, the use of a metaphor can be extremely valuable. A metaphor is a mental picture that facilitates understanding when applied to an unknown or unfamiliar concept or more accurately it is the creation of a parallel meaning that helps understand one concept by relating it to another. Flood (1999) more precisely defines a metaphor as ‘the application of a descriptive form to an object or action to which it is not literally applicable.’ (1999, p125) Metaphors then can help frame a problem or provide a more tangible reference point to an intangible concept. Pepper (1942) in his *World Hypothesis* discussed the root metaphor concept as a means for understanding an area under investigation. Dunford and Palmer (1996) discuss the utility of metaphors as being ‘compactness.. quick, concise and effective, *inexpressibility*...way of saying something for which literal terms do not exist and *vividness*... metaphors build on experiences and thus have enhance cognitive and emotional impact.’ (1996, p8). Morgan (1993) has referred to metaphors as lenses, which can be used to gain a new perspective. In changing perspective, alternative courses of action can be taken which may not have been considered otherwise.

An examination of metaphors in use can indicate how people view their world and how that shapes their actions. This researcher has observed the strategic management process referred to as ‘The Strat Plan’, which automatically narrows the process to the planning phase only, inferring a discrete event without any connectivity to the cyclical process. Behaviours seemingly reinforce this belief with frantic activity over a two month period. Once the event is over, the plan written it’s “back to business.” Hence an examination of metaphors can provide insight and learning opportunities, for example as Argyris (1991) states, participants could learn ‘how the very way they go about defining and solving problems can be a source of problems in its own right.’ (1991, p100)

An appropriate metaphor for the strategic management process is one of an iterative cycle, whose learning outputs become inputs through a process of continuous feedback. While the use of such a metaphor can be extremely powerful in initiating a mindset shift, for many managers this is a difficult and quite different approach to take. As Flood states ‘the notion of metaphor may seem a radical approach to creative thinking, asking people to learn to think on a completely different plane from everyday reasoning.’ (1999, p25) Hence, this researcher’s approach in the broader study will be to surface and then explore the metaphors in use. The intent is to gain an understanding of how individuals within the organisation view strategic management and how that shapes their actions and to then to collaboratively develop a metaphor for the strategic management process to encourage the recognition of the ongoing, cyclic nature of the process.

## **SYSTEMIC APPROACH**

### **Introduction**

Systems Theory emerged in the 1940s as a critique of reductionist thinking. Systemic thinking aimed to use two aspects to interpret social systems, namely 'emergence' where the sum of the parts is greater than the whole, and interrelatedness which address the relationships between component parts. Such an approach aims to build to a holistic view, one which coexists with the environment, taking into account the continuous flow of information backward and forward known as feedback. It is a powerful tool with its emphasis on holism, context and seeking processes of change or behaviour over time.

### **Alignment to Strategic Management**

Systemic thinking brings together in one discipline the concepts of connectedness and interdependencies, feedback and feedback processes, mental models, and the whole being greater than the sum of the parts. A systemic approach can aid the understanding of the strategic management process because of their respective emphasis on a holistic view. 'Strategic planning encourages, if not forces, managers to take a holistic view of both the business and its environment.' Wilson (1998) A failure to integrate systemic thinking with strategic management may result in the 'unhooking' of the key elements of the strategic management process, (particularly around the implementation and evaluation phases which represent the essential parts in which learning will arise) and where each phase may be addressed incompletely, inadequately or not at all. Additionally, such a failure presents a risk that a strategy's context is ignored or only a portion of a strategy devised and therefore a portion implemented, which in turn may result in the strategy itself causing a problem. A systemic approach to strategy recognises that systems are purposeful and the system itself is part of a suprasystem. These parts are constantly interacting. Hence each of the elements within the strategic management process have meaning and purpose, yet are not autonomous. The strategic planning phase, involving the development of a vision, objectives and strategies firmly outlines the way forward for the organisation however for it to be brought to life, requires implementation and execution. Performance evaluation and review will then assess the success of the preceding tasks. Hence, each phase within the strategic management process can only be understood completely in the context of the other phase and how it relates to, and influences, the other. These interrelationships are the essence of the systems approach, and are complemented by the adoption of a holistic view and seeing processes of change (behaviour over time). This contrasts to the traditionally held view of linear cause and effect, focussing on snapshots or moments in time. The practice of systemic thinking starts with understanding feedback, a concept that shows how actions can reinforce or counteract (balance) each other or as Senge (1992) states 'reciprocal flow of influence.' (1992,p75)

Thus systemic thinking offers a powerful perspective, a means of understanding reality. It is valuable because it can help structure problems and design solutions while simultaneously keeping a focus on the long term. This in turn encourages thinking about consequences (intended or otherwise).



## **TSI**

Framing problems and designing smart and enduring solutions is an important aspect of a systemic approach. When applied to the strategic management process, it offers a range of methodologies and tools that may be selected according to their applicability and appropriateness to a given strategic problem. 'Total Systems Intervention' (TSI) is a technique that provides a methodology for the application of various systems methods to the relevant strategic situations. It relies on metaphors to help frame a problem and guide practitioners to the most appropriate problem solving method. The philosophy of TSI is best encapsulated by Flood and Jackson's statement 'the future prospects of management science will be much enhanced if (a) the diversity of the messes confronting managers is accepted, (b) work on developing a rich variety of methodologies is undertaken and (c) we continually ask the question 'what kind of problem situation can be managed with which sort of methodology?' (1991, pxi) Thus given the range of strategic problems confronting managers today, one methodology alone will not suit all situations nor meet all parameters, accordingly the manager should be able to draw upon a tool bag and select "the right tool for the job."

### **Exposing and Validating Assumptions**

Given the range of strategic problems there are a number of possible 'solutions' to those problems. These solutions will be dictated largely by the strategic practitioner's choices. Individual's mental models will shape these choices. Thus subjectivity is an inherent factor in the strategic management process. No human activity system is intrinsically relevant to any problem situation, the choice is always subjective. We have to make choices, see where the logical implications of those choices takes us, and so learn our way to truly relevant systems .... have to accept this initial dousing in subjectivity, and though this is never a problem for those whose inclinations are towards the arts and humanities, it can be difficult for numerate scientists and engineers whose training has not always prepared them for the mixed drama, tragedy and farce of the social system. (Checkland, 1990, p31)

Thus Checkland has surfaced the importance and difficulties associated with individuals' mental models. To this end systemic thinking helps by 'testing if mental models are systemically flawed in the sense that they neglect critical feedback or delay or miss points of high leverage. It helps to expose assumptions mental models are making about the dynamic nature of reality and to evaluate the validity of the assumptions.' Flood (1999, p22)

Surfacing underpinning assumptions around drivers, actions and outcomes and then validating these assumptions to seek clarity and consensus is important to the strategic management process. This can be aided by a systemic approach, in the deployment of various tools such as *Strategic Assumption Surfacing and Testing (SAST)*. In brief SAST relies upon four principles: 'adversarial – consideration of opposing perspectives, participative, integrative – any differences from the previous aspects are brought together in a higher order synthesis, and managerial mind supporting – managers exposed to different assumptions will have depth in understanding.' Flood (1999, p123) Hence SAST when applied in a strategic management context enables assumptions that underpin strategic decisions to be surfaced, their validity discussed and meaning and implications drawn. Furthermore, the process encourages consensus being participative, clarity in outcome and transparency in decision-making.

## CONCLUSION

In conclusion, strategic management is a cyclic process that takes into account planning, implementation and ongoing performance management. Its prime purpose is as a learning process, with the application of these learnings to achieve desired change and to build capabilities. The use of metaphors can aid the understanding of the process, creating Senge's 'shift of mind' whilst the application of a systemic approach offers a powerful perspective, a specialised language and a set of tools to help shape problems, design solutions and create a long term focus.

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# Revisiting the Social Reality Implied by Soft Systems Methodology

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## ABSTRACT

*It is 20 years since the first discussions of the social reality implied by Soft Systems Methodology (SSM) attempted to lay the foundation for the development of Critical Systems Theory. Yet SSM itself has progressed dramatically since those first critiques of its underpinning social theory were first developed. The contention of this paper is that revisiting this area will reveal both weaknesses in the original analyses and show how the development of SSM has been affected. Revisiting the area also provides a focus for considering new directions for research and development. SSM is introduced and examined according to the primary literature and re-evaluated using Burrell and Morgan's four-paradigm matrix in order to understand the social reality implied by SSM. The rest of the paper examines the criticisms of SSM, the recent evolution of SSM, and suggests future directions for SSMs development.*

*Keywords: Soft Systems Methodology, Social Reality, Critical Systems*

## INTRODUCTION

The Social Reality implied by SSM has been important to the development of the Applied Systems Thinking discipline. It forms the intellectual basis for the distinction between the so-called 'Hard' and 'Soft' approaches and has been seen as a limitation to SSM, which in turn provided intellectual legitimization for to the development of Critical Systems ideas. In this paper we re-visit this important area and by doing so aim to create a clearer understanding of the ways in which the social reality implied by SSM can be addressed. The examination will expose a change in SSM from that of a problem/action orientation to that of Learning System orientation (Checkland and Holwell, 1998, p:12:160). SSM therefore has moved from being concerned with facilitating change in the real world to a focus on learning in the real world. The implications of this change in direction for SSM in terms of social reality needs to be clearly understood and is our focus in the rest of this paper.

SSM began its long process of evolution in the late 1960's when traditional methods for systems analysis were found wanting. Peter Checkland, then a manager in ICI was dismayed that traditional hard systems methods for organisational problem solving had difficulty in handling the complex nature of real world management problems. A thirty-year research program into real-world problem situations of a socially rich nature resulted from those concerns eventually leading to the establishment of Soft Systems Methodology as a distinctive management approach.

There are many misconceptions about SSM, but the most glaring is the lack of a critical treatment of the radical humanist elements within SSM. In order to examine this area, a paradigm-based examination of SSM is required. Whilst such a treatment was developed originally in *Systems Thinking, Systems Practice* (see Checkland, 1982 pp.280-4) it seems as though this area has not been addressed with contemporary SSM and its focus on the 'learning system' (Checkland and Holwell, 1998, p.12:p160) rather than action oriented problem solving (Checkland, 1981, p154:p161). The situation may be a reaction to an argument made against SSM primarily by Prevost (1976) and Jackson (1982, 2001). The social reality implied by SSM is seen as interpretive by Jackson and as Functionalist according to Prevost. However Checkland argued that SSM is both interpretive and partially radically humanist (Checkland, 1981, pp.280-4 and Checkland, 1982, p.36-9)

These issues are examined in more detail in the rest of the paper. It begins by establishing a basic understanding of SSM based upon the primary and secondary literature. A look at the paradigmatic framework derived from this literature will then be examined and then the evolution of SSM will be examined. These three points lay the foundation for examining the paradigmatic framework in the primary and secondary literature. The section that follows takes an outward look at criticisms of SSM's paradigmatic framework. A graphical examination of the various points of view will be done using Burrell and Morgan's four paradigms as a guide and will compare differing views on SSM's paradigmatic positioning. The paper then concludes with a summary of the major points and offers some ideas for future research.

## **SSM IN THE PRIMARY LITERATURE**

The Core texts include: *Systems Thinking, Systems Practice (STSP)*, *Soft Systems Methodology in Action (SSMA)* and *Information, Systems and Information Systems (ISIS)* and *Soft Systems Methodology: A Thirty Year Retrospective (SSM30)*. Two main texts form the body of the secondary literature. *Information in Action (Davies and Ledington, 1991)* and *Systems: Concepts Methodologies and Applications (Wilson, 1984:1990)*.

### **SSM according to Checkland**

The traditional scientific approach to management problems has three major faults. Firstly, there are problems for the scientific method when it comes to complexity because:

'Cursory inspection of the world suggests that it is a giant complex with dense connections between its parts. We cannot cope with it in that form and are forced to reduce it to some separate areas which we can examine separately. (Checkland, 1981, p.60).

Further, Checkland suggests that reducing the world into separate parts is not feasible in networks of social complexity. Checkland argues that science, both natural and social sciences, ineffectively deal with the social world, especially the organisations in the social world. By this Checkland means 'human activity systems' where humans participate in some purposeful/rational activity, not necessarily companies but groups of humans pursuing purposeful activity. This moves away from the idea that all systems have goals or objectives and towards the idea that these systems of human activity pursue purposeful activity in a social context.

The third area that science fails in is 'Management'. These real world 'management' problems are everyday things that humans have to deal with that simple hypothesis testing to destruction cannot accommodate. More specifically Checkland found that it is useful to divide the world into two types of problems. First, there are hard problems and soft problems. Hard problems are easy to define technical problems that often have specific properties or forms. (Checkland, 1981, p.74) These properties are the same every time and the same solution could be given every time. This means that a hard scientific view of the world could be applied using 'systems ideas' and problem solving could

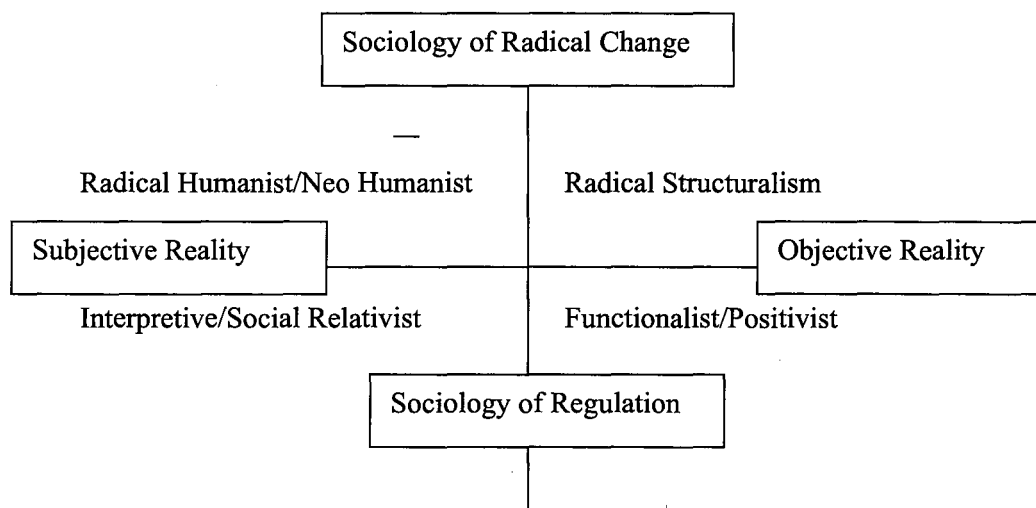
take place. This is termed hard systems thinking. Soft problems are those other ‘management’ problems mentioned above.

The way SSM deals with such social ‘management’ problems is well-documented. In *SSMA* Checkland and Scholes present examples of SSM’s usage in chapters three to nine. Remembering that Checkland wanted to use systems thinking, he took the above mentioned Complexity, Social Science and Management issues and moved towards a systems approach for real world problem solving.

Thus the next ten years were taken up with the formulation and presentation of SSM. Checkland and associates tested the systems ideas and concepts for problem solving and eventually came up with what is now known as ‘Prescriptive’ SSM. (Checkland, 1999, A35-A36). The seven stage model of SSM that emerged is an iterative process of flexible learning, not a rigid method. The process of SSM begins with the problem situation and ends with problem situation improved, ideally. This raises questions as to what the methodology hopes to achieve in the real world.

### SSM AND IT’S PARADIGMATICAL CONTEXT

Burrell and Morgan (1979) presented their now classical four-paradigm model of approaches to social reality. Most critics who have tackled SSM have critiqued it according to this model: (Prevost, 1976, Naughton, 1979, Mingers, 1980:1984, Checkland, 1981,p.280, Jackson1982:2001, Flood, 1999).



(Burrell and Morgan, 1979, p22)

Functionalist Paradigm is the dominant framework for social research assuming pure functionality and objectivity in the social world. Functionalist schools of thought are what Checkland called ‘scientific methods’ or the method of science. Hard systems thinking belongs to this view. The key assumption here for systems theory is that the world is made up of systems that can be engineered. Interpretive thought is a subjective approach to reality based firmly upon the assumption that social reality is created continually, by humans in the social world. Trying to engineer the unknowable is likened to trying to mow the lawn with tweezers or trying to get a watermelon into a shot glass, it’s impossible!

The Interpretive Paradigm seems to be the paradigm that has little or nothing to do with action as such, just meaning, and it is important to note that interpretive paradigm sees:

‘The social world as an emergent social process that is created by the individuals concerned.’

and:

'Social reality, insofar as it is recognized to have any existence outside the consciousness of any single individual, is regarded as being little more than a network of assumptions and intersubjectively shared meanings. (Ibid, p.31)

The third, and arguably the most controversial, quadrant of the paradigm matrix is the Radical Humanist Paradigm which embodies many differing doctrines including, anarchy, emancipation, consciousness, anti-organisation theory and existentialism. However:

...it's frame of reference is committed to a view of society which emphasises the importance of overthrowing existing social arrangements. One of the most basic notions of this paradigm is that the consciousness of man is dominated by these ideological superstructures with which he interacts, and that these drive a cognitive wedge between himself and his true consciousness. This wedge is the wedge of 'alienation' or 'false consciousness', which inhibit or prevents true human fulfillment. (Burrell and Morgan, 1979, p.32)

An important part of this view is critical theory which uses existing disciplines, ideologies and theories to provide a critique of the status quo in order to drive change. This change is supposed to 'emancipate' the human from ideological superstructures of the consciousness imposed on the individual by the social world in which he/she lives. Therefore they:

*...seek to change the social world through a change in cognition and consciousness. (Burrell and Morgan, 1979, p.33)*

SSM deals with perceptions and not cold hard facts about the real world. Central to this is the idea of the worldviews (or Weltanschauung) in human activity systems. Checkland argues:

*The concept of human activity system is crucially different from the concepts of natural and designed systems. These latter, once they are manifest, 'could not be other than they are', but human activity systems can be manifest only as perceptions by human actors who are free to attribute meaning to what they perceive. There will thus never be a single (testable) account of human activity system, only a set of possible accounts all valid according to particular Weltanschauungen. (Checkland, 1981, p.14).*

The worldview then is subjective. So the social reality of SSM is subjective. Looking at the four paradigms, that places it in either the radical humanist or interpretive paradigm. The next test is the degree of change that the methodology will perform. According to the primary literature:

*...given the analyst's complete freedom to select relevant systems which, when compared with the expression of the problem situation, embody either incremental or radical change, the area occupied must include some of the subjective/radical quadrant. (Checkland, 1981, p.281).*

Before examining criticisms of Checkland's idea of the social nature of SSM, it is important to examine a trend in SSM. This is the move from action based to learning based orientation.

## **SSM AND IT'S JOURNEY FROM 1981 TO 1998**

SSM from the seven stages model migrated to a process of two streams in 1988 (Checkland and Scholes, 1990, p.29) combined with three streams of analysis. The social system analysis comes straight from the work of Sir Geoffrey Vickers and the appreciative system model (Checkland and

Scholes, 1990, p.48). Checkland argued that three things interact with each other, these are: roles, norms and values.

Each continually defines, redefines and is itself defined by the other two. (Checkland and Scholes, 1990, p.49) It is a continuous process, out of which the analyst can successfully create a mental picture of norms, roles and values in the organisation. The political system analysis is a variation of the social systems analysis in as much as it is derived from Vickers' model (ibid, p.50). Checkland argues:

'...Analysis Three in the stream of cultural analysis accepts that any situation will have a political dimension, and it needs to be explored. (ibid, p.50)

and politics is taken to be:

*'...a process by which differing interests reach accommodation...'*(ibid, p.50)

Checkland goes on to add that politics, endemic in human affairs, is about managing the relationships between those of differing interests.

The next big advance by 1990 was the invention of mode 2 SSM which is the process that happens when SSM becomes internalised. However, several changes in SSM apparently take place when the shift from mode 1 to mode 2 occurs. Firstly SSM mode 2 users will focus less on intervention and more on interacting in the problem situation, and intensive reflection, and 'using SSM to make sense' (Checkland and Scholes, 1990, p.284).



Mode 2 has permanently changed the focus of SSM, to that of a learning system, as shown below.

Mode 1	Versus	Mode 2
Methodology driven	Versus	Situation-driven
Intervention	Versus	Interaction
Sometimes sequential	Versus	Always iterative
SSM as an external recipe	Versus	SSM as a internalized model

(Adapted from Checkland, 1999, A36)

Moreover the learning gained from the situation is the goal rather than change in the real world (see SSMA p.283)

### 1998

By this stage of the development, SSM has only five stages. (See *ISIS* p.160) However, the approach now is taken to be five models of purposeful activity molded into one process as a learning system.

Contemporary SSM contains many of the principles found in previous incarnations but with specific re-wording and the complete demolition of the systems thinking line (See Checkland and Tsouvalis (1997) for a full explanation of this). In this incarnation the focus is on learning and a lot less on intervention and problem solving. This is a decided shift in parts of SSM from Humanism to the Interpretive paradigm.

The original reason SSM was developed was to 'solve' hard to define problems in the real world. Now the focus in SSM seems to be on the learning, and the improvement is not as important

### Present

The contemporary view of SSM is that of *ISIS* mentioned above. The constitutive rules of are now:

- you must accept and act according to the assumption that social reality is socially constructed continuously;
- you must use explicit intellectual devices consciously to explore, understand and act in the situation in question; and
- you must include in the intellectual devices 'holons' in the form of systems models of purposeful activity built of the basis of declared world views. (Checkland, 1999, A35)

Changes to the existing processes have been suggested by Ledington and Ledington (1999) in the form of Decision Variable Partitioning and Extending the Comparison phase of SSM (1999) but few other theorists have offered any worthwhile contributions to date.

## INTERPRETATIONS AND CRITICISMS OF SSM'S PARADIGMATIC FRAMEWORK FROM SECONDARY LITERATURE.

The most consistent critic of SSM is critical systems theorist Mike Jackson. In 1982 he suggested, after Mingers (1980) that SSM had no provision for political structure and was limited by its paradigmatic framework. For example:

*Using Burrell and Morgan's framework I argued soft systems thinking is situated within the interpretive paradigm in that its guiding assumptions are subjective and regulative. (Jackson, 2001, p.236)*

Jackson also argued that because of SSM's conservative bias it would never be able to help the afflicted in anyway. Jackson's critique continued by stating that SSM could not be radical and emancipatory like critical theory but would only help to confirm the status quo because of its philosophical implications (Jackson 1982).

This philosophical examination of SSM, by Jackson was done according to the Burrell and Morgan's paradigms. Jackson in essence was arguing that SSM fits into the interpretive paradigm. Checkland presented the methodology as fitting over radical humanism/interpretive paradigms as mentioned earlier. Mingers (1984) opened the debate again. However, Mingers who suggested that critical theory and SSM could share a mutual dialogue (Mingers, 1980) has chosen to focus on the critical systems thinking developed by Jackson.

Jackson says that soft systems methodology has an inbuilt inability to handle complex human and social aspects of social situations then offers no physical evidence to support this claim (ibid, p.235). SSM seems flexible enough to jump paradigmatic boundaries into humanism or even back to functionalism if the user so desires. It is a methodology not a method. At least Checkland some has evidence to support his position (see *SSMA* Chapters 6,7,8,9 and *ISIS* Chapter 7 especially). Others have looked at SSM's paradigmatic framework, not to the extent that Jackson did but they are worth noting.

It is interesting to note that Hirshheim et al, (1995) and Ledington and Ledington have both criticized the modeling phases of SSM as too simple and possibly functionalist. Naughton (1979) argued against the case that SSM is functionalist, a charge made by Prevost (1976) but stated that SSM had a whiff of functionalism (Checkland, 1981, p.252).

Despite all these critiques of the social reality implied by SSM there is no evidence from either side to support their the cases. Checkland in 1981 said:

*...the comparison will lead to a discussion of possible changes. These are of several kinds, and any combination maybe appropriate in a particular situation. (Checkland, 1981, p.180)*

Is this interpretive practice? Checkland argues that it isn't:

*...given the analysts complete freedom to select relevant systems which, when compared with the expression of the problem situation, embody either incremental or radical change... (Checkland, 1981, p.281)*

This will be limited by a desire for action in the real world (ibid) but the ideals are still humanist ideals.

Secondly, SSM contains underlying principles that can provide a critique of the status quo in any given organisation. Stage 5 provides a tool for using the systems ideologies against the real world perceptions found in stage 2. It is hoped that by comparing stage 4 with 2 that a debate will be started about feasible changes. This suggests that SSM is built around rudimentary principles rooted in critical theory.

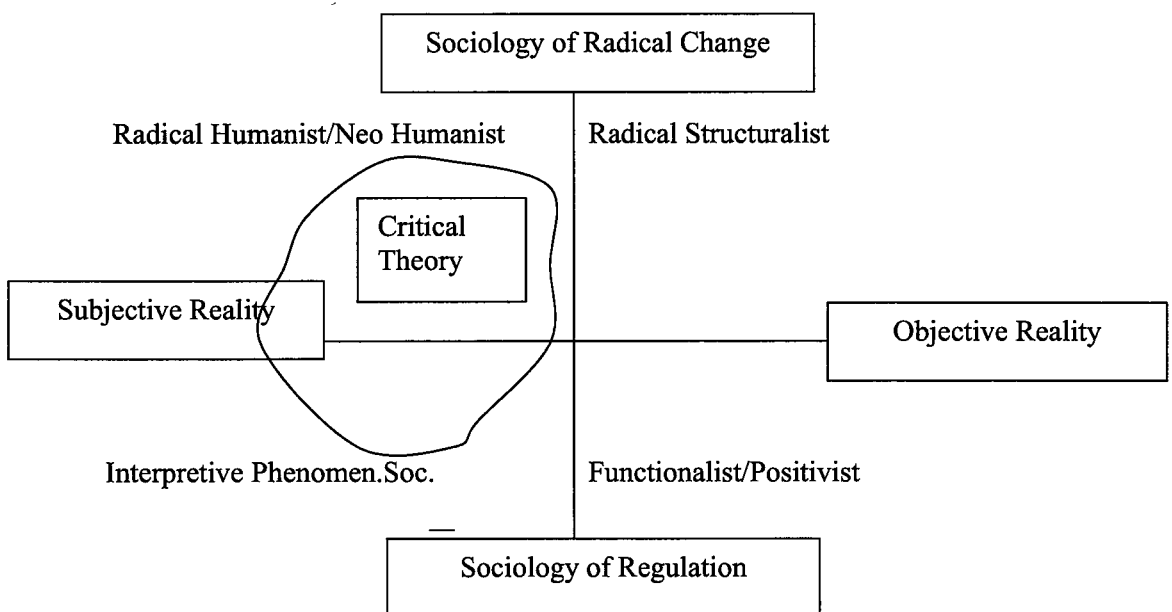
Mingers (1980) recognized this:

*...three major points of agreement. Firstly both take seriously the problem of human action – at the same time purposive/rational ... and natural or unchangeable as a result of the characteristics of human animal. Secondly, both conclude that hard systems analysis, cannot cope adequately with the multi-varied complexities of the real world. Finally both deny the inevitability of the divorce between rationality and the values which characterizes natural science. (Checkland, 1981,p.283)*

In order to understand the various perceptions of SSM and its paradigmatic framework, this paper will now present tables that map SSM.

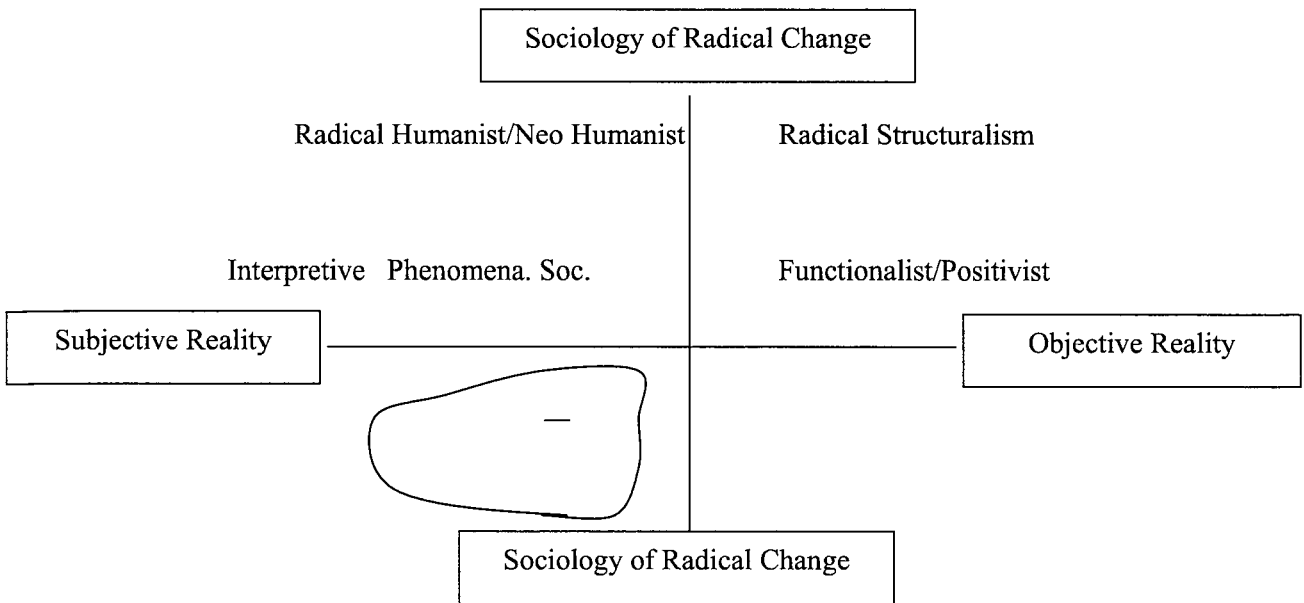
## THE MAPPING OF SSM

The first map presented is Checkland, 1981.

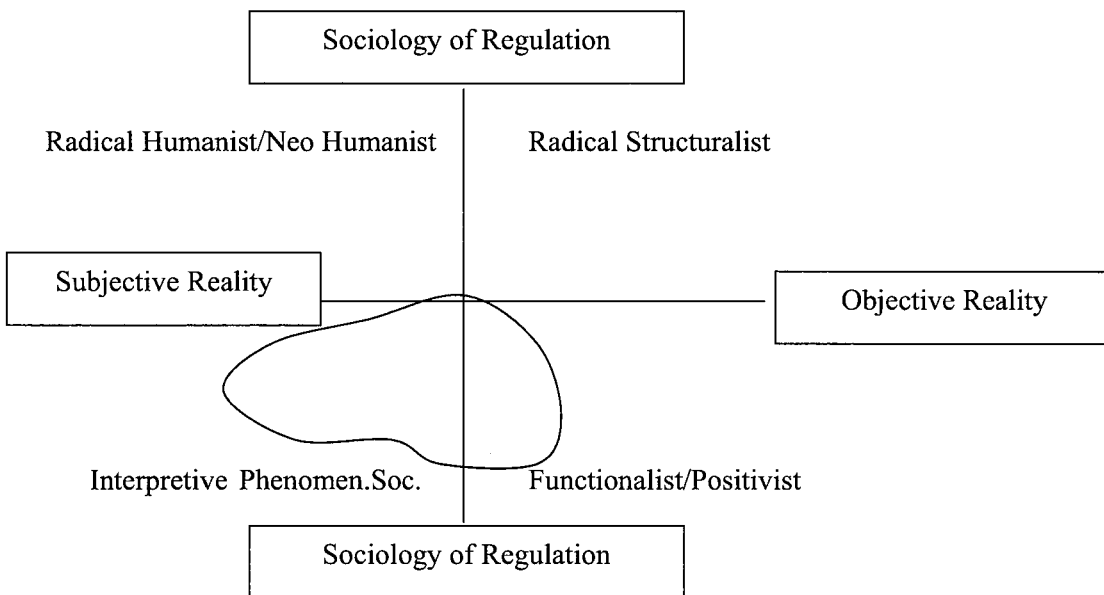


(Burrell and Morgan, 1979, p22)

As previously mentioned Checkland argued that SSM had compatibilities with Critical Theory therefore should be mapped that way. Next is Jackson's case.



The critics of conceptual modeling which are Hirschheim et al. and Ledington and Ledington.



(Burrell and Morgan, 1979, p22)

Hirscheim et al. and Ledington and Ledington have argued that SSM's conceptual modeling is too simple. There is evidence (unlike most critics of SSM's paradigmatic framework) in Ledington and Ledington to suggest this (Ledington and Ledington, 1999) but it is not expressed as a direct argument against SSM's paradigmatic framework. The above is just an assumption derived from the literature and is not explicitly stated. The maps here and the previous section lead to the question. What then is the social reality implied by SSM?

The answer to the question is that SSM does not imply a social reality that is defensible. This becomes evident when examining the material presented here. There is no agreement as to whether or not SSM is mappable over two paradigms or even one. Jackson provided no evidence for his position and Checkland provided no evidence for his either.

## **FUTURE RESEARCH INTO SSM**

Future research into SSM should seek to return to a more real world problem oriented approach with the learning system ideals to be taken as given. This means a focus on how SSM can change the social world, rather than what can be learnt (despite the fact that learning, if SSM is used will take place anyway). By focusing on how SSM could change problem situations, SSM as a benefit to the real world of problems instead of the theoretical world of learning, will surface. Hopefully future research into SSM will yield a more problem-based approach, much like the original did, and become less focused on the ideals of learning system that the contemporary seems to be focused on.

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# Interpretive Inquiry: From Comparison to Engagement in SSM

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## ABSTRACT

*The theme of this paper is emergence of the twin concepts of 'Engagement' and 'Interpretive Inquiry' as major extensions of 'Comparison' and 'Soft Systems Methodology' respectively. These concepts are outcomes from our current research program into the use of Systems Thinking in Management. The paper describes the context of the research, discusses the nature of 'Engagement' and presents its methodological form, which is called 'Interpretive Inquiry'.*

*Keywords: Soft Systems Methodology, Comparison, Engagement, Interpretive Inquiry, Interpretive Management*

## INTRODUCTION

Management in the context of real-world problem situations, and the use of Soft Systems Methodology to plan, enact, and learn about effective management activity is the focus of this paper. The ideas that are developed here stem from work on a major research theme called the 'Comparison Paradox'. The paradox is that although comparison is clearly a crucial part of SSM it is ill-defined and poorly understood.

The activity of Comparison can be considered one of the defining features of Soft Systems Methodology, along with the concept of the Human Activity System and the goal of 'structuring a debate about change'. It is however an area that has received surprisingly little attention in the research literature. It is in the context of research activity to extend the understanding of this important area that the concept of 'Engagement' has emerged. The introduction to 'Engagement' provided in this paper begins with a brief review of SSM and the 'Comparison Paradox' and then introduces the practical context of the research. Finally, a consideration of the potential impact on practice and research of these themes completes the paper.



## BACKGROUND AND MOTIVATION

Systems theory is an established theoretical basis for examining management problems, and is the basis for a rich stream of Management related research activity. The Systems-in-Management research literature may conveniently be divided into two established generations of systems thinking, the well-known 'Hard' and 'Soft' systems approaches, together with a third, Critical Systems, that is still struggling to establish a separate intellectual identity. A second-generation answer to the question of how systems theory might be employed to improve real-world management has ostensibly been developed in the action research program that can be labelled as 'Soft Systems' (Checkland 1981, Checkland & Scholes 1990). The research discussed in this paper can be considered as an innovative contribution to the development of second-generation systems thinking.

Soft Systems Methodology and its development can be readily accessed in the research literature (Checkland 1981, Checkland & Scholes 1990, Checkland & Holwell 1998, Davies & Ledington 1991, Wilson 1984). Two key findings can however be usefully noted here. First, that the idea of taking real-world contexts to be systems that can be externally engineered to achieve some desired end does not align with the reported research experiences of tackling ill-structured real-world problem situations using SSM. A finding that underpins the well-known separation of Soft Systems ideas, as representing a new model, generation, or paradigm of systems thinking, from the first generation, or Hard Systems perspective. Secondly the reported experience of tackling real world problem situations also does not support the notion of taking models to be simplified representations of the problem context. It is implicit in first-generation applied systems thinking is that the problem context can be represented in a simplified model, and thus that the model can be used to examine (predict) the impact of possible changes to the situation. In SSM, the concept of model-as-representation is abandoned whilst the idea of using systems models is still retained. What becomes embedded in the methodology is the need to somehow 'Compare' the model and the problem situation yet quite what 'Compare' means is not adequately addressed.

The 'Comparison Paradox' becomes evident when it is realised that the models used in SSM are supposedly systemic whilst the nature of the real world is taken to be 'not-established', or unknown, and the body of SSM literature argues against simply taking the problem situation to consist of systems. Hence it must be that comparison is concerned with relating non-systemic phenomena with systemic representations. Again, systems models are not purported to be descriptions of the real world phenomena but are images that are 'Relevant To' the problem situation. At least in the sense that they form the basis for useful debate about change to the situation. Taken together these two ideas are central to any discussion of SSM and correspond to the third of five constitutive rules of SSM proposed by Checkland & Scholes (1990). Yet it has previously been shown that the area of Comparison both theoretically and practically has had little attention in the research literature (Ledington & Ledington 1997, 1999, 1999) and is poorly understood. Hence the 'Comparison Paradox' that lies at the heart of SSM.

If we seek, through the use of SSM to develop greater insight into the nature of management then developing a stronger understanding of what is currently termed Comparison may provide an opportunity for some progress in that direction. It is to the practical context of this research that attention is now directed

## RESEARCH CONTEXT AND APPROACH

The practical context of this research is the professional management of academic research activity and the development and management of research students. Research students is a term covering honours, masters, and doctoral students, who are engaged in a complex knowledge-based activity. They are simultaneously developing knowledge skills, self-direction and management skills, and advanced communication skills, whilst conceptualising, planning and enacting research, or formal knowledge-developing activity. The operational environment is complex and dynamic. They are under considerable pressures from many directions including tight time schedules, and their work is externally (and essentially publicly) evaluated. Creating an effective environment for the development of such advanced knowledge workers, and facilitating effective progression through it, is part of the professional role of educators in universities. It also provides a research opportunity for developing an appreciation of management activity from the position of being an involved actor within such activity rather than as an external consultant. The research approach adopted is action research with the same people as both researchers and as involved actors. A research cycle involving making sense of the experience of management 'practice', identification, expression and evaluation of ideas involved in that sense-making, and the subsequent purposeful application of those ideas to facilitate 'practice', has been initiated and sustained over 5 years or so.

In many ways this research context is similar to that reported by Checkland (1981) in the development of SSM. In the original Lancaster program generations of masters students undertook action research consultancy projects and their experiences formed the basis for data gathering and reflective learning. They were trained in SSM and this shaped their experiences. Such a process will of course produce a highly developed concept of the 'practice' of "Intervention-with-SSM". It is perhaps therefore not surprising that much of the debate in this area concerns itself with what may be labelled as "Soft Consultancy".

There are however profound differences between the Lancaster research program and our own. First, our area of interest is everyday management activity, and not with special project activities. The focus is on the researcher's management of research development activity and not on the nature of the research itself. It is not in any sense mandatory for students to use SSM or even be involved in action research. Although the majority of student projects have been interpretive in nature there are some that have undertaken positivistically-oriented quantitative studies. The topic areas have not been unduly constrained, although it is also inevitable that within an institutional structure the boundaries of the student population and their areas of interest will be limited. In general the students and projects involved lie within the broad context of 'Business Information Systems'. There are some exceptions however, as for example one student is researching mass media perceptions of disability, whilst another is extending the concept of corporate entrepreneurship, and a third is utilising a version of SSM as a management development tool. Indeed the diversity of students, their interests, and the research methods that they adopt is a bonus.

The second difference is that our program can build upon prior work on SSM, and in particular recognise that it doesn't have to be used in its explicit consultancy-project version. It is that version that has been labelled as mode 1 (Checkland & Scholes 1990), or as 'formalised novice SSM' (Checkland & Holwell 1998). The intention is to investigate the use of SSM in everyday management practice rather than in 'unusual' consultancy-type situations. This mode of using SSM is labelled as 'Interpretive Management'.

The basis for this research program is therefore to investigate to what extent SSM could be used to make sense of, and create development in, the practice of research development management, and to use the practice of research management to investigate the concept of Interpretive Management. The overall learning should emphasise both the situation and SSM, and both should be seen as trying to gain insight into Management from an interpretive perspective. In this paper however the focus is upon research

themes within SSM and Interpretive Management rather than the research management context. Having thus established the context and briefly outlined the research approach underpinning this work the focus of the paper will now turn to some outcomes from this research process.

## CONTEMPORARY RESEARCH THEMES IN INTERPRETIVE MANAGEMENT

The research started with a number of SSM-oriented research themes. These were primarily problems associated with systems modelling and use, the Comparison Paradox, and the development of the EDI concept (Expectation, Desirability, and Importance) as a basis for managing the comparison process (Ledington & Ledington 1997, 1999, 1999), and the intention to move from consultancy to everyday management situations. The research began with the *Expectation* that SSM would prove useful in making sense of, and improving, our everyday professional activities. That, in some (undefined) sense, SSM could be taken to be a *Desirable* model of ideas relevant to Interpretive Management. Finally, that adopting SSM as a starting point for the research reflected its *Importance* to knowledge about 'Systems Thinking in Management'.

The outcome of operating the research cycle has been the emergence of four research themes, namely; Engagement, Interpretive Inquiry, Interpretive failure, and Inquiry-based Modelling, and these will be examined in the following sections.

### From Comparison to Engagement

It was evident to us very quickly that most of our activity in research management and development involved orchestrating 'Mutual Sense-making', or put another way creating opportunities for structured debate. A discussion between supervisor and student, between supervisors, between students, presentations, written work, all of these could be seen as opportunities for debate leading to action. The situation is thus consistent with SSM. However although SSM provided a basic structure for making sense of such debate activities the concept of Comparison as understood in the literature was extremely limited and limiting. In the end we came to use the term 'Engagement' rather than Comparison. The limited notion of comparing model and situation to see if they are mutual reflections of each other can perhaps best be seen as a limited case of this wider notion of Engagement.

It has already been argued that Comparison is fundamental to an understanding of SSM, but, paradoxically, that it is poorly understood. The basis for this claim can be examined in the work of Ledington & Ledington (1997, 1999, 1999). The conventional treatment of Comparison envisages addressing the issue of whether some version of the system expressed in a model does or should exist in the problem situation (Checkland 1981, Davies & Ledington 1991). To achieve this the model is used as a basis for structuring a set of questions about the situation and the situation is evaluated from the perspective that it should in some sense reflect the nature of the model against which it is compared. Note that this would imply that the situation is, or could be made to be, systemic; a view that conflicts with the basic philosophical position of SSM that the situation is not (necessarily) systemic. Further the models are built from root definitions and reflect the intuitive knowledge of the model builder(s) concerned. The idea that somehow these intuitive models are conceptually design ideals is surely to overstate the power and status of the analyst/modeller. There is surely no theoretical basis for the model and situation having any form of relationship, except through the interpretations of the analyst. Finally, the role of Comparison is seen as providing a means to structure debate about change in the problem situation.

Thus three ideas define the Comparison activity. First it employs activity models, second it interprets the situation model relationship from the perspective of the model as a design ideal (does or should a version of the model exist in the situation), and third the outcome is orientated towards change in the situation. In our research management context we found ourselves 'structuring debate' using ideas in a way akin to Comparison, but also in ways which did not always use activity models, was not using the ideas as design ideals, and was not always orientated to direct change in the situation. We termed this broader concept of structuring debate with formal ideas as 'Engagement'.

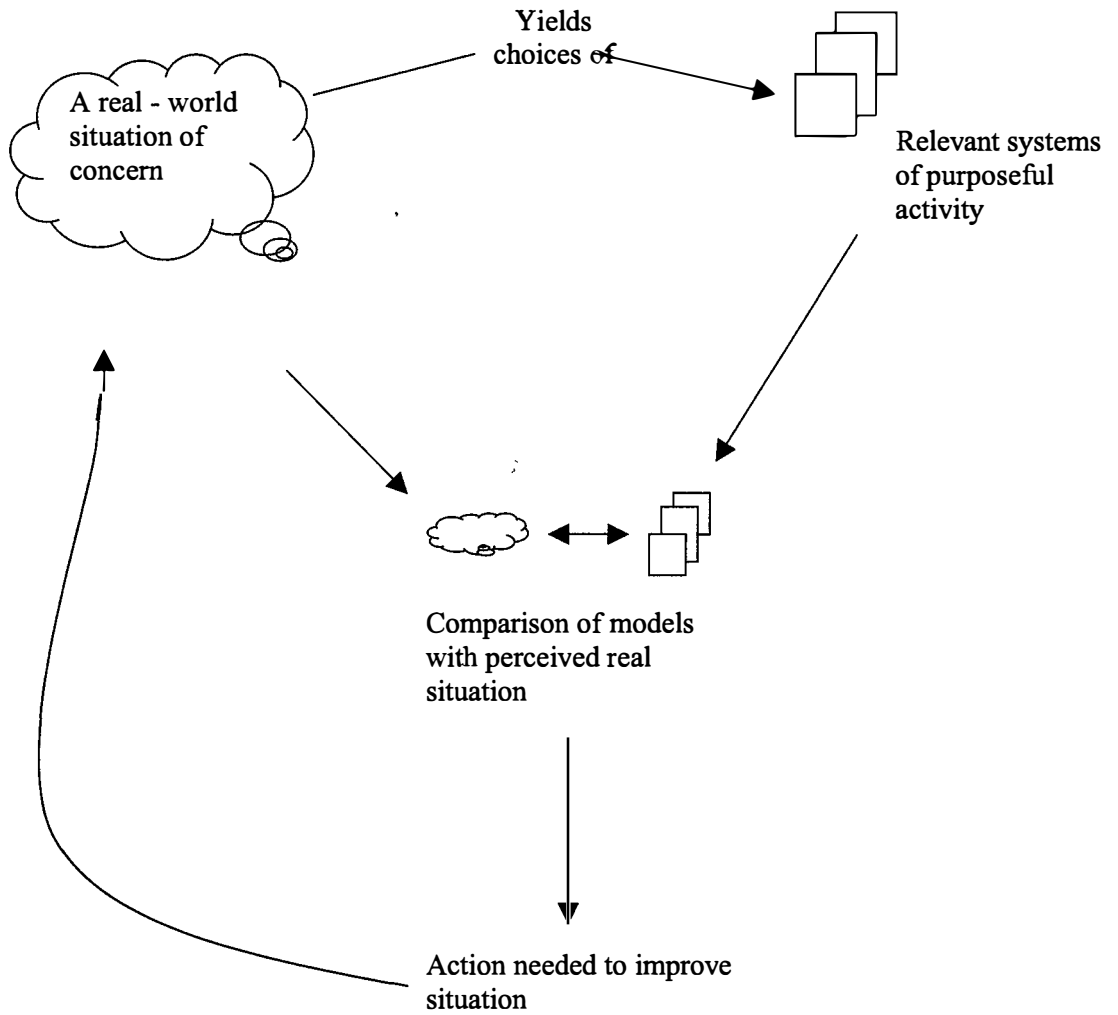
The concept of Engagement extends the notion of Comparison in a number of ways. It recognises that some relationships between situation, model and process of interpretation must be assumed. Creating an engagement involves choosing and formalising a set of ideas (only sometimes in the form of an activity model) which are thought to be relevant to the problem-solving activity in a specific context. The result of an Engagement will be change in one or more of three possible outcomes, first the situation may be reinterpreted (and hence suggest possible changes), second the framework of ideas (model) may be re-evaluated and reinterpreted, and thirdly the relevance relationships (EDI) may be re-interpreted. Engagement, unlike Comparison, asks how expressed perceptions from the situation are to be interpreted from the standpoint of a particular framework of ideas, it does not assume that the ideas are design ideals. It is not limited to the use of Human Activity System models; given that in SSM activity systems models are claimed not to be descriptive then there is no fundamental basis for choosing to use activity models. The choice of a 'Framework of Ideas' is essentially arbitrary in principle, but formative in practice. The ideas we choose and how we express them will influence the process of interpretation and learning, but we cannot say in advance what ideas will be relevant. Finally, Engagement is a social process in that it involves a set of people who may be involved in various roles, for example situation owners, idea owners, and process owners, actors, and victims/beneficiaries.

Engagement and Comparison are summarised in table 1 below and shown diagrammatically in figs 1 and 2. To differentiate the two ideas further, Comparison is seen to be embedded within the process called Soft Systems Methodology, whilst engagement is seen as embedded in a broader process called Interpretive Inquiry.

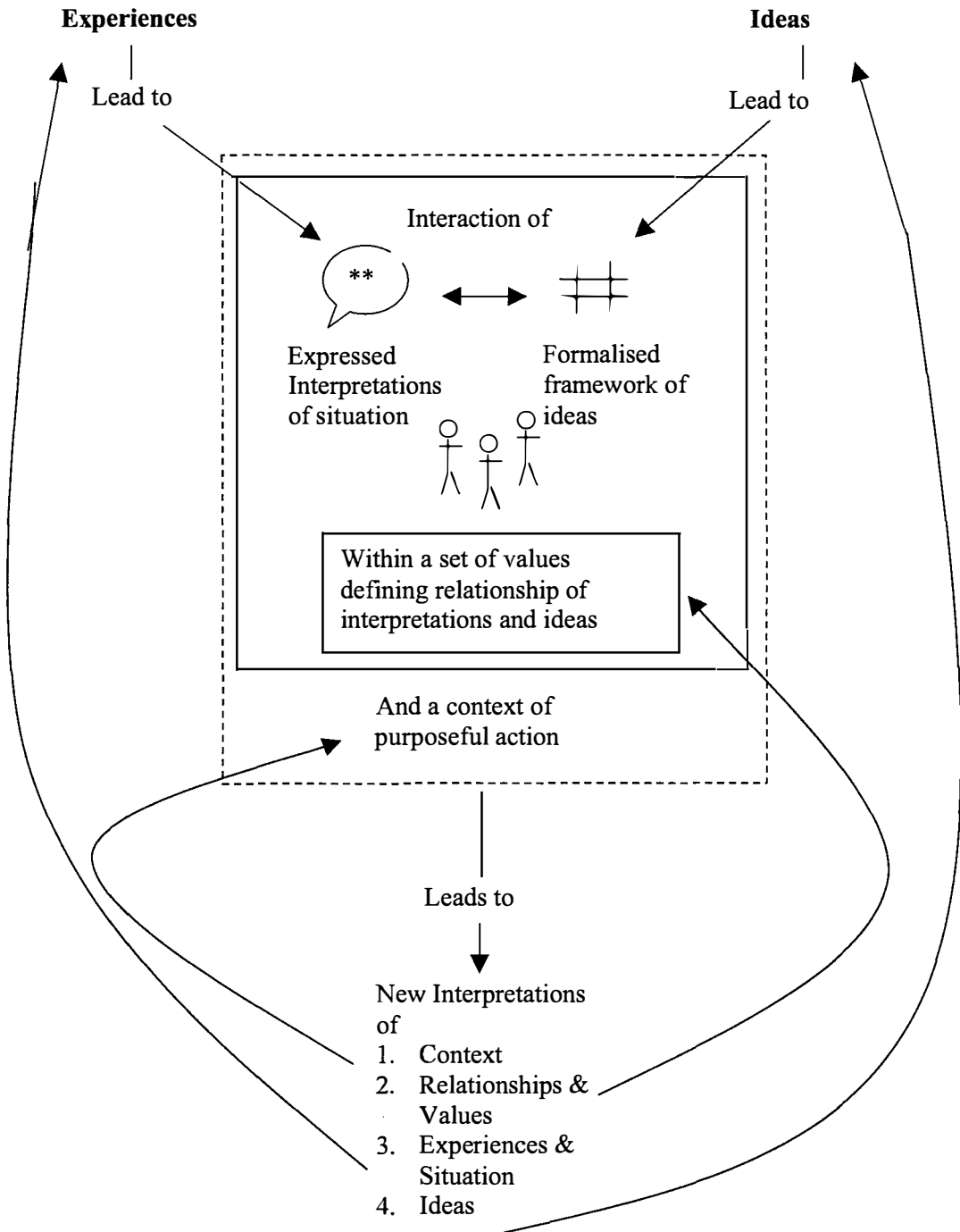
**Table 1**

	<b>Comparison (SSM)</b>	<b>Engagement (Interpretive Inquiry)</b>
Key Elements	Perceptions of real situation and activity system models	Expressed Interpretations and Framework of Ideas
Relationship between elements	Relevance - Implicit	Explicit as Expectation, Desirability, & Importance
Basis for Interpretation	Whether a version of the model exists, or should exist in situation	How framework of ideas makes sense of expressed interpretations
Models	Human Activity System	Not specified
Social Context	Problem-Solving and problem-solving system	Sense-making and interpretive management

**Figure1: The Core process of SSM**  
(Adopted Checkland & Scholes 1990)



**Figure 2: The Concept of Interpretive Inquiry**



Just as Comparison can be seen as a limited version of the notion of Engagement then similarly the process of SSM is a constrained version of Interpretive Inquiry.

In relation to our experience of research management we found that SSM provided a limited concept. Two images seem evident based upon SSM, first that of the student seeking to understand and apply a formal model of research that is essentially taken as given. It is an image which leaves untouched both the sense of students learning and challenging ideas about research and also of them seeking to enact research as 'living' purposeful action rather than as an abstract set of ideas. The second image provided by SSM is that of the supervisor as problem-solver evaluating student activity against accepted models of research and giving directions for improvement. This image compares poorly with the experience of debating ideas with students and helping them appreciate the actions that they have already taken and thinking about how they might proceed. First the supervision was more about continuously creating engagements, second it was less directed towards formal change, and third it could be seen as a process of facilitating students to become more self-directed and engage in critical self-management. Engagement by contrast provided us with a more sophisticated understanding of our Interpretive Management activity. The Interpretive Inquiry framework allowed us to recognise and shape our activities and recognise the range of outcomes associated with interpretive activity. In particular two related situations that we term 'Interpretive Failure' and 'Inquiry-in-Inquiry' have been recognised.

### **Interpretive Failure**

'Interpretive Failure' usually becomes apparent through encountering students in deep distress and intellectual confusion. Typically, a student would have adopted or developed a particular model and sought to apply it to a case study, or as part of a data analysis, and found themselves unable to make sense of the results. For example, a student set about examining Information Systems strategy development using a Business Alignment Model ie. define the strategic business goals and strategy and then align the IS strategy to support them. However in the case study situation involved this model proved inapplicable. The Interpretive inquiry framework allowed us to identify the mismatch between ideas and situation and to structure ways in which progress might be made such as changing the case study situation, changing the IS strategy process model, or changing the focus of the research itself. The possibility of such a mismatch is part of the Engagement concept but is not a part of Comparison. Similarly another student found themselves experiencing problems because they had set out to create major change in a situation but found that the research format they had adopted was not action-oriented. They found great difficulty in reconciling their research motivation with the values implicit in their research design. Again this was a situation that was recognised and tackled using the concepts of engagement and interpretive inquiry.

An 'Interpretive Failure' is an interpretive paradigm parallel to the idea of not rejecting a hypothesis when that is what all theory suggests should happen. We wondered however why students did not recognise the situation or realise that they had indeed found something of interest. Most students we conjecture are intensely interested in a particular topic, such as why certain enterprises adopt e-commerce technologies and others do not, and not in some apparently obscure methodological phenomenon such as Interpretive Failure. Again the Engagement model provided an enhanced understanding of the issue when compared with standard SSM.

## **Inquiry-In-Inquiry**

One of the interesting side effects of moving to the Interpretive Inquiry model is that we began to use it as a framework of ideas as well as a methodology. Many aspects of management activity are involved with sense making and the idea that such activity involves creating and re-creating interpretations seem appealing. Thus the concept of Interpretive Inquiry is relevant to real-world activity – it is a generic concept that can be used to create Inquiry-based activity models. We term this usage ‘Inquiry-in-Inquiry’ (see Ledington & Glen 2001 for an example).

## **CONCLUSION**

The focus of this paper has been the experiences arising from a research program that has focussed upon the use of SSM as an everyday management tool and upon exploring the issues involved in the ‘Comparison’ Paradox. The limitations of Comparison were explored and this led to the development of the concept of Engagement and its wider process called Interpretive Inquiry. These concepts have emerged in a very limited stream of research yet clearly hold some promise in extending Interpretive Management ideas beyond the consultancy-based orientation of SSM. To this end a number of research projects are underway to extend the use of the concepts into other areas of management.

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# THE USE OF SOFT SYSTEMS METHODOLOGY AS A PROCESS TO REDESIGN AN ORGANISATIONAL EMPLOYMENT SYSTEM

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## ABSTRACT

*Soft Systems Methodology is a development of systems thinking that is especially useful in diagnosing and addressing organisational problems in cultures characterised by pluralistic views and values. This paper illustrates how SSM is being used by a large government agency to redesign their employment system so that it becomes more relevant, cost effective and reliable. The initial change process involved engaging and working with a diverse stakeholder group. The development of an "ideal system" through the SSM process is explored.*

*Keywords: Soft Systems Methodology, Employment system, Systems thinking.*

## INTRODUCTION

One of the challenges facing contemporary organisations is the effective management of large-scale change. Such endeavours are fraught with difficulties, including overt and covert resistance, cost overruns, ineffective solution design or implementation, and creation of internal tensions (Schein, 1988, 1999; Kotter and Heskett, 1992). This paper illustrates how SSM is being used by a large government agency to redesign its employment system so that it becomes more relevant, cost effective and reliable.

## SOFT SYSTEMS METHODOLOGY

Soft Systems Methodology was created by Peter Checkland (1981) as an answer to the lack of specific applicability of other systems approaches to the complex area of human activity systems (see also Davies and Ledington (1991), Checkland and Holwell (1998)).

SSM is defined by von Bulow (1989) as:

‘a methodology that aims to bring about improvements in areas of social concern by activating in the people involved in the situation a learning cycle which is ideally never-ending’.

It is the alignment with social reality, that gives SSM an edge over other systems methodologies in relation to problems involving human activity systems:

'...we may regard the ontological status of SSM as lying in an interpretative or socially constructed view of reality, its epistemology as the exploitation of systems constructs to structure learning, and its research strategy as that of model building' (Rose, 1997).

The flexibility in the SSM process is highlighted by Taylor and DaCosta (1999):

'It is from these models (SSM) that the learning process may be undertaken as the impetus for change may come as a result of an activity that is identified through any of these conceptual models. As models are constructed, the direction of learning is changed and further questions are prompted about the problematical situation'.

Mode 2 SSM is an enhancement of the original SSM (now referred to as Mode 1). It is introduced by Checkland and Scholes (1990) and expands the methodology to consider streams of cultural analysis, incorporating cultural and political factors.

Flood (1999:58) states that Mode 2 SSM is:

'a conceptual framework to be incorporated in everyday thinking. The main feature of mode 2 SSM is recognition of two equally important strands of analysis – a logic-based stream of analysis and a stream of cultural analysis'.

## **THE PROBLEM CONTEXT**

The employment system in the organisation was complex and expensive to run. There was little consistency across business lines in relation to methods used or coordination of various campaigns. Business lines were often acting in competition with one another. Staff members were also unhappy with the process, as evidenced by letters to the organisation's electronic magazine, and by complaints to the internal complaints handling area.

On the basis of these and other issues, management of the organisation developed a vision for its people systems, which included the aim to have a consistent, flexible, and effective employment system. Given this context, a small team was set up to design and build a new employment system. The engagement of key stakeholders was a significant issue, and the first author thought that co-design workshops would be an ideal method to engage them.

## **THE DESIGN PROCESS**

After attending an SSM workshop facilitated by Prof. Robert Flood, the first author and a colleague who was leading the 'Employment Project', initiated a design process using the first author's understanding of SSM. The design consisted of a two-day workshop, based around an SSM Mode 1 design, slightly modified, with the addition of an analysis from SSM Mode 2 of systemic viability, cultural feasibility, and political acceptability, and a self-evaluation adapted from Checkland and Tsouvalis (1997).

At each of the workshops, the participants were split into groups of three to five. The process used was the following design:

- a) The introduction provided the context of the workshop, the strategic drivers, and related broad organisational issues.
- b) The first author explained some of the basic concepts in systems thinking and outlined the structure of SSM.
- c) Participants were asked what they thought were the major elements included in the organisation's employment system.
- d) Participants then were led through a seven-phased process, as outlined overleaf:

### **Phase 1: Problem unstructured**

Draw a rich picture of your understanding of the issues and problems in the employment system.

### **Phase 2: Problem expressed**

Explain the picture to the other participants, and respond to questions, clarifications, comments and suggestions by other participants.

### **Phase 3: Ideal systems**

Name the sorts of ideal systems contained in the employment system.

Make logical links between them and choose one that is important to you, to work on for the next day and a half.

Analyse the system in terms of its 'CATWOE'.

### **Phase 4: Conceptual models**

List the verbs or action words required as ideal elements of your sub-system.

Link them in an ideal process or flow map.

### **Phase 5: Compare and contrast**

List the action words from the flow map and compare with current reality. Analyse to what extent do we do these things now, and explain your reasoning.

### **Phase 6: Feasible and desirable change**

Comment whether your ideal sub-system will work, and respond to the three questions of:

- Is it systemically viable?
- Is it culturally feasible?
- Is it politically acceptable?

### **Phase 7: Action required**

Outline the actions required for the system to be implemented, including: who? – the players involved; how? – the process required; when? – the timeframe recommended.

Evaluate the transformation required by your sub-system in terms of:

Ethical – is it legal, moral, the right thing to do?

Equitable – is there transparency, non-discrimination?

Efficient – does it optimise the use of resources?

Effective – does it deliver the organisational outcomes required?

Efficacy – is it practical and workable?

Elegant – is it a pleasing system, will it engage people?

## THE WORKSHOPS

Four workshops were run, and evaluated using a questionnaire and by verbal feedback, following each of the workshops.

Choices of sub-systems varied such as: 'assessment', 'evaluation', 'career planning' and 'retention'. Some chose traditional titles, such as those mentioned, whereas others went for more creative names, such as 'welcoming and informing system' instead of induction, and 'keeping on board system' instead of retention, etc.

Participants generally became quickly engaged in the tasks, and worked effectively in the small groups, often with people they had not known beforehand.

## WORKSHOP EVALUATION

The workshops were evaluated using questionnaires, containing a mixture of 5-point scale questions and qualitative questions.

As outlined in Table 1, the use of the SSM methodology was rated as good or excellent by 87% of applicants. 77% of participants rated their level of involvement in the workshop as fully- or mostly-involved, 87% rated the delivery of the workshop as excellent or good, and 84% rated the objective of 'developing an understanding of the employment system' as fully or mostly met.

%	Excellent	Good	Satisfactory	Borderline	Poor
The use of SSM	25.8	61.3	9.7	3.2	0
Delivery of workshop	48.4	38.7	12.9	0	0
%	Fully	Mostly	Partly	Not well	Did not
Met objective	22.6	61.3	12.9	3.2	0
Level of involvement	29.0	48.4	22.6	0	0

Table 1: Ratings by participants of SSM workshops

However, it was qualitative comments that highlighted the learning which took place, particularly around systemic understanding and complexity. Comments such as 'it's quite complex', 'culture is a very strong factor to prohibiting new ideas', 'there are lots of processes that either need to be deleted or changed', 'how outdated the current process is, yet how much simpler it can be'. Also, the systemic approach 'helps to analyse cause and effect', 'shows you the critical inter-dependencies and critical components', 'learned how to build a conceptual model', 'gives a more comprehensive understanding of complex interactions', 'a change in a single component of the system shouldn't occur without some thought of its impact on other components or the system as a whole', 'highlighted the inter-linkages with other parts of the people system'.

Emerging from the workshops was a general understanding that the current system was not viable, that a systemic design was necessary, and that stakeholders were willing to work together to achieve it.

## PULLING IT TOGETHER

The employment project team was charged with pulling all of the information together to work on an ideal design and circulate their design to all participants, and to other key players. Later, an agreed design and policy was to be tested with stakeholders and prototyped before being implemented.

## CONCLUSION

The SSM methodology was used to help redesign an employment system in a large public sector organisation. Evaluation of the workshops showed a high level of acceptance of the methodology and engagement with the process. As a result of the success of the workshops the corporate area of the organisation is to use SSM as a tool to redesign other processes and systems.

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# Action Research and Systemic Thinking

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## ABSTRACT

*This paper discusses action research intervention and total systems intervention (TSI) and their application in a not-for-profit membership based organisation undergoing strategic change. Specifically the use of strategic assumption surfacing and testing (SAST) to explore the divergent views of managers on membership is discussed. The effectiveness of the SAST methodology when used in conjunction with action research is considered.*

*Keywords: action research, systems methodologies, not-for-profit organisation*

## INTRODUCTION

Membership based health related organisations are fighting for survival and relevance in a climate of competition and rationalisation of services. These not-for-profit organisations began as support groups, self-help groups and societies where members of the community responded to gaps in services provided by government. Funds for activities were obtained through donations, fundraising and group membership fees. In the process of their development these groups formalised as legal entities such as companies, and friendly societies. The Board or Committee of Management was usually comprised of elected financial members. As the organisations developed, they have applied to various sources for grants to provide a range of health, housing and welfare services and have become accountable to these funding sources as well as to the membership. This natural evolution is the genesis of the dilemma they now face.

The purpose of the study on which this paper is based, is to use action research and systems methodologies to facilitate the evolution from a membership-based to a professional-based service organisation while still maintaining the commitment of an active membership. The organisation in which the study is being conducted provides membership and services for people with mental illness, their families and friends. It is a statewide organisation with branches and networks in urban and rural locations. The duality of membership, as recipients of, and contributors to, the work of the organisation (and often as elected Board members) gives rise to conflict around the purpose of the organisation. This is compounded by the fact that the organisation is currently undergoing major strategic change in response to five years of rapid growth in funded service.

This paper outlines action research intervention, total systems intervention (TSI) and strategic assumption surfacing and testing (SAST) and their application in relation to two of the research problems identified for the study. The two problems are:

1. How effective is the process of action research as a research methodology?
2. How useful is Total Systems Intervention (TSI) to understanding the organisation and for facilitating strategic change?

## **ACTION RESEARCH**

The study uses action research as the method that 'aims to contribute *both* to practical concerns of people (including people in organisations) *and* to the goals of social science, via joint collaboration within a mutually acceptable ethical framework' (Warmington, 1980, p. 25). The aim of action research is the same as that of science in that it is for 'the improvement of man's lot on earth, ... achieved by collecting facts through organised observation and deriving theories from them' (Bacon, In Chateaus, pxvii). The reductionist cause-effect approaches of the traditional methods of investigation were considered by the researcher not to provide the wholeness of the interactions to enable the understandings required. The use of action research is useful in this study as the problems to be addressed are linked to the people of the organisation and the way they construct and experience the reality of a change process.

Action research (Rapoport, 1970; Susman & Everard, 1978), action science (Argyris, 1992) and action learning (Revans, 1982) are often used interchangeably and are closely linked. The approaches are built 'on ways of linking theory to practice so that knowledge can be action based and derived from practice in the real world as opposed to being generated in scientific laboratories or through abstract survey methods' (Morgan & Kocklea, 1997, p. 297). Flood (1999), in a reference to Checkland and Howell and the words of Argyris, defines action research as a collaborative process of critical inquiry between the researcher and the people in the situation. This process involves the diagnosis of a problem, issue or intention for change, proposing and implementing action and evaluating the results of that action. The outcomes of evaluation provide useful insight into the problem though reflection and generate further action. In this research, the aim is to contribute both to the practical concerns of the people and the goals of management. It is an inquiry in which ideas and practice are explored concurrently (Marshall & Reason, 1997).

There are a number of philosophical viewpoints for action research (Susman & Everard, 1978). In this study, an ethnographic perspective is being taken that includes the researcher and the members of the executive management (the participants) in the collection of formal and anecdotal data. It involves direct participation in, and observation of activity of the researcher and participants and the description, sharing and evaluation of that activity throughout the study. The evaluation involves individual reflection within a group setting and includes all available evidence from records, observations, and interviews used for theoretical purpose (Minichiello, Aroni, Timewell, & Alexander, 1990, p. 165).

## **TOTAL SYSTEMS INTERVENTION**

The systems methodology being used to complement the process of action research is Total Systems Intervention (TSI) (Flood and Jackson, (1991) or as Flood (2001) now prefers in the context of action research, local systemic action research. The methodology of TSI is underpinned by the philosophy of critical systems thinking of Churchman and the critical systems theory of Habermas (Flood, 1999). Critical systems thinking encompasses the view that different theoretical positions and methodologies can be used in partnership to deal with the complexities of management and to achieve the maximum development of the potential of all individuals while being aware of the social and organisational pressures.

Being critical has involved questioning in a way as to generate insights into the problems being addressed so as to provide choice and a practical approach to taking action. In the context of this study, it has been structured into the process of action research and by using the phases of TSI. It has involved questioning to generate insights into the problems being addressed so as to provide choice and a practical approach to taking action. It has also been used to ask questions as to which systems methodologies could be used at different phases of the research, why they should be used and the usefulness of the methodologies (Flood, 2001).

Phase 1 of the process of TSI uses a range of metaphors linked to different systems methodologies to enable the complexity of an organisation to be addressed. The use of metaphor provides the opportunity to consider problems through familiar analogies. Where likeness exists it brings into focus difficulties or issues that could be faced by the organisation. Once the metaphor with the best fit has been found the nature of the problems can be identified and the systems methodology best aligned with the metaphor used to address the issues raised. In this study strategic assumption surfacing and testing (SAST) was identified as one methodology.

SAST is used to focus attention on the relationships between the people involved in a problem context rather than the structures or the framework in which the relationships occur. These relationships between stakeholders, who may be '... any individual, group, organisation, institution that can affect as well as be affected by an individual's, group's, organisation's, institution's policy or policies' (Mitroff & Linstone, 1993, p. 141), can be better understood through the use of the cultural and the political metaphor. Metaphor provides a framework for understanding and comprehending behaviours, occurrences or experiences from the basis of previously known experiences or events which might present a likeness and is particularly useful for developing an understanding of complex or difficult events (Clancy, 1989; Flood & Carson, 1993).

SAST is a problem solving methodology used in situations where the policy-making is complex and where the problems and issues are inter-related and "messy" (Flood & Jackson, 1991, p. 122; Mason & Mitroff, 1981). The specific philosophy of SAST is based on four arguments about the nature and resolution of problems. These are that: (1) problems are strategic and are a result of organisational complexity in which the existing management strategies can only deal with simple problems; (2) organisations fail to challenge the accepted ways of doing things; (3) challenging the way it has always been done requires going beyond existing theories and requires the generation of radically different policies and theories based on different interpretations of data; and (4) the advent of tensions are likely to result from these interpretations.

There are four principles inherent in the SAST problem solving methodology (Flood & Jackson, 1991; Mason & Mitroff, 1981). The first is adversarial, where solutions on ill structured problems are to be found after considering opposite positions. The second promotes participation based on the belief that the knowledge relevant and necessary to solve problems and implement solutions is held by a number of participants in a variety of representative groups. A synthesis of the differences identified through principles one and two, is the third principle of integration, necessary for the development of an action plan. The fourth principle is that of managerial mind supporting which is based on the belief that exposure to a range of assumptions will result in managers developing an increased insight into the problems of the organisation. These principles are supported by four behavioural stages, group formation, assumption surfacing, dialectic debate and synthesis (Flood & Jackson, 1991; Mason & Mitroff, 1981).

The *group formation stage* is based on within-group and between-group criteria using principles to minimise internal group conflict while maximising differences between groups. To minimise internal conflict within the group, groups are formed with members who have the capacity to get along with each other. Whereas the number of groups formed will be influenced by the number of people involved and the requirement to maximise the different perspectives on the problem. The perspective of each group should be open to challenge by one or more other groups.



The *assumption surfacing stage* is facilitated through the use of three techniques, stakeholder analysis, assumption specification, and assumption rating. Stakeholder analysis involves a process of identifying the stakeholders with an interest in the problem who in a position to influence the implementation and outcome of the strategy. The assumptions the stakeholders hold about the strategy and how they believe it will succeed are then identified and rated against two criteria in terms of importance of its influence on the success or failure and on the degree of certainty that the strategy is justified (Flood & Jackson, 1991, p. 126).

The *assumption rating stage* (Mason & Mitroff, 1981) includes a *dialectic debate and synthesis stage*. Dialectical debate is based on a principle of defence and attack. Each group presents their perspective and identified assumptions. These are then compared with each other. Assumptions where there is agreement are put aside and the debate focused on those that present the key differences. The desired outcome from the debate is a modification or synthesis of assumptions that will facilitate strategy implementation.

To be affective, communication is required whereby differences in views can be raised, assumptions can be checked and a mutual understanding can be developed. This process of dialogue facilitates creative thinking and is an '...essential element of any model of organisational transformation' (Schein, 1994, p. 1). With these views and assumptions revealed and resolved, common understandings develop. By thinking and feeling as a group or a team, new assumptions are developed that have a shared meaning.

Senge (1992) discusses the value of dialogue to team learning and the need to master discussion and dialogue as two distinct ways in which teams converse. Discussion is the process by which 'different views are presented and defended and there is a search for the best view to support decisions that must be made at this time' (p. 237). Or as Schien (1994) proposes in his road map of ways of thinking, issues that are deliberated through the process of discussion are resolved by 'logic and beating down' (p.2) of opposing views.

## **PROGRESS AND REFLECTIONS**

### **The Strategic Problem of Maintaining the Commitment of and Active Membership**

The managers as a group did not have an understanding as to who constituted a member nor the role of membership within the organisation. At the commencement of the study the total membership, where they were active and their role was not known. The need to know these details and to identify other voluntary contributors to the organisation was important for the strategic directions of the organisation to be implemented. An identified component for the transition of the organisation to a professional organisation was the continued and active participation of members. The difference in manager understanding resulted in limited and uncoordinated action being taken to maintain an active membership in the functions of the organisation. The inability to take action had continued for approximately 12 months.

The role of members in the organisation was based on an historical perception of self-help and advocacy for improvement in health and social well being of persons with a mental illness and their families. However, the strategic changes to the organisation resulted in a formal structure being introduced that placed an emphasis on both advocacy and provision of services. Not only did the role of member involvement in services need to be defined, there was competition for member participation between different member and service functional areas. There was also evidence that members continued to see their role as providing advocacy and self-help (Walker & Crowther, 2000).

### **The SAST Process.**

Following the process of stage 1 of TSI, two metaphors were identified as reflecting current thinking about the organisation that could make sense of the difficulties and concerns of the organisation (Flood & Jackson, 1991). These were the cultural and the political metaphor. Members of the organisation and staff contributed to the development of the strategic plan and inclusion of a set of stated values. While the managers participating in this research accepted the direction of the strategic plan and the values of the organisation, they were experiencing difficulties in the implementation of the plan to meet these values. This was evident when considering the role of members and led to the use of SAST as a means of addressing the problem.

The SAST session was conducted using a process that had been previously established for the action-reflection forums. Each participant had the opportunity to express his or her understanding of what constituted a member of the organisation. Participants were asked to listen and ask questions for clarification of meaning but to hold debate until all participants had expressed their understanding of the problem. Discussion and debate followed. The synthesis of the debate resulted in a number of stakeholders being identified as contributing to the organisation in a voluntary way. An action plan was developed with key managers allocated the task to draft definitions of these stakeholders for discussion at subsequent meetings. Two action reflection forums were conducted before agreement on who were members and who constituted other stakeholders was achieved.

### **Manager Assumptions**

The assumptions held by managers around the nature of membership are central to the strategic problem. On the topic of membership a range of divergent views about members and membership surfaced. It was clear that no progress could be made by the managers on their consideration of the issue of maintaining an active membership until this was resolved. In the process of exploring the managers understanding of member or membership, it became apparent that there were a number of groups of people who contributed to the organisation in a voluntary capacity and who were loosely considered to be members of the organisation but were not formally recognised.

There were further misunderstandings about the constituted status of members and membership. Not all managers were aware that there was a legal definition of members and membership within the organisation. This prompted one manager to say, '[this] points to a problem [if there is] confusion between member and volunteer' and attempted to clarify for other managers that a 'members pays dues and own the organisation and participate [in the organization] through advocacy. We have a constitutional status that defines what is, who is and the role. The ultimate objective is to achieve change [for the improvement of mental health for individuals and families]'

The outcome of this session was an agreement that there were a number of stakeholders who contributed in a variety of ways to the benefit of the organisation. These were subsequently defined and agreed to by the managers and included as a glossary in the organisational manual. In addition to the different understandings managers held about members and membership, it was also apparent that there was a different understanding as to the meanings associated with 'active' and 'passive' contribution of stakeholders to the organisation. While this was not addressed directly in the session, it was addressed in the definitions.

## **EXAMINING THE OUTCOMES OF SAST AND REFLECTIVE PROCESSES**

The SAST process used to tease out the meaning of membership and highlight the differing opinions held by the managers was effective in that an understanding of member and membership was achieved. This included the formal definition of membership as spelled out in the constitution of the organisation. In addition, the recognition that there were many stakeholders that contributed to the viability of the organisation was significant. Agreement on who were the additional stakeholders was achieved and subsequently described. This was a significant milestone for the managers as they were now in a position to move forward and address the strategic structures and processes necessary to ensure the stakeholders remain active contributors to the viability of the organisation.

The process was not dissimilar to the process established for the regular action-reflection forums established as part of the action research project. The structure put in place for the regular sessions occurred following reflection by the researcher and participating managers on the experience of a number of action reflection forums. These reflections identified the need to encourage participation and in depth discussion and debate on complex problems one at a time.

The structure implemented for the action-reflection forums incorporated additional processes that replicate the cycle of reflection in action and on action. At the commencement of the forum, the opportunity is provided to reflect on and question personal or collective progress on issues raised and action plans of previous forums before moving onto the task or issue of the day. The task or issue to be addressed in the current session is then identified and agreed upon. The tasks have included both structural and process issues of concern to the managers in their implementation of strategic change. Each participant has the opportunity to comment on the issue while others listen. Participants then have the opportunity to raise issues for clarification. If there is a disagreement in understanding, either discussion or a deeper dialogue occurs and action agreed upon. The session concludes with time for reflection on the process of the session and outcome for each participant. Key individual learning will then be shared with the group.

## **CONCLUSION**

This paper has briefly outlined the process of action research and discussed the application of TSI and SAST in the context of a not-for-profit membership-based organisation. The next stage of the action research process will address the requirement to maintain an active membership within the organisation and to proceed with strategic change to a professional management structure. This will involve achieving agreement on whether the focus remains on membership or is expanded to include all voluntary stakeholders who are needed to maintain the financial and operational viability of the organisation.

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# A Multi-Perspective Approach to Learning about Information Systems Development Methodologies

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## ABSTRACT

*Helping students to appreciate the 'soft' side of the information systems field and to develop a broad, multi-perspective view can be somewhat problematic, particularly with students who have experienced a more positivist approach in previous studies. The teaching 'flavour' of the Masters course discussed here was essentially interpretive and explored the philosophical issues that 'drive' development methodologies. To help students develop this broad view they were encouraged to take the role of a key figure in the Information Systems area and to present their views of how that individual might undertake the development of a specific system.*

## INTRODUCTION

In discussing the similarities between 'systems engineering' and 'systems analysis' Checkland (1981) comments that these approaches assume that problems can be 'formulated as the making of a choice between alternative means of achieving a known end' and suggests such a belief that real-world problems can be approached in this way to be a characteristic that describes all 'hard' systems thinking. The successful application of 'hard' approaches to engineering-type problems has proved to be less than successful when the approaches were applied to the development socio-technical information systems. It could be argued that teaching, for example, from the Project Management Body of Knowledge (PMBOK), essentially a 'hard' approach, may be a dubious idea given that this approach would appear to lead to low levels of success in the development of actual systems. On the other hand teaching from a purely 'soft' position with 'reality as a social construct' is a difficult process with students who have a rather more concrete view of the world. Ideally we would wish that students faced with the development of information systems in typical organizational settings characterized by change, political machinations, 'e' approaches and so on would be able to consider a range of possible development methodologies and choose one that provides best fit with the prevailing environment. For example, a short project of several months duration and low complexity or social impact would probably be well suited to a PMBOK related approach, whereas a three year project that involves organizational re-structuring would probably be more appropriately managed from a softer perspective that keeps a careful eye on the whole of the issues rather than just a specific projects.

It was these thoughts that guided the development and teaching of a Masters subject titled "Information Systems Development Methodologies", explored overleaf.

## **APPROACH**

The aim of the course is to introduce students to a range of information systems development methodologies and to encourage them to consider how and under what circumstances the various approaches, or combinations of them, may be usefully applied. Given the available time of thirty hours contact time it was felt that it would not be viable to consider specific methodologies to any practical depth. The approach adopted was therefore to work within a 'hard – soft' spectrum with the various methodologies placed appropriately along that spectrum and to explore the relative merits of the approaches for a variety of problem situations.

Some time was spent exploring the meaning of the term 'methodology', working mainly around the views of Avison and Fitzgerald (1995) who regard a methodology as more than simply a collection of 'procedures techniques, tools and documentation aids', in that it should have a 'philosophical' view that distinguishes it from being a method, or recipe. It was this idea of a 'philosophy' that caused the students the greatest concern in the course and this will be returned to later in the paper.

The views presented in the lectures ranged across the hard and soft areas with 'soft' being explored in more depth than 'hard' simply because this was a new perspective for most students. The traditional PMBOK approaches were outlined and the reported levels of failure discussed. Lectures outlined a spectrum of hard and soft approaches from Soft Systems Methodology (Checkland, 1981), Multiview (Avison, Wood-Harper, Vidgen and Wood, 1998), ETHICS (Mumford, 1994) through Viable Systems Model (Espejo and Harnden, 1989) and on to SSADM, PRINCE, SDLC and other 'harder' approaches. The problems of attempts to turn the softer, human process oriented approach, into hard approaches was also explored by reference to Mumford's (1994) concerns that people wanted to turn her ETHICS approach into a software-based format.

The assignment structure used to help the students develop a critical view of the various methodologies comprised a number of short critiques of book chapters and journal and conference papers. These were deliberately short (1000 words maximum) to force the students to focus on key issues and also to give them practice in structuring a reasonable argument. The final piece of work was an individual conference-style paper of around 3500 words.

## **'PHILOSOPHICAL' PROBLEMS**

Students found the idea of a guiding philosophy behind a development methodology a little difficult to cope with at first. There were a number of comments along the lines of 'surely philosophy belongs in academia rather than the real world?' The perceived gap between academia and 'the real world' was explored using a variety of pieces of literature including Flood (1995), who fears that too many academics remain out of touch with the manager's world, some being too theoretical, others wishing to 'prevent their precious theories from being sullied through the pollutive exercise of using them and evolving them in this way'. Those students involved in information systems projects in their working life were, initially, the most resistant to a theoretical or philosophical analysis of development methodologies. The most commonly used phrase was 'But surely that's just common sense?' Bringing them constantly back to literature describing failed systems kept their skepticism bounded by the unavoidable fact that development failures are commonplace and that we need to try to understand why this is the case and then consider a variety of possible approaches.

The real breakthrough in helping students understand how a particular 'philosophy' would influence a project was achieved through a multi-perspective session examining a single short case study from the viewpoint of a number of significant individuals typically represented in IS/IT/Quality literature. The objective of the exercise was for each student to attempt to express a view of the relatively simple case study through the worldviews of a specified individual. A list of names was produced and the names allocated to the students on a random basis. The names included Ackoff, Alavi, Avison, Beer, Champey, Checkland, Davenport, Davies, Earl, Espejo, Flood, Galliers, Hammer, Hirschheim, Jackson, Khosrowpour, Klein, Linstone, Martin, Mason, Mitroff, Mumford, Newell, Nunamaker, Simon, Turban, Utterback, Von Bertalanffy, Wood-Harper, and Yourdon.

Students first produced a biography for each 'player' and then went on to explain how they thought 'their' player would have tackled the case study. One enterprising student e-mailed 'their' person, much to the dismay of some other students who complained that 'their' person was dead! The session was treated fairly light-heartedly but it very quickly became evident that it had a strong impact on the students. As each student presented 'their' credentials and argued their case for their particular approach to be adopted for the common project the students began to understand the notion of an underlying world view.

## **CONCLUSION**

The use of critiques of a number of short papers and chapters supported by the development of a Toulmin-based (1958) approach to critically evaluating the material provided a vehicle for students to grasp some of the ideas of the 'philosophy behind the methodology'. They still found the softer development approaches to be difficult to conceptualise in the real world and had problems seeing how some approaches, especially those that are action based and apparently open-ended, could be married with the need to generate schedules and meet milestones etc. However, most recognized the potential value of choosing appropriate methodologies rather than following a traditional approach and felt that the softer approaches, particularly Multiview, offered useful and practical possibilities.

The more mature students, ie mainly those in work, probably gained more from this course than the younger ones as they were able to recognize the complexity of typical work environments with their inherent personal and political agendas, resistance to change and other real world features. One student in particular, who was closely involved with the problems of a merging of project groups in her organization was initially quite hostile to any methodology other than the one she had previously used. By the end of the course she was able to be more objective and critical of both her own views and those of the people who wished to introduce a new methodology to the organization. She felt that she was able to mount a cogent and well-structured argument that recognized the potential values and problems of the various methodologies available to the organization.

This course will be developed further as it moves into 'distance' and web-based format and this may pose challenges in preserving the key issues of debate, philosophy and the link between theory and practice.

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# A review of IT Benefits and Costs in Construction

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## ABSTRACT

*Information technology (IT) evaluation is an area of research that has received limited attention in the construction and engineering literature. Yet, the justification of investments in IT is one of the many challenges facing managers in the construction industry today, as there is an ever-increasing demand for organisations to improve their performance and productivity. In developing a deeper understanding of the evaluation process, this paper presents a review of IT evaluation in construction from a benefit and cost perspective. In addition, challenges of future IT cost evaluation research in construction are identified in the conclusions.*

*Keywords: IT, evaluation, investment justification, direct and indirect cost portfolios.*

## INTRODUCTION

Information technology (IT) evaluation is defined as “a process that place at different points in time or continuously, for searching for and making explicit, quantitatively or qualitatively, all the impacts of an IT project”. The justification of investments in IT is one of the many challenges facing managers in the construction industry today, as there is an ever-increasing demand for organisations to improve their performance and productivity. The evaluation of IT investments, as well as the IT function, has received widespread attention in the IT and business literature. Yet, it remains relatively unexplored in construction, albeit limited to a few studies. The IT literature is replete with innovative attempts to surmount the theoretical problems of IT evaluation, such as conventional financial and economic evaluation techniques (Brynjölfsson, 1993), (Brynjölfsson and Hitt 1996), return on management (Strassman, 1988), information economics (Parker et al, 1988). In addition, others have proposed taxonomies of methods such as Cronk and Fitzgerald (Cronk and Fitzgerald, 1997) and Irani and Love (Irani and Love, 2001).

Many of the evaluation methods that have been proposed, especially those in construction (Andersen et al, 2000) (Marsh and Flanagan, 2000), fail to address the complexity associated with decision-making as well as provide management with a strategic framework for determining the ‘true’ cost of their IT investment. The reasons for this are that they tend to neglect the indirect (organisational and human) costs of IT (Love et al, 2000a). Lefley and Sarkis (Lefley and Sarkis, 1997) have found that the investment justification processes used by management are typically based on traditional appraisal techniques. Such traditional techniques, however, lack the preciseness in definition and results that management expect. Irani and Love (Irani and Love, 2001) have found that management tends to be myopic when considering IT investment decisions, primarily because they have no framework to evaluate their investments. In addition, management gives less attention to the ‘hidden’ or indirect

costs surrounding IT, which can be up to four times greater than its 'direct' IT cost component (Hochstrasser, 1992).

The implications of ignoring 'indirect' costs can therefore have far-reaching consequences for construction firms, as they are dependent on cash flow to support their daily business activities. In fact, many construction firms only realise the significance of these additional cost factors once they have actually developed their IT infrastructure (Li et al, 2000). It would therefore appear that poor IT decision-making can result in financial losses, which can translate into a loss in competitiveness, and perhaps jobs. The costs associated with such losses are invariably passed on to the client and other members involved with the construction firm's business and project related processes. In developing a deeper understanding of the evaluation process, this paper presents a review of IT evaluation in construction from a benefit and cost perspective. In addition, challenges of future IT cost evaluation research in construction are identified in the conclusions.

## **INVESTMENT JUSTIFICATION OF IT**

There is an implicit assumption in most of the construction IT evaluation literature that while IT benefits can be difficult to ascertain, it is often assumed that the identification and calculation of IT costs are relatively straightforward processes. According to Andresen *et al.* (Andersen et al, 2000) and Love *et al.* (Love et al, 2000a) IT costing is a difficult, complex and a time-consuming process as both business and project activities need to be costed. Even experienced accountants are often stymied by the problems they face when it comes to recording and calculating the costs of IT due to differences in interpretation and organisational politics. The reason for this is that the traditional concept and notion of IT penetration has been superseded, by the broader notion of information systems that have wider organisational implications (Liebenau and Blackhouse, 1990). A further complication with IT evaluation is that cost may be seen through the lens of an accountant or manager, which may result in different interpretations of costs as there tend to be significant differences between their two mindsets. For example, accountants generally accumulate data in order to be able to answer the question of what was actually paid to achieve a specific objective that offers a financially tangible return, whereas a manager may consider the question of investment alternatives and therefore include opportunity costs in their evaluations, albeit implicitly.

## **BARRIERS TO IT EVALUATION IN CONSTRUCTION**

Research into the justification of IT suggests that the decision making process is one of the major barriers to the implementation of new technology (Lefley and Sarkis, 1997). The factors that generally have an impact on the adoption of IT and the problems of IT evaluation particularly benefits and costs, are not unique to the construction industry. Yet, the problems associated with assessing benefits and costs seem to be more acute in construction than other industry sectors because of the industry's structure, fragmented supply chain and under capitalisation (Andersen et al, 2000) (Marsh and Flanagan, 2000). Considering these unique industry characteristics, it has been suggested that IT investment evaluation in construction should consider costs, technical issues, means of implementation, risk assessments, procurement strategy, and the likely benefits that will result from the implementation of the IT (Construct IT Centre for Excellence, 1997).

The process of investment justification has been identified as a major barrier to implementing IT in many construction firms (Andersen et al, 2000), (Love et al, 2000a). A lack of awareness about information and communication technologies coupled with an over reliance on cashflow contributes to making the processes associated with IT investment justification a burdensome process for many managers (Love et al, 2000a) (Irani et al, 2001). Consequently, managers may view the justification process as a 'hurdle' that has to be overcome, and not as a technique for evaluating the worth of implementing IT. This has serious consequences, as during the preparation of an IT proposal, managers may spend too much time and effort investigating technical aspects of IT and thus become committed to the belief that from a technical perspective. Moreover, managers may be easily susceptible to persuasion by software developers and consultants, and be prepared to accept untypical demonstrations, which show unrealistically high levels of savings (Irani et al, 2001). Hence, managers may focus their efforts on trying to identify and estimate maximum benefits and savings, at the expense of overlooking the 'full' cost implications of IT.

The inability of construction firms to quantify the 'full' implications of their investments in IT; from both a cost and benefit perspective questions the predictive value of those justification processes that are dependent on traditional appraisal techniques (Irani et al, 1998). There remain, however, serious implications with not carrying out a rigorous evaluation process. Small and Chen (Small and Chen, 1995) point out a lack of management guidelines that support investment decision making may force organisations to adopt one of the following positions:

- refuse to implement an IT infrastructure that could be beneficial to the long-term competitiveness of the organisation;
- invest in IT as an 'act of faith'; or
- use creative accounting (assigning arbitrary values to benefits and costs) as a means of passing the budgetary process.

The costs associated with IT are often perceived to be easier to estimate than the benefits, though Hogbin and Thomas (Hogbin and Thomas, 1994) argue that this is rarely the case. The costs associated with IT implementation appear more tangible in nature. The reasons for this are that the assumptions and dependencies on which they are based are often not fully acknowledged, or are poorly understood by management. Indeed, it is considered widespread practice during the investment decision making process to account for the upper estimates for costs and the lower estimates for benefits (Hogbin and Thomas, 1994). However, this heuristic appears not to be solving the problem of IT projects running over budget, as much of the problem lies in management not 'fully' understanding IT cost portfolios. Here there appears to be a dichotomy, with the need to identify costs to support their management, which in turn contributes towards their control. There might also be political and organisational reasons for not understating the cost implications of an IT investment; the main one being the need to gain support for, and acceptance from senior managers. Farbey *et al.* (Farbey et al, 1993) found that those responsible for implementing IT in organisations often ignore the 'full' cost implications of their investment and thus advocate optimistic estimates of benefits and cost savings. In this instance, the failure to identify the 'full' cost implications, when combined with the use of over optimistic savings and benefits, may result in several extra years of use to achieve expected financial returns.

## INVESTMENT APPRAISAL TECHNIQUES

Traditional investment appraisal techniques, such as *Return on Investment*, *Internal Rate of Return*, *Net Present Value*, and *Payback* approaches are often used to appraise capital investments in IT (Ballantine and Stray, 1999). Yet, these techniques are based on conventional accountancy frameworks and specifically designed to assess the 'bottom-line' financial impact of investments by setting direct IT-related costs against quantifiable benefits. Consequently, many management executives are not comfortable with the available set of tools and techniques used to justify their investments in IT. Consequently, as Currie (Currie, 1995) suggested that when evaluation techniques are used they are simply required to support business decisions that have already been made.

Irani and Love (Irani and Love, 2001) and Serafeimidis and Smithson (Serafeimidis and Smithson, 2000) have suggested traditional appraisal techniques offer an inappropriate prescription in today's technology era and are therefore regarded as being unable to accommodate the wider human and organisational implications associated with technology. However, as more organisations realise that such techniques are unable to accommodate strategic benefits and 'indirect' costs, many are left with the quandary of deciding which approach to use. Consequently, there has been ubiquitous debate about the types of techniques that constitute meaningful justification (Small and Chen, 1995) (Ballantine and Stray, 1999). The vast array of traditional and non-traditional appraisal techniques leaves many organisations with the quandary of deciding which approach to use, if any. Research undertaken by CIRIA (CIRIA, 1996) in the UK and Love *et al.* (Love et al, 2000b) in Australia found that the organisations in the construction industry do not use any form of cost-benefit analysis to evaluate their IT investments.

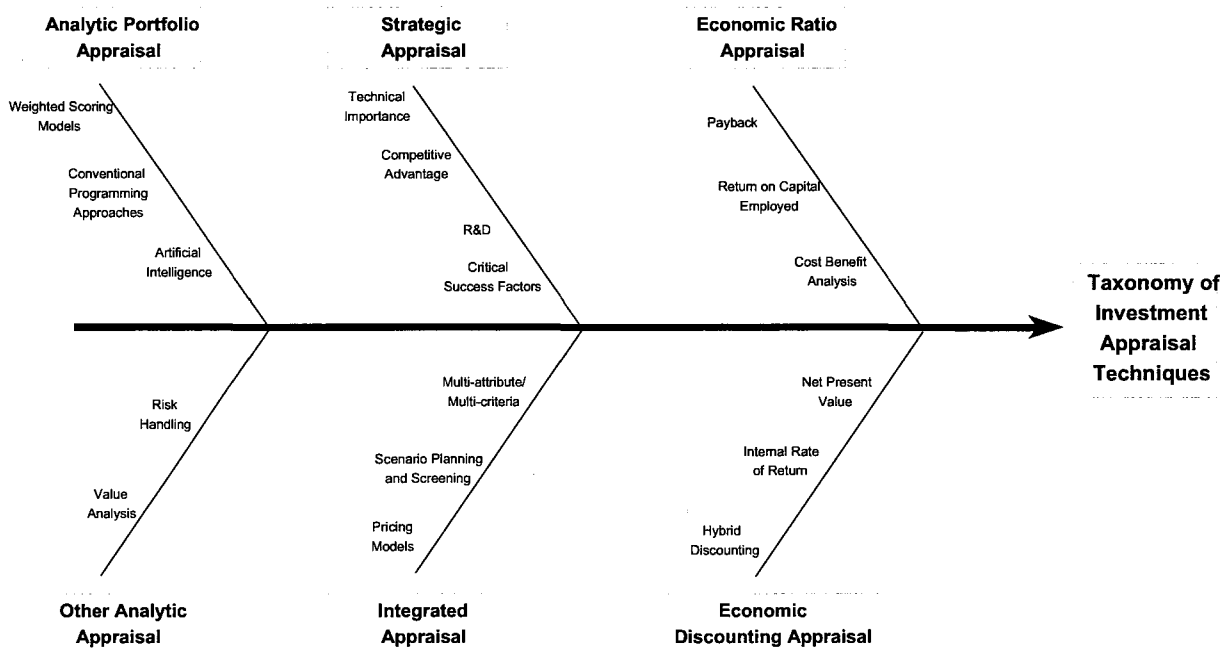


Figure 1. Taxonomy of investment appraisal techniques

Love *et al.* (Love et al, 2000a) noted that construction organisations using traditional approaches to appraise their IT often do not know how to measure the full impact of their IT investments. Furthermore, Irani (Irani, 1998) suggested that evaluation techniques exclusively based on standard accounting methods simply do not work for organisations relying on sophisticated IT environments to conduct their business. While the construction industry currently does not rely on sophisticated forms on IT to support its business and project activities, the processes used to deliver projects are, when compared to other industries. Information and communication technologies have the potential to revolutionise the way that business is conducted and projects delivered in construction (Aouad, 1996) (Betts et al, 1999). Although, it must be acknowledged that simply automating existing processes will not provide benefits and cost savings to construction organisations.

In essence, the organisational culture, behaviour and structure of the business organisation and projects needs to change and therefore strive toward becoming an adaptive learning organisation that will support the leveraging of IT (Love and Gunasekaren, 1997). In addition, construction organisations will need to embrace non-traditional evaluation methods so that they can account for complexities associated with their business and project environments. Noteworthy, construction organisations need to realise that IT investments do not usually constitute an end in themselves but, are generally part of wider business re-organisation in which IT has a specific role (significant or otherwise). In such cases, it is important that the investment in the wider business change is also evaluated in conjunction with the IT.

## IDENTIFICATION OF IT COSTS

Initial cost estimates that contribute towards determining the level of IT investment required are often governed by the performance characteristics that are established by an organisations IT manager during the system requirements planning stage. Yet, such estimates of system costs are often restricted to the architecture and infrastructure of the system and therefore tend to solely focus on:

- hardware and software performance required to process types;
- data volumes of transactions;
- the development work content needed to provide a given set of functions;
- shared processing facilities, for example, terminals/peripherals and networks;
- functions that are extra to a given users' immediate requirement. For example, mandatory security facilities;
- system design factors that might protect performance in the long-term but which have short-term development costs;
- ongoing operating expenses;
- the balance of development costs against eventual maintenance costs;
- weakest links in the network topography;
- network architecture and associated hubs, routers and gateways;
- file server facilities and in particular dedicated servers; and
- network security such as firewalls.

In addition to identifying architecture and infrastructure costs, there is the issue of whether project cost implications should include indirect cost factors. While these cost factors need to be included in an IT evaluation exercise the process as to *how* they are calculated is an area that has not been adequately addressed in the construction IT literature (Love et al, 2000a). In the case of a new system, which can use available processing power, the investment cost may be calculated, as a marginal cost of the processing power needed to run the extra application (Irani, 1998). This marginal cost may be acceptable for one new individual system but will lead to an underestimate of the total costs for the entire systems being implemented, especially when the full processing costs include operating and management expenses. Once the initial cost estimates of a proposed IT system has been decided and the system justified, a process of recording the cost implications and allocating these cost factors to departmental budget often begins (Remenyi et al, 2000) (Banister, 2001).

This process is known as 'charge out' and is where the project costs are offset against the benefits achievable (Hogbin and Thomas, 1994). This management process has evolved from where IT costs were once all in a centralised IT department. However, many IT costs in construction are often incurred and accounted for at a departmental level or for specific project, with each department or project purchasing their own hardware and software, and sending people on training courses from their own departmental or project budget. Hence, without some structured mechanism of allocating cost implications at a departmental or project level, it would appear to be extremely difficult to keep track of exactly *how* much expenditure is IT related in construction organisations.

## **DIRECT COST PORTFOLIO**

'Direct' IT/IS costs are those that can be attributed to the implementation and operation of new technology. Although these costs often go beyond the initial user specification of the system, it is the focus made by management on these aspects, which often dictate the projects' budget, and ultimate justification (Remenyi et al, 2000) (Banister, 2001). 'Direct' IT costs are often underestimated and go beyond the obvious hardware, software and installation costs (Hogbin and Thomas, 1994). These costs may also include unexpected additional hardware accessories, such as increases in processing power, memory and storage devices. Installation and configuration costs are also classified as direct costs, and typically include consultancy support, installation engineers and networking hardware/software. Table 1 provides a summary of direct IT costs, which were reported from a case study that explored the IT evaluation process in a contracting organisation (Love et al, 2000a).

<b>Classification of Direct Costs</b>	<b>Direct IT Costs</b>
<i>Environmental Operating Costs.</i>	Un-interruptable power supply
<i>Hardware Costs</i>	File server
	Dumb terminals
	Backup tape streamer
	Network printer
<i>Software Costs</i>	Key vendor software module
	Relational database software
	Additional networking software
<i>Installation and Configuration Costs.</i>	Consultancy support
	Network wiring, junctions and connectors
	Installation hardware
	'In-house' customizing time
	Re-engineering of business processes to suit software.
<i>Overheads.</i>	Running costs: electricity; insurance premium rises. Consumables, Toner cartridges, disks, and paper
<i>Training Costs.</i>	Database software course
<i>Maintenance Cost.</i>	Yearly service Contract (Hardware)
	Database user group fees

**Table 1. Taxonomy of direct IT costs**

## INDIRECT HUMAN COST PORTFOLIO

It is increasingly recognised that the 'indirect' costs associated with the adoption of IT that are more significant than the 'direct' costs identified in Table 2 (Irani, 1998). However, it is the illusive nature of these costs that make their identification and control difficult and cumbersome to determine (Andresen, 2000). In trying to calculate these costs Love *et al.* (Love et al, 2000a) and Irani and Love (Irani and Love, 2001) have suggested that such costs can be classified into human and organisational factors as noted in Tables 2 and 3.

Indirect Human Costs	IT Cost Factor
Management/Staff Resource	Integrating computerised administration and control into work practices
Management Time	Devising, approving and amending IT/IS and marketing and procurement strategies
Cost of ownership: System Support	Vendor support/trouble shooting costs
Management Effort and Dedication	Exploring the potential of the system
Employee Time	Detailing, approving and amending the computerisation of estimating, cost planning, planning and project/contract administration
Employee Training	Being trained to manipulate vendor software and training others
Employee Motivation	Interest in computer-aided estimating and planning reduces as time passes
Changes in Salaries	Pay increases based on improved employee flexibility
Staff Turnover	Increases in interview costs, induction costs, training costs based in the need for skilled human resource

**Table 2. Taxonomy of indirect human costs**

Indirect Organisational Costs	IT Cost Factor
Productivity Losses	Developing and adapting to new systems, procedures and guidelines
Strains on Resources	Maximising the potential of the new technology through integrating information flows and increasing information availability
Business Process Re-engineering	The re-design of organisational functions, processes and reporting structures
Organisational Re-structuring	Covert resistance to change

**Table 3. Taxonomy of indirect organisational costs**



Love *et al.* (Love *et al.*, 2000a) found that management time was the most significant indirect cost experienced by construction organisations. Invariably management time is spent leading, planning, and organising the integration of new systems into current work practices. The result of implementing newly adopted technologies may also force management to additionally spend time revising, approving and subsequently amending their IT related strategies. In addition, a significant amount of resources may also be used to investigate the potential of the IT, and in experimenting with new information flows and modified reporting structures. System support and trouble shooting are other indirect costs that are often overlooked. Indeed, many firms are now finding it quicker and more efficient to employ their own technicians to provide this service. According to Love *et al.* (Love *et al.*, 2000a) this appears to be the preferred option for construction organisations, over the reliance on software vendors, who initially try to solve the problems remotely, and when unable to, then make personal visits that add to the cost of the system.

System support costs can be substantial and therefore needed to be accounted for in the evaluation process. Research undertaken by Wheatley (Wheatley, 1997) found that a third of respondents could not estimate the cost of IT supporting IT in relation to the technologies original purchase price. Those respondents that did provide an estimate thought the cost to be a small fraction of the original cost of acquisition to be less than 20% of their original purchase price.

Another 'indirect' cost may result from employees developing new skills, and therefore increasing their flexibility/overall contribution towards the organisation (Love *et al.*, 2000a). After, employees have developed new skills they may request revised pay scales or leave to go to competitors. Clearly, such 'indirect' costs associated with employee pay and rewards, together with the cost implications of increases in staff turnover need capturing, and bringing into the IT decision making arena.

## **INDIRECT ORGANISATIONAL COST PORTFOLIO**

'Indirect' costs are not simply restricted to human factors but encompass organisational issues as well. Organisational costs are caused by the transformation from old to new work practices, based on the impact of the new system. At first, a temporary loss in productivity may be experienced, as all employees go through a learning curve while adapting to new systems, procedures and guidelines (Remenyi *et al.*, 2000). This also involves employees being trained and training others.

Additional organisational costs may also be experienced once the basic functions of the system are in place. These costs are associated with management's attempts to capitalise on the wider potential of the system at the business and project level. Further costs include management's attempt to integrate information flows and increase its availability.

As pointed out by Hochstrasser (Hochstrasser, 1992), companies with extensive IT infrastructures in place, tend to change their corporate shape, by reducing the number of management levels. This is often achieved by re-defining the role of many management functions, through increasing their flexibility and overall contribution to the organisation. The costs of organisational restructuring are considered to be expensive, particularly if isolated groups within the company resist change, and are unwilling to make the transition. These costs therefore need acknowledging and building into a justification costing structure.

## CONCLUSION

This paper has presented a review of the IT evaluation placing particularly emphasis on complexities and problems often encountered when trying to justify IT from a cost perspective. There has been limited research in the construction on IT evaluation and it would appear that there is a need for construction organisations to approach IT evaluation in a structured and robust way if they are to leverage the 'full' benefits of IT. In particular, IT evaluation research in construction needs to address the indirect costs (human and organisational) associated with the lifecycle IT projects.

While the construction organisations seek to leverage the benefits of IT, they should not underestimate the increasing portfolios of indirect costs that may also occur. As this cost-centric concern increases in importance, construction organisations will need to better position themselves to *identify* indirect costs, thus enabling management to maximise the benefits and control their IT expenditures.

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# An Application of Soft Systems in Determining User Requirements

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## ABSTRACT

*This paper describes the application of the 'Soft Systems Methodology' (SSM) to a real world situation. An investigation was conducted relating to the use of Web based services as provided to a University educational department and conclusions made based upon applying SSM. This paper is an account of this study as derived from an exhaustive SSM application process. The results indicated that there were conflicts, issues and some scrutiny required between particular areas within the department. The Soft Systems approach to system engineering enabled the identification of these issues and a prioritisation of their importance for implementable changes, from a human activity point of view.*

*Keywords: Soft Systems Methodology, Systems Analysis, User Requirements.*

## INTRODUCTION

The Soft Systems Methodology was inspired by the failure of systems engineering when attempts were made to use conventional systems engineering approaches for management problems. 'The 'manager' tries to 'improve' situations which are seen as problematical-or at least less than perfect-and the job is never done because as the situation evolves new aspects calling for attention emerge and yesterday's 'solutions' may now be seen as today's problems.' (Checkland and Scholes, 1990). The method attempts to alter systems theory into a practical methodology, based on the theory that the "whole" is important, when designing systems, and that by negating an analysis by breaking up the "problem" into small sections you actually lose the focus. This is especially so when considering the human involvement in the analysis and design of systems, in part because these systems are complex and the human components may react differently when examined singly to when they play a role in the whole system (Avison & Fitzgerald, 1997).

The design of this methodology incorporates the re-examination of systems ideas in order to link them to the tradition of scientific thinking from which systems thinking purposefully evolved. This approach is based on neither theory nor practice but rather sees each as the source of the other. The SSM has some noticeable benefits for systems engineering. Importantly the focus is on users and their interaction (human activities) with the system in question. This is significant since it allows the analyst to examine, learn and understand the whole human situation as opposed to conventional techniques that concentrate on identifying costs/savings, staffing changes, developing user requirements and identifying equipment and software needs. Soft systems has been developing over a number of years, this can be shown by the following trends in regards to SSM(Checkland and Scholes, 1999):

Stage 1:	1972 Blocks and Arrows
Stage 2:	1981 Seven Stages

Stage 3            1988 Two Strams  
 Stage 4            1990 Four Main Activities

The authors wanted to use SSM to try and determine some key issues in regards to web-based information systems. Looking at how users within an organisational department interact and use web-based information systems. The department analysed was an educational department within an Australian University consisting of 45 staff. This paper is based upon the results of that study.

## SOFT SYSTEMS METHOD

The seven steps of the SSM are depicted in Figure 1.

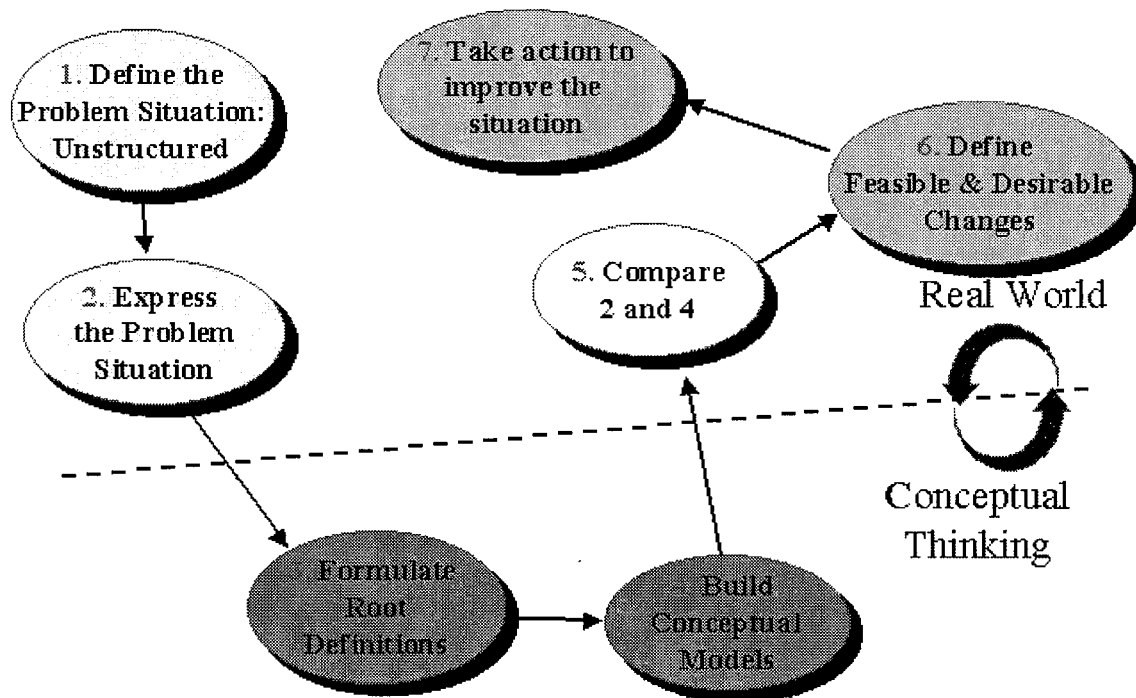


Figure 1: The Seven Steps of SSM

The next sections will detail the SSM approach (based on figure 1) used to analyse the departmental based services. The stages are described at each iteration of the process.

### Step 1 – The Problem Situation: unstructured

The first stage of the methodology are concerned with expressing an unstructured situation. In this case the aim was to uncover and define discrepancies within the department between interacting parties with regard to the Web based services that are provided.

Despite there being some structure to the approach of decision making within the department, there exists some vagueness in terms of what needs to be done and the communication practices currently in place.

Finding out more about this problem involved the following steps:

- Identifying the departments within Computing and Mathematics and parties involved e.g Administration, Teaching, Student;
- Talking to the persons involved interviewing the identified parties;

- Defining communication structures between parties;
- Determining locations of and processes between information sources;
- Gauging views of individuals and prevailing issues.

Typically other additional investigative techniques such as reading current and past reports and other documents would be conducted here.

## Step 2 – The Problem Situation: Expressed

In stage two the situation has been represented pictorially, using a device called a rich picture. This reflects some of the *richness* of the circumstances being examined. Based on interview responses, a set of attributes were derived of the department. These included structure, people, processes, conflicts, issues, scrutiny. The rich picture of the department can be found in figure 2 at Appendix A.

These attributes were integrated to form the final rich picture, (see figure 2) developed by concatenating the individual rich pictures from each subsystem. The result of these two stages was the binding of all the collected factors that influence the Computing and Mathematics Department and the creation of a complete picture indicating what is really going on. From here the investigation temporarily leaves the real world and the systems thinking phase is entered in stages three and four.

## Step 3 – Root Definitions of Relevant Systems

Step three of SSM requires the extraction of what is termed a root definition. The derivation process is based on first creating a CATWOE chart which basically gives the analyst an overview of a system's characteristics (Patching, 1990). CATWOE is an acronym that covers the six following attributes of a system.

### Explanation of CATWOE Chart

*C = Customer – who would be victims/beneficiaries of the purposeful action?*

*A = Actors – Who would undertake the activities?*

*T = Transformation Process – What is the purposeful activity?*

Expressed as: Input  $\Rightarrow$  Transformation process  $\Rightarrow$  Output

*W = Weltanschauung (Worldview) – What view of the world makes the definition meaningful?*

*O = Owner – Who could stop this activity / make or break the system?*

*E = Environmental factors – What factors affect the environment?*

The authors have included an illustrative CATWOE, there were a large number developed to describe the departmental functionality and sub systems.

*The (A) are mainly influenced by the (O) and have the task of completing (T) within (W) Constraints include (E). These tasks are completed for the benefit of (C).*

### Teaching Staff - CATWOE Chart

*C = Students and Teaching Staff*

*A = Teaching Staff*

*T = Use of web-based services and personal consultation as well as other information services to as is required*

*W = To provide the most effective and efficient education and research practise to students and other staff*

*O = Head of School*

*E = Time, financial, technological and school enforced restrictions*

### Teaching Staff - Root Definition

*The (Teaching Staff) are mainly influenced by the (Head of School) and have the task of (providing the most effective and efficient education and research practise to students and other staff) by (use of web-based services and personal consultation as well as other information services as is required). Constraints include (Time, Finance, Technology and School enforced restrictions). These tasks are completed for the (Students and Teaching Staff's) benefit.*

### Step 4 – Conceptual Modelling

Step 4 of the SSM is reliant on discussion that leads to the creation of what are called conceptual models. The building of conceptual models is based on taking systems and mapping them into what is called a Human Activity System (HAS). Each HAS is expected to have approximately 7 +/-2 activities involved which are depicted as being linked pictorially by arrows. There is no set pattern or model to these HAS and they are subject to change. It is expected that the HAS will form a relationship which is able to follow the life of a process. The analysis that took place led to the creation of six conceptual models and a conceptual model key. The complete conceptual model is shown in figure 3 at Appendix B.

### Step 5 – Comparison of Conceptual Models and Problem Situations

During the fifth step of SSM a comparison between the rich picture and the conceptual models took place and from this an overall agenda for change was derived. Other changes that are required during this step are adjustments to root definitions and conceptual model based on findings in this step. The findings showed that no changes were required within the generalised root definitions and only minor, access related as opposed to process related steps were deemed changeable within the conceptual models. The systems' conceptual models (Soft Systems - Step 4) show how, in a 'perfect world', the department would be conducted with regards to web and computing services. Table 1 depicts the problems and concerns which can be derived from reading and understanding the real world representation of the system, the rich picture (Soft Systems - Step 2).

Section of School	Associated Problems and Concerns
Teaching	<p>ITS – Conflict, Issues</p> <ul style="list-style-type: none"> <li>• <i>Access to STUDENT DB is slower via the web than server</i></li> <li>• <i>Video link lacking technology</i></li> <li>• <i>I must ask ADMIN for access to academic history</i></li> <li>• <i>Slow DB access</i></li> <li>• <i>WebCT—class sizes? Permission to modify</i></li> <li>• <i>Third party required for info update</i></li> </ul> <p>• <b>Slow access—too many users</b></p> <ul style="list-style-type: none"> <li>• <i>Report printing from Callista is poor</i></li> </ul> <p>Technical Support – Conflict, Issues</p> <ul style="list-style-type: none"> <li>• <i>Procedures are “ad hoc” “no scheduling” of Web updates</i></li> <li>• <i>Slow DB access</i></li> <li>• <i>Slow access—too many users</i></li> </ul>

**Table 1: Teaching subsystem for department and associated problems**



The following list is an extraction from a larger agenda and is included for example purposes. This agenda is based on the problems and concerns that were highlighted in the previous four steps in this methodology. The list is numbered for future reference to the problems and is in no particular order.

### Agenda for Change

1. Possible video link upgrade.
2. Standardisation of e-mail reply times between groups so that communication is more efficient.
3. Look at ways of standardising, informing and scheduling with regards to software image updates.
4. Allow web updates to be completed by authorised parties as opposed to requiring third parties to complete the changes.
5. Look at upgrading the report printing that is available currently from the student database

### Step 6 – determine desirable and feasible changes

The sixth step of SSM requires discussion and presentation of the desirability, acceptability and implementability of solutions to problems that were listed in step 5. The following table is based on the agenda for change in step 5 with the numbers referring to the corresponding problems as illustrated by table 2.

Prob.No.	Desirable	Acceptable	Implementable	Comments	Code
1	➤➤	STA	➤➤	Currently this medium is sub-standard.	Blue
2	➤➤	➤➤	↔↔	Not easily doable. Reply time is dependent on too many human factors.	Red
3	➤➤➤➤	STA	↔↔	Standardising this process, may not allow for change to occur, i.e., Software Updates	Red
4	➤➤	STA	↔↔	Security requirements outweigh the need for this capability.	Red
5	➤➤	➤➤	STA	Resource & budget limitation feasibility limitations	Gray

➤➤ = Positive Attribute	↔↔ = Negative Attribute	STA = Subject to Authorisation
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**Table 2: Presentation of the desirability, acceptability and implementability of changes**

If a cross were received in any of the classifications it came about mainly because of discussion which led the group to believe the action would result in an overall negative change to the school of computing and mathematics. A tick basically meant that discussion allowed us to see the positive side of a particular change within the school. Two ticks meant that discussion about a particular attribute showed an extremely positive reaction would occur if this change was implemented. A subject to authorisation (STA) tag came about due to discussions where our group believed that a particular problems attribute would be better discussed within particular committees as opposed to decision being made solely on the basis of our groups limited knowledge regarding certain specialised situations.

A colour coding scheme was also used to help classify the problem solutions in to four main groups as shown by Table 3.

Classification	Colour
Not implementable. Possibly desirable and/or acceptable.	Red
Desirable and/or acceptable but implementation STA	Gray
Desirable and implementable. Acceptability STA	Blue
Positive in all attributes	Green

**Table 3: Solution prioritisation colour code scheme**

These tasks were then prioritised in such a way so that any green coded tasks were grouped and ordered, and so on through blue and grey coded tasks. Red coded tasks were dropped from consideration due to the aforementioned characteristics of these tasks. After completing these analyses the group then discussed what changes needed to be made to the root definitions or conceptual models. From this discussion it was concluded that no root definition adjustments were in order and only minimal concept model changes were required.

### Step 7 – Take Action To Improve The Situation

Step 7 requires a final implementation order of any changes recommended in the sixth step. This must include details of where responsibilities lie for correct and efficient completion of the set tasks as well as justification of the ordering of the tasks. The problem numbers for the tasks still apply within this table. A selection of tasks derived from a larger prioritised table is depicted in Table 4. The responsibility column shows the groups within the school will be responsible for the tasks to be completed.

Priority	Problem Description	Responsibility	Colour
3	Regular and scheduled renewal of student and staff information such as e-mail address, home address, phone no. Etc.	Administration CM tech. supp	Green
4	Look to increasing access capabilities to students and staff.	CM tech. supp. Web committee	Blue
7	Possible video link upgrade for improved communications.	CM tech. supp. Web committee	Blue
9	Look at upgrading the report printing that is available currently from the student database, Callista.	ITS CM tech. supp. Administration	Gray

**Table 4: List of prioritised solutions to problems**

The major reason for ordering in this fashion was to make sure the most readily possible solutions were given a higher priority than tasks that were less likely to occur for many reasons such as lack of funding or the lack of likelihood of the project going ahead at all. Secondly the tasks were ranked on the way they would assist students to improve their study, as this is the major role of the school as designated within the root definitions. Administration based tasks tended to be rated on a much lower priority level.

It is important to remember that the SSM can have a range of outcomes from a fully implementable set of changes along with plans and quotes etc. to a set of recommendations based on discussion with both system users and amongst a group. In this case the outcome was a simple set of recommendations based on systems analysis intuition and no timetabling or scheduling other than job prioritisation will be offered.

## CONCLUSIONS

The use of SSM has shown that there were far more problems, concerns, issues and conflicts within the department than would be expected. The models, both real world and conceptual, that were derived will be quite helpful for any future overviews that may be taken by any other analytical group. There were a number of problems that were highlighted throughout the analyses and these have been presented in a prioritised list of possible changes. SSM is effective in helping to understand where problems occur and where conflict exists but, tends not to show where good communications and policy examples are in place, which could assist planning.

As mentioned within the text, a more inclusive consultation schedule over the duration of the project would have been far more useful to the outcomes of the analyses. This more inclusive approach would have allowed more scope for understanding the changes that were depicted as being 'Subject To Authorisation' (STA). Another positive that would have eventuated from this improved understanding is that recommendations that were made could also have been carried on into the scheduling and possibly the implementation stage.

Overall, this project has allowed for a far more advanced understanding of exactly what processes, especially web-based processes, take place within the department analysed. To this end the SSM as a way of conducting systems analysis and obtaining user requirements, will become ever so more apparent for managers dealing with undefined systems in an unstructured environment.

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*Rich Picture for School of Computing and Mathematics  
Web based Services*

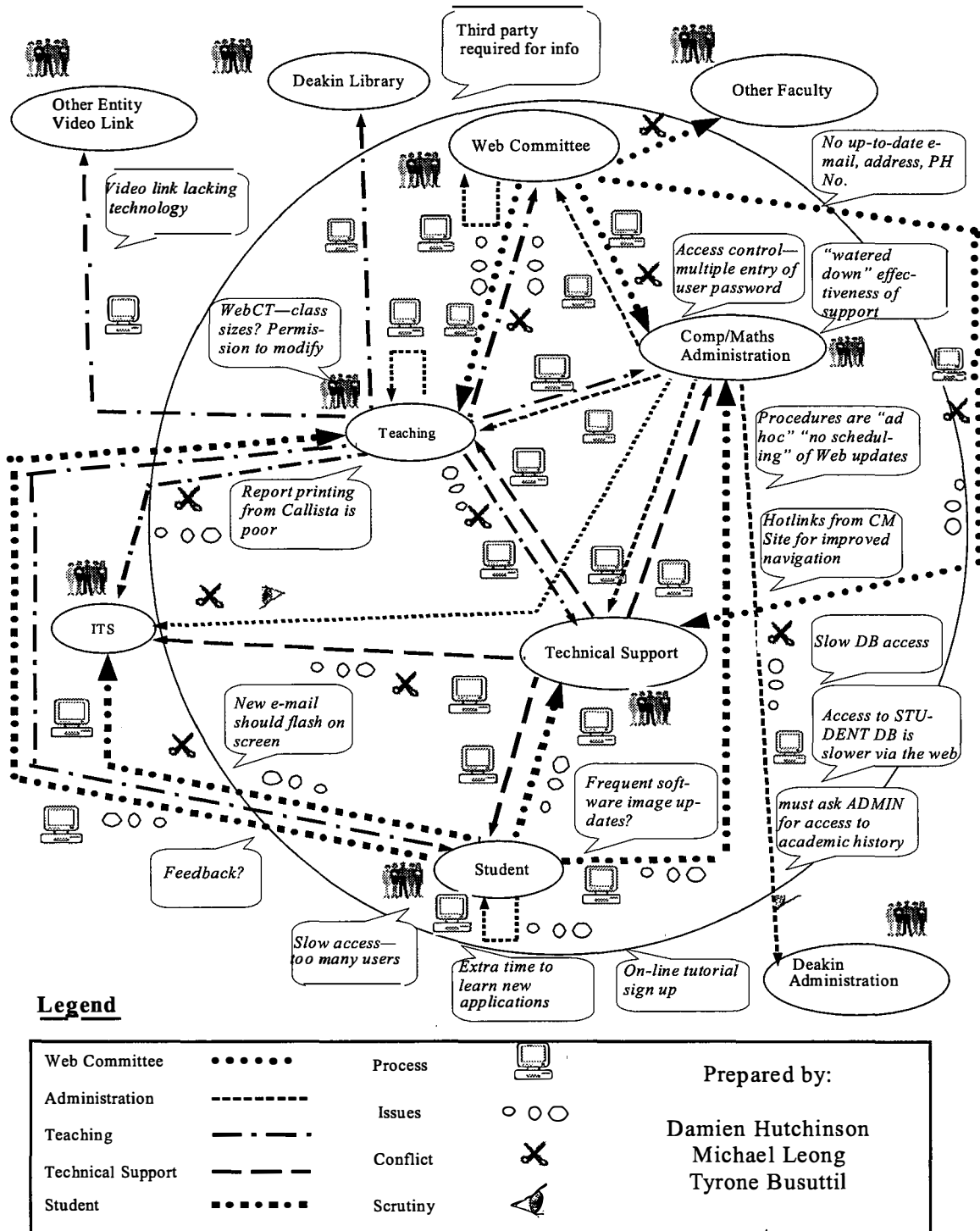
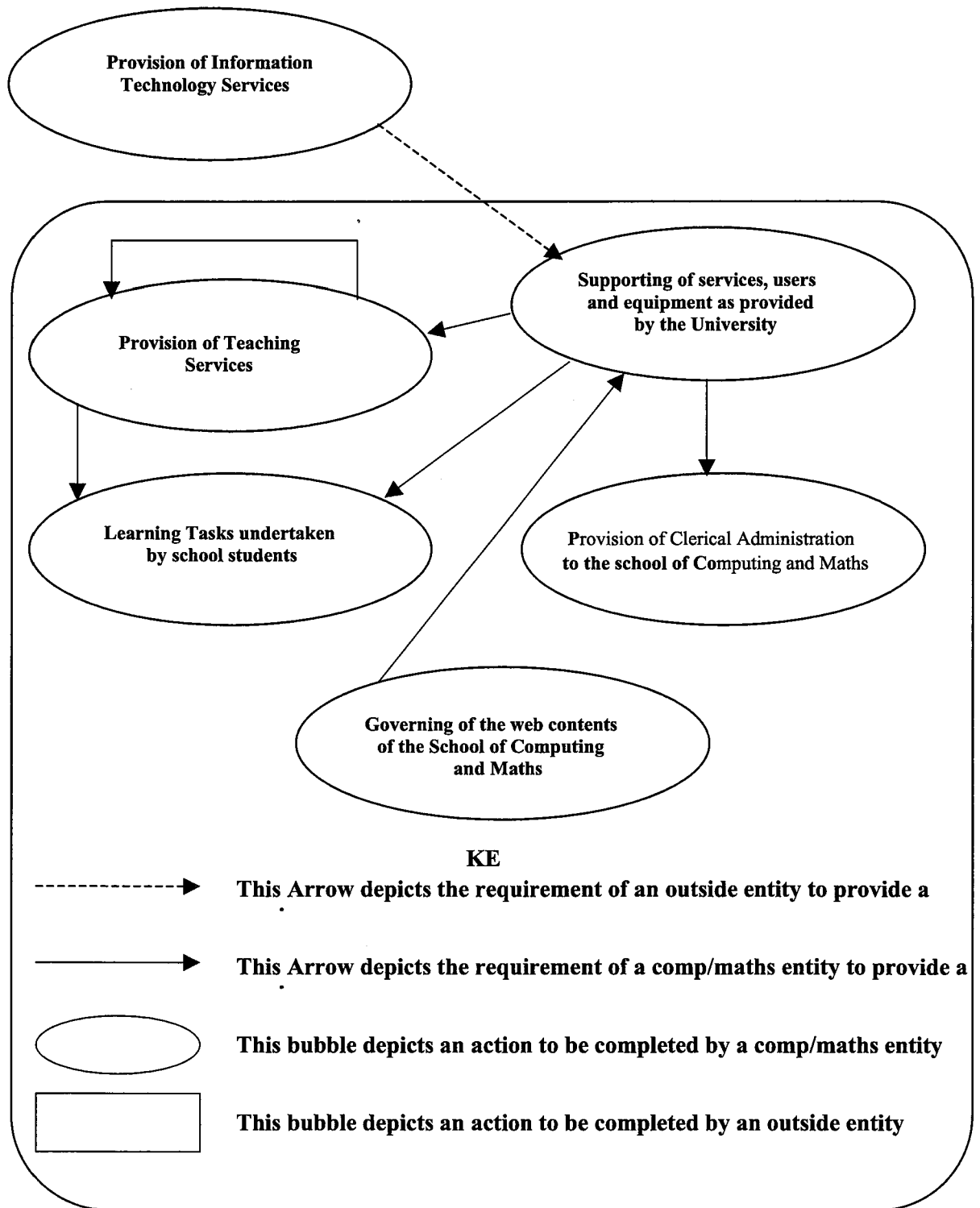


Figure 2: Rich Picture of current situation as derived from interview responses

**Appendix B**



**Figure 3: Overall view of the conceptual model**

# Local Rules: Some propositions for their establishment and continuation

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## ABSTRACT

*This paper is based on findings from field research that identified local rules in organizations. It discusses these findings into a set of propositions that may explain the operational dynamics of local rules and the processes by which local rules survive or become extinct. The central metaphor for this discussion is that of the fitness landscape developed by Kauffman (1989) and Holland (1989). This metaphor provides a useful framework for understanding how stable and predictable patterns of behaviour develop in organizations. It is proposed that local rules have localities of action on fitness landscapes and that there is a set of conditions for their establishment and continuation based on the interactions across the locality boundaries. It is further proposed that there are conditions, characterised by co-adaptation, under which rules will survive in relatively stable forms and other conditions, characterised by competition, under which local rules change.*

*Keywords: Local rules, adaptation, locality fitness landscapes*

## INTRODUCTION

This paper sets out to examine behaviour in organizations using the theory of local rule adaptation on fitness landscapes. Fitness landscapes and local rule adaptations by (Kauffman, 1995) provide a theoretical framework for understanding dynamic interaction in biological and social systems. A fitness landscape is the domain in which the fitness of any behaviour to survive is tested. Organizations comprise of sets of interconnected fitness landscapes on which organizational behaviour plays out. It is the testing of behaviour against fitness criteria that ultimately determines what actually happens in organizations. Local rule theory provides an integrative framework in which dimensions of the organizational landscape, such as leadership, morale or organizational structures, can be seen as determinants of the survival or extinction of behaviour.

Local rules have been seen as an organizing principle in the behaviour of wasps (Putters and Vonk, 1990), neural assemblies (Kerszberg, Dehaene, and Changeux, 1992), broad-band transport networks (Grover, 1997) In this paper it is suggested that local rule theory can be applied to organizational behaviour. In this context, organizational behaviour is seen as dynamic and competitive, where competitive means selective in relation to the behaviours of agents. Agent is a term frequently used in the self organization literature (Epstein and Axtell, 1996). Here however, "individual" will be used as a more appropriate term. Local rule theory also suggests that behaviour is emergent, that is, constantly changing in relation to the immediate environment. It further suggests that the emergent behaviours are the current "best fit" between the individuals and their immediate environmental demands. This behaviour emerges on an organizational landscape termed a fitness landscape. It is on fitness landscapes that adaptive behaviours create fitness peaks, where adaptive behaviours are most effective for the individuals that populate the landscape. The landscape is the organizational setting and the adaptive behaviours those behaviours that maximise payoffs to all individuals in the organization. It is important to recognize that while this applies to all individuals in an organization, the payoff for given individuals may not be the same.

Holland (1989) stated that many organizations were intrinsically dynamic, far from global optimum (always room for improvement), and continually self-organizing through the use of local rules that were the individual's attempts at adaptation to environmental demands. It is this continuous self-organization that maintains the organization in a state of dynamic equilibrium. Drawing on Holland (1989), it is argued that all behaviour is adaptation to some environmental imperative. It follows that such behaviour is also a response to an immediate, or local, set of conditions. The behaviours that emerge are termed "local rules".

Behaviour is an emergent property of the interaction between the local environment and the individual's survival instincts. However, survival has a broader definition than in the animal kingdom. Here survival behaviour is designed to optimize the chances of such "survival" imperatives as keeping one's job, earning more money, receiving a promotion, avoiding being injured or finishing work in time to pick up the kids. Each of these imperatives represents a peak that the individual must climb and these peaks are part of the landscape that individuals inhabit.

## **RELATED WORK SERVING TO VALIDATE THIS RESEARCH**

Related work in the field of agent-based modeling provides cross validation of this approach.. Much of this work demonstrated the application of specific functions, such as trust or co-operation, in the context of some organizational structure or policy. The specific functions are the equivalent of local adaptive rules and the organizational factors are the equivalent of landscape conditions. Moreover, such approaches allowed for an understanding of the complex, ongoing dynamics of organizations. Prietula and Carley (1999) suggested that organizational behavior could be viewed as "emergent behaviour from the collective interaction of intelligent agents over time" and called for "better operations of certain organizational phenomena" (1999, p. 41).

Sociologists would observe the interaction of local rules as "weak ties". Granovetter (2000) sought to link individual behavior to macro-sociological phenomena and commented that most network analysis dealt with "strong ties, thus confining their applicability to small, well defined groups" (2000, p. 41). He demonstrated that, by contrast, weak ties helped explain the interaction of small-scale dyadic ties. In sociological terms, local rule propagations would be the result of weak ties. Earlier, Granovetter (1973) commented "emphasis on weak ties lends itself to discussion of relations between groups and to analysis of segments of social structure not easily defined in terms of primary groups" (1973, p. 1360).

Kauffman (1989) used “fitness landscapes” to describe the space in which the rules or adaptive behaviours evolve. The evolutionary landscape is multi-dimensional with parameters that consist not only of the normal three dimensions of length, breadth and height, but also other dimensions that define the landscape such as climate, terrain, vegetation and density of species. In an organizational context, the landscape could be defined by dimensions as diverse as organizational structure, reporting relationships, Occupational Health and Safety legislation, rates of pay, and the physical layout of the organization. The dimensions of a landscape are invariant over lengthy periods of time. The contours of the landscape within these dimensions consist of peaks and valleys, which are, constantly evolving as the individuals in the landscape climb peaks or descend into valleys. Kauffman (1995) terms the peaks “fitness peaks” on which the payoff, or adaptive potential, for behaviour can be optimised. As an individual climbs such a peak, fitness conditions for other individuals on the landscape will change, both for better or worse, creating new peaks and valleys. Thus, while the dimensions of the landscape are relatively invariant, the contours of the landscape are a result of the interaction between the adaptive behaviours of the individuals on the landscape. The emergent behaviour on these landscapes is self-organizing around the imperatives of the local environment.

In such a system organization and order is an inevitable outcome of the dynamic interactions on the landscape. Kauffman, (1995:71) terms this “order for free”. Here stable networks of successful local rule behaviours constitute the fundamental operating structure of an organization. It is this structure, defined by the fitness peaks of the landscape, which sets the limits for optimizing organizational performance. The extent to which local rule behaviour sets the limits on organizational performance is a central concern of research into local rule behaviour. (Haslett, Moss, Osborne, Ramm, 2000)

In a self-organizing system, it is useful to distinguish between individuals who are “landscape setters”, those people who have the power to establish the dimensions of the landscape, from “landscape adaptors”, those people who must adapt to such dimensions but whose adaptations set the contours of the landscape. The most effective role that management can take is that of landscape setter, setting the invariant dimensions of the landscape, rather than landscape adaptor, involved in the local interactions and adaptations. Organizational performance will be optimised by the extent to which the landscape dimensions are set by the organization considerations and sub-optimised by the extent to which the landscape dimensions are set by non-, or extra-, organizational considerations. Haslett et al (2000) demonstrated the impact of nationally set wage rates and conditions on local behaviour in mail sorting centres where work rates were varied to climb local fitness peaks created by national wage regulations.

Conventional wisdom would propose that performance is determined by organizational structure, set from the top, shaped by some grand design. Much of the organizational redesign of large corporations in recent years reflects this strong belief that top down re-organization will improve organizational performance. In contrast, local rule theory suggests that organization, in the forms that materially affect behaviour, occurs at a local level and is self-organizing.

The extent to which any consistent structured behaviour occurs across large sections of an organization will be entirely determined by the extent to which certain sets of behaviours are successful adaptive mechanisms in the specific ecological context. This paper suggests that local rules determine behaviour and that such behaviour is always sub-optimal, because of the complexity of the landscape dimensions. It also suggests that the extent of sub-optimization is defined by the operation of local rules. It is argued that understanding the ecological context of behaviour places organizational behaviour in framework that is on one hand dynamic and ever changing but on the other is characterised by long periods of stability. The following section outlines theoretical constructs for that understanding.



## THE CONCEPT OF LANDSCAPE, LOCALITY AND LOCALITY

This paper proposes that local rules operate within localities and can be defined by the concepts of size, density, generative power (competitive-adaptive and co-operative-adaptive), and robustness. These concepts are described in the next section of the paper.

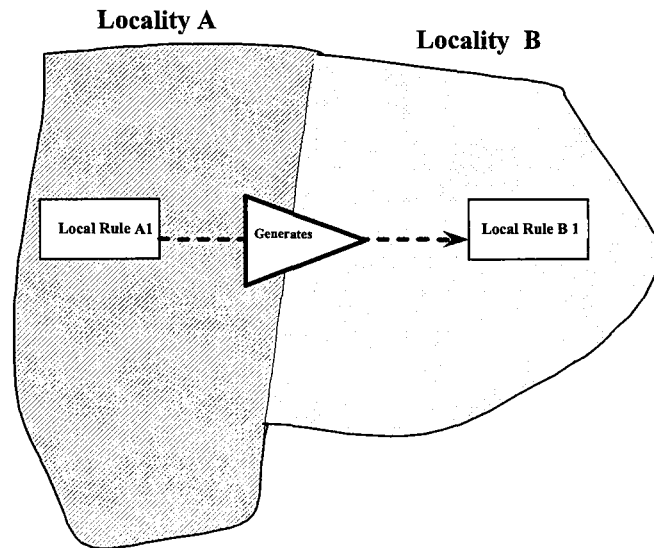
Locality size can be defined by the number of individuals who use the rule. A local rule that is used by only one person has a smaller locality than a second local rule that is used by a larger number of people. Most importantly, locality size will determine the persistence (or stability) of the rule. If one person is using the rule, that rule may be influential in terms of its interactions but its persistence will be related to that individual's tenure. A small locality may also have a very high level of interaction depending on the hierarchical position of the individual enacting the rule. Nonetheless, the life expectancy of such rules is limited to the enactor's tenure. Walker and Haslett (2000) reported the impact of a medical registrar's local rules on hospital admissions and the financial performance of the hospital. Here, the tenure of a registrar was usually six months and each new incumbent brought a new set of local rules, each set of rules generating different patterns of patient admissions.

Density of locality is the number of situations in which the rule is applied relative to the number of situations where it could be applied. A dense locality would have a high ratio of number situations in which the rule is applied to the number of situations in which it could be applied. The medical registrar's locality was small, (limited to one person) and dense because the rule was applied consistently.

The impact of local rules is described by their generative power, which is a measure of extent that a given local rule generates other local rules and adaptive behaviours in different localities. Generative power is therefore, also a measure of the extent to which a local rule changes the contours of the fitness landscape. Rules with low generative power are likely to be stable as they do not change the fitness landscape by generating new behaviours in individuals affected by the local rule. In this situation, competition and the threat of extinction to the rule is low, leading to stability and continuity in the local rule. In this situation there is limited interface and interaction between localities.

High generative power (and extensive interface and interaction between localities) produces two types of response: competitive-adaptive and co-operative-adaptive. In the case of competitive-adaptive generation, the local rule generated in one system will alter the fitness landscape of a second to the extent that a response will be required from the individual or individuals in the second locality (as shown in Figure 1). Here Local Rule A1 generates across the interface between the two localities resulting in adaptation in the form of a new rule, Local Rule B1.

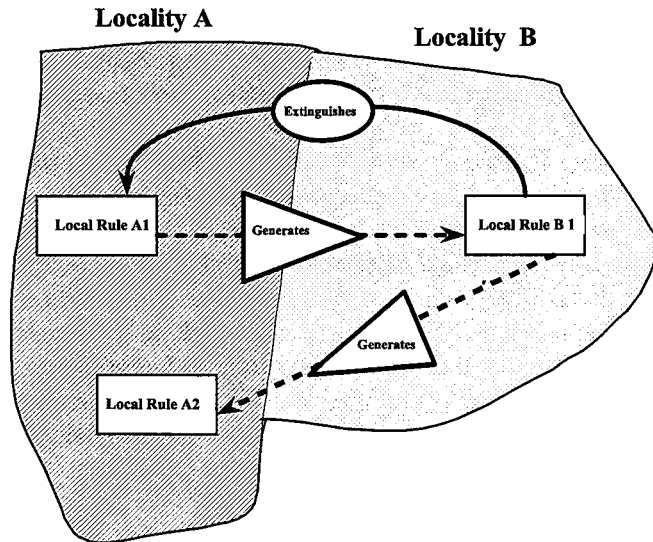
Figure 1: Rule generation across locality interface



In this example of generation, Local Rule A1 has generated Local Rule B1 in Locality B as a competitive response. Local rule A1 represents a competitive threat to Locality B and some response will emerge. The generation of Local Rule B1 is therefore termed competitive adaptive and Local Rule B1 is aimed at maximizing payoff, or the chances of survival, in the face of the competition from Local Rule A1. If the Local Rule B1 prove to be a successful adaptation, it will continue as a new local rule in Locality B. Haslett and Osborne (2000) observed local rules in a Kanban system. The managers local rule ( Local Rule A1) involved changing ordering priorities for parts needed on an assembly line to avoid criticism from senior management. This change of priorities meant that assembly workers regularly ran out of parts. The assembly workers' local rule ( Local Rule B1) was to take more parts than they needed and hide this buffer stock under their work bench.

Figure 2 shows the continued dynamic interaction across the interface between localities in competitive-adaptive generation. Local Rule B1's success extinguishes Local Rule A1 but also generates Local Rule A2 which is the competitive response to the success of Local Rule B1. Dooley (1997:85) described generation as a second order change of a schema "where there is purposeful change to better fit observations and extinguishing as third-order change where a schema survives or dies". The process of competitive-adaptive generation represents the on-going dynamic involving the constant evolution of new local rules.

**Figure 2: Competitive-adaptive rule generation across localities**

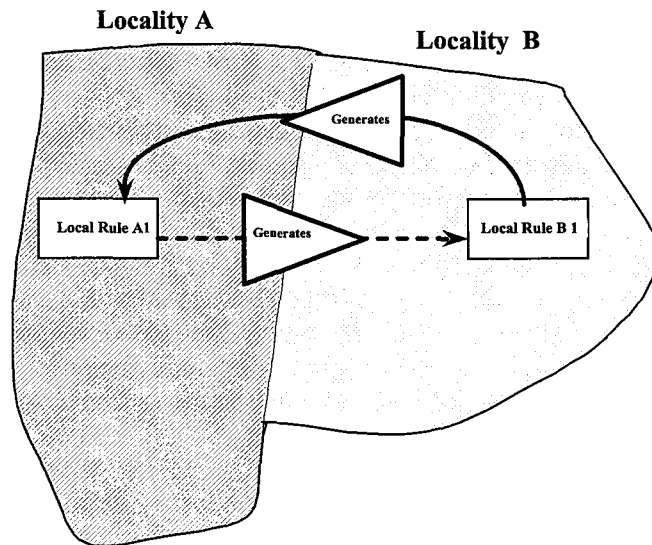


Haslett et al (2000) reported competitive adaptation in mail sorters in six geographically separated mail centres slowing their work rates to maximise payment through overtime or increasing them to minimise time at work ( known as a “fly day”). The preference was for increased overtime but there were conditions where minimising work time was always the preferred option. This local rule could effectively add 50% to weekly pay rates. This was Local Rule A1. The management’s response to “excessive” overtime payments was to employ more staff. This was Local Rule B1. This raised staff levels to a point where work loads were sufficiently light for every day to be a fly day, Local Rule B2, and sorters used their newly acquired free time to get a second job to make up for lost earnings in the mail centre.

Co-operative-adaptive generation is in contrast to competitive-adaptive generation. Here Local Rule A1 would enhance the fitness of Local Rule B1 by providing an opportunity for increased fitness rather than the threat of decreased fitness.

While competitive-adaptive generation can be seen as a negative feedback loop where the newly generated Local Rule B1 would seek to balance the impact of Local Rule A1, a co-operative-adaptive generation would, in contrast, be a positive feedback loop where each rule enhances the fitness of the other. This is shown in Figure 3 where the two local rules re-inforce each other’s behaviour.

Figure 3: Co-operative adaptive rule generation across localities



In the mail centre, supervisors took no active role in counteracting the slowing of work rates by sorters. This was because when sorters slowed their work rates to get overtime, supervisors automatically got overtime. It is worth noting that supervisors had no mechanism for creating overtime. Here the slowing of work rates and the supervisors turning a blind eye constitutes two reinforcing local rules.

The concept of generation leads to the final definitional aspect of local rule theory: that of the robustness or fragility of local rules. Robustness and fragility refer to the likelihood of the continuation of the local rule. A local rule is robust when its generation is co-operative-adaptive and it creates a positive feedback loop that serves to stabilize the fitness landscape of other interacting, rules thus ensuring their continuation.

In contrast, a local rule is fragile when its generation is competitive-adaptive. Fragility is indicative of the behaviours being unlikely to persist. Here, because the rule is in a negative feedback loop, where it seeks to extinguish the impact of a rule in another locality. If a generated rule is successful, it will reduce the payoff to the original rule generator and this in turn will produce a new competitive response across the interface. Thus a rule is fragile in that its very success led to its extinction. Robustness and fragility are related to how long a local rule persists not to the payoff that is secured. Highly successful local rules can provide large payoffs but be fragile and hence short-lived.

In summary, the measure to be used for defining dimensions of local rules will be:

1. The initial conditions for a fitness landscape on which the locality of a local rule will be defined by multiple dimensions. These will be relatively invariant over time. They will be interactive with propagating local rules.
2. The measures of locality will be: size, the number of individuals using the rule, density, and the number of situations in which the rule is applied relative to the number of situations where it could be applied.
3. The measures of generation across the interface of localities will be competitive adaptive and co-operative adaptive. Robustness and fragility describe the longevity of the rule based on the nature of generation.

There are three aspects of this work that need to continue. The first is building the data bank of examples. The second is to develop and test some quantitative measures of local rules and their localities. The third is to develop a deeper understanding about the nature of the interactions across locality interfaces.

The application of local rule theory to organizations provides an integrating framework for management theory. For example, the extent to which leadership, group membership or organizational structure (all common aspects of management theory) can be assessed by the extent to which they set the dimensions of local landscapes. It also provides a framework for understanding organizational life as a set of dynamic and emergent interactions in which some aspects of organizational life are stable and others not. Understanding management interventions as competitive adaptive local rules can provide insight into the reasons for the possible failure of such interventions. Understanding that management interventions need to be at the level of setting the dimensions for the fitness landscape can lead to increasing the chances of intervening successfully.

Most importantly, local rule theory suggests that behaviour is locally determined and that there is no grand management plan which co-ordinates and controls the life of an organization. Individuals work in a local environment where the pressures exerted by management may only be a small proportion of those to which they must respond. Local rule theory suggests to managers that their interventions in organizations must be at the level of landscape dimension and that even then their success will be limited because many of the dimensions of the landscapes of individuals are beyond management's control.

The extent to which we have come to believe organizations can be managed may well turn out to be a myth as we develop a deeper understanding of the role of local rules and self-organization in organizational life. Espejo, Schumann, Schwaniger and Bilello (1996) observe

"Lower level primary activities create and do what people at higher structural levels could not discover and do by themselves, it is beyond their capacity. This is the meaning of autonomy at all levels. Each primary activity creates and responds to chunks of complexity of its own and strives for its own viability in the same way as the parent activity strives at a more global level" (pg 110).

This research on local rules demonstrates in detail how the striving for viability takes place. The challenge for management is make viability at the global level closely related to viability at the local and autonomous level. Carley, Kjaer-Hansen, Newel and Prietula (1992) found that in some agent-based models, increases in agents capabilities could degrade organizational performance.

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# Models of Governance: a Viable Systems Perspective

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## ABSTRACT

*This paper suggests a framework for examining governance issues spanning the corporate, public and nonprofit sectors that draws on existing frames-in-use, and that reflects the systemic communality apparent within varied attempts to describe and effect change in governance. The paper surveys alternative conceptualisations of governance that have surfaced in the academic and practitioner literature and draws attention to the cybernetic and systemic features of diverse views of governance. Beer's viable systems framework is used to reinterpret alternative views of governance and to suggest a means of diagnosing the completeness/coherence of governance systems.*

*Keywords: governance, governance systems, corporate governance, viability, viable systems*

## INTRODUCTION

This paper begins by outlining a seeming diversity of views and conceptions of governance. Then, following a brief resumé of Beer's work, these views will be examined and reinterpreted using Beer's systems framework. The paper will conclude with some observations on the usefulness of Beer's framework in understanding the systemic roles and functions required of governance in determining the viability of organisations.

## Issues in Governance

Jessop (1998: 29) claims that the notion of 'governance' has only recently entered what he terms the 'anglophone social science lexicorn'. Yet even so, he states that in its short life, its usage has been eclectic, diverse and 'pre-theoretical'. Kay *et al.* (1995: 84) comment similarly that whilst issues of governance may have existed for as long as there have been social institutions, the now common-or-garden term 'corporate governance' did not emerge until the seventies.

Common conceptions of governance connote not only government and governing, but also the activities of governing boards and bodies, the terms often being used interchangeably (Stoker, 1998: 17). The opinion of Maw *et al.* (1994: 1), based on their practitioner experiences, that '(c)orporate governance is a topic recently conceived, as yet ill-defined, and consequently blurred at the edges', is somewhat in keeping with these and many other views, and with empirical findings that describe corporate boards as 'complex, dynamic human systems charged with an ill-structured set of responsibilities' (Demb *et al.*, 1992), findings which have been endorsed by Cadbury (1999: 15), and which have a counterpart in the nonprofit sector (Middleton, 1987: 141). The implicit criticisms of the lack of a common view, or the lack of a commonly accepted view, and perhaps the lack of rigour in defining governance, have led to different research agendas amongst academics and practitioners.

Since the seventies, interest in corporate governance has been catalysed by considerable media attention given to poor company performance, corporate failure, inappropriate accounting/audit practices, excessive remuneration packages for senior managers and executive directors, insider trading, pension fund mismanagement etc. But, as implied by Kay *et al.* (1995: 84), such events are not just recent phenomena, and much of the increased scrutiny can be attributed to the advent of harsher economic conditions that have drawn to the surface these manifestations of underlying corporate frailty, weaknesses or excesses.

Growing interest in governance can also be attributed to enhanced awareness by those organisations that operate in an international context, of the different governance practices that exist in an increasingly global corporate sector operating in global markets (Witherell, 1999: 78; Lannoo, 1999: 270; Cadbury, 1999: 13). Additionally, the extent to which governance issues pervade society is exemplified by the behaviour of organisations in the voluntary or non-profit sector, and by their perceptions of the role and importance of governance. Many leading sports bodies have restructured their governance processes voluntarily in recognition of a need to bring about greater organisational effectiveness (Davies, 1997), accepting the notion that performance is predicated on effective governance (Schlefer, quoted in Byrne, 1998: 82-85). Others have engaged in reforms of the governance and management structures, for example, the Football Association in England, to effect change to the balance of stakeholder representation and stakeholder interests, and to limit any potential abuse of executive power. At the European level, the erstwhile success of UEFA in developing its marketing, commercial, and financial strengths, followed by the collapse of its marketing agency in 2001, has focused attention on its governance processes, particularly the relationship between governors, executive management and their agents. Indeed, the changes that are taking place in the world of sport reflect a climate that mirrors the movement for reform of corporate governance described by Tricker (1984), Cadbury (1992). In an interesting comparison to governance issues arising in sport, Hampel (1998: 9) contrasts the perspective of his report to that of earlier work (Cadbury, 1992; Greenbury, 1995). He suggests that whilst their approach and guidelines 'concentrated largely on the prevention of abuse', responding to 'things which were perceived to have gone wrong', his work was equally concerned with the articulation of principles of corporate governance that would make a positive contribution to organisational life. The collective result now appears as the combined UK code on corporate governance (Parkinson *et al.*, 1999: 101; Lannoo, 1999: 283). Similar initiatives have taken place worldwide.

## **GOVERNANCE – AS ACTIVITIES, FUNCTIONS, NETWORKS AND SYSTEMS**

Maw *et al.* (1994: 3) have conceptualised corporate governance as a complex of relationships – involving duties and obligations - between the board, its shareholders, financiers, customers, employees, auditors and regulators. Based primarily on substantial practitioner experience, they too, have developed a prescriptive framework - a suggested code of practice for boards, favouring compliance - to guide boards in meeting their 'a priori' duties, and legal obligations. However, somewhat differently, Demb *et al.* (1992) have sought empirically to discover how board roles relate dynamically to the internal and external forces impinging on the organisation. They take a systems view and see boards as part of a wider system of governance, beyond duties and obligations.

Demb *et al.* (1992) conceptualise a governance system wherein a board, as a sub-system, has an integral, interdependent role interacting with, and being influenced by three other sub-systems – the wider regulatory system, the system of ownership, and the societal system. They argue that '(c)orporate governance is the process by which corporations are made sensitive to the rights and wishes of their stakeholders', a stance disputed by Argenti (1997), who acknowledges shareholders, as owners, to be the only legitimate stakeholders. We note that Parkinson *et al.* (1999: 101) suggest that the three major reports on corporate governance in the UK (Cadbury, Greenbury and Hampel) were predicated on the shared assumption that 'governance is understood to be about the relationship between shareholders (ie the owners) and managers'. Such debates that have taken place in the



literature often reflect different perspectives of the nature of governance and of what constitutes an appropriate balance of these interests and activities.

Others have offered similar notions to Demb *et al.* (1992), outlining 'governance frameworks' or 'systems of governance' within which organisations operate. Cadbury (1998:2) describes a framework structured by interacting forces: by the force of law impacting upon organisations; by the regulatory forces of, for example, the Stock Exchange; by shareholder meetings and by the force of public opinion. Allison (1998: 29) has similarly commented that 'the system of contemporary world governance in sport' is also one of complex interdependence - between international and national governing bodies, international law and the courts, the media, commerce and business, the fans and the public etc. Worthy *et al.* (1983) offer yet a similar view that governance is 'concerned largely, though ... not exclusively with relating the corporation to the institutional environment within which it functions.' Issues of governance for them include 'the legitimacy of corporate power, corporate accountability, to whom and for what the corporation is responsible, and by what standards it shall be governed, and by whom'.

The implication is that discussing governance and governing boards in terms of structural elements - size, committees, roles, meeting frequency, board fees, chairman and CEO relations - may be necessary, but not sufficient to build understanding of the governance processes that facilitate effective functioning (Demb *et al.*, 1992; Cadbury, 1998; Charkham, 1994; Pettigrew *et al.*, 1995). Indeed, as suggested by Charkham (1994: 6), understanding a system of governance 'means studying both its structure and dynamics', that is, not just the legal framework but also personal relationships and patterns of behaviour. In addition, Demb *et al.* (1992) contend that effective board performance is linked to an appropriate understanding of the tensions, or paradoxes, that would otherwise 'destabilize' boards.

The desire to promote effective corporate governance and to effect appropriate board member behaviour has been manifest in different prescriptive approaches. Whilst Maw *et al.*'s code of practice addresses perceived structural requirements, Carver's approach (1999, 1997) is intended to guide a board's debate so that they embrace values in the consideration of necessary governance functions. Maw *et al.*'s code relates to the composition of the board, specifying a minimum number of non-executive directors, and appointment criteria. It addresses the functioning of the board, specifying responsibilities and matters 'reserved' for board consideration; accountability: directors' responsibilities, disclosure and compliance requirements, sanctions; and the use of independent non-executive board committees for audit, remuneration and director nomination purposes. Carver goes beyond Maw *et al.*'s embrace of duties and obligations, and seeks to engender debate on values about ends, results, impacts, goals etc, and to whom, as constituents, they relate. He also focuses attention on the values that can be attributed to means - that they are employed in a prudent and ethical way; and on values implicit in the board-executive relationship - affecting the delegation of authority and power, the CEO's role, performance assessment etc.

Whilst some of these prescriptions are likely to have relevance for organisations in both the corporate and the non-corporate sector (Charkham *et al.*: 1999: 242-243), there is minimal guidance for those who seek to determine the appropriateness of any prescription. It is this latter inadequacy of descriptive and prescriptive frameworks that needs to be addressed. In the final sections, we seek to employ a Beer's viable systems framework to develop perspectives and insights about governance that more directly address the nature of effective governance functioning, and the adequacy of prescriptions.

## BEER'S VIABLE SYSTEMS FRAMEWORK

Beer's approach (1979, 1981, 1985) to issues of organisational design and effectiveness, just like Cadbury's approach to governance (1992, 1998; also quoted in Demb *et al.*, 1992: vii-viii) is not pre-occupied with structure. Neither is the approach pre-occupied with the organisational typologies often used to reflect structure, or the configurations that are often embodied in organisational charts.

Instead, Beer focuses on the systemic functions that enhance organisational viability, and which provide a basis for adaptive learning about what are effective organisational behaviours and goals in a climate of complexity and change (Davies, 1999). Beer's research (1979, 1981, 1985) has demonstrated that certain systemic features or functions are necessary to any system's viability or survival. To be viable in Beer's terms, that is, to survive and be effective, an organisation must be able to manage uncertainty and complexity by achieving requisite variety of response. It can develop requisite variety either by creating increased variety in its own systemic behaviour and functioning, or by acting as if to reduce the environmental variety to which it would otherwise be exposed. Knowledge of these systemic functions can therefore be used to analyse the systemic strengths and weaknesses in existing organisations, and/or to, guide the design of organisations to provide required systemic features. Beer's cybernetic framework for analysing organisational systems is known as the Viable Systems Model (VSM).

The use of cybernetic science to underpin the design of self-regulating, adaptive technical systems that can maintain required outputs, and work within established norms, is well known and predates Beer's attempts to extend its use to organisational systems (Francois, 1999; Shenhav, 1995). However, Beer's conceptualisation of cybernetics as 'the science of effective organisation - the science of communication and control, in the animal and the machine', extends the applicability of cybernetics beyond natural and technical systems. Indeed, in doing so, he emphasises the importance of communication as part of organisational systems design - building communication channels, generating information flows and installing information feedback mechanisms - to enhance learning and adaptive response, that is, to develop requisite variety in action.

### The Viable System Model

Beer conceptualises all viable systems as a network of communication channels bonding five complementary sub-systems. The sub-systems, whose effective functioning and communication links are necessary to any system's viability, comprise - an operational system, S1, of autonomous operational units that act out the very identity and purpose of the overall system, and a meta-system comprising four other sub-systemic functions: S2 - effecting overall coordination of the autonomous units; S3 - operational planning, monitoring, control and audit functions relating to the autonomous units; S4 - intelligence and strategy development serving the whole organisation's future; and S5 - the creation and promulgation of identity, vision, direction, purpose and mission, throughout the organisation and its wider environment (Brocklesby *et al.*, 1995). All sub-systems are part of the larger system under investigation, which is defined as the System-in-Focus (SIF). In terms of systems logic, no one sub-system is considered to be more important than another in contributing to the viability of the SIF. However, it will be S1's activities that directly serve the organisation's purpose; and it will be the meta-system's function to provide the organisational climate, the direction, resources and support for S1 to best manage in a changing complex environment, and for the S1 units to become viable sub-systems themselves at a lower level of recursion or embeddedness. The SIF may, itself, be part of, or embedded within a larger organisation or system (Davies, 1999).

In contemplating the use of Beer's VSM to examine aspects and models of governance, we take the view of Rosenau (1992: 3) who states that 'to presume the presence of governance ... is to conceive of functions that have to be performed in any viable human system'. Interestingly, and without reference to Beer, those functions are listed as setting goals, developing strategies and policies, procuring resources necessary for 'preservation and well-being', preventing conflict among its members or factions from tearing it apart etc, and more generally, as a measure of effective functioning, coping with environmental uncertainty and external challenges. 'Whether the systems are local or global in scope, those functional needs are ever present if a system is to persist intact through time.'

## **OTHER MODELS OF GOVERNANCE**

This section outlines various models of governance which have been identified as exhibiting cybernetic features and functions, and uses Beer's VSM to examine the systemic qualities, completeness and coherence of the different models. First, we look at the models of Young (1996), who focuses on information and feedback mechanisms, and Jessop (1998) and Rosenau (1992) who explicitly refer to systemic functions of governance. Then we use the Beer's framework as an interpretive filter to identify the systemic qualities of models of governance proposed by Carver (1997), Charkham (1997), Kay (1995), Senge (1999).

Young (1996: 15-17), has proposed a feedback model of governance. He has made explicit reference to the cybernetic concepts of positive and negative feedback in describing the function of governance as being 'to keep an organisation on course by detecting where it is going and providing information that will allow necessary corrections to that course.' Young asserts that governance is not just about boards, but can be regarded as 'a cluster of mechanisms that measure an organisation's performance and feed it back.' Young suggests that his model thus accommodates and complements the notions of Middleton (1987: 143) relating to the 'boundary-spanning and control' role of boards in the necessary and purposeful transfer/feedback of external information to managers.

He conceives of board roles as reflecting and harnessing the nature of feedback. For example, with negative feedback mechanisms, one measures the difference between desired and actual performance, in order to move performance closer to the target level, a process of homeostasis, that is, self-adjusting stability. Young thus interprets the work of a 'negative governor' as being to ensure that the organisation stays on course and focussed on achieving its mission. Then, since positive feedback mechanisms work to reinforce movement away from pre-determined levels, creating either spiralling success or ever-decreasing performance levels, he describes the work of a 'positive governor' as being to provide the condition and support for growth and innovation.

Young understands the importance of feedback and information flows, but his conceptualisation does not differentiate between external feedback along horizontal communication channels and internal feedback via vertical communication channels, in the way that Beer's framework does. This point may be illustrated with an example of feedback mechanisms operating within a system comprising an international association of member groups. If the international association is performing inappropriately or poorly, then as is now the case with FIFA, it is possible for the continental confederations, acting as de facto S1 operational units, to vocalise their concerns 'upwards' along vertical communication channels to the FIFA meta-system, perhaps demanding changes. This can be described as an example of 'bottom-up' accountability. On the other hand, FIFA in seeking to make its member organisations accountable for specific activities and targets, may require formal reporting - an example, in Young's terms, of top-to-bottom accountability. Both sets of information can be conceptualised as flow along vertical communication channels within the organisational system, with the confederations being S1 viable systems 'nested' within the system that is FIFA. However, boundary-scanning activities can be described as an example of horizontal information exchange, with horizontal communication channels providing a conduit between the system and its various environments.

Young's model implicitly accepts governance responsibilities as including systemic functions such as 'steering' and the setting of strategic direction (S5); the maintenance of an intelligence function, the development of strategy and a capacity for self-assessment (S4); and the resourcing of activities together with the development of accountability and control mechanisms to keep things on course (S3). His explicit precondition is, of course, the development of information networks to build a capacity for learning, adaptability and requisite response. So, Young's model of governance, whilst nominally emphasising feedback, can be stated to exhibit many of the meta-systemic qualities required of viable organisations.

Jessop (1998: 29) conceptualises governance as referring 'to any mode of coordination of interdependent activities', such as that created through the development of a planned formal organisational hierarchy, a self-organising 'heterarchy', or even the anarchy of exchange that constitutes free markets. Jessop sees heterarchy as being as relevant at the level of self-organising inter-personal networks as it may be in the self-organising of agencies, institutions or systems 'which are operationally autonomous from one another yet structurally coupled due to their mutual interdependence.'

Jessop (1998: 30) contrasts the self-organisation of inter-organisational relations with the notion of 'de-centred, context-mediated inter-systemic steering' as described by Glasgow and Willke (1987). In the latter scenario, Jessop suggests that whilst the often complex operational logic of a differentiated sub-system may prevent effective control of the wider system's development from the outside, it does not prevent some 'context specific' steering. He offers a view that inter-systemic 'noise reduction' can be achieved through appropriate direct communication involving negotiation, cooperation in shared projects, and what he terms 'negative coordination' - activities to prevent mutually undesirable outcomes. The latter notion equates with Beer's anti-oscillatory behaviour.

Whereas Young seemingly emphasises feedback and control, Jessop emphasises coordination. However, Jessop's notion of 'coordination' can be interpreted as contributing to various systemic functions in diverse ways at different levels of recursion relating to the system-in-focus (SIF). In particular, his notion of inter-systemic 'noise reduction' can be regarded as equivalent to S5 building of shared values and identity for the organisational system that comes together with a common purpose of conducting mutually beneficial business. On the other hand, employing a code of practice to prevent undesirable outcomes emanating from S1 units acting with designed levels of autonomy, would constitute the coordination as being an S2 function for the SIF.

Although Jessop does not deny the importance of information, it does not hold as central a position in his model as it does for Young. Nevertheless, Jessop's use of the term 'context-mediated steering' does imply building an S5 strategic flexibility or responsiveness to S4 knowledge of environmental change. Indeed, in acknowledging the inevitable incompleteness of attempts at coordination, Jessop (1998: 43) implicitly surfaces the cybernetic necessities required of any viable system, which are to engage in double-loop learning (Beer, 1959) and to build through this self-reflexive capacity for learning, an adaptability and requisite variety to respond to internal and external change.

In enunciating his 'principles' of good corporate governance, Charkham has stated that management must have freedom and autonomy to drive the enterprise forward, of course - 'exercised within a framework of effective accountability' (Charkham, 1994: 4; Governor, 1992: 211). Indeed, he has stated that 'the main point of a good (governance) system is to give power to those best able to use it' (Charkham, 1997: 3). His view is that a system of corporate governance should be 'concerned with checks and balances on the exercise of power, and with its peaceful transfer'. Indeed, Charkham has been forthright in asserting that the success of a corporate governance system is dependent upon 'its ability to reconcile entrepreneurial freedom with effective accountability', or as Beer frames it, to effect an appropriate balance of S1 autonomy and meta-system control. Although working predominantly in the corporate sector, Charkham (1993: 391), claims that these principles of governance have relevance in many other spheres of activity - economic, political, sporting etc.

Senge (1999: 10-11) offers a different notion of what constitutes power or control, commenting that 'the source of legitimate power' in an organization is its guiding ideas, values and ideals, its mission, purpose and reason for being. He asserts the need for an organisation or any human community to express its aspirations and to articulate its identity to provide a basis for evaluating whether strategic and operational decisions reflect vision and mission oriented behaviour. In doing so, he is expressing the need for S5 functionality. He implies consequent impact on authority/control mechanisms and on operational activities, suggesting for example, the need for less formal approaches to say, coordination and control, as identity and values pervade the organisational system and its nested sub-systems, guiding behaviour and choice. Such views fit within Beer's framework, and provide a complementary view to the notions of authority and power expressed by Charkham.

In contrast with the prior frameworks of governance that give explicit emphasis to a subset of systemic features, Rosenau's model (1992: 3) can be considered more comprehensive. He conceives of governance as equating with the broad provision of necessary meta-systemic functioning relating to setting objectives (S5), developing policy options (S4) and policy guidelines (S3), resource acquisition (S3), anti-oscillatory coordination (S2) etc. Other writers offer models or views of governance that bear surface resemblance to, but are not founded on or legitimised by viable systems thinking. For example, without being specific about meta-system functions, Chelladurai (1987) has suggested taking a 'Parsonian' perspective on organisational design, and on board functioning. In relation to the design of amateur sports organisations, he has advocated the separation of the board as an 'institutional' sub-system from the managerial and technical sub-systems. However, any comparison between the contribution of the board to Beer's meta-system and the role of the board in Chelladurai's 'institutional' sub-systems is limited by the ambiguity and lack of clarity about the conceptual and functional make-up of Chelladurai's sub-systems. We may conclude that any resemblance of the 'institutional' sub-system to Beer's meta-system is perhaps coincidental rather than based on cybernetic considerations.

However, Carver's values-led-policy-driven governance framework (1997) can be considered to be as comprehensive as Rosenau's, and to have notable systemic coherence. Carver's prescriptions relate predominantly to S5/S4 meta-systemic functions, and cohere with Beer's notions of the systemic functions that engender viability and the long-term sustainability of organisations. In particular, Carver promotes governing board S5 behaviour that builds identity by facilitating diversity; that is relationship oriented, identifying and describing constituencies and accountabilities; that is values driven, explicitly addressing fundamental values; that is visionary; that is proactive, leading and creating rather than approving, reviewing and monitoring etc. Similarly, he would attempt to strengthen S4 functionality by endorsing forward thinking, taking the long term view; by developing an external focus, building responsiveness; by valuing intelligence; by being self-aware and how it engages in self-monitoring; by how it represents the 'ownership', and how it seeks an understanding of its systemic role on any matter. Carver's awareness of the need to seek the right balance between autonomy and control reflects the systemic balancing act between S3 and S4, and then between S3/S4 and S1; and his call for decisions to be outcome driven, weighing decisions against purpose, would require and lead to enhanced S2/S3 functionality (Carver, 1997: 32-33; 1999: 1-10).

In many ways, Kay *et al.*'s trusteeship model of corporate governance (1995: 90-91) shares similarities with Carver in its value-laden expression of governance responsibilities. Their conception of governance requirements is in line with the views of Young (1996: 15-17), Jessop (1998: 29), and Demb *et al.* (1992), in seeking 'to balance the conflicting interests of current stakeholders ... to weigh the interests of present and future stakeholders'. In Kay *et al.*'s view, trusteeship responsibilities require effective governance 'to sustain the corporation's assets', including such assets as its identity, reputation, the skills of its employees, and the favourable expectations of customers and suppliers etc. Effective governance, in Kay *et al.*'s view, can thus be interpreted as being primarily dependent upon S5 functioning involving the building and sustenance of appropriate identity and values related to reputation, the values placed upon relationships with employees, suppliers, customers etc. As such, they concur with Demb *et al.* (1992) in a concern 'to balance the intimacy of operational involvement with the detachment presumed to be required for objective strategic review and analysis etc'.

## DISCUSSION AND SUMMARY

Charkham (1994: 248) has remarked how difficult it is to be objective with the familiar, and that to shed light on governance may require the examination of alternative governance systems, and the development of alternative perspectives. This paper has outlined a variety of views of governance practices, processes and systems, and has demonstrated the value of a systemic perspective and of Beer's framework in attempting an evaluation of alternative models of governance.

As Espejo *et al.* (1989: 445) propose, if we accept the notion of a 'model-as-convention', rather than as a description of reality, then, at the very least, we can accept Beer's model as providing a context which provides 'a way of talking about something in a manner that is understandable and useful, that is, as a communication vehicle'. Indeed, Beer's organising framework, the VSM, 'provides a language in which to identify key features of a complex reality', and can help to pose significant questions about that reality (Stoker, 1998: 1). As such, Beer's model can act in the form of a sensitising framework – as a way of seeing and thinking which alert the analyst to alternative ways of understanding (Thomas, 1993: 210). Just as Carver (1997: xvi) claims that his values-based policy model enables board members to see their role in a new light, so, too can Beer's framework provide an alternative perspective on the design of governance relations.

Beer's conceptualisation of viability in organisations is based on cybernetic and systems concepts and a consideration of the systemic functions that contribute to systems viability. Beer would contend that organs, instruments, activities and processes of governance need to be effective in the sense that they establish or contribute to the maintenance of systemic identity and purpose(s) which have coherence, and which are projected, shared and accepted within and without the organisation by its internal and external constituents. That identity is obviously linked to the organisation's purpose, its *raison d'être*, and together, they can provide a guiding beacon and logic that cultivate the values and ethics that underpin ends-oriented and mission-oriented behaviour.

Effective organs of governance must balance the competing attentions of multiple constituents, and of long and short-term objectives. In keeping with fundamental purpose and values, the processes of governance must decide on strategic direction and goals for the organisation, and be capable of assessing the performance of senior management in operationalising those goals. Those involved in governance processes, for example, a governing board, must also be capable of critical self-reflection, self-monitoring and self-assessment, that is, they must be capable of embracing in concept, a 'model' of the organisation – its purpose, identity, structure, functioning etc.

These are primarily S5 functions within Beer's framework. Beer's approach, however, requires recognition of the need for quick response to environmental change, the need for adaptability – or to use Demb *et al.*'s terms (1992: 195), 'the imperative of adaptability'. It implies autonomy to act, within Charkham's framework of controls and accountabilities, and within the 'tight-loose' framework of Peters and Waterman (1980), but which in Beer's terms and in Carver's terms means working

within a framework of S2 policy guidelines and 'controls', whose development is a necessary S3 systemic function, reflecting S5 identity and values.

In reflecting on Beer's model of viable organisations, we note the role and functions of governance as being a sub-set of meta-system roles and functions: creating identity, building shared values and purpose, setting direction, steering; providing resources and delegating authority for managerial and operational staff to act with autonomy and appropriate responsiveness in changing environments. However, many of those involved in governance roles fulfil other systemic functions within organisations. For example, in many voluntary organisations, at local, regional or national governing body level, those elected or appointed to take on S5 stewardship of the organisation, to guide its future direction and activities, are often the volunteers who undertake S1 operational activities. They may also engage in S3 operational planning and budgeting activities, and in S4 strategy development activities.

The potential for systemic role conflict to exist is apparent. Unless those who are charged with S4 governance functions are able to conceptualise the organisation's being, and to view its activities in a holistic sense, that is, in systemic terms, then it is possible that in failing to recognise the various systemic functions and roles that exist, they will, as volunteers, engage in multiple systemic activities, creating role overload, role overlap and role conflict. Indeed, one common systemic ailment arises when, with the best of intent, the S5 governors necessarily engage in S1 activities, but in doing so denude S1 staff of their autonomy, undermining initiative etc.

Additionally, when board members, governors or trustees are elected from (or possibly to serve) particular constituencies, difficulties may arise in building common identity, purpose and values for the organisation. The systemic dysfunction most likely to be caused by parochialism amongst say, governors can then be described as that of S5 dysfunction - lack of identity, lack of common purpose, lack of shared values etc.

We conclude that understanding governance requires a holistic approach. Conceptualising governance and board activities in terms of Beer's systemic roles and functions not only delivers insights about the design of governance, but also contributes understanding to common issues of role overload and role conflict that arise among governing board members, and which can impact adversely on board/staff relationships. Moreover, the VSM provides clarity in disentangling the various views about what constitutes governance. Indeed, using the VSM as an interpretive framework suggests that there is evidence that concepts and notions that are cybernetic in nature, and which underpin viability, are incorporated within extant models of governance, but mostly in piecemeal fashion. Such models can be regarded as incomplete when set alongside Beer's model of viability and systemic functioning.

However, pursuit of the Beerian ideal may not be straightforward. Beer's emphasis on systemic functioning supports the views of Boyd (1995: 301) and Demb *et al.* (1992:182) that mimetic behaviour, copying the structure of another board, or following blanket prescription, will unlikely work any better than for, say, a production line subject to different demand patterns. As Cadbury (1999: 18) has stated, whereas market forces can be expected 'to bring about a convergence of governance standards and processes', he would 'neither expect nor see the need for a convergence of governance structures'. Effective governance is dependent on an understanding of required systemic functioning and other systemic requirements, rather than structural or procedural mimicry.

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**Figure 1: Views of Governance**

<b>Views of Governance</b>	
Collins ED, 1994: 669	'governance is the action, manner or system of governing; governing is directing, controlling, ruling, regulating, influencing' from the Latin, 'gubernare: to steer'
Parkinson <i>et al.</i> , 1999: 101	'governance is understood to be primarily about the relationship between shareholders (viewed unproblematically as the owners of a company) and managers'.
Lannoo 1999: 272	'(c)orporate governance ... is defined as the organization of the relationship between the owners and the managers in the control of a corporation.'
Blair, 1999: 3	'corporate governance ... refers to the whole set of legal, cultural, and institutional arrangements that determine what public corporations can do, who controls them, how that control is exercised, and how the risks and returns from those activities they undertake are allocated'
Blair, 1995: 273	'Governance systems, broadly defined, set the ground rules that determine who has the control rights under what circumstances, who receives what share of the wealth created, and who bears what associated risks'
Cadbury, 1992: 15, para 2.5; Charkham, 1994: 1	'Corporate governance is the system by which companies are directed and controlled'
Demb <i>et al.</i> , 1992	'(c)orporate governance is the process by which corporations are made sensitive to the rights and wishes of their stakeholders'
Worthy <i>et al.</i> , 1983	'governance is ... concerned largely, though ... not exclusively with relating the corporation to the institutional environment within which it functions.'
Pound, 1995: 90	'corporate governance is not, at its core about power; it is about finding ways to ensure that decisions are made effectively.'
Blair, 1995: 273	'Governance systems, broadly defined, set the ground rules that determine who has what control rights under what circumstances, who receives what share of the wealth created, and who bears what associated risks'.
Rosenau, 1992: 3	'to presume the presence of governance ... is to conceive of functions that have to be performed in any viable human system ... to cope with external challenges, to prevent conflict ..., to procure resources . to frame goals and policies designed to achieve them'
Young, 1996: 15-17	'the function of governance is 'to keep an organisation on course by detecting where it is going and providing information that will allow necessary corrections to that course.' 'governance is about ... a cluster of mechanisms that measure an organisation's performance and feed it back.'
Jessop, 1998: 29	'governance can refer to any mode of coordination of interdependent activities'
Carver, 1997: 24-25	'excellence in governance begins when boards recognise ... setting goals, ... developing plans ... depend on values and perspectives ... (these values) ... can be unstated as well explicit'
Ashburner, 1997: 280	'Good corporate governance is ... reliant ... upon the (existence) introduction and maintenance of mechanisms to promote behaviour and performance on the part of the manager, which is in the interests of the organization's stakeholders.'
Kay <i>et al.</i> , 1995: 84	'key goals of corporate governance: freedom for managers to manage, combined with real accountability for their performance'
Charkham, 1994: 3	'the main point of a good system ... corporate governance ... is to give power to those best able to use it'. corporate governance is 'concerned with checks and balances on the exercise of power, and with its peaceful transfer'
Charkham, 1994: 4; Governor, 1992: 211	'the success of a corporate governance system is ... dependent upon its ability to reconcile entrepreneurial freedom with effective accountability' 'management must have freedom and autonomy to drive the enterprise forward, of course - exercised within a framework of effective accountability'
Cornforth, 1998: 2	'governance ... ... embrace(s) all the functions performed in organisations by the members of their governing bodies'
Senge, 1999: 10-11	'the cornerstone of a truly democratic system of governance is not voting'
Allison, 1998: 29	'the system of contemporary world governance in sport' is also one of complex interdependence - between international and national governing bodies, international law and the courts, the media, commerce and business, the fans and the public etc.'
Thoma <i>et al.</i> , 1996: xiv	'sport governance ... is particularly concerned with the ways in which sport is organised and managed'

# What's in a name? - 'BPR' versus 'Outsourcing' - a critical realist perspective on emancipation.

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## ABSTRACT

*Maru and Woodford (2001) call for a greater commitment to the development of emancipatory development methodologies. They suggest that Ulrich's critical systems heuristics is the only critical systems methodology that offers real practical tools for achieving emancipatory development. They also suggest that the emancipatory focus required as a cornerstone of critical systems theory has been diverted through a concentration on pluralism. This paper argues that this diversion to pluralism within critical systems theory is a logical outcome of the epistemological focus of the underlying critical theory of Habermas. This focus on the epistemological or knowledge based aspects of the development process forces a concentration on methodological pluralism through its emphasis on interaction and the communication aspects of the development process. Such a focus must necessarily relegate the importance of the (ontological) **conditions** necessary for emancipatory practice. This paper proposes the use of the philosophy of critical realism to examine emancipatory practice. Such an emphasis highlights the ontological issues in more detail by arguing for a recognition of the deep structures and mechanisms involved in social situations. Following from a brief introduction to both theories the paper then presents a vignette from a case study under investigation to highlight some differences between Habermas' critical theory and Bhaskar's critical realism with respect to emancipation and emancipatory practice.*

*Keywords: emancipatory practice, systems approaches, critical realism, critical theory*

## INTRODUCTION

This paper introduces a case study concerning an organisation moving through a radical business change process involving the outsourcing of their IT Department. The paper presents an example of emancipation within this change process and discusses how the emancipation can be examined using two different theoretical perspectives - that of Habermas' critical theory and that of Bhaskar's critical realism. The first part of the paper presents a necessarily brief summary of each theories perspective on emancipation, followed by a discussion of the case under study and finally a reflection on the case from the two different perspectives.

## **CRITICAL THEORY AND EMANCIPATION**

Alvesson and Willmott (1992, p. 432) reflect their emphasis on critical theory when they describe emancipation as:

the process through which individuals and groups become freed from repressive social and ideological conditions, in particular those that place socially unnecessary restrictions upon the development and articulation of human consciousness.

They see the purpose of critical theory as to enable 'members of a society to alter their lives by fostering in them the sort of self-knowledge and understanding of their social conditions which can serve as the basis for such an alteration' (Fay, 1987, p. 23).

Alvesson and Willmott (1992) argue that 'central to critical theory is the emancipatory potential of reason [-] to reflect critically on how the reality of the social world, including the construction of the self, is socially produced and, therefore, is open to transformation. The task of critical theory is to combine philosophy with social science to facilitate the development of change in an emancipatory direction'. They point out this view suggests that the process of emancipation is a linear cycle of 'suffering-critical reflection-emancipation' and question the negativity of this view and whether the process is so simple. The individual's power to reason and consequent self-emancipation play a major role in Habermas' critical theory.

Hirschheim and Klein (1994) see emancipation as involving both an organisational element and a psychological element. 'The former calls for the realization of the full creative and productive potential of individuals; the latter refers to the establishment of social conditions, which encourage effectiveness through organizational democracy, specifically overcoming existing forms of authoritarianism and social control if they perpetuate inequities of the status quo in the work place' (p. 84). This introduction of an organisational element is necessary as it recognises the important contextual element in any emancipatory practice – 'self-emancipation is only one part of the emancipatory process.

Habermas (1984) argues that people can follow two fundamental postures in a social situation - achieving success or communication. Actions directed towards achieving success (purposive rational) can be either instrumental or strategic. Instrumental action treats participants as inanimate constraints who can be manipulated to serve the self-interests of the main actor. In contrast strategic action would treat participants as intelligent involved players with their own self interests and aims - thus requiring a strategic approach to properly achieve the main actors self-interest.

The second fundamental posture that actors may represent is that of communication - the primary desire is to achieve a consensus and understanding. Hirschheim et al (1994) argues that a communicative orientation is directed towards sense making - an emergent process that involves mutual understanding and shared appreciation of situations based on common shared background assumptions and beliefs. Where such a common base does not exist, discursive action may ensue. Discursive action may result when participants have some doubts as to the clarity, truthfulness, correctness or appropriateness of any communicated message. Instrumental and strategic action fundamentally emphasise control, whereas communicative and discursive action emphasise sense making and argumentation.

In the case vignette to be discussed later in this paper some of the above insights will be used to highlight important aspects of the situation under study. An interesting contrast to critical theory is critical realism which, rather than follow Habermas' focus on epistemology (that is, a focus on our theory of knowledge and how we acquire knowledge), directs its examination more towards ontological issues (addressing our account of the 'things' that make up the world and their essential nature).

## **CRITICAL REALISM AND EMANCIPATION**

For the critical realist emancipation involves the transformation of pre-existing social structures by self-determining agents. Smith (1998) defines social structures as involving 'relations and patterns of behaviour which have become so well established across time and space that they provide the (largely unquestioned) conditions for human action and thought'. (p. 27). For the realist emancipation is more than simply improving conditions within existing structural arrangements, emancipation implies the transformation of structures rather than 'freedom enhancing ameliorations of states of affairs' (Collier 1994 as quoted in Archer 1998 p. 464).

Critical realism sees social structures as referring to actual forms of social organisations, as 'real entities with their own powers, tendencies and potentials' (Archer 1995, p. 106). Such structures cannot be perceived and thus cannot be identified except through examination of their effects. Social systems depend on the relations between and within a plurality of structures, such relations having their own independent causal properties. The resulting system founded on the various relations has emergent properties which may affect agents acting within the system.

Critical realism is termed 'depth realism' by Collier (1994) due to its recognition of deeply stratified layers of structure. Emancipation is seen to involve deep structural change and is thus revolutionary in its intent (ie deep and sudden, rather than necessarily violent). Critical realism suggests that structures will not be changed through the cumulative effect of reforms in accordance with those structures, the structures themselves must be addressed.

Bhaskar provides little real guidance for progressing emancipatory practice apart from elevating the role of explanatory critique. Collier (1994, p 171) explains the important role of explanatory critique within the critical realist conception of emancipatory practice:

...the production of explanations of social institutions is not only, as a general rule, a precondition of criticising and changing them; sometimes it is criticising them and beginning the work of their subversion.

An explanatory critique of unfair institutional practices and the associated unearthing of the false beliefs supporting such practices provide the necessary pre-conditions for emancipatory practices. In this situation social science can generate practical emancipatory projects by 'showing there to be (a) a need, (b) some obstacle preventing its satisfaction, and (c) some means of removing this obstacle' (Collier 1994 quoted in Archer et al 1998, p. 455). It may also have a more direct effect in that the unearthing and exposition of false beliefs can directly undermine the imposing institution.

Much of critical realist argument is concerned with explanatory critique asking questions such as 'what must be the case in order for intentional action to be possible' (Bhaskar, 1991 p.147). According to Bhaskar (1986 p. 211) emancipatory action requires the following be met:

- The results of the emancipatory action must be achievable, realistic and popular.
- The new transformed structure itself must have 'knowable emergent laws'.

The emancipatory action itself must also meet the following requirements:

- The emancipatory action needs to be a direct result of agency intervention (ie critique) - that is, the emancipatory reasons for the action must actually cause the action (otherwise it may be just co-incidence rather than emancipative practice).
- The explanatory critique must originate from within that part of society of which it is a critique.

In short, Bhaskar (1986) sees emancipation as involving the transformation of constraining structures by self-determining agents who act from within the imposing structure to produce popular realistic change that can again be structurally supported after the event.

It is useful to consider a particular case study and to examine whether Bhaskar's suggestions can provide new insights into emancipatory practice.

## **'BPR' VERSUS 'OUTSOURCING' - WHAT'S IN A NAME?**

The case study under investigation was traditionally an engineering organisation that had little time for the information systems department - IT was seen as a cost centre with a primarily non-core role. The organisation had just developed its first Information Business Plan with the help of a supportive Managing Director. After the development of the Information Business Plan the organisation began to move towards outsourcing non-core operations. This was a result of wider governmental policies that encouraged smaller government and required a move towards privatisation of governmental departments. In the mid-1990's the investigation into this operation was termed internally as a 'business process re-engineering' project.

Initially staff accepted this 'BPR' tag but over time they came to reject the term as they felt that it did not reflect what was actually happening - they felt that the study was basically an investigation into the feasibility of 'outsourcing', not 'BPR'.

In a minor way I was involved in this change in the perception of the organisation towards BPR. One of my contacts at the organisation was heavily involved in the change investigation and I provided a number of articles discussing successful BPR. On reading these case studies of successful re-engineering he came to realise that the change process within their organisation did not fundamentally involve any real consideration of business processes. He and other staff objected to the term BPR and prompted a change in title to 'corporate re-positioning' and then again at a later date to 'outsourcing'.

According to the IT Manager at the time the term 'BPR' annoyed staff:

Well the staff simply refused to call it that, lets call a spade a spade - 'bugger this we won't call it BPR any more', they said - it's a false term. Let's not pretend. After a while it became obvious what the agenda was and some of the directors who pushed BPR objected themselves to hiding outsourcing under the term BPR.

Perhaps the process was termed BPR, not specifically to reflect a concentration on process thinking but as a reflection of the almost religious following that BPR had at that time. The naming issue seems to the outsider to be unimportant - however it was critical to those involved. By calling the process 'outsourcing' rather than 'corporate re-positioning' or 'process re-design' it required a recognition that people were going to be seriously affected. As the IT Manager suggested the recognition lead to the establishment of career counselling and advice being given to those likely to be outsourced:

I'd go to meetings and I'd have to try and push the party line and I did for a while, but after a while I said O.K. let's be honest because my staff had been saying 'This is dishonest, we know what's going to happen, let's be honest about it.' IT were probably some of the first to be very honest with the staff to tell them exactly what's going to happen. They started providing career counselling, we had [consultants] come in .... to talk about the transition and a lot of people decided they wanted to go and we helped them in making sure they could tick all the boxes for gaining their severance pay and that sort of thing. It is interesting to look at how critical theory and critical realism might support an examination of this short vignette.

## **DISCUSSION**

The forcing of management to refer to the process as 'outsourcing' initiated a process that ultimately lead to career counselling and a better severance process. For the critical realist this change in name was a form of emancipation. From a critical realist perspective the emancipatory process met Bhaskar's conditions for defining emancipatory practice:



- The emancipatory action of changing the name to outsourcing was a direct result of agency intervention (it was clearly not co-incidental) - management recognised that staff were not getting a fair deal and instituted new policies to assist staff over the difficult period.
- The explanatory critique originated from within a group who would ultimately be affected by the outsourcing. It would not have been emancipatory if an outside party originated the suggestion as the most important issue was that it came from within the organisation and reflected their heart-felt concerns.
- The results of the emancipatory action were achievable, realistic and popular. Staff action could not have changed the movement to outsourcing but at least the recognition that it was an outsourcing project allowed a more equitable position for concerned staff.
- The new transformed structure that was put in place after the name change did have 'knowable emergent laws' in that the new policies and procedures were achievable within existing remuneration structures and did not require unrealistic concessions on the part of management.

Would critical theory arrive at the same conclusion? Certainly the example given is a strong reflection of the power of language. The original naming of the process as BPR can be seen to reflect instrumental action on the part of management to force the change process through. BPR at the time was very 'faddish' and the tag would have been useful as a means to justify the severe change that would necessarily follow. The change in name to outsourcing represented a mellowing of this approach and can be seen to reflect the acceptance by management that personnel concerned were 'intelligent involved players with their own self interests and aims' (see above). A strategic approach was necessary to properly achieve the management's self interest.

However, Habermas' second fundamental posture of communication cannot be seen to be active. In such a highly emotive and distressing situation as that evident within an outsourcing process communicative action cannot be expected. The primary desire of management was not to achieve consensus and understanding - their target was to achieve the strategic action they required - the outsourcing of the department. Given that personnel were clearly to be terminated (or moved over to the outsourcing partner) there could be no basis for open communicative action. For Habermas communicative action is a necessary pre-condition for emancipatory practice - the process of changing the name from BPR to outsourcing would not be seen to be emancipatory for the critical theorist.

## CONCLUSION

Bhaskar's theory is concerned with explanation. It argues that predictive use of theory is not possible in the open systems evidenced by social situations, all one can hope for is explanation and identification of 'tendencies'. On first view the heavily theoretical approach of the critical realist does not seem to provide much guidance towards effective emancipatory practice. However, there may be benefit from its explanatory focus which provides the ability to identify 'tendencies' and thus learn from the situation. We can see that certain conditions are required for emancipatory action and thus ensure that such conditions are met in future practice.

The three commitments of critical systems theory are seen to be:

- Critical awareness
- Methodological Pluralism
- Emancipation

Maru and Woodford (2001) call for a greater commitment to the development of emancipatory development methodologies. They suggest that Ulrich's critical systems heuristics is the only critical systems methodology that offers real practical tools for achieving emancipatory development and they argue for a greater commitment to the development of new methodologies in the area. They point out that critical systems theory reflects a practitioner focus in that emphasis is very much directed towards action. They quote Schechter (1991, p. 213) who describes the commitment to critical awareness as a never-ending attempt to uncover hidden assumptions and conceptual traps of paradigms, methodologies, plans and practices together with the conditions that give rise to them. The commitment to pluralism 'is a result of the critical awareness that all systems approaches are partial and therefore have their own limitations and legitimacies' (p. 63). Such an epistemological focus must necessarily neglect the ontological conditions for emancipation. As Maru et al (2001) argue the emancipatory focus has been diverted largely due to a concentration on pluralism. They quote Jackson (1997, p. 359) who sees the commitment to emancipation and critical awareness as buttressing pluralism. The focus becomes not on emancipation but on pluralism, thus reflecting the practitioner focus of the systems practitioner.

Critical systems theory was developed based around Habermas' epistemological focussed critical theory and as such must concentrate more on the knowledge aspects of the situation. Bhaskar would suggest that this represents a concentration on the transitive aspects of the situation; the intransitive relatively enduring real structures and mechanisms impacting the situation often of lesser consideration.

Flood and Jackson's TSI is an example of a systems approach based around critical theory. It rests on the assumption that the organisation has no meaning outside the mind of the participants - the underlying view behind TSI being that the only way to change social systems is by changing people's world views or Weltanschauungen. Such a perspective makes it difficult to focus on the actualities of real organisational change. Without a clear recognition of the reality of social structures there can be little guidance as to ways and means of changing them. Bhaskar's critical realist approach can provide a useful insight into the (ontological) pre-conditions for change and the need for popular, realistic change. It also allows for an examination of the deeper mechanisms and structures behind the change process - more work needs to be done on examining whether the adoption of such a perspective is possible within systems approaches and whether it can offer any valuable new insights..

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# Innovation Information – An Inquiry-In-Inquiry Approach

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## ABSTRACT

*The concept of 'Inquiry-based' activity models in SSM is introduced. It is argued both that SSM embodies a process of Inquiry and that the notion of Inquiry is often relevant to conceptualizing activities of interest in a problem situation. Combining these two positions leads to the idea of using SSM as a generic reference model within itself. The term 'Inquiry-in-Inquiry' is used to denote this use of SSM as a generic reference model for the development of Inquiry-based activity models. The concept of Inquiry-based activity models is illustrated through the use of a model to investigate the handling of Information Technology innovation information in Small to Medium Enterprises.*

*Keywords: soft systems methodology, inquiry-in-inquiry*

## INTRODUCTION

Many forms of real-world activity are concerned with making sense of complex poorly-understood situations. Such activities have many different names such as appreciation, assimilation, business intelligence, sense-making, or strategic information / intelligence systems. It is the core conjecture of this research that the notion of real-world problem-solving, or for short Inquiry, is relevant to understanding and improving such forms of activity. Further, as Soft Systems methodology (SSM) is a highly developed and widely acknowledged concept of Inquiry then it may be possible to use SSM as a basis for investigated such inquiry-based activities. The difference in this proposal is that SSM is being used in a new and innovative way. In its conventional sense SSM is regarded as a methodology but in the sense used above it is being treated as a generic reference model for the structure and organisation of Inquiry-oriented activity. The broad conjectures of this research project are that (a) it is possible to use SSM as a reference model and therefore to create Inquiry-based activity models, and (b) that these models will prove useful in tackling problems related to sense-making activities in real-world organisations. The rest of this paper describes the first stages of a research project to investigate these research themes.

The practical context of this research is an investigation of how small to medium enterprises (SME's) handle the plethora of information associated with information technology innovations. How, for example, do they handle information regarding electronic commerce? It is usually considered as a decision problem in which the enterprise must decide whether to adopt or not adopt a particular technology innovation. However this is a somewhat limited conceptualization of the situation. Increasingly IT has become a strategic issue not only affecting internal business systems, but products, services, markets and competition patterns within industries. The issue for business is not

whether to adopt or not adopt but more generally what action out of many possibilities to enact with regard to new IT innovations. To distinguish this process from that of the standard technology adoption model we term it 'Assimilation'. The assimilation concept suggests that enterprises must continuously learn about IT innovations and their potential impact upon the business. In this paper we report the first phase of a research program into IT assimilation processes in SMEs.

## **BACKGROUND AND MOTIVATION**

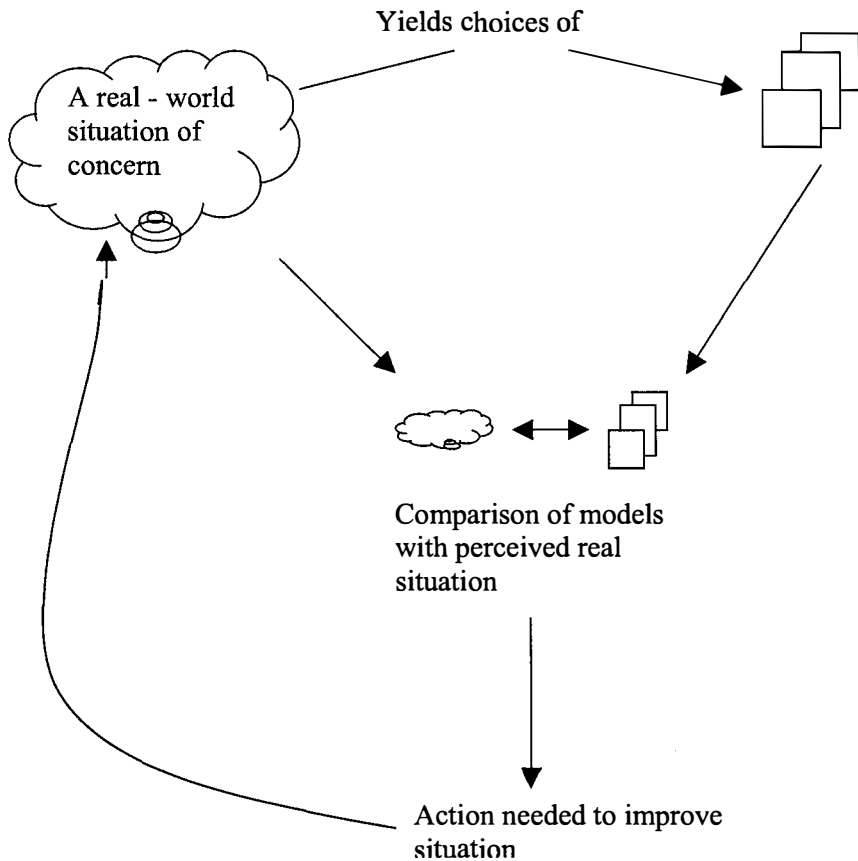
There is a practical need to improve the ability of SMEs to manage IT innovations, particularly in the area of E-Commerce. The use of SSM to facilitate such management improvement has been suggested, and a research project to investigate the use of SSM in IT innovation management has been initiated. Although it was intended to use SSM as an investigative approach it also became apparent that it might serve another purpose. The type of activity being investigated potentially had many parallels with ill-structured real-world problem-solving as embodied by SSM. In other words SSM as a model of activity could be seen as being relevant to conceptualising IT innovation management.

Adoption or non-adoption is usually viewed as the only response to a new IT innovation but this may miss a range of other changes that are possible. Arguably there is no IT application that is a universal panacea which must necessarily be adopted and used in all circumstances. Therefore all responses to IT innovations are contingent and situation dependent. If business enterprises are regarded as socio-technical systems then their behaviour is shaped in part by the perceptions of the social networks that make them up. Thus appreciation or sense making becomes a primary process of the enterprise and is clearly a process that may operate well or poorly depending upon its history, structure, and context. The practical concern of this research project is with how to improve the sense making, or assimilation, process in SMEs with regard to IT. In turn the key methodological issue is what form of framework of ideas to employ as a basis for seeking improvement in these areas – what form of 'relevant system' to employ.

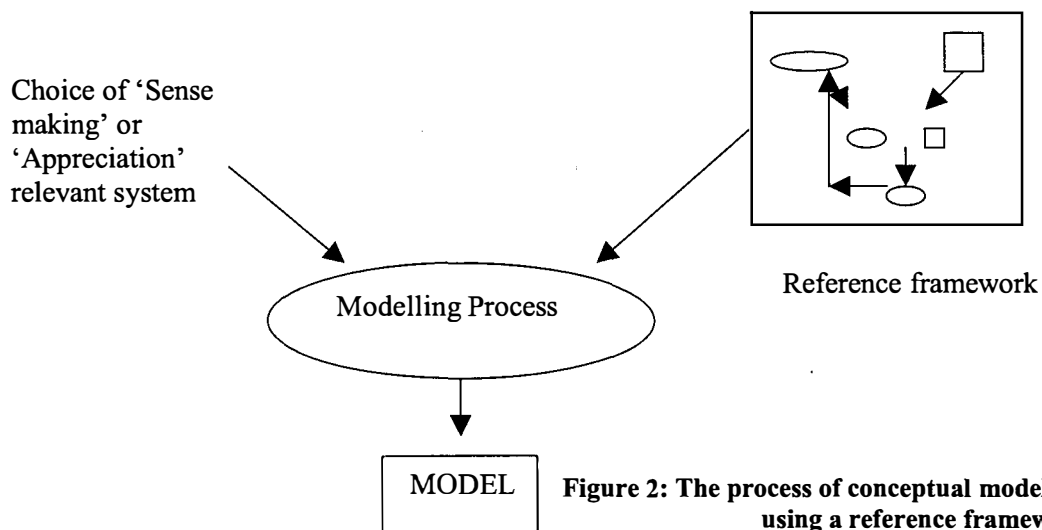
## **INQUIRY-IN-INQUIRY**

The basis of the approach taken in this work is both to regard SSM as a process of 'Inquiry' and to suggest that 'Inquiry' is also relevant to the problem situation of strategic assimilation ie. IT innovation management. A version of SSM is given in Fig.1. 'Inquiry' therefore becomes a potentially relevant way of thinking about the sense making activities undertaken in enterprises. This is called 'Inquiry-in-Inquiry' as it is the use of an inquiry model as a relevant system within a process of inquiry.

**Figure: 1 The Process of SSM (Adopted Checkland & Scholes)**



The argument developed here is that any choice of relevant system that is seen as a sense making system, or is a process of appreciation, actually incorporates a reference to a broader concept of inquiry and the development of a conceptual model will require reference to this broader concept. Further that SSM provides a basis for that broader concept of Inquiry. The idea is similar to referencing a formal system model for the creation of a conceptual model (Checkland 1981). The core idea is shown in fig. 2 below.



**Figure 2: The process of conceptual modelling using a reference framework**

Sense making relevant systems models, developed using the 'Inquiry-in-Inquiry' approach, have been used as part of a research project into IT Innovation management in SMEs. The first phase of this project is a pilot study aimed at evaluating the models concerned as tools for analysing and facilitating IT Innovation management. A simplified example of such a model is given in fig 3. below. The root definition for the model is:

“A system to continuously appreciate IT innovations and their organisational relevance, and to frame appropriate actions, by gathering, recognising, and evaluating, information regarding potential IT innovations with respect to a given situation.”

The developed model consists of three inter-linked cycles of activity. In the first cycle, communication channels are scanned to identify information concerning potential IT innovations. The image of such innovations that is generated is then compared and engaged with the image of organisationally relevant innovations. The cycle continues by further refining the underlying thinking about what is generally meant by a potentially relevant IT innovation. Such a concept is of course required in order to scan and evaluate the information channels. The second cycle continually refines what is seen as an organisationally relevant innovation. These two cycles are brought together in a comparison such that the organisation is continuously revising its evaluation of new IT innovations and its definitions of organisationally relevant. Finally, there is also an outcome in which the 'picture-in-situation' generated by the system is enacted, thus essentially creating a third dynamic cycle of practical change that feeds into the other two cycles. Finally, the process is considered to be a purposefully managed system, although the details of this monitoring and control system have been suppressed in the interests of presenting the model.

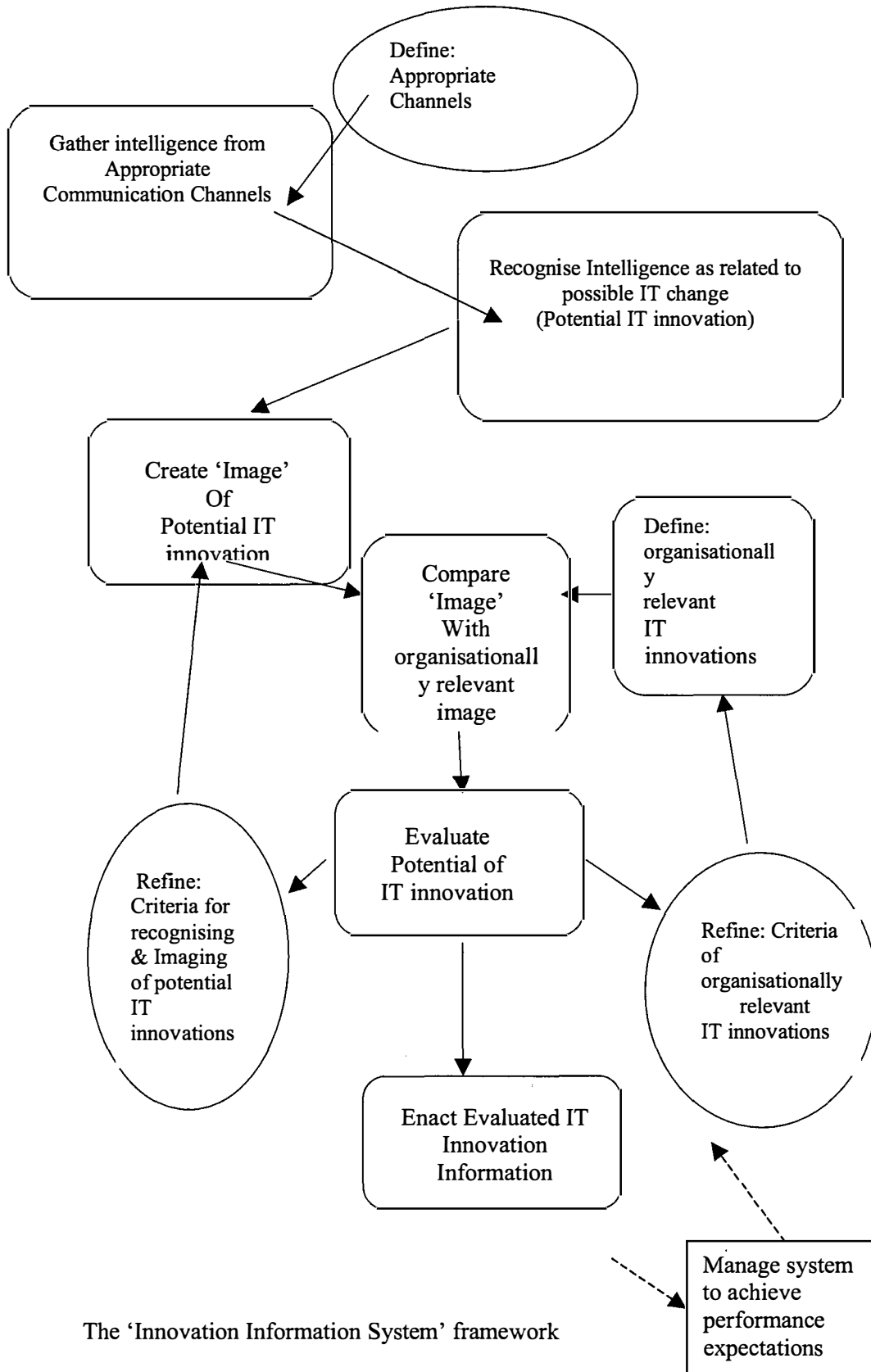
## **CURRENT SITUATION**

A pilot study into IT-oriented strategic sense making in SMEs that uses the Innovation Information System model is in progress. The initial data analyses have revealed some unexpected insights; such as that the reported information environments are both richer and more constrained than expected. In particular the importance of industry bodies in shaping IT innovation management has emerged as a critical finding. The other major focus of the work is in evaluating the proposition that sense-making inquiry is a useful and insightful way of considering strategic thinking in small organisations and that the 'Inquiry-in-Inquiry' concept provides a practical means for developing activity systems models that are useful within a problem context. The initial findings are supportive of the two propositions but further analysis and evaluation is awaited.

## **SUMMARY**

The concept of 'Inquiry-in-Inquiry' as a basis for activity system modelling has been described and a practical model based upon the concept has been illustrated.

**Figure 3: An IT Innovation Sense Making System, or Innovation Information System**





# Negotiating Meaning within a Situation

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## ABSTRACT

*Soft Systems Methodology (SSM) is a methodology used to enable different meanings or views within the situation to be expressed and negotiated. A functional decomposition approach to model representation is used within SSM.*

*An alternative systems framework is Decision Variable Partitioning (DVP) that uses decision variables as the basis for decomposition.*

*This paper continues the work on DVP, by using the DVP framework to analyze two situations where opposing worldviews were expressed to understand how accommodations were reached in these situations.*

*The accommodation of views was reached not through a comparison of activities with the situation as in the conventional SSM approach but rather, through the debate about conditions under which the transformation could be enacted. Systems models that do not include the concept of the conditional states may miss this important aspect of reaching accommodations in world views particular when the views appear to be so opposed that it is difficult to see how they can be reconciled.*

*Keywords: Soft Systems Methodology, SSM, Decision Variable Partitioning, DVP, Negotiation, Conceptual Models*

## INTRODUCTION AND BACKGROUND

Soft Systems Methodology (SSM) is a methodology used in complex situations to enable different meanings or views within the situation to be rigorously expressed, discussed, debated, and negotiated. For example, a prison could be viewed as a rehabilitation system, a punishment system, or a university of crime (Checkland, 1981), (Checkland & Scholes, 1990). There are numerous studies reporting the use of SSM in management and information systems development projects as a means to enable an appreciation of the situation and the negotiation of meanings prior to determining the information support for the activities associated with a particular worldview (Avison & Wood-Harper, 1990), (Davies & Ledington, 1991), (Checkland & Holwell, 1998), (Lewis, 1994), (Stowell, 1995), (Stowell & West, 1994), (Wood-Harper et al, 1985).

The concept of systems is used within SSM as a framework to express differing views. The systems framework used within SSM comprises a set of logically connected activities needed to express a particular view of the world. This set of activities is then compared with the situation to determine changes deemed culturally feasible and systemically desirable. A functional decomposition approach to model representation is used within SSM but it has been suggested that SSM models are too simplistic (Hirschheim et al, 1995).

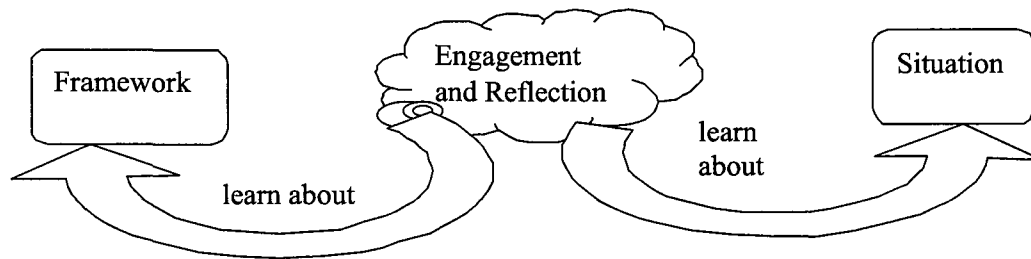
An alternative systems framework, Decision Variable Partitioning (DVP), that uses decision variables as the basis of decomposition has previously been proposed (Ledington & Ledington, 1999). This paper continues the stream of work on DVP, by using the elements of the DVP framework to analyse two situations where opposing worldviews were expressed to appreciate the meanings that were negotiated and the accommodations reached in the situations.

The rest of this paper proceeds as follows. Section 2 describes the methodology used in this research. Section 3 describes an alternate decomposition strategy termed Decision-Variable Partitioning (DVP) and Section 4 provides an analysis and interpretation of the situations using the DVP framework. Section 5 concludes with a discussion on limitations of the research and directions for future research.

The following section describes the methodology used in this research.

## METHODOLOGY

The strategic methodology used for managing this research is Checkland's FMA model of research, as depicted in Figure 1, where a framework is compared with a situation to learn about the framework, the methodology, and the area of application. Although this model is used by Checkland as an interpretive action research approach in Soft Systems Methodology, it can be viewed as a generic research model (Checkland & Holwell, 1998). In positivist research, the framework (theory) is viewed as a description of reality (ontological) and tested from this perspective. The framework proves useful if it can be shown that it provides a description of reality and can sustain rigorous testing in many situations. In interpretive research, by contrast, the framework is seen as a lens that can be used to appreciate the situation with the emphasis being on learning about the framework and / or on learning about or improving the situation (epistemological). The framework, from an interpretive perspective, provides a language to appreciate the situation or engage with people in the situation to bring about change in the situation. It may provide enlightenment about the situation but is also limiting in that it is only one lens through which the situation can be appreciated. The framework can yield insights specific to a particular situation and those insights will differ depending on the situation. Rigour is achieved in interpretive research if the framework used for interpreting the situation is declared and the interpretations based on the framework are clear (Klein & Myers, 1999), (Checkland, 1981). Therefore the value of the interpretive framework is in the lessons and insights that it can yield in different situations.



**Figure 1: Research Methodology**

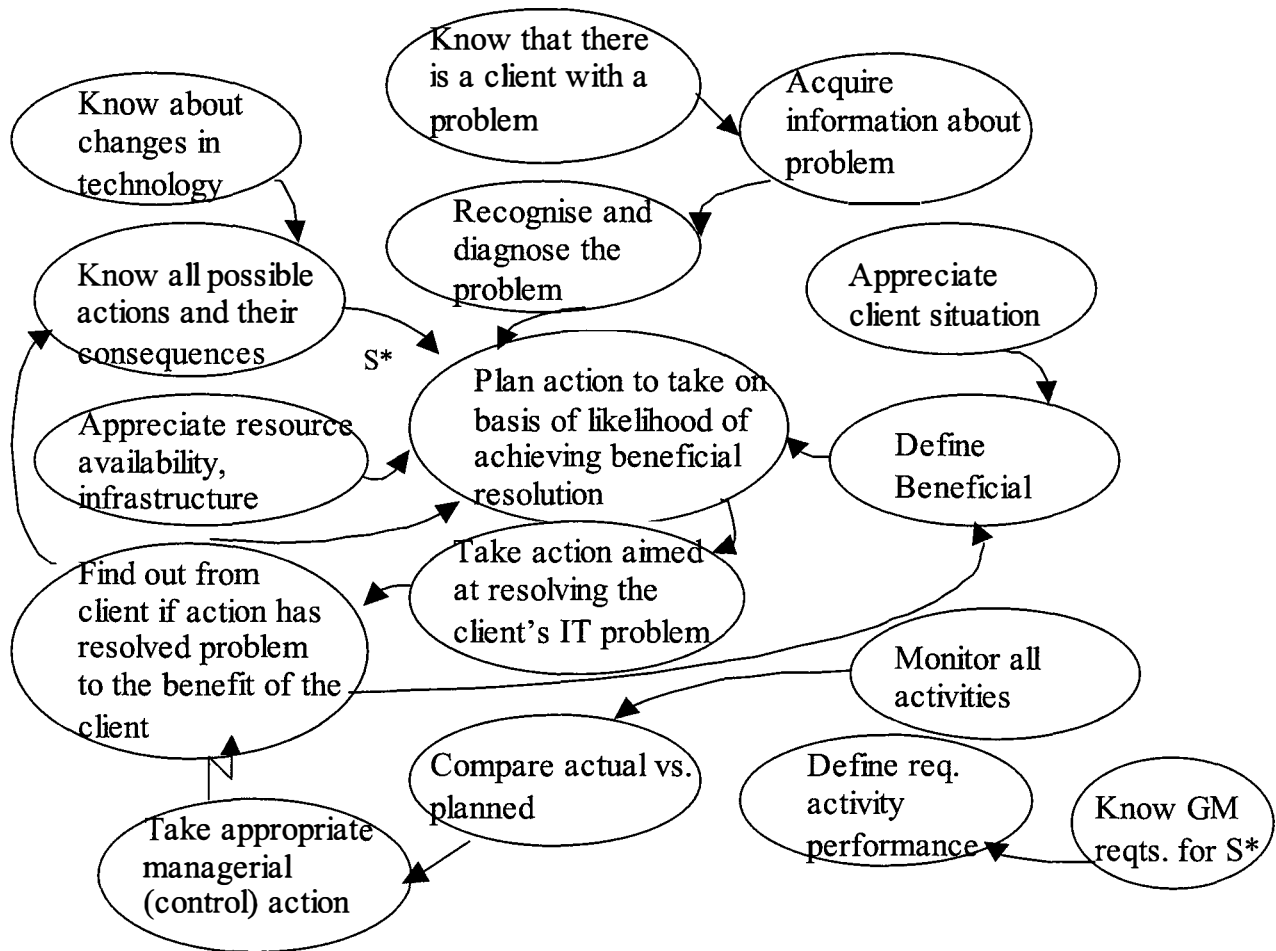
In this study, the language of the systems framework using DVP is used to reflect upon the meanings that were negotiated in two situations in which the researchers were involved. It is not used in action research mode within the situation to question participants in the situation and express differing views but rather as a reflective tool to appreciate the negotiations that occurred within these situations. The emphasis in this study is on the learning about the DVP framework as a sense-making lens rather than being used to structure conceptual activities.

The next section describes the DVP systems framework.

## **THE DVP SYSTEMS FRAMEWORK**

The systems framework used in SSM comprises a set of logically connected activities representative of a particular worldview as expressed in a root definition (Figure 2). The activities carry out a particular transformation that is not explicitly shown on the model.

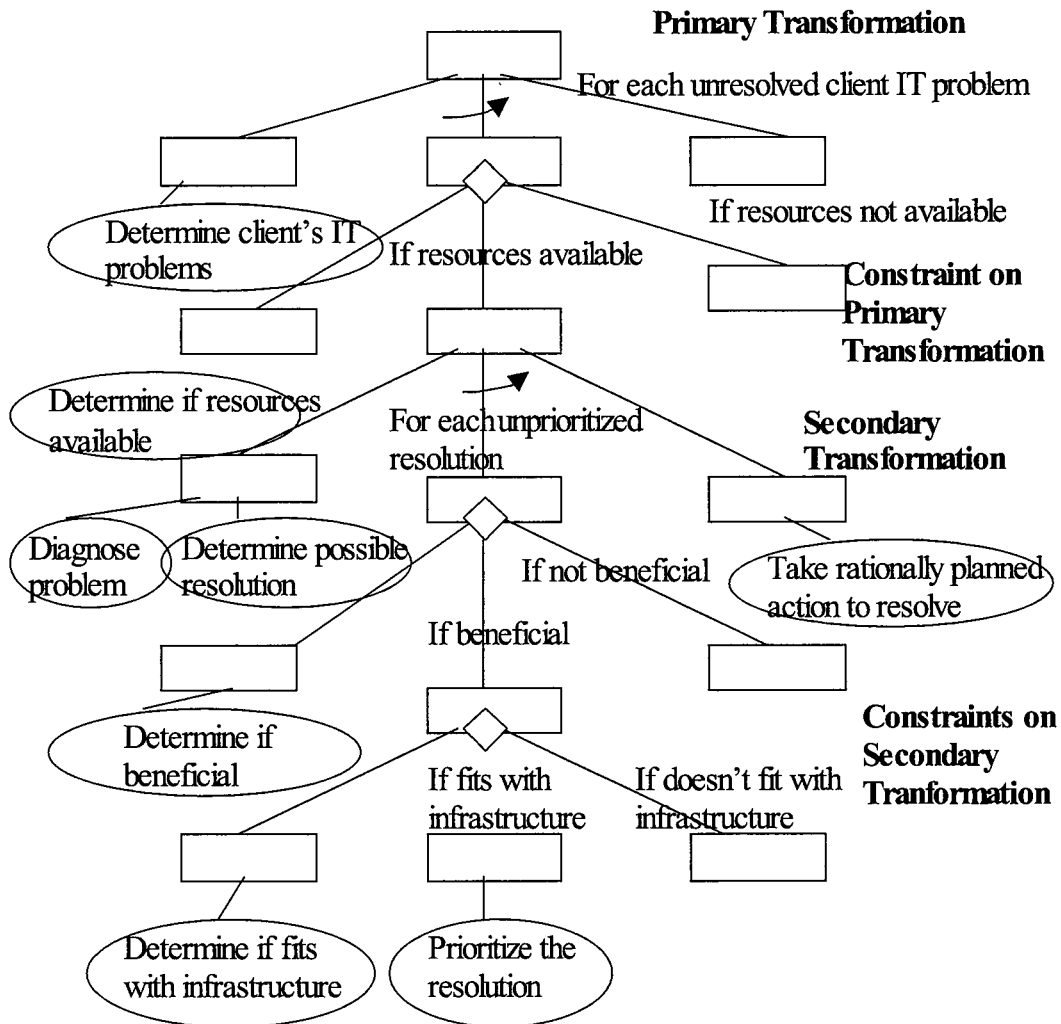
**Root Definition:** A Group Manager-owned system, manned by IT knowledgeable and customer focussed personnel which recognises, diagnoses, and takes rationally planned action to resolve IT related problems which affect end-user (clients) such that the client finds the resolution beneficial. The system operates under the constraints of resource availability, rapid technological change, and the limitations of the existing infrastructure.



**Figure 2: Conventional SSM Model** (Adapted from Ledington & Ledington, 1999)

The systems representation using DVP for the same root definition, (Figure 3), contain additional decision elements where the looping construct represents the transformations expressed in the worldview. In this example, two transformations 'from unresolved to resolved client IT problem' and 'unprioritised to prioritised resolutions' are shown on the model. The if-then-else construct represents the constraints under which transformations may occur. 'If resources available', 'If resolution is beneficial', 'If resolution fits with infrastructure' are the constraints shown in this example that govern whether activities to achieve the transformations will be carried out or not. The activities needed to carry out the transformations under the conditions specified are also contained in the model. It has been argued that the additional language elements of transformations and constraints upon a transformation allow more complex situations to be expressed, for example, more than one transformation can be represented (Ledington & Ledington, 1999). It also has been argued that the constraints under which the transformations may occur are an important aspect of the social negotiation of meaning and this argument is also supported in the literature (Mills & Murgatroyd,

1991). In the conventional SSM model, the constraints may be implicit in the model or referred to as activities. For example, in Figure 2, the activity ‘appreciate resource availability, infrastructure’ is shown as an activity; however, this activity is not explicitly shown as a state that may govern whether subsequent actions are carried out or not. Nor is the activity highlighted as an important element of negotiation but rather as a logical activity within the model. That is, there is no explicit focus on the constraints.



**Figure 3: Decision Variable Partitioning Example Based on the Root Definition**  
(Adapted from Ledington & Ledington, 1999)

The DVP approach to systems modelling brings into focus the elements of constraints. Activities are seen to be undertaken only when certain conditions apply. Further, the modelling approach itself places greater emphasis on understanding the constraints deemed relevant in a situation.

A discussion of two situations where opposing worldviews were expressed and an analysis using DVP of these two situations follows.

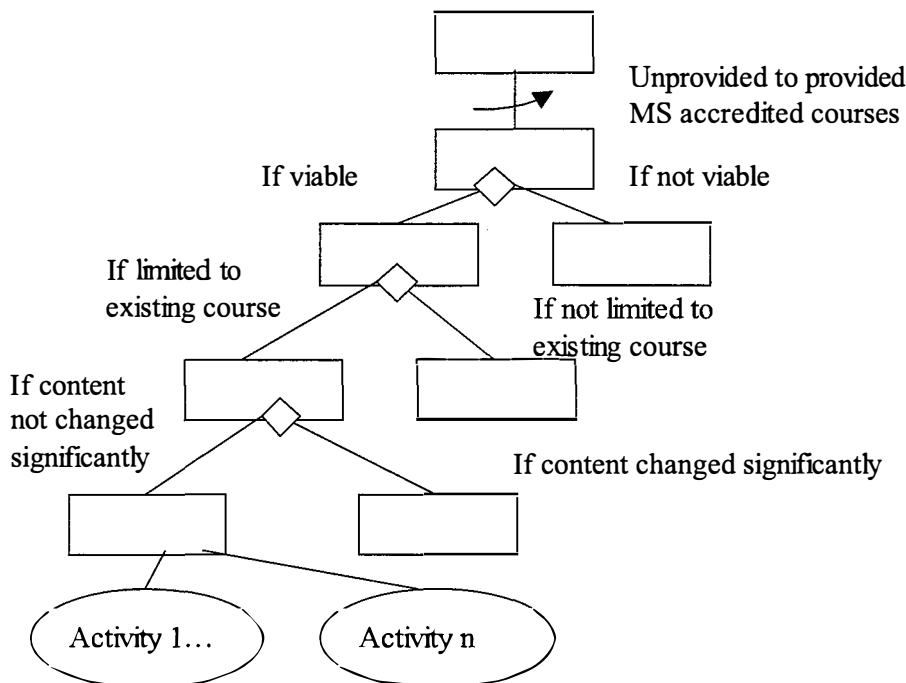
## DESCRIPTION AND ANALYSIS OF THE SITUATIONS USING DVP

In this section, two situations in which opposing worldviews are expressed and debated are described and the language elements of DVP are used to interpret the accommodations that were reached in each situation. Each author of this paper was involved in one of these situations.

The first situation was one in our information systems school that is located in the Faculty of Business. A proposal was raised to include Microsoft accredited courses in our curriculum. The school is a small one with five members at the time. Two members of the school were very opposed to the suggestion, one of the authors of this paper being one of those members. These members believed that the proposal did not fit the school's focus that was on information systems in business rather than on information technology. Two members of the school strongly supported the idea arguing that it provided students with much-needed skills for the workplace. Hence, two members of the school wanted the transformation from unprovided to provided Microsoft accredited courses to occur and two members did not. A strategic planning day for the school was organized and the issue was raised. Discussions for and against the proposal started to become quite heated.

The argument was diffused by the Head of Discipline when she said that she would accept the proposal if it was limited to the one fairly technical course that was already in existence; it did not seriously affect the content of what was already taught in that course and; it was financially viable. Both parties accepted these conditions. This acceptance came as quite a shock to the one author involved in the situation because my beliefs against the proposal were so strong that I did not believe my thinking could be shifted.

Using the language elements of constraints in the DVP model to analyse this situation, the accommodation of views was reached not through a comparison of activities of the conceptual model with the situation that would be suggested by the use of SSM but through a negotiation of the constraints under which the transformation of providing the courses should occur. That is, the conditions under which it was agreed that the transformation should occur ('If viable', 'If limited to existing course', 'If course content not changed') were the basis for reconciling the worldviews. The accommodated worldview as expressed in systems terms using DVP concepts is shown in Figure 4.



#### Figure 4: Accommodated DVP Representation – Microsoft Accredited Courses

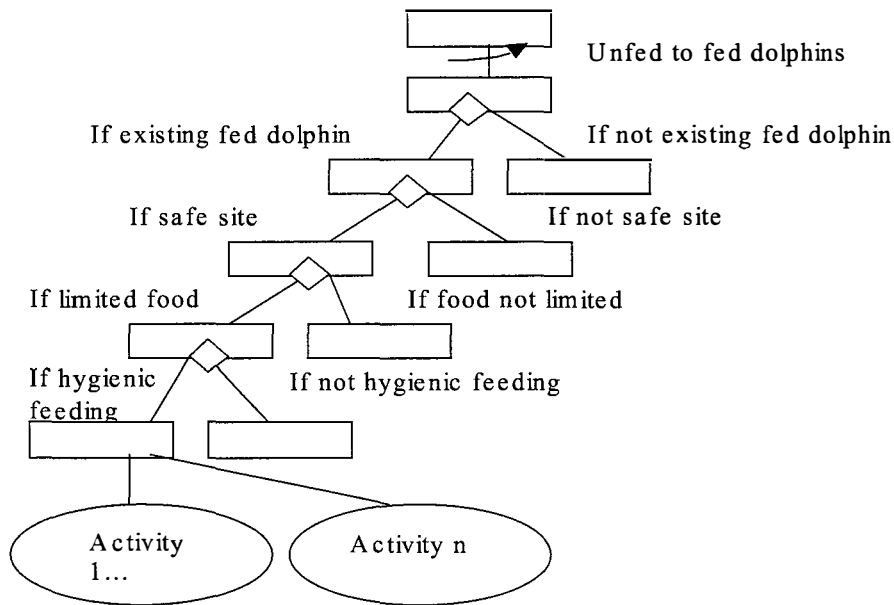
The conceptual model in this study is not used as a means of bringing about change but as a reflective tool to appreciate the negotiations that occurred within the situation. While this analysis, using the framework, may seem simplistic, the head of school, when questioned, was unaware she had used the constraints or conditions under which the transformation was or was not acceptable as a means of negotiation. She had simply expressed what she felt was an acceptable solution from her perspective. Without the framework to help make sense of what occurred, this learning may have been missed.

It has been argued that the constraints may play an important role in the negotiation of meaning and if they are not made explicit an important element of the social negotiation process may be missed (Ledington & Ledington, 1999). In this situation, the role of the concept of constraints was to provide a language for reconciling very opposing worldviews that seemed irreconcilable. Using DVP concepts, the insight to be gained from this illustration is that any discussion about doing an activity can be represented as the set of conditions under which it would be done.

The second situation was one that received a lot of media attention in our region. The hand feeding of dolphins was occurring at a particular site in the region. The practice had come about unofficially as locals and then tourists to the area began to feed the dolphins. Concerns were raised about the dolphins' safety at the site as it was near a boat ramp, the possible changes that could occur to these wild animals feeding patterns and the health risks to the animals. Stakeholders to the debate about whether the feeding should be allowed to continue or not included politicians, government bodies, environmentalists, and residents. Some of the stakeholders were totally opposed to any kind of human / dolphin interaction while others wanted the situation to continue without any intervention. Again, in this situation, very opposing worldviews were debated where one group wanted the transformation of feeding the dolphins to occur while another group did not and the views appeared irreconcilable. A public meeting was held which again became very heated.

While negotiations are still continuing on this issue, it appears that accommodations are being reached in terms of the conditions under which feeding should continue with suggestions including moving the feeding to a safer site, limiting the amount of hand feeding, strictly regulating the hygienic aspects of the feeding process, and limiting the continuation of the practice to the already existing dolphins that come to the sight.

Using the DVP concepts to analyse this situation, the accommodation of views is being reached by negotiating the constraints under which the transformation of feeding the dolphins should occur. Figure 5 depicts the DVP systems representation of the accommodated worldview.



**Figure 5: Accommodated DVP Representation – Dolphin Feeding**

Again, in this situation, the language elements of the DVP model provide an appreciation of the role of constraints in the negotiation of opposing worldviews and actions.

To create a conventional SSM model, Checkland (1981) argues that activities are conceptualized by considering those activities that are logically required to carry out the transformation contained within the root definition. From the DVP representation, however, more than one set of logically derived activities could be conceptualized. In Figure 5, the constraint 'if safe site' could be used as a basis for designing activities to try to ensure this constraint is met, for example, the model may contain activities 'determine safety requirements' and 'design site to meet requirements' or 'choose site to meet requirements'. Alternatively, it may be that participants in the situation take the condition as given and not used as a basis for design but rather only used to determine whether the activities of feeding should occur or not. In the MS accredited course situation, for example, it may be participants don't wish to design activities to ensure the constraint 'if economically viable' is met. The constraint may be determined by Microsoft's charges in relation to the course and the Government's standard fees that can be charged for a course or participants may choose to try to design activities such that the condition is met. Therefore, a logical set of activities to carry out the transformation seems impossible without considering the implications of the negotiated constraints.

The two examples given illustrate the use of DVP concepts to reconstruct an explanation of an historical situation. However, it also can be noted that any choice of system really implies the set of conditions under which the system can be enacted and is thus meaningful. The broader implication from this finding is that, in choosing a relevant system in SSM, certain constraints are implied. Thus, whereas the differing views of a prison that introduced this paper are treated as isolated perceptions by SSM, they can be seen as related by using DVP concepts. Whether, predominantly, a prison is a rehabilitation system or a punishment system is a reflection of the pairing of constraints and actions shaping the situation. The DVP concepts, therefore, extend SSM in a new and innovative way of thinking about problem situations.



## LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

This study has described two situations in which the language of constraints has been used to appreciate, historically, the process of negotiation enacted in these situations. The negotiation of opposing worldviews was shown to be through debate about the conditions for action not the comparison of conceptual activities with the situation. Systems models that do not include the concept of the conditional states may miss this important aspect of reaching accommodations in worldviews particular when the views appear to be so opposed that it is difficult to see how they can be reconciled. This is a major innovation to Soft systems Methodology that is focussed on the comparison of activities.

It has also been argued that deriving a set of logical activities to carry out a transformation is not a simple process but requires discussion regarding the treatment of the constraints and their implications for the design process.

The major limitations of this research are that in neither situation did a win - win situation occur and it cannot be known whether if the conventional approach to SSM had been used in consultancy mode a win - win situation could have eventuated. In the two situations reported in this study, systems models were not used to facilitate the debate about change but rather the DVP concept was used to analyze the situations in retrospect. Future research will use the DVP modelling approach in action research consultancy mode to further understand the additional constructs of the DVP model in the process of negotiating meanings and bringing about changes to situations based upon the use of systems ideas.

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# Applying Checkland's FMA Approach to a Software Engineering Problem using Action Research

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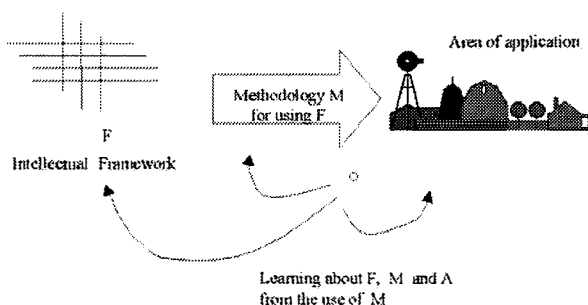
## ABSTRACT

*The purpose of this paper is to show how Checkland's FMA approach was applied to an action research project conducted into a software engineering problem of designing new diagrams. Checkland's FMA approach involves explicitly declaring at the outset of an action research, a framework of ideas (F), the methodology to be used (M) and an area of application (A) as a means of learning about the research process in order to improve rigour. The paper describes how the FMA approach was applied to designing new diagrams and outlines how in particular the framework of ideas (F) was used to guide and direct the outcomes. The results indicate that the framework of ideas (F) is likely to be modified by the experiences of the research and may be considered a set of starting assumptions only.*

*Keywords: Action research, software engineering, information systems, information systems development*

## INTRODUCTION

The research approach known as Checkland's FMA approach which is discussed in this paper frames **action research as a process of learning** (Checkland 1985, Checkland 1991, Hindle et al. 1995). It involves declaring a framework of ideas at the outset of the research. A framework of ideas is a set of ideas or a theory which 'a priori are thought to be relevant to an understanding of the problems faced' (Hindle et al. 1995, p455). As such, Checkland's FMA approach is both a means of expressing the underlying philosophical perspective that the researcher adopts in carrying out the research and later it becomes a means of interpreting and evaluating that research. Figure 1 shows how the FMA approach interacts with learning through action.



**Figure 1: The Organised Use of Rational Thought** (Adopted: Checkland, 1985)

In figure 1, F represents a framework of ideas which underpin the execution of a particular methodology M in an area of application A. The purpose of the Checkland (1985) paper was to discuss soft systems thinking in terms of a learning paradigm. In this paper, the framework of ideas (F) discussed consisted of soft systems ideas and the methodology (M) was SSM (Soft Systems Methodology). Checkland's point was that there is strong intellectual consistency between a framework of ideas based on soft systems ideas and a methodology which facilitates the application of soft systems ideas. In electing to distinguish the three constructs of framework, methodology and area of application, Checkland clearly considered that there is advantage in this delineation as far as evaluating learning is concerned. Further, Checkland makes the point that *'this is a very general model of the organised use of rational thought and applies not only to O.R. [operations research] but to applied natural sciences as well'*. (Checkland 1985, p758). In other words, Checkland was presenting this as a **general learning and evaluative** framework that could be applied generally in research. A related question is whether researchers working in a specific domain (such as designing new diagrams) might not be aided by a domain-specific set of ideas to assist them in their work.

An advantage of this approach is that it forces the researcher to make **explicit** conceptual issues which are considered relevant to the research process (Checkland 1985). However, it also has to be recognised that the very act of making explicit aspects of one's research while conducting it, even for learning and evaluation, changes the nature of the research process. For example it may cause researchers to frame and structure their thinking in certain ways and so the implications of this have to be considered carefully.

The paper proceeds as follows. The next section discusses the history of using action research to design diagrams to support information systems development and also briefly the uniqueness of this research. In the following section there is a brief overview of the framework of ideas (F) made explicit at the beginning of the research, the action research methodology (M) and areas of application (A) respectively as they applied to this research. This is followed by a discussion of findings in terms of the learning that took place through using this approach. This learning caused the role of the framework of ideas (F) to be reconsidered. The paper concludes by discussing the broader implications of what has been outlined in this paper.

## **ACTION RESEARCH AND DESIGNING DIAGRAMS**

It would appear that there is a wide diversity in the use of action research as a research approach in Information Systems. For example, in a comprehensive literature review of action research in Information Systems over the last 25 years, Lau (1997) observed a wide range of research topics including computer-based planning models, comparisons of experienced and novice analysts, online catalog systems, healthcare issues and so on. While the range and novelty of such research is impressive, there are clearly still many research topics which have not yet taken advantage of the opportunities and flexibility that action research has to offer. For example, no action research study in Lau's review focused on designing new diagrams to model information systems.

The closest types of study to this type of research in the literature are those that use a field study approach to test a diagram which was previously designed by a researcher. However, such studies do not directly involve analysts or users as **co-researchers in the actual design process**. Examples include Calloway and Ariav (1990), Fitzgerald (1991) and Flynn and Davarpanah Jazi (1998). With regard to Calloway and Ariav's work, they had previously designed a dialogue chart and then used field trials with students with interview follow-up to gauge the success of their diagram. In other words, they did not use action research as a **research process** for designing their diagram. Similarly, the work reported by Fitzgerald reflected on how a type of action diagram might be validated, but again action research was not used to design the diagram. Flynn and Davarpanah Jazi tested an event flow diagram with users in the context of user led development. Again, the diagram had been designed prior to research commencing. These approaches reflect a particular mindset concerning designing diagrams. In these approaches it is assumed that the designers know and

understand the problems of analysts and users and have addressed these in their candidate diagram(s). The object of these studies was therefore to test (or as Fitzgerald puts it to validate) the diagram after it had had been designed. In the action research studies described in this paper it was not assumed that the diagram designer (researcher) knew or understood the problems of analysts and users, and **so analysts and users were involved as co-researchers in designing the diagram itself**. This offered the opportunity for other aspects, for example social, contextual and workflow aspects which the researcher may have had little insight into, to be addressed while the diagram was under design.

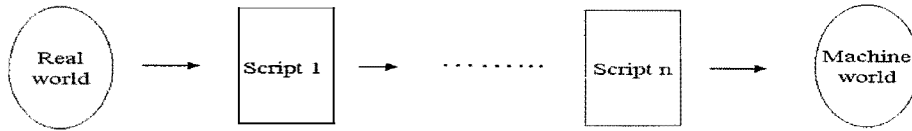
## CHECKLAND'S FMA APPROACH

### Framework of Ideas (F)

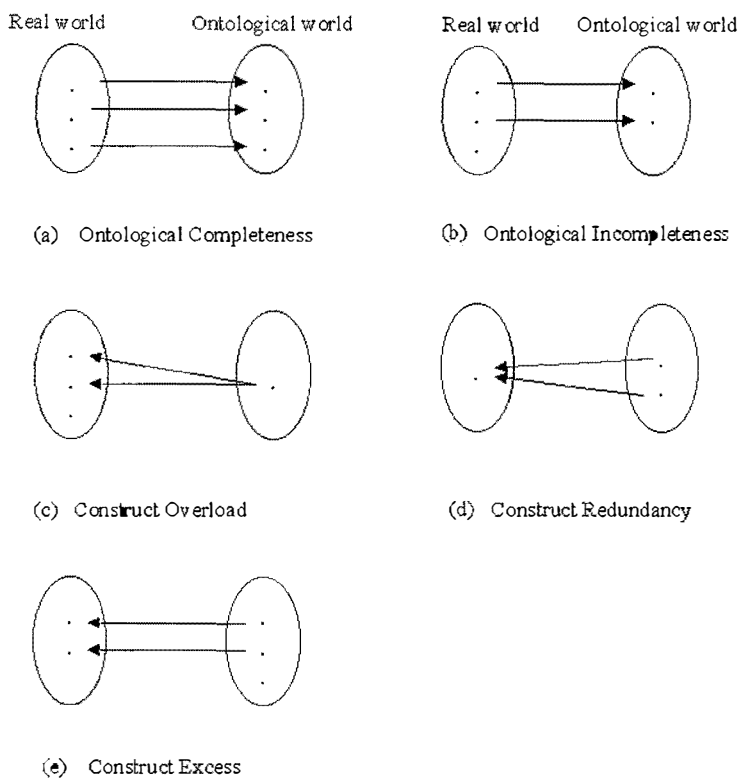
An intellectual tool was required to make the underlying perspective and approach to the action research study explicit (as far as possible). After some search, an approach by Wand and Weber (1993), hereafter referred to as the W+W model was selected as suitable for guiding research into new diagrams. It is based upon a particular ontological model developed by Bunge (1977, 1979). Ontology is a branch of philosophy concerned with articulating the nature and structure of the world (Bunge 1977). Of particular relevance to the problem of designing diagrams is the notion of mappings of ontological constructs onto design constructs. Ontological constructs are asserted to represent perceived relevant constructs in the real-world. For example, when working with an early version of the new diagram, events were considered to be a fundamental construct of the real-world and so the ontology reflected that. Design constructs are constructs which exist in the design world (e.g. in diagrams) and these should represent the constructs in the ontological world. In other words, design constructs are syntactic representations of the semantic concepts of the ontological world. So, for example, in the early diagram referred to above, there was a notational symbol to represent an event.

W+W provide a model which is consistent with and formalises this view of elaboration. They speak of the mathematics of mappings in which the real-world is mapped via scripts onto the machine world (figure 2). Many scripts are necessary in information systems development because typically there are many intermediate models (design worlds) between the real-world and the machine world (program code).

Figure 3 shows five scenarios. In figure 3a, ontological completeness is shown. This means that there is a good mapping between the ontological world and the design world, i.e. all ontological constructs have a corresponding design construct and all design constructs have an ontological construct. In figure 3b however, there is ontological incompleteness. Here one particular ontological construct does not have a corresponding design construct. W+W argue that ontological incompleteness is undesirable because the design world would not be able to represent all real-world phenomena which are considered relevant. In figure 3c a situation called construct overload exists. Construct overload occurs when one construct in the design world represents two (or more) constructs in the ontological world. Again, this is argued to be undesirable because it lacks clarity and may lead to confusion or ambiguity when reading design models. Figure 3d shows construct redundancy which in one sense is the opposite of construct overload. In construct redundancy there are two (or more) constructs in the design world which can represent a single construct in the ontological world. This is considered undesirable because designers have to work with more constructs than necessary as well as leading to possible confusion. Lastly figure 3e describes construct excess. Construct excess arises when a construct exists in the design world which does not have a counterpart in the ontological world. The presence of construct excess may indicate three things. Firstly, it may indicate deficiency in the ontological world. Secondly, it may suggest that the design world contains an unnecessary construct, i.e. one which is outside the scope of interest of the ontological world. Thirdly it may be symptomatic of a generally fuzzy understanding about the nature of the abstraction process.



**Figure 2: Mapping of Scripts from Real World to Machine World**



**Figure 3: Five Scenarios in Ontological Framework**  
(Adopted: Wand and Weber , 1993)

Wand and Weber have applied their ideas to the evaluation of a number of existing techniques and methodologies (although these ideas have not been used in the design of new diagrams). For example, their ideas on mappings and scripts have been used in evaluating object-oriented concepts (Parsons and Wand 1991), the dataflow diagram (Wand and Weber 1993), the entity relationship model (Wand and Weber 1995) and the NIAM methodology (Weber and Zhang 1996).

In terms of this research therefore, the W+W model was to be used to check the consistency of the mapping between the real-world and script 1 (see figure 2), the tests for goodness being those identified in figure 3. Note that the W+W model did not contain any sense of which specific constructs were good or bad for this task, that is there was nothing in the W+W model which suggested that an event was a better construct than a dataflow or entity for example. This was considered an advantage of choosing this model for the framework of ideas because it did not constrain the research to preconceived ideas about the goodness of one construct over another.

## Methodology

Over the course of the two action research studies, six different versions of the new diagram were developed. Earlier versions contained fewer constructs; as each version was evaluated, it was concluded that there was a need for additional constructs to ensure completeness in the description of a business rule. By the end, four major constructs (different symbols) were identified as the minimum for holding a reasoned yet complete discussion with users about requirements.

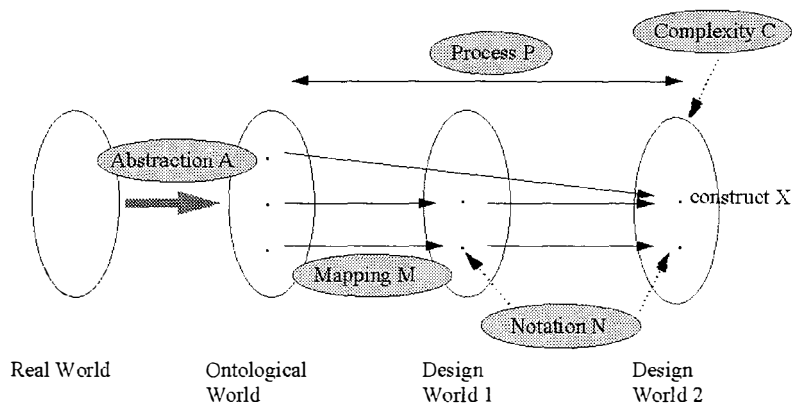
## Areas of Application

Action research studies were performed in two organisations (McDermid 1998). In the first organisation the researcher worked with a systems analyst on an existing system (a portbilling system). The research objective of this study related to the problem of completeness in specifying business requirements in information systems. The outcome of this study was the production of an initial definition of a 'business rule' and a means of diagramming it. In the second organisation, an analyst and users were studied using this Business Rules Diagram (BRD). In this study, although to some degree a confirmation of many of the technical aspects which emerged in the first study, aspects of how users prefer to use and work with diagrams were also observed.

## RESEARCH FINDINGS

Figure 4 shows an extended version of the original W + W model. In figure 4, the thick arrow represents abstraction, single-headed arrows represent mappings, the double-headed arrow shows the span of effect of the process P category and the dashed arrows show the object to which each category relates. This was constructed by reflecting on the preceding research. It highlights various categories of issue that had emerged in the research.

Three aspects are particularly noteworthy. Firstly, figure 4 contains a number of new annotations. These annotations represent **categories** into which all the issues occurring in action research study were classified (through content analysis). As such it represents a more sophisticated view of the development process than did figure 2 since, with the exception of mapping (M), all other categories were not identified in figure 2. Abstraction (A) is to do with the process of abstracting the real-world into the ontological world. So, where issues arose concerning whether a construct ought to exist in the ontological world, this issue was categorised as an abstraction issue. Mapping (M) is the category which deals with issues associated with mapping from one set (world) to another set (world). This was the only category predicted by the original W + W framework (figure 2) i.e. in terms of ontological incompleteness, ontological completeness, construct overload, redundancy and excess. Notation (N) is a category of issues concerned with notation, i.e. how best to depict a particular construct. Process (P) is a category which refers to issues to do with process steps in creating a design construct. The last category was complexity (C). This category is allocated to issues associated with the perceived complexity of a design world in terms of how easy such a world would be to be construct or use.



**Figure 4: Extension of Wand and Weber's Model**

Secondly, figure 4 shows an **abstraction** from the real-world to the ontological world. Whereas **mappings** can be argued to exist from the ontological world to the design world and from one design world to the next, the relationship between the real-world and the ontological world is better described as an abstraction. The ontological world contains a set of constructs which are considered to represent the real-world or some part of it. Other ontological worlds may similarly assert that they also represent the real-world. By declaring an abstraction between the real-world and the ontological world we focus attention on the purpose of the ontological world which is to represent what is considered important in the real-world with respect to the problem on hand.

The third aspect is to note that sometimes constructs from both the ontological world and the design world can be mapped onto constructs in another design world. Construct X in figure 4 illustrates this situation graphically.

Collectively the above three aspects demonstrate that the business of designing new diagrams is more complex than the original W + W model of figure 2 implied. Space limitations in this paper do not permit a full discussion of all of the above. However, a discussion leading to the conclusion that a category of process (P) was required now follows to illustrate the arguments and reflections that took place.

Process (P) is a category that addresses issues associated with the steps in a methodology and the type of deliverable appropriate at each stage. The model in figure 2 implied that the development process was quite linear and that for example no alternative routes or pathways to achieving a deliverable were possible. The experience of the research was that this was restrictive. A richer model was required which explicitly showed steps and alternative routes through a development activity and this was found in Glasson's model of systems evolution (1989). The model involves three concepts namely system evolution, states and deliverables. The concept of system evolution allows for the existence of different design worlds in W+W's terms, but further it allows for flexibility in the routes that are taken by developers. A states is used to describe its position in relation to its evolution through systems development. So at any given moment, an evolving information system can be said to be in a particular state. States may be decomposed into deliverables which are specific outcomes of development work e.g. a screen or a diagram. Indeed, deliverables if large may be decomposed into sub-deliverables. Figures 5 and 6 illustrate these concepts.



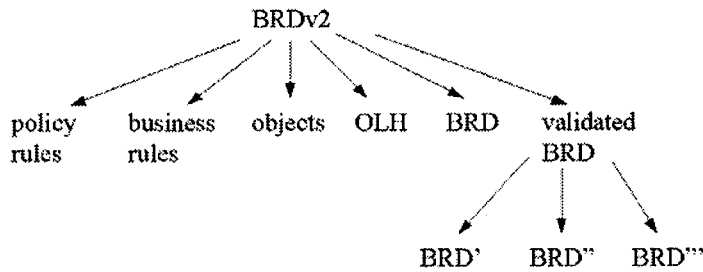


Figure 5: Structural Decomposition in Glasson's Model

Legend:

BRDv2: version 2 of the Business Rules Diagram i.e. the diagram being developed by this research  
 OLH: Object Life History

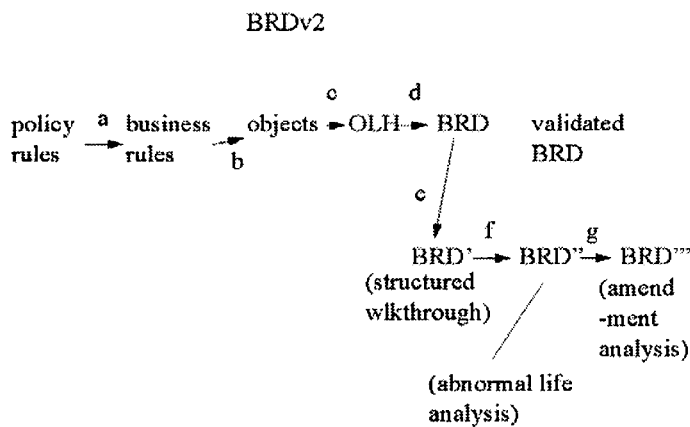


Figure 6: Development Sequence in Glasson's Model

In figure 5 the relationship between state, deliverable and sub-deliverable is shown. The BRDv2 is considered a state in Glasson's terms, i.e. either it has been constructed and therefore exists or it does not exist. If it has been constructed it implies that a number of deliverables have been constructed. Further, in figure 5 the validated BRDv2 (ie a deliverable) is decomposed into three sub-deliverables. These sub-deliverables represent versions of the BRDv2 which have undergone a structured walkthrough, abnormal life analysis and amendment analysis respectively. Figure 5 can therefore be seen to be able to describe aspects of the structure of deliverables in information systems development generally. However, that particular version of his diagram does not define the sequence of tasks. Figure 6 shows one possible sequence for developing the BRDv2. Here arrows are annotated so that the sequence of constructing these deliverables is shown. Other sequences are possible. For instance, business rules may be identified before policy rules or even at the same time. Such variations are more easily shown on this type of diagram. Further, it is also possible to show situations where alternative deliverables are used in the development process. For example, for this problem domain it would have been possible to use either a data model or an object model to create life histories.

In summary, therefore Glasson's model (1989) was better able to describe a specific development process (compared to figure 2) by defining the sequence of earlier versions of deliverables required to create a final deliverable. Alternative routes of development or alternative models used could also be depicted. So it was decided to incorporate this model into the intellectual framework. Further, the model was also able to describe aspects of the structure of deliverables in terms of their component deliverables. Overall, this is a more realistic view of the development process as any experienced software engineer will confirm.

## SUMMARY AND IMPLICATIONS

This paper has described how Checkland's FMA paper was applied to the problem of designing new diagrams. At the outset of the research, a model by Wand and Weber was declared and was subsequently used to guide the research. The experience of the research indicated that the W + W model had in fact identified only one of a number of categories that was needed to manage the research. Other intellectual tools (such as Glasson's model) were required to deal with other categories.

On reflection, the real value of this kind of research is considered to lie not only in the quality of the diagram designed in this instance. Rather, a greater value must surely lie in whether the researcher is in a better position to design another new diagram and whether in general the emergent categories of this research (abstraction, notation, process, complexity) might be transferable to other instances of designing new diagrams.

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# Viable Systems Diagnosis and Organisational Learning.

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## ABSTRACT

*This paper identifies the importance of organisational viability within the Australian Not For Profit sector. Organisational Learning is promoted as a conscious viability strategy. Progress by a practitioner/ scholar implementing Viable Systems Diagnosis as a framework for embedding adaptive strategies engendering Organisational Learning is reviewed. Typical of Action Research seeking improvement and involvement through active participation, the specific case study indicates Organisational Learning amelioration and an embryonic relationship of Organisational Learning to positive performance outcomes.*

*Key words: Action Research, Not For Profit, Organisational learning, Viable System Diagnosis.*

## INTRODUCTION – WORK IN PROGRESS

This paper sets out to describe work in progress introducing Viable Systems Diagnosis (VSD) (Beer 1985) as a framework for embedding adaptive strategies within an Australian Not For Profit (NFP) organisation. It cites literature on Action Research (AR) and the importance of the NFP sector. It links Organisational Learning theory to the VSD foundation commenced this case study.

AR is recognisable in the work of (Dewey 1929,1939) but (Lewin 1946) is generally acknowledged as its founder. Lewin's further work (1948); (Argyris 1985); (Checkland 1991); and members of the Tavistock Institute, including (Trist 1976); (Trist and Murray 1990) continue to advance debate for AR as a legitimate methodology for addressing complex organisational issues such as viability. AR's aim 'to contribute both to the practical concerns of people in an immediate problematic situation and to the goals of social science by the joint collaboration within a mutually acceptable ethical framework' (Rapoport 1970:499) permeates its applicability to this study.

Organisational viability is normally focussed toward tangible business indicators. Dissecting viability according to profit indication usually directs organisations into one of two main categories, those with a corporate for profit orientation, and those with a social or not-for profit (NFP) guidance (Lindorff and Tan 1997).

NFPs are a significant part of the Australian business sector. There are an estimated 8000 to 10000 NFP organisations (The Age 2000) each responsible for turnovers in the \$20-40 million p.a. range. Expending \$27 billion p.a. the NFP sector has grown to a position of fiscal importance 6.2% (Morris 1999) to Gross Domestic Product (GDP) amplifying the importance of their organisational viability. When considering organisational viability, NFP can be considered an unfortunate misnomer. 'NFP is the wrong term – it causes people to lose track of monitoring the performance of a business. You should call them not for dividend' (Clarke 1994). Many NFPs (Charities, Sporting, Local Government, Racing and Gaming Clubs) have adopted a quasi-government role as tax collection and/or service and support agencies whereby their collective worth is perhaps better understood.

Strategically it is important to Governments that NFPs maintain viability without threatening cultural fabric (Taylor 1996, Drucker 1997). Maintaining cultural fabric, the playing out of societal and shared purposeful roles (Ryan 1999) while coping with change, encapsulates the genesis of this exercise. Competencies required to balance fiscal and cultural demands in all businesses have compounded amid an accelerating emergence of new and alternative economies, social and technological trends and radically dynamic environments (Toffler 1980, De Geus 1997, Ackoff 1993). A desire to maintain NFP culture and viability prompts the question: can a VSD framework assist viability in promoting organisational strategies?

## **ORGANISATIONAL LEARNING AS A CONSCIOUS VIABILITY STRATEGY**

Establishing whether VSD assists viability requires awareness of reflective thinking and learning as ongoing organisational processes. In this organisation awareness has been rekindled via Russell Ackoff's (1993) coherent expression of the emergence of systems thinking and conscious Organisational Learning as new-age thinking.

Evolving from the Open Systems Theory of von Bertalanffy (1968) Organisational Learning and the concept of a Learning Organisation became popularised within common management vocabulary by Peter Senge's (1990) best-seller 'The Fifth Discipline'. Senge's disciplines, personal mastery, mental models, shared vision and team learning combine systems thinking as a cyclic reflective learning framework tracing from the work of (Dewey 1929, Kolb 1976). Systems' thinking suggests understanding learning can help unravel organisational complexity (Stacey 1993, Flood 1999). An organisation is able to learn independently of some individuals, but not independently of all individuals (Argyris and Schon, 1978). Organisational Learning is the logic that learning is a primary process affecting the way in which successful organizations consciously learn and manage their responses more successfully than those who do not.

The case study involves an organisation that has evolved rather than learned over time. Viability has been dependent on core business consistency in a relatively stable environment. Recent environmental changes (transparency, probity, animal welfare) requiring attention are not reflected in current strategies. The task is to create a learning atmosphere appropriate to today's environmental complexity.

Of significance to this practitioner/scholar is a recurring management theme of addressing complexity by trying to map what is really happening, onto what is meant to be happening. This theme essentially equates to addressing Ashby's (1956) Law of Requisite Variety:

'Only variety can destroy variety' – (Ashby 1956:207)

Now more commonly quoted as 'only variety can absorb variety' (Beer 1974) and continually reaffirmed (Nonaka 1994, Nonaka and Takeuchi 1995) requisite variety is identified as an enabling condition for the knowledge creating process. VSD is founded on requisite variety. VSD categorises interdependent feedback and control of five operative components (implementation, coordination, control, information and policy) as providing for variety, organisational learning and system viability. VSD has strong support (Cavaleri and Obloj, 1993, Espejo, 1994, Stacey 1993) as an appropriate methodology to address NFP social and organisational problems arising from radically dynamic environments. However VSD has also been criticised (Jackson 1988,1989, Flood and Jackson 1995), for its machine-like structure and lack of recognition of the human features necessary in any viable system, Social mechanisms promoting 'informal networks of learning conversations' (Sterman et al 1999) need to be examined in this study as an adjunct to VSD. In this way, social dialogue involving distinct issues such as culture and performance (Denison 1990, Gagliardi 1986), organisational power (Pfeffer and Cohen 1984, Pfeffer and Salancik, 1978) and both internal and external politics (Schuler 1986) can contribute to the understanding of Organisational Learning. Beer's template allows for this type of 'features lacking' inclusion. 'The value of VSD is to make clear how an organisation actually works, as distinct from the way that it allegedly works - so that it maybe improved' (Beer 1981:155).

## **METHODOLOGY**

The methodology used in this research involves two parts. Currently an initial organisational status is being established using:

- (a) Quantitative analysis of financial indicators in the ten-year period to June 2000
- (b) A focus on the qualitative adaptation of management structures and managerial competencies as a function of success based on both structured and informal interviews.

Secondly with respect to the AR component, the progressive implementation of VSD will involve:

- (a) Recognition of the VSD introductory process as an Organisational Learning methodology.
- (b) Preliminary understanding of the VSD and the identification of five operative components (implementation, coordination, control, information and policy)
- (c) Adoption of an introductory Organisational Learning model based on the Beer (1985) VSD.
- (d) Successive adaptation of that model through the two reflective cycles in the organisation
- (e) Positive progression in percentile indicators
- (f) Organisational ability to have in place a 'stand alone' process for future success and adaptation based on their VSD
- (g) Acceptance by other organisations to investigate an entrenched Case Study process.

## **RESULTS TO DATE: CREATING A CONSCIOUS ORGANISATIONAL LEARNING FRAMEWORK**

After some eight months work the study has:

1. Established data relevant to organisational structure, aims and objectives of employees and Key Performance Indicators (KPI) at commencement date. These comprise; market share, contribution to subsidiaries, return on investment, employment strategies. Employee KPIs include attendance, tenure, productivity, job-satisfaction, and education standards.
2. Implemented a formalised protocol of dialogue sessions at various levels of organisational responsibility. These sessions have introduced systems thinking via individual learning sessions embracing; the completion of diagnostic tests (Kolb 1976, Belbin 1981); video presentations (Ackoff 1993); having relevant staff implement time management

methodologies (Covey 1992) at all levels and dialogue involving Organisational Learning papers (Argyris 1991, Covey 1995).

3. Introduced VSD – not in its classical form comprising five operative components implementation, coordination, control, information and policy, but as an elementary isomorph known as PICCO to the organization. The mnemonic embraces a reversal of the original order of components with the implementation function replaced by an ‘operations’ function. PICCO is seen as a phase one VSD establishing a platform for future development. Evolution to a truer VSD will be in the future.

The Espejo (1989) yo-yo metaphor perhaps best describes progress to date. Development toward a true VSD rises and falls up and down the PICCO surrogate in a cyclic learning fashion. There is slow sometimes-serendipitous progress but it seems we can attribute causation back to VSD. In this study a diffusion of the PICCO process throughout the organisation and its subsidiaries has occurred promoting significant increases to levels of adult learning. PICCO has contributed to human resource management; infiltrating “protection of territory” in subsidiary organisations, getting people out of departmental defensiveness; generating well-being and fairness; providing firm logical direction; suggesting positivity for life and learning at work and arousing conscious consideration of the environment.

It should be emphasised that this exercise is a base for future development with two fundamental tenets. A traditionally conservative Board having endorsed this new learning methodology being prepared for not always aligned ideas. Secondly a practitioner/scholar with a desire to have a red-hot go at aligning NFP viability with organisational learning by the implementation of VSD.

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# Towards a Syncretic Method for Complex Systems-of-Systems Problems

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## ABSTRACT

*This paper attempts to identify some of the characteristics that a soft systems method for treating complex systems-of-systems, such as those arising in defence contexts, should have. This is done by examining several existing methods from a variety of disciplines and assessing how certain of their features may be beneficial or otherwise in addressing systems-of-systems problems. The methods considered include Conventional Systems Engineering, Personal Construct Psychology, Quality Function Deployment, Soft Systems Methodology, Distributed Knowledge Engineering and Critical Systems Heuristics. Eleven characteristics that would appear to be beneficial in a systems-of-systems method are identified.*

*Keywords: Soft Systems, Systems Methodology, Systems-of-Systems, Joint Systems, Defence.*

## INTRODUCTION

Conventional systems engineering methods have been found not to function effectively when clearly expressible crisp and rigid requirements cannot be established (Buede 1997). The problem is evidently greater when there are several 'customers' or 'stakeholders', since they may have conflicting needs or place different interpretations on requirements. However, situations where crisp and rigid requirements cannot be established frequently arise in high-level decision-making (Jackson 1990).

One example is strategic decision making in business. Another is acquisition decision making in defence (Allison and Cook 1998). In the case of high-level defence issues, there are usually at least four 'stakeholders' that should be considered. These are government and the three armed services. Defence acquisitions need to be carefully chosen so that they can be brought together into joint systems of systems that are capable of fulfilling the objectives of the government when called upon to do so. Unfortunately, in a world dominated by change and uncertainty, the needs of these stakeholders, in particular those of government, are labile and difficult to predict. The basic concept of a system of systems has previously been described by (Eisner et al. 1991).

In a world where defence budgets were unconstrained, it might be possible to have the best available of everything in whatever number desired. However, in the real world, defence budgets are tightly constrained. In such a world, allocating too much to one part of a system of systems may have the result of reducing overall effectiveness, because insufficient funds will be left available to enable other parts of the system of systems to be able to perform their functions effectively. A properly balanced allocation of funds is crucial. In other words, the opportunity cost impact on the overall defence asset portfolio resulting from large investments in single systems must be given due consideration.

## **METHODS REVIEW**

A number of methods and techniques that have appeared in the systems engineering, management science, public administration and knowledge engineering literature will be outlined in this section. It is felt the selection of methods presented forms a reasonably representative sample of those that might have features relevant to systems-of-systems problems.

### **Conventional Systems Engineering**

The concepts and methods of Conventional Systems Engineering (CSE) are described in considerable detail by (Blanchard and Fabrycky 1998). In summary, CSE seeks to translate a fixed and precise set of customer requirements into a set of technical products that meet those requirements. As explained above, There may be difficulties with this method if requirements are uncertain or if diverse clients must be satisfied simultaneously.

### **Personal Construct Psychology**

Personal Construct Psychology (PCP) was developed by George Kelly, a clinical psychologist who lived from 1907 to 1967 (Shaw and Gaines 1992). He sought to develop an axiomatic system for psychology somewhat similar to that developed by Euclid for plane geometry. This system is based on the notion of a multidimensional psychological space in which the elements of experience may be framed. His psychological geometry is based on dichotomous distinctions between these elements, so called 'constructs'. By creating such distinctions, elements are divided into similarity classes. Elements implicitly have values associated with them. The psychological space has 'angle' corresponding to correlations between elements, but no concept of distance. A construct has two poles associated with it which represent the extreme ends of the range of element values for which the distinction is meaningful. A human subject's 'construction system' is supposed to consist of a finite number of such constructs.

Based on these ideas, Kelly developed the 'Repertory Grid'. This consists of a table with rows representing constructs and columns representing experience elements or cases. Each case is given a numerical rating for each construct (typically integers in the range 1 to 10), according to its perceived proximity or distance from the two poles of the construct.

Computer aided tools such as those described by (Shaw and Gaines 1992) can be used to help elicit relevant constructs from subjects. Kelly originally employed the Repertory Grid as a psychoanalytic aid, and it has been widely employed in similar psychometric roles since. However, when the subject is a subject matter expert, it may also be used as a means for eliciting implicit expert knowledge. A system that uses Repertory Grid techniques to eliciting expert knowledge has been described by (Boose and Bradshaw 1999).

Several mathematical analysis techniques are traditionally associated with Repertory Grids. These include cluster analysis and principal component analysis. Cluster analysis of constructs identifies those which produce similar ratings for many cases and hence might be related in the mind of the subject. Cluster analysis of elements identify those which are similarly rated for many constructs and which hence may have characteristics in common in the mind of the subject. Principal component analysis allows clustering of elements in the plane of greatest variation to be observed, again identifying elements that are perceived as being similar.

For the purpose envisaged here, the subject would be a stakeholder who would be regarded as a subject matter expert for his own needs. A problem with Personal Construct Psychology is that, as the name implies, the focus is on the personal. Consequently, it would only appear to be useful for eliciting a subject's personal needs and preferences, rather than those of a group of stakeholders.

## Quality Function Deployment

The Quality Function Deployment (QFD) approach (ReVelle et al. 1998) was originally developed in Japan. Its origins lie in the post-World War II era during the reconstruction of the Japanese economy by America. An original focus on process quality control shifted to include an emphasis on design quality control as well. The aim of QFD is to assist the development of new high-quality products that have high appeal to potential purchasers. QFD concepts are claimed to have achieved considerable acceptance by Japanese industry by the 1960s.

The means by which QFD achieves a high level of appeal is by ensuring that the 'Voice of the Customer' is incorporated into each stage of product or service development and implementation. The initial stage of the QFD approach involves determining the potential purchasers' needs and preferences. Technical measures relevant to these are then identified. Alternative design solutions are rated on how well they score against the technical measures. The relationships are usually tabulated in a particular fashion, termed the 'House of Quality'.

A problem with QFD is that the potential purchasers are treated as homogenous. Thus, possibly conflicting needs are not addressed. Nor is there provision for explicit interaction between potential purchasers to allow consensus or varied opinion groups to be formed. Potential purchasers are not assisted to develop a better understanding of their needs and those of other stakeholders.

## Checkland's Soft Systems Methodology

Checkland's Soft Systems Methodology (SSM) was originally developed to assist managers in business situations to improve their businesses (Checkland and Scholes 1990). As implied by the name, SSM employs a system metaphor. Its emphasis is on assisting a group of stakeholders to learn about their mutual needs and the overlaps and conflicts between these. By resolving conflicts and comparing the harmonised needs with what exists in the real world, stakeholders are hopefully able to reach conclusions about what actions to take to improve the situation.

Checkland makes use of the system metaphor to help structure investigation of the situation. His usage differs however from the positivistic one that is frequently employed. His systems are subjective, and do not necessarily have an objective existence. Since they are concerned with human activity, they are termed Human Activity Systems.

Checkland's Human Activity Systems (HAS) consist of a number of elements. These are Customers, Actors, Transformation, Weltanschauung, Owner and Environment. The term 'customers' is used to refer to stakeholders who are affected by the HAS. The 'actors' are those involved in performing the activities associated with the system. The 'transformation' performed by the system is implicitly defined by the change that the system produces. Weltanschauung refers to the subjective viewpoint from which the system is considered to exist. The owner is the person who has authority over the system. The 'environment' represents constraints within which the system must operate.

Identification of stakeholder needs is achieved by constructing so called 'Conceptual Models' for the Human Activity Systems. These are diagrams containing nodes that represent the functions that it is perceived should be undertaken in order to bring about the transformation performed by the system. Thus, the functions in the Conceptual Models correspond to the needs of the stakeholders. The SSM process is intended to be highly interactive and requires meetings between stakeholders to enable this interaction to take place. As indicated earlier, conflicts in Conceptual Models need to be resolved through consensus or, possibly, the intervention of higher authority. SSM copes with change by being applied cyclically, with learning occurring from the results of earlier application iterations. A problem with SSM is that it does not appear to be well-suited to dealing with problems where complex technical constraints must be satisfied and many permutations must be considered.

### **Distributed Knowledge Engineering**

Knowledge engineering is concerned with the development of so called 'expert systems' designed to replicate part of the knowledge held by an expert or group of experts. Acquisition of this knowledge in a form that can be used to create an expert system is the principle task of a knowledge engineer. Knowledge acquisition tools have been developed to assist in this task (Boose and Bradshaw 1999). More recently there has come to be a greater emphasis on what will be termed here Distributed Knowledge Engineering (DKE). This typically uses world-wide web technologies to allow geographically distributed participants to electronically contribute to and use a shared repository of knowledge. The Ontolingua Server is an example of such a DKE system (Farquhar et al. 1997).

A key feature of a knowledge repository that distinguishes it from a conventional database is the inclusion of meta-information that allows the interrelationships and characteristics of information elements to be recorded and reasoned about. A problem with DKE is that it is not specifically concerned with problem solving, merely with knowledge elicitation and capture.

### **Critical Systems Heuristics**

Critical systems theory originally arose in the context of urban planning. It focuses on ensuring that the process of harmonising the needs of stakeholders is 'democratic'. The object is to ensure that the most significant needs are addressed and that deliberations are not subverted by powerful special interest groups. Otherwise, undue influence by the more powerful could result in solutions that are inferior overall (Flood and Jackson 1991). The Critical Systems Heuristics method (CSH) that is based on this theory identifies a number of issues that should be openly debated to ensure that some stakeholders do not excessively influence results. A problem with this method is that it is solely concerned with process, not with obtaining solutions.

	-	Conventional Systems Engineering	Personal Construct Psychology	Quality Function Deployment	Checkland's Soft Systems Methodology	Distributed Knowledge Engineering	Critical Systems Heuristics	+
1	"Pure" reason	-	-	+	0	-	+	"Practical" reason
2	Positivist	-	+	0	+	-	+	Humanistic
3	Subjective	+	-	-	-	-	-	Objective
4	Personal	-	-	0	+	+	+	Social
5	<i>Laissez-faire</i>	-	-	-	0	+	+	Democratic
6	Passive	-	+	-	+	+	-	Interactive elicitation
7	Concentrated	-	-	-	-	+	+	Distributed
8	Episodic	-	-	-	+	-	-	Action learning
9	Flat method	+	-	-	+	+	-	Structured method
10	Unstructured knowledge capture	-	-	-	-	+	-	Electronic knowledge repository
11	Lacks clearly defined comparison method	+	+	+	-	-	-	Clearly defined comparison method

**Table 1: Features of Comparative Methods**

Table 1 provides a comparison of the methods that have been mentioned. As an exercise to demonstrate the application of Personal Construct Psychology, the table has been constructed in the form of a Repertory Grid. Of course, it merely gives the author's own impressions of the methods. Any consensus on its validity must come through the normal scientific process of publication of ideas and peer review.

The 'constructs' in the Repertory Grid are arranged so that features thought to be beneficial for systems-of-systems problems appear on the right, and those that are thought to be unhelpful appear on the left. These constructs have been established by an introspective application of the 'triadic elicitation' technique of PCP with the author as subject. A simple rating scale has been used which only consists of three values, negative (-) if the method is inclined to have the unhelpful feature for the construct concerned, neutral (0) if it is considered to be intermediate and positive (+) if it is inclined to have the beneficial feature.

Eleven constructs have been used to help compare the methods. Perhaps the most important of these is whether the method is only concerned with reasoning about a situation, 'pure' reason, or whether it is also concerned with reasoning about what ought to be done to improve the situation, 'practical' reason. The distinction between 'pure' and 'practical' reason was originally emphasised by the German enlightenment philosopher Immanuel Kant (Kant 1788).

CSE presupposes that client needs have been condensed into a set of top-level requirements and hence that what ought to be done has been decided *a priori*. Hence, it is concerned with pure reason. The Repertory Grid technique used by PCP, in itself, is purely descriptive. It provides insight into how a subject perceives the world and therefore it, too, only involves pure reason. DKE is concerned with capturing a representation of the knowledge contributed by participating experts and thus is also purely descriptive.

QFD, SSM and CSH are all concerned to some extent with practical reason. QFD explicitly considers potential purchasers' needs and hence provides guidance about what ought to be done. SSM has been given an intermediate rating because it seems ambiguous whether its Conceptual Models represent what is thought to be the situation or what ought to be the situation. CSH is concerned with ensuring that the needs of all stakeholders are treated equitably and, thus, embodies practical reason.

The second criterion on which the methods are compared is the degree to which human concerns are addressed by the method. CSE largely restricts its attention to technical matters. Similarly, DKE is usually concerned with facts. PCP, SSM and CSH explicitly include human concerns. QFD has been regarded as intermediate because, while it does seek to establish human needs, this is done using relatively crude and remote means such as surveys of samples of potential product purchasers. As a result of its product manufacturing origins, its focus is on relating the established needs to technical measures.

The third criterion is the extent to which the method is grounded in objective reality. Of all the methods considered here, it seems that only CSE is concerned with maintaining a link with objective reality. It does this through a program of real world testing that ensures that product characteristics meet the client's requirements.

The fourth criterion is whether the method is concerned with individuals or with groups. CSE has been classed as personal, since implementation decisions will normally be taken by the client, without consultation with wider stakeholder groups. PCP is concerned with the perceptions of a single human subject. QFD is regarded as an intermediate case because it only considers potential purchasers of a product, and these appear to be considered to form a homogenous group. SSM, DKE and CSH all involve the interaction of a number of individuals.

The fifth criterion concerns whether explicit attention is paid to making the method democratic and avoiding a situation where certain stakeholders exercise an undue influence on results. In the case of CSE, it is usually only the opinion of the client that matters. PCP is obviously concerned with a single subject. With QFD, it is ultimately the manufacturing company that decides what features the product purchaser wants. Potential purchasers or other stakeholders do not have direct influence over the decision. SSM makes some attempt to allow all stakeholders to contribute, but is not concerned with explicitly analysing how influence has been exercised in arriving at a result. DKE is regarded as democratic because participants inherently contribute on an equal footing. CSH is regarded as democratic because it is concerned with enabling stakeholders to explicitly critique the exercise of influence in arriving at a result.

The sixth criterion concerns whether knowledge is assumed to be explicitly available to be passively gathered, or whether implicit knowledge must be made explicit through some interactive process. CSE assumes explicit knowledge of the customer's needs is available in the form of top-level requirements. QFD assumes that potential purchasers can explicitly state their desires. PCP is concerned with interactively eliciting implicit knowledge about how a subject perceives the world. SSM is concerned with enabling stakeholders to interact to better understand their joint explicit and implicit needs. CSH entails a debate between stakeholders about whether a fair result is achieved.

The seventh criterion concerns whether the process is centralised at a particular location or whether participants may contribute from geographically dispersed locations. DKE is by nature distributed.

CSH might be regarded as distributed because the debate it requires might occur through the postal system, telecommunications system, public media, the Internet or the like.

The eighth criterion concerns whether the method is designed to learn from the experience of repeated application. It is important to continually iterate and learn from experience if changing circumstances and new challenges are to be effectively dealt with. Only SSM seems to explicitly incorporate this idea.

When dealing with complex matters it may be helpful if knowledge is organised according one or more hierarchies that are meaningful to stakeholders. The ninth criterion concerns whether knowledge hierarchies are employed. CSE, SSM and DKE all make use of knowledge hierarchies to various extents. The other methods appear to assume a flat knowledge space.

Knowledge can be most easily examined and reused if it is stored in an electronic knowledge repository. The use of such a repository is the tenth criterion. Clearly, only DKE has this feature as a general rule.

The eleventh criterion concerns whether a clearly defined comparison procedure is associated with the method. CSE has traceability matrices to compare product characteristics with client requirements. PCP uses the Repertory Grid to compare experience elements. QFD uses the 'House of Quality' table to compare technical product requirements with purchasers' needs. SSM and CSH are somewhat more vague about how comparisons should be performed. DKE generally does not make comparisons.

## THE HYPOTHETICAL IDEAL METHOD

Examining the positive poles of the constructs in the Repertory Grid in Table 1 suggests that the hypothetical ideal method should embody 'practical reason' to ensure that an improvement in the common good is achieved by its use, should include consideration of the human issues, should be grounded in reality, should foster interaction between stakeholders to elicit implicit knowledge about joint needs and should be democratic in ensuring that some stakeholders do not exert undue influence to achieve an unfair and inferior result.

Furthermore, it should be a method that is continuously reapplied while learning from the results of previous iterations. This feature should enable it to cope with changes and challenges arising in the real world. In addition, it should accommodate the participation of geographically-dispersed stakeholders, should have means for dealing with complexity, such as knowledge hierarchies, and should have a clearly defined procedure for comparing needs and solution options. Finally, support for many of these features could be facilitated by storing captured knowledge in an electronic knowledge repository.

As discussed earlier, all the individual methods are deficient for systems-of-systems purposes. What is required instead is a *syncretic* method that combines the beneficial features of the methods, while remedying any shortcomings that they individually may have. Some work is currently being undertaken towards devising such a systems-of-systems method.



## CONCLUSION

Some work towards identifying the characteristics that a method for dealing with complex systems-of-systems problems should possess has been described. The paper has identified eleven features that such a method should possess through considering the positive features, for systems-of-systems applications, of a number of methods from the fields of systems engineering, management science, public administration and knowledge engineering. Current work is focused on developing a syncretic method that combines the beneficial features of the individual methods and on providing supporting analytical tools.

The work reported here has been performed in conjunction with the Systems Engineering and Evaluation Centre of the University of South Australia in pursuit of a research degree.

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# Transdisciplinarity and Integrated Catchment Management

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## ABSTRACT

*This paper discusses the general development and particular case studies of Integrated Catchment Management (ICM) with reference to the general concept of transdisciplinarity. Transdisciplinarity is described in terms of 'civic science', whereby practical research engages with the public and political spheres, and pluralist practice informed by conceptual meta-methodologies.*

*A brief overview of trends over the past two decades outlines how Integrated Catchment Management has been perceived and practiced. A range of Australian and international case studies are then presented. Conclusions are drawn in terms of transdisciplinary practice.*

*Keywords: transdisciplinarity, transdisciplinary practice, integrated catchment management, holistic landscape ecology*

## TRANSDISCIPLINARY PRACTICE

Recent literature regarding questions of transdisciplinarity reflect a broad range of interests in integrative frameworks which attempt to overcome traditional reductionism and mechanistic approaches. The need for transdisciplinary methods that involve natural, social and political sciences along with local knowledge systems is recognised in moving towards sustainable land management and sustainable development (eg. Hurni 2000). A number of integrative frameworks are currently being proposed including 'holistic landscape ecology' (Naveh 2000), the role of discursive communities (Meppem 2000), transdisciplinary learning in ecological economics (Meppem and Gill 1998), and linking ecological and social functions of landscapes through resource governance (Brunckhorst and Rollings 1999). A recent systems paper by Brier (2000) presented a discussion of an attempt to overcome a scientific ontology as a basis for transdisciplinarity. These recent papers reflect common themes found in the broad ranging literature on the philosophy and practice of post-normal science and integrative praxis.

In this paper, the notion of transdisciplinarity will be described in two ways, both of which attempt to guide the use of multi-disciplinary perspectives and tools. Firstly, transdisciplinarity as 'civic science', where practice, research and science must engage with public and political spheres. Secondly, the search for understanding pluralist practice through recourse to 'meta-methodologies' as a guide to the tools and ideologies which may be brought into play in engaging with particular situations or perceived problems. In the case of 'meta-methodologies', while a search for a systemic 'grand unifying theory' would be foolish, two general meta-methodologies have shown themselves to have a robustness and usefulness in explanation and as a platform for developing new ideas. The first is Kolb's learning styles, and the second is the 'system of systems methodologies'.

## **Transdisciplinarity as 'civic science'**

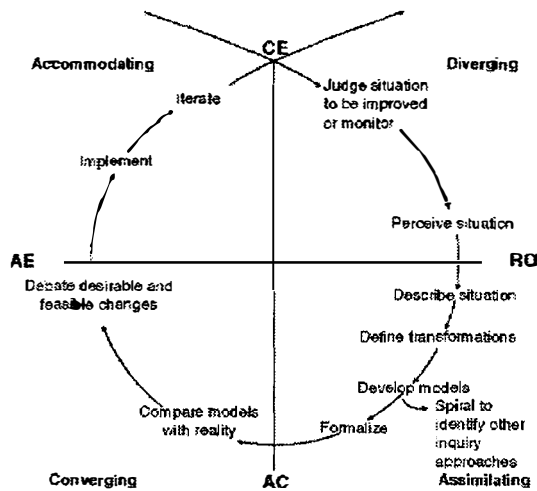
A fundamental way of considering transdisciplinarity is as 'civic science', where practice, research and science must engage with public and political spheres. In the use of our tools of inquiry, the public and political interests which ultimately contextualise, and guide our use of these tools, are by their very nature transdisciplinary. Examples include personal wellbeing and health, environmental quality, effective organisation, and ultimately sustainable societies.

This view of transdisciplinarity, as public and political engagement, is somewhat analogous to the Aristotelian concept of rhetoric. A simplified definition of rhetoric, whereby all available tools, including logic, metaphor and ethos, are brought to bear in discourses of ethical and political action. The particular point of view taken by any particular commentator will of course depend upon their personal view and ideology in relation to society and information. That of, at least one of the authors of this paper, is informed by neo-pragmatist and neo-Aristotelian conceptions. Aspects of this are discussed further in relation to pluralism and economic metaphors in Attwater (2000).

## **Learning and learning styles as a basis for transdisciplinarity**

Systemic inquiry in general, is underpinned by a processual view of experiential learning. The work of Kolb developed upon that of John Dewey and Kurt Lewin. The common pictorial representation of learning styles has a horizontal axis is derived from Dewey's conception that we grasp knowledge through apprehension of the external world or comprehension within our mind. Influenced also by the social psychology of Kurt Lewin, Kolb (1974) posed a vertical axis of the ways we then act: through either seeking concrete experience or developing abstract conceptualisations. The types of learning abilities could then be described in terms of concrete experience (CE), reflective observation (RO), abstract conceptualisation (AC), and active experimentation (AE). Depending upon our cultural and personal style and educational background, we tend to focus more on one or another of these learning skills. Natural diverges tend to be imaginative and enjoy brainstorming ideas, while good assimilators have strengths in logically sound conceptualisations. Those with a predominantly converger style like practical applications of ideas, and accommodators tend to focus on getting things done and getting involved in new experiences (Kolb 1974).

This basic conceptual typology has been used in a number of ways including the relationship between different forms of inquiry, the relationship with non-experiential learning, and ways to facilitate the emergence of practical partnerships and strategic alliances. In terms of approaches to inquiry, Wilson and Morren (1990) have described processes of research in applied science, soft systems, and hard systems engineering over this learning framework. A representation of the logic-driven stream of soft systems methodology is presented as a step-wise cycle of a learning cycle in figure 1. What is suggested by overlaying types of inquiry on a typology of learning styles is that in any form of inquiry we use all of these aspects, just some better than others, depending upon our personal style. This provides a robust model upon which we can seek to integrate different styles of inquiry, and perceptions according to our particular worldviews.



**Figure 1: The logic-driven stream of SSM as a learning cycle**  
(Wilson and Morren 1990)

This model of experiential learning has also been used as a platform by Bawden (eg. 2000) for developing a conception of broader ‘knowing systems’ incorporating experiential learning with inspiration learning. With a more pragmatic leaning towards the question of the emergence of practical partnerships and strategic alliances in catchment situations, Attwater (1999b) discussed this basis, as well as the linkages with a broad processual model of property entitlement.

### **The ‘system of systems methodologies’ and transdisciplinarity**

The ‘system of systems methodologies’ (SOSM), originally posed by Jackson and Keyes (1984) has been part of an ongoing of discussion of methodological pluralism within the critical systems literature. A broad review of the critiques of SOSM, including questions of the use of Habermasian notions of knowledge-constitutive interests as a foundation, and the incommensurability of assumptions made by proponents of other systems paradigms, is discussed by Midgley (1996, 1997). However, the usefulness of building upon this typology as the ‘modelling space’ for a overlaying ideological conflicts in other disciplinary areas can work to both apply questions raised in critical systems to other areas of inquiry, while potentially contributing to the discussion of shortcomings of the SOSM typology. An example is Attwater (2000) who developed philosophical underpinnings, and methodological implications, of neoclassical, institutional and neo-Marxist conceptions of economic theory. While shortcomings are recognised, the foundations of economic epistemology shown in Figure 2 have great similarity to the range of arguments found in questions of social inquiry and the philosophy of science in general.

**Table 2: Foundations of Economic Epistemology (Attwater 2000)**

Economic tradition	Neoclassical	Institutional	Neo-Marxist
<i>Philosophy</i>	Cartesian analytic	Pragmatist	Hermeneutic
<i>Normative ethic</i>	Science is truth Pareto-optimality Utilitarianism	Warranted assertions Adaptive problem-solving Instrumentalism	Constructed realities Emancipation
<i>Axiology</i>	Value in exchange	Value in problem-solving	Critique
<i>Ontology</i>	Realist	Humanist / normative construction	Critical realist
<i>Epistemology</i>	Positivist Post-positivist	Interpretivist	Constructivist Critical theorist
<i>Champion</i>	Friedman Popper	Dewey	Habermas

## INTEGRATED CATCHMENT MANAGEMENT AS TRANSDISCIPLINARY PRACTICE

Catchments are becoming more widely accepted as a unit of focus which allows for the integration of socio-economic and environmental factors. Geographically, catchments are topographically delineated areas upstream from a stream or river, and are nested in structure. The rationale of catchments as functional regions is based upon linkages through the hydrological cycle, allowing a holistic view of resource management. The linkages of land use, soil and water, and the linkages between upland and downstream impacts, are the biophysical basis for a catchment approach. From a socioeconomic perspective, catchments are useful heuristics for considering the temporal and spatial relationships between the historical, social and institutional organisational structures which overlap these landscape patterns in an open and complex way. Catchments can be considered as a 'lens' between the local and adaptive systems of livelihood and the forces of historical and contemporary political economy (Attwater 1996, 1997). In this way, catchments are open microcosms of our social relationships with the biophysical environment.

In a paper to the 1997 National Workshop on ICM, Macpherson (1997) discussed how rather than focusing on hydrological or social interests, a differentiation can be made between 'tight integrators' and 'loose integrators'. 'Tight integrators' prefer a process logically built from objectives to policy settings to outcomes. Commonly these include biophysical scientists, with a representative area of developing sophistication being the application of geographic information systems. 'Loose integrators', on the other hand, prefer statements of principle as a 'general guide to more or less parallel action by many agents', and are more likely to be interested in social arrangements and practical action (Macpherson 1997). A challenge is to make the most of this dynamic tension between tight and loose integrators.

### International perspectives on ICM

Catchments, or watersheds, have been promoted as useful integrating units since the early 1980's (eg. Hamilton and King 1984, Easter and Dixon 1986), though approaches have tended to change from an engineering focus, to a rational comprehensive approach, and more recently from the perspective of participatory development. The rationale for an integrative catchment/watershed approach in the mid 1980's includes the following: (Easter and Dixon 1986) the watershed is a functional region, logical for evaluating biophysical entities linked through the hydrological cycle; it is holistic allowing ready examination of the chain of environmental impacts; it is an integrated framework for analysing the effects of human interactions with the environment, including economic.

The central importance of the need to incorporate the concerns of local people and local institutions became a major theme of the late 1980's (eg. Rao 1986). Failure to adequately deal with local institutional arrangements has been recognised as the major cause of the failure of traditional project approaches (White 1992). Rather than the traditional physical focus, White (1992, and White and Runge 1994) proposed that watersheds should be considered as sets of vested interests, with the question of social relations, and cooperation between actors. This conception paralleled conceptual developments in rural development such as 'Beyond Farmer's First' (Scoones and Thompson 1994) which recognised the importance of socio-political actors with differing networks and fragmented knowledge systems.

Over recent years, there have been a number of applications of participatory catchment management. An international workshop supported by IIED (Hinchliffe et al. 1995) described experiences from a range of countries, including Guatemala and Honduras, Brazil, the Philippines, Australia, Burkina Faso, Kenya, Lesotho and Malawi, India, Nepal, and Pakistan. From these experiences, participatory catchment management was defined as an approach which involved communities in the analysis of their own soil and water problems, with external facilitatory and catalytic support.

The major aspects of these collective experiences include the following: (Hinchliffe et al 1995) local communities are participating in the analysis of their own conservation problems; the role of the external support agency is as facilitator allowing farmer to farmer extension as a key process for passing the information; problems are approached on individual needs with emphasis on sustainability and equity of improvement. While needing to go beyond a strategy of sustaining water bodies as isolated resources, '...true sustainable development takes account of the ecological, social and economic values of still waters within the context of living catchments' (Everard 2000). The integration of science, government and community-decisions requires a local 'place-based' focus, with techniques to 'naturalise' streams one way to accommodate and demonstrate the real benefits of an integrated catchment approach to managers and the community (Rhoads et al 1999). The interaction of these social and landscape factors are why local, small-scale integrated demonstrations are a fundamental aspect of Integrated Catchment Management.

Australian and international experiences have reinforced the importance of a learning approach which is adaptive, inclusive and participatory, strategic, creative and generative. Effective knowledge management is based upon an understanding of the complex processes of interaction between natural resources, and stakeholder values and activities. Practical partnerships and strategic alliances between science, management, and society are actively sought through the processes of inquiry (Mitchell and Hollick 1993, Ewing et al 2000, Rogers et al 2000).

### **Challenges for Integrated Catchment Management in Australia.**

Experiences over the last decade suggest that state-sponsored participation in catchment management can be effective in addressing a range of difficult, long-term environmental problems impacting upon productivity, biodiversity, public health and living standards (Curtis and Lockwood 2000). There have, however, been substantive problems and critics of the institutionalised approaches. In Australia, the development of Landcare as a social movement to address problems of land degradation has been a fundamental platform for ICM. Critiques of catchment management and Landcare in NSW (eg. Martin and Lockie 1993) suggest that conflicts have occurred due to the technocentric ideology of government agencies, conflicting interests between traditional sectoral agencies and community groups, and the failure to address the heterogeneity of local communities, and the problems of scale between TCM and Landcare groups. In attempting to scale up the Landcare model, Cullen (1997) suggested that there are fundamental challenges generated in terms of scale in both time and space, being inclusive to the range of interests, accessing appropriate knowledge, and being strategic so that we treat causes not symptoms.

While these challenges remain, Cullen (1997) does suggest that given the policy environment and attempts to develop upon the Landcare model of participatory environmental management there is a

newly emerging paradigm for water management in Australia. Cullen states: ‘...It is clear that our present strategy of splitting the water cycle into a whole range of different elements, managed by different groups of professionals, has now outlived its usefulness and we need to now put the pieces of the jigsaw back together again. This affects the disciplinary basis of professionals and their training, and the organisational structures within which they are employed.’

One of the major challenges across Australia is the question of urban ICM. This poses difficulties, particularly in terms of building upon the Landcare model. Macpherson (1997) describes ‘...perhaps most importantly, urban land values are so much higher than rural ones that there is more scope for overriding the forces of nature. Problems can often be replanted, concreted over, piped elsewhere, chemically treated, or spin-doctored, and, if all else fails, compensated. To this extent the catchment nature of a problem can be more easily obscured from the urban community, even if it is “obvious” to a technocrat.’

## **CASE STUDIES OF TRANSDISCIPLINARITY AND ICM**

The following section provides a brief overview of a number of Australian and international catchment situations that the authors have been involved in. These reflect the range of scales, situations and issues faced and the approaches taken to provide a transdisciplinary logic to the mix of methods used. Australian and international case studies include:

- The Community Catchment Centre, Peel-Harvey Catchment, W.A.
- The Upper Parramatta River
- A socioeconomic study for the Hawkesbury-Nepean Catchment Mgt. Trust.
- An upland case study in Thailand,
- The Brantas ICM program in East Java,
- Developing ICM application in Wuhan, China.

### **The Community Catchment Centre, Peel-Harvey Catchment W.A.**

In the early 1990’s Roger Attwater was part of Agriculture W.A.’s ‘Peel-Harvey Catchment Support Group’, established within the Community Catchment Centre (CCC) as a central shopfront within the township of Pinjarra W.A. The role of this group was to provide technical and facilitatory support, particularly to the local Land Conservation District Committees. In its early years, many operations of the centre could be described as attempts to develop ‘the art of public listening’ (Bradby 1992). Initiatives included community-based monitoring, farm planning, ‘streamlining’ local creeks, utilising bauxite residue (red mud) for phosphorus adsorption, as well as a range of technical initiatives, and the review and targeting of traditional technical programs given the local Landcare initiatives developing. There were, however, considerable differences of perspective as to whether the CCC was a community-directed centre, or an office of the regional or central Department of Agriculture. Questions regarding the systemic nature of the locally successful initiatives prompted the

## The Upper Parramatta River Catchment

In 1994, the Upper Parramatta River Catchment Management Trust invited all stakeholders (residents, local government, agencies, groups and organisations) to help identify and agree upon water quality goals and an implementation strategy. The independently facilitated project had three separate, but integrated strands: a scientific investigation of water quality culmination in a model of the system, a community involvement program to determine local commitment and expectations, and policy formulation outcomes by way of endorsed Water Quality Objectives. (Booth and Burgin 1997)

Within an Integrated Catchment Management approach, the project's aims were to establish a set of community endorsed water quality objectives for the catchment, together with an integrated strategy to achieve the desired standard of water quality identified by the community, consistent with the National Water Quality Management (NWQM) Strategy (ARMCANZ & ANZECC 1995).

The procedures involved in successfully achieving the aims included:

- Initiation of high level community involvement to identify and discuss desirable environmental values for local waterways;
- Achievement of optimal agreement among all parties on what the environmental values should be and identification of the applicable water quality objectives;
- Development of water quality improvement strategies and an action plan which realistically aimed at achieving community water quality objectives within an identified time frame; and
- Achievement of appropriate levels of 'ownership' by the community, local governments and state agencies to ensure their continued commitment and support for the strategies and action plans.
- A Pilot Socioeconomic Project for the Hawkesbury-Nepean Catchment Management Trust

For many years the Hawkesbury Nepean River system in NSW has been experiencing a range of significant water quality problems, attributable in a large part to inadequate stormwater and wastewater management. The former Hawkesbury Nepean Catchment Management Trust advocated and sort to facilitate more systemic action to improve stormwater and wastewater management recognising that:

- current levels and forms of public and private investment are generally too low;
- infrastructure development may not be making best use of current investment in terms of achieving desired outcomes; and
- current institutional arrangements favour a segmented management approach.

In early 2000 the Trust commissioned a pilot socio-economic research project to investigate current investment, identify alternative or complimentary opportunities and facilitate informed system discussion and exploratory action with key stakeholders to help achieve more integrated, cost-effective investment in stormwater and wastewater management. As described in detail in CICM (2000), Attwater (2000) and Attwater, Booth, Davey and Guthrie (in press) the pilot project was undertaken using methodology which can be likened to an action research 'cascade' of methods. From an initial review of material and trends in institutional arrangements, an initial workshop with a range of stakeholders discussed the issues involved and potential methods of investigation. From this, two 'streams' of inquiry developed. One of these was an analysis of the cost-effectiveness of a range of management practices, undertaken on baseline data as a step towards adaptive assessment. This was supported by a targeted workshop to review assumptions used. The second 'stream' of inquiry was through semi-structured interviews and focus groups with key organisational stakeholders. These were later clarified and rechecked with interviewees. Results were then pooled in terms of a complementary bundle of institutional initiatives. Opportunities were then taken to present and discuss the results in a range of stakeholder fora.

### **An upland Thai catchment situation**



From 1992 until 1995, an adaptation of soft systems methodology was used as a methodological guide into participatory appraisal with village, government, and commercial stakeholders in an upland Thai catchment in Phetchabun Province. The conceptual developments from this inquiry have been reported in terms of the complementarity of SSM and institutional economics into Thai political economy and adaptive rural livelihoods (Attwater 1996), a processual view of property entitlement and land reform (Attwater 1997), and the relevance of pragmatist philosophy in approaching an inquiry in non-western cultural contexts (Attwater 1999a).

### **Establishing an ICM Program for the Brantas River, East Java**

The challenges associated with the institutional framework for natural resource management in East Java parallels that of many states and provinces around the globe. It consists of a wide range of agencies with a complex mix of multi-layered responsibilities and often overlapping and unclear jurisdictions.

Building on the success of Australian-based ICM training programs, a series of short term attachments between October 1998 and May 1999 to BAPEDALDA, East Java Environmental Protection Agency enabled the collaborative development of an ICM Strategy for the Brantas Catchment. (Booth, Warianti and Wrigley 2000). The ICM Strategy seeks to address the causes of the priority natural resource issues confronting the catchment. It embraces a large number of existing programs and projects of the 18 participating agencies plus agreed new initiatives. Community awareness, education and involvement form important components of the Strategy.

The ICM process was planned and facilitated by an independent advisor and resulted in a single and agreed strategic framework in which all natural resource management activities could be focused and undertaken. The planned principal outcomes included improved co-ordination, co-operation and consistency of government and community efforts in sustaining the catchment's economic, environmental and social values.

### **Developing ICM projects in China**

The authors are currently involved in establishing an ICM initiatives in Northern and Central China. In both of these, it is envisaged that an action learning approach will be developed with stakeholders, developing upon the WSR methodology developed in China (Gu and Zhu 2000, Midgley and Wilbey 2000). A collaborative project developing in China is with Huazhong University of Science and Technology in Wuhan, where independent and facilitatory catalytic support will seek to adapt and develop ICM to the local situation.

## CONCLUSIONS

These case studies reflect a broad mix of rural, urban and peri-urban situations, and cultural contexts. In all of these, a process of facilitatory and participatory inquiry grounded on the knowledge and interests of key stakeholders was the driving necessity for legitimacy, grounded in local public and political issues. These interests, by their nature, drive the transdisciplinarity of any attempt towards 'integrated' catchment management.

Depending upon the scale at which the case study operated, and the needs of the key stakeholders, a range of different policy and analytical tools were assessed or used. At the scale of a small rural catchment, livelihood systems take precedence and therefore tools appropriate for farming systems are relevant. At the scale of a catchment encompassing urban and rural landuses, a new suite of policy tools are needed, and must be legitimised through support from rigorous and adaptive assessment. At larger catchment scales, general tools for intersectoral policies and programs take precedence. So, scale is a fundamental driver of which transdisciplinary framework is used.

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# A system dynamics view of the role of customer satisfaction in increasing company profits

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## ABSTRACT

*Customer satisfaction and its antecedents have been investigated extensively in the customer satisfaction and service quality literature, and the consequences of customer satisfaction have received some attention in the research literature. Customer satisfaction research literature contends that higher customer satisfaction increases customer retention and hence organisational profitability. Much of the research examines the influence of customer satisfaction in a linear, open-loop manner. This study applies systems thinking principles to an investigation of the linkage between customer satisfaction and firm profitability, thereby permitting interactions among the constructs and other mediating variables to be included. The investigation uses causal loop diagramming to develop possible models relating customer satisfaction to profitability and presents some results from ensuing system dynamics simulations.*

*Keywords: Causal loop diagramming, system dynamics, systems thinking, customer satisfaction, customer retention.*

## INTRODUCTION

Customer satisfaction and its antecedents have been investigated extensively in the customer satisfaction and service quality literature (Oliver 1977; Oliver 1980; Churchill and Suprenant 1982; Bearden and Teel 1983; Parasuraman, Berry and Zeithaml 1991; Anderson and Sullivan 1993). The consequences of customer satisfaction have received somewhat less attention (Bearden et al. 1983; Anderson et al. 1993; Boulding, Kalra, Staelin et al. 1993; Rust and Zahorik 1993; Anderson, Fornell and Lehmann 1994; Zeithaml, Berry and Parasuraman 1996). Research from the consulting field has suggested that increasing customer retention contributes significantly to increased profitability (Reichheld, 1993).

While it would appear that there should be a natural linkage between customer satisfaction and customer retention, the relationships among customer satisfaction, customer retention and firm profitability have not been fully explained in the customer satisfaction and service quality literature. Few empirical studies have researched the sequential linking of the constructs and much of the literature is bedevilled by inconsistencies in definitions and unsubstantiated assumptions (Fornell and Wernerfelt 1987; Reichheld 1993; Rust et al. 1993; Storbacka, Strandvik and Gronross 1994; Bolton 1998).

The link between customer satisfaction and profitability is often implied, and definitions of customer satisfaction and profitability vary from one study to another (Buzzell and Gale 1987; Capon, Farley and Hoening 1990; Fornell 1992; Rust and Zahorik 1993; Anderson, Fornell and Lehmann 1994; Zeithaml, Berry and Parasuraman 1996). Bonsu (1998) conducted a metatheoretical review of the literature and concluded that the overall customer satisfaction-performance relationship is theoretically weak. He commented that present studies show only a direct link from satisfaction to a number of mediating outcomes, and that increased financial performance is implied rather than explicitly demonstrated. He emphasised that these intermediary outcomes do not necessarily translate into increased profitability, and concluded that their positive relationships to performance in the literature are questionable.

Storbacka et al (1994) also examined the links from service quality to customer satisfaction to customer retention to profitability. They commented that most of the literature examined only the link between service quality and satisfaction, with a few extending their research to include behavioural intentions, but point out that purchase intentions do not necessarily have high predictive power. Like Bonsu (1998), the 'relationship profitability model' presented by Storbacka et al (Storbacka, Strandvik and Gronross 1994) emphasised that customer satisfaction does not influence firm profitability in isolation. Bonsu included customer satisfaction within the overall marketing strategy, each part of which has an impact on profitability, while Storbacka et al (1994) placed customer satisfaction within a chain linking service quality and profitability.

As can be seen, the research literature on the economic consequences of customer satisfaction has not fully explained the relationships existing from customer satisfaction to profitability. In addition, the literature tends to depict the flow from customer satisfaction to profitability in a unidirectional manner, from customer satisfaction to customer retention, to profitability. The implication being that improving customer satisfaction increases customer retention and hence firm profitability. This approach, however, ignores possible interactions, including feedback influences, among the various constructs. Manipulating customer satisfaction may, for example, detract from necessary expenditure on other organisational strategies that, in turn, affect financial decisions or human resource policies, and changes in these may influence, either in a positive or negative way, customer satisfaction.

Concepts of systems thinking can be applied to the development of a conceptual model of the customer satisfaction – profitability linkage. The use of causal loop diagramming permits the investigation of feedback loops and enables the development of a deeper understanding of interdependencies among various constructs.

## **SYSTEMS DYNAMICS**

The application of systems dynamics allows the complexities of the system, linking customers to revenue and profitability, to be examined in a more cogent manner. Much of the research has investigated the constructs - customer satisfaction and profitability - in isolation from the parent system. This does not imply, however, that the results are not valid. Some research has identified generally agreed antecedents of customer satisfaction: consumer expectations, performance, and value, among others. Other research has shown a linkage from customer retention to profitability. Problems arise when an attempt is made to manipulate profitability by altering some of the antecedents of customer satisfaction. Most of the research regards the linkage from customer satisfaction to profitability as linear. The implication is that increasing some antecedent of customer satisfaction should increase customer satisfaction, which in turn increases customer retention and, finally, company profits.

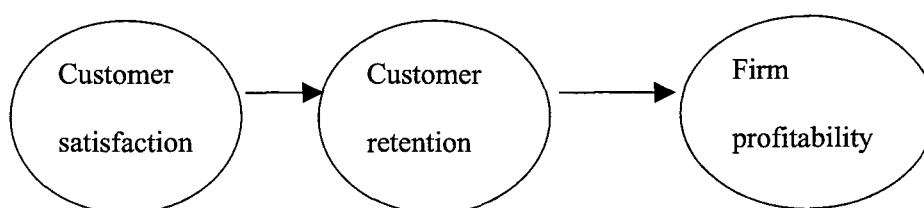
Of course, the linkage between customer satisfaction and profitability does not exist in isolation. Other variables affect profitability: price, quantity, the economy etc. To take account of these interacting variables, it is necessary to examine the complete system governing the generation of profits.

Systems dynamics retains the essential features of systems thinking, interdependencies and feedback loops, enabling the development of a much richer model and leading to greater insight into the operation of the system under investigation. The use of a sub-set of systems dynamics, causal loop or influence diagramming, allows the development and examination of a system structure that highlights the interactions among the variables.

The influence diagram is the basic tool for examining the structure of a system, including the interactions among components. Senge (1990) describes the modelling of these interactions as circles of influence, emphasising that the influence of one construct on another is rarely in one direction only.

The implied linear influence diagram of many organisations' thinking on customer satisfaction can be drawn as:

**Figure 1: An influence diagram representing the linear view of the customer satisfaction – revenue linkage**



The influence diagram above reveals the linear approach of most investigations. They, generally, tend to be open-loop; that is, no feedback paths exist among the constructs. This may explain some of the anomalies existing in the research literature. While some studies have found a direct or inferred relationship between customer satisfaction and firm profitability (LaBarbera and Mazursky 1983; Reichheld and Sasser 1990; Anderson et al. 1993; Rust et al. 1993), other results have indicated that satisfaction beyond a certain threshold is not necessary (Fornell 1992; Anderson et al. 1994). The relationship among these constructs is also confounded by other factors (Storbacka et al. 1994). Thus, it is possible for the quality of service provided to be high, customer satisfaction to be high yet the customer is not retained. Similarly, it is possible for the quality of service to be low resulting in low customer satisfaction, yet the customer may be retained, perhaps due to geographical constraints or lack of competitors. Storbacka et al (1994) discuss some of these counter-intuitive examples, introducing the concept of 'bonds' that retain customers in spite of unsatisfactory service.

In addition to the binding factors, value – separate from satisfaction - is an important construct in determining whether a customer is retained (Bolton et al. 1991). Clearly, in the face of a price rise, customers will reconsider their allegiance to a particular firm in spite of their previous satisfaction with the firm's offering. When assessing retention, therefore, value must be considered an influencing factor.

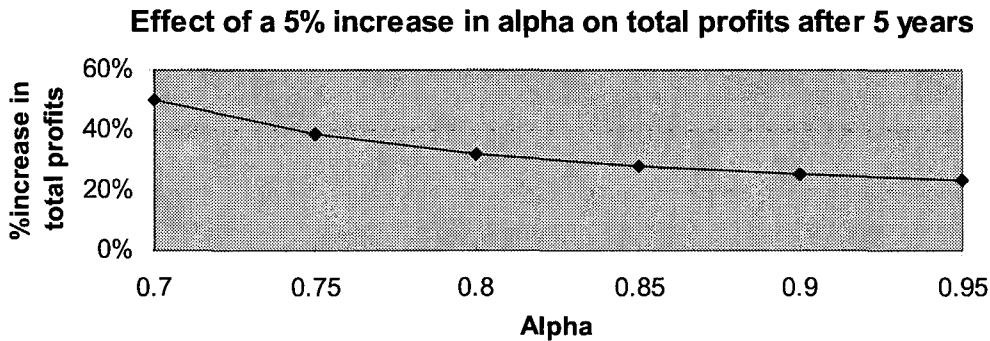
Finally, a customer may be retained by the firm yet provide little or no contribution to profit. For example, Storbacka (1994) quotes earlier research that concluded that as few as 10% of the customer base may be contributing up to 100% of the firm's profits. In a study of retail banking, customer satisfaction was higher among the most unprofitable customers (Storbacka and Luukinen 1994).

The existence of these contributing variables strongly suggests a greater complexity in the linkage between customer satisfaction and profitability. For such systems, the use of systems dynamics should prove informative.

## RESEARCH STUDY

A research study is currently being conducted in conjunction with a national organisation in consumer durables. Whilst customer satisfaction measures are extensively collected and examined by the organisation, little effort is made to integrate the complete data collected; that is, there is no attempt to adopt a systems approach. The research study is designed firstly to demonstrate the usefulness of systems thinking; secondly, to explain the dynamics that the company is currently experiencing.

The organisation's view of the customer satisfaction-revenue linkage follows that outlines in Figure 1. To demonstrate the outcomes from such a linkage, King and Rickard (1995) developed a simple mathematical model relating customer retention and profitability. It was assumed that customer satisfaction was directly and immediately reflected in customer retention. The model related customer retention to total customer numbers, profit per year and the net present value of a single customer. The results (Figure 2) indicated that a five-percentage point increase in customer retention ( $\alpha$ ) could increase revenue after five years by 23-50% - an impressive result that agree with those of Reichheld and Sasser (1990).



**Figure 2: Five-percentage point increase in customer retention**



The linear mathematical model is easily translated into a dynamic simulation using the Ithink software. Figure 3 displays the profit per year and the total customers for a constant value of customer satisfaction.

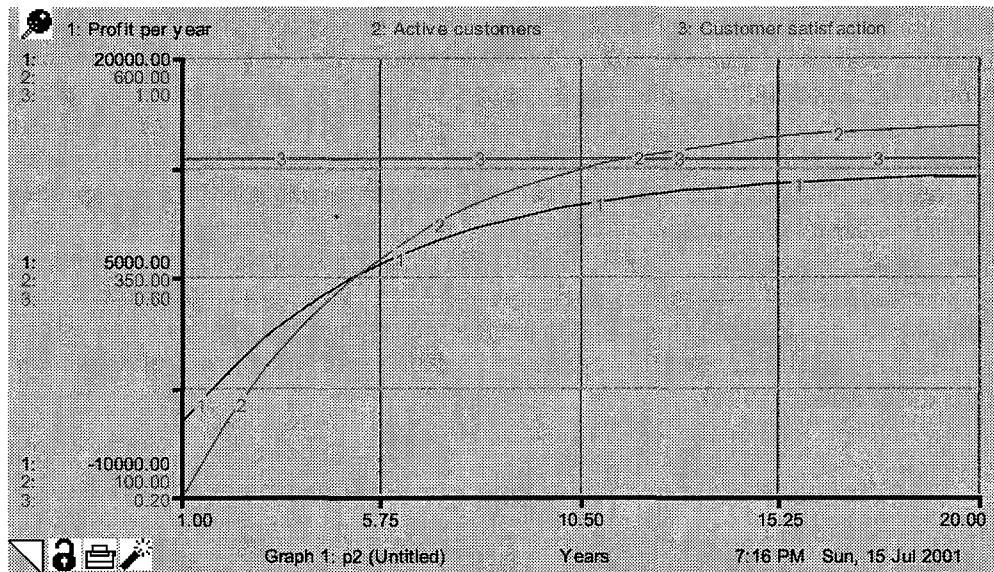


Figure 3: Profitability and total customers resulting from a fixed value of customer satisfaction

One possibility postulated in discussions with the organisation was that increasing the total customer base changes the internal value structure of the organisation, or that of crucial partners of the organisation, in such a way as to decrease its ability to satisfy customers. The simple linear model is no longer able to explain the dynamic response of the system. A systems approach, however, permits the effect of the added complexity to be investigated. Consider the influence diagram in Figure 3.

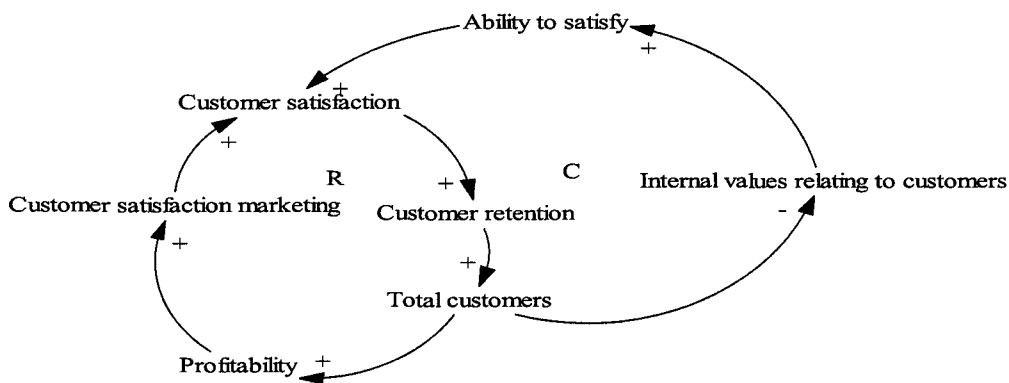


Figure 4: An influence diagram relating customer satisfaction to profitability that includes a counterbalancing loop

The reinforcing loop - from customer satisfaction, through customer retention, total customers, profitability, and customer satisfaction marketing - is counterbalanced by the loop from total customers, through values, ability to satisfy, and customer satisfaction. As total customers increase, the internal values relating to customers decrease, thereby decreasing the organisation's ability to satisfy customers, leading to a decrease in customer satisfaction. In addition, there is likely to be a delay between the change in customer satisfaction and the resulting change in customer retention; similarly, a delay is likely to exist between the company's ability to satisfy customers and the resulting change in customer satisfaction.

The dynamics resulting from the addition of the counterbalancing loop are displayed in Figure 4.

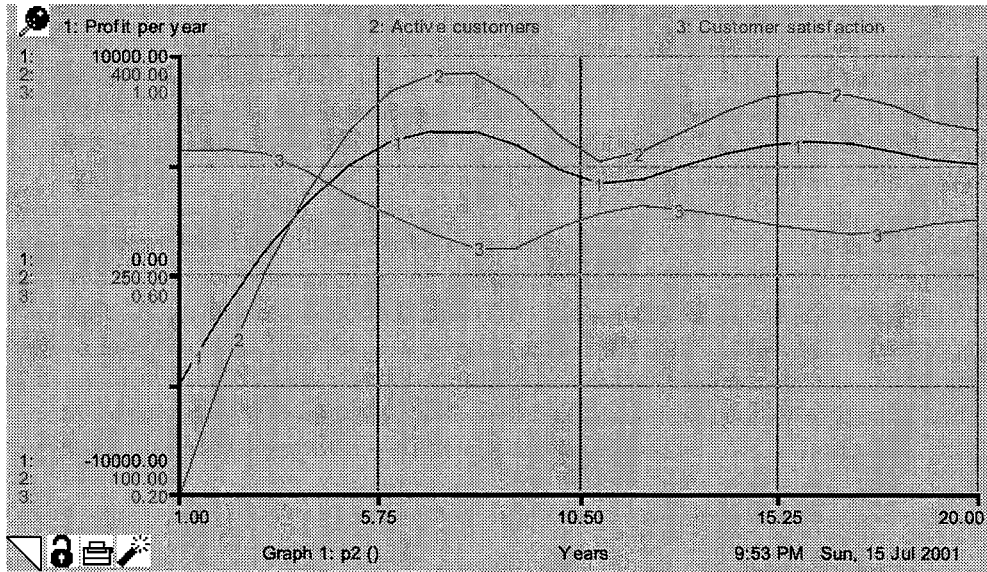


Figure 5: Profit per customer and total customers resulting from the inclusion of a counterbalancing loop

A comparison of Figures 3 and 5 indicate that the interconnections in the systems model make quite dramatic changes to the profit figures and that focusing simply on the antecedents of customer satisfaction could be very misleading.

A slightly more realistic model was also considered, the influence diagram for which is displayed in Figure 6.

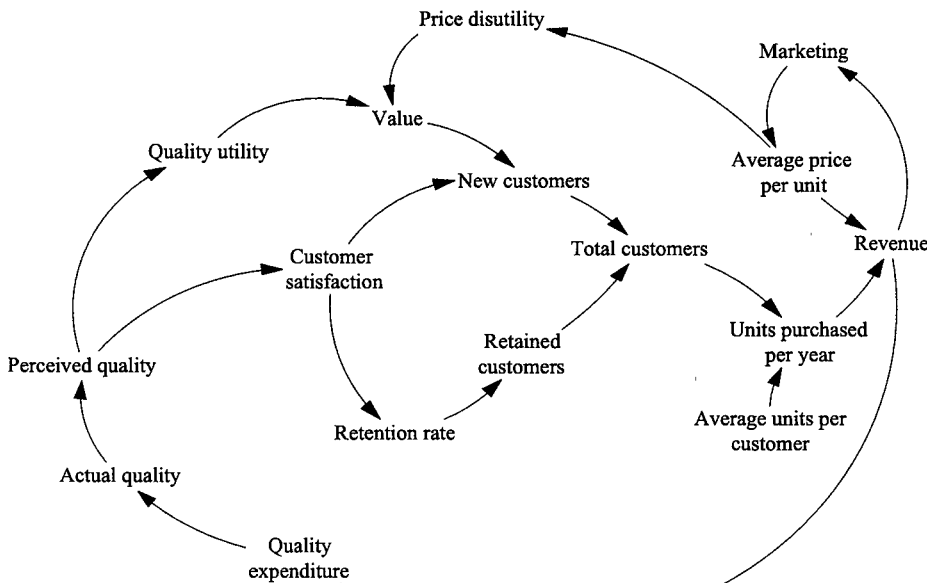


Figure 6: An influence diagram for customer satisfaction/profitability linkage containing a 'value' construct

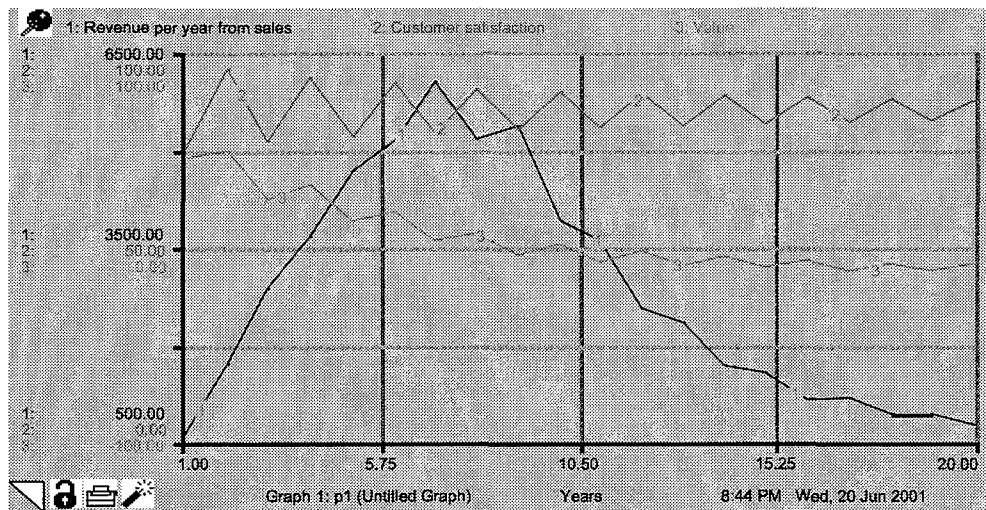
This model allows for interaction among the various constructs. While still a rather simple model, it is sufficient to demonstrate the effect of interrelationship among the various constructs. Thus, while

customer satisfaction drives revenue through Total customers, the construct Value also drives revenue, perhaps in an opposing manner.

The above influence diagram emphasises the complexity, through the existence of feedback loops, of the customer satisfaction – profitability linkage. Revenue represents the amount of cash flow from operations - the major source of possible funds for quality improvements and actual quality (both product and service quality), and, hence, customer satisfaction. Although not shown here, service quality encompasses the service product – the service as designed to be delivered – service environment, including employee satisfaction, and service delivery.

Actual quality drives quality utility, while price drives price disutility. The difference between these represents value that, in turn, is an influencing factor for customer satisfaction. Cash flow from operations also supplies the funds for offensive marketing directed at attracting new customers, rather than retaining present customers. Thus, while profitability is clearly influenced by revenue and, in turn, customer retention and customer satisfaction, these latter variables are also influenced by revenue and the manner in which revenue is allocated among various conflicting strategies. The link from customer satisfaction to profitability is not linear and may be investigated in a more thorough way by the application of systems thinking.

The above causal loop diagram can be modelled to show the effect on revenue of conflicting influences. Figure 6 displays Revenue, Customer satisfaction and Value over a period of years. Note that although Customer satisfaction settled to a constant score of 85 (out of 100), Revenue, while increasing for a few years, begins a rapid decline. The reason for the decline in Revenue is a steadily decreasing Value. While the product satisfies the quality requirements of customers resulting in high customer satisfaction with the product, customers do not view the product as representing good value. While this is a slightly artificial result, as value is forced to decrease, it demonstrated clearly to the organisation the effect of possible interactions among variables affecting revenue.



**Figure 7: Revenue and customer satisfaction resulting from a decrease in value**

Within a more complex representation of the interrelationships, one might wish to examine the effect on revenue of: money spent on establishing brand image; revenue directed back to operations to improve quality; pricing strategies to increase demand; the conflicting demands of product quality, sales quality and service quality; and others. Building a model will assist this organisation in developing an understanding of a dynamic response that has been observed and discovering ways of countering undesirable dynamics.

## CONCLUSIONS

This research study was designed to demonstrate the usefulness of a system dynamics approach to the investigation of the customer satisfaction-profitability linkage. Relatively simple systems dynamic model were developed in conjunction with an organisation in consumer durables. Results from these models have been presented and compared with those obtained using a simple linear model. The study reveals the weakness of the linear approach. A more thorough investigation is currently underway with the national organisation.

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# On the Status of Natural Boundaries: A Complex Systems Perspective

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## ABSTRACT

*The aim of this paper is to consider the status of natural boundaries from a complex systems perspective. Contemporary science tends to trivialise the nature of boundaries with its inherent positivism whereby boundaries are considered real in an ontological sense. Furthermore, naïve versions of the scientific method fail to acknowledge the bias involved in making observations, implying that what we see is what there is. In short, contemporary science considers boundaries to be real and easy to recognise. This paper argues that there are no boundaries in any absolute sense (the no-boundary hypothesis), and that all apparent boundaries are emergent and temporary. This has important consequences for science, both natural and social, as well as the relationship between these same two branches of science.*

*Keywords: Complexity, Epistemology, Boundaries, Ontology.*

*Beyond the horizon of the place we lived when we were young  
In a world of magnets and miracles  
Our thoughts strayed constantly without boundary  
The ringing of the division bell had begun*

Gilmour/Samson, *High Hopes*, 1994.

## INTRODUCTION

Contemporary science with its strong positivism tends to trivialise the nature of boundaries. Boundaries are supposedly real and our ability to recognise them as such is regarded as a straightforward exercise. This by-product is a direct result of science's focus on the quantifiable and mathematisable (Goodwin, 2000). Given such a naïve belief in the ontological status of boundaries it is easy to understand how some scientists can wholeheartedly buy into their models as true representations of what is. If absolute boundaries exist then as scientists we have to simply map them and with a bit of mathematical manipulation 'hey presto!' we have true knowledge of the universe.

Complexity thinking forces us to review our conceptions of what natural boundaries are.

In this paper the reader is briefly introduced to the bear essentials of complexity 'science' including an exploration of the nature of boundaries within simple complex systems. It is then argued that the universe as a whole is a complex system. From this assumption and the explorations regarding boundaries in complex systems, a view of natural boundaries is developed. The paper then concludes with a brief discussion on the relationship between natural boundaries and the conceptual boundaries that shape our understanding. This relationship will not be as simplistic as previously supposed.

You might ask why such a discussion is of importance. The fact is that all of our human knowledge is built upon a foundation of assumptions that implicitly regard natural boundaries *an sich*, i.e. these underlying assumptions carve up the whole into (sometimes arbitrary) parts that are assumed to have ontological status. If the boundaries implicit in particular knowledge are real then a very strong case for the ongoing validity of that knowledge can be made. So an exploration into the status of natural boundaries is an exploration into the status of our knowledge.

## Defining Complex Systems

For the purposes of this paper a short summary of the features of a general complex system (though the complexity community is far from agreement, see Richardson & Cilliers, 2001) is provided. In Richardson (2001a) a complex system is defined as follows:

“A complex system is comprised of a large number of non-linearly interacting non-decomposable elements. The interactivity must be such that the system cannot be reducible to two or more distinct systems, and must be sufficient (where the determination of sufficient is problematic) to allow the system to display the behaviours characteristic of such systems.”

Previously a complex system (Richardson *et al.*, 2000, 2001) has been derived simply as a system comprising a large number of nonlinearly interacting entities. However, systems that we might call complicated, such as a computer system, contain a large number of nonlinearly interacting components (transistors have a non-linear response for example). The principle difference between a complicated system and a complex system is *not* the presence of large numbers of entities and nonlinear interactions. The key difference is the nature of the overall connectivity, particularly the existence of feedback mechanisms. Despite the existence if nonlinearity complicated systems do not self-organise into new structures. They do not display a wide range of qualitatively different behaviours. The extent and nature of the nonlinear interactivity is what differentiates between a complicated and complex system. The division between these two categories at a compositional level is very blurred however. It is problematic to know from compositional information whether a system is complicated or complex without having information about its behaviour. Complicated and complex systems, then, can only safely be differentiated from each other by observing their respective behaviours.

Complex systems display many possible qualitatively different behavioural regimes (the nature and variety of which evolve), as well as exhibiting emergence, i.e. the emergence of macroscopic system structures and behaviours that are not at all obvious from their microscopic make-up (Allen, 1999). Complicated systems do not. The order parameters that best describe the current behaviour of a complex system are not fixed, they evolve qualitatively as well as quantitatively. Complicated systems have qualitatively fixed order parameters. The subsystems of a complex system are emergent and temporary (and critically organised – Bak, 1996), where as the subsystems of a complicated system are prescribed and fixed.

The last differentiator listed above hints at a boundary issue, i.e. the boundaries describing subsystems in a complicated system are prescribed and fixed whereas the boundaries delimiting subsystems in a complex system are emergent and temporary. The nature of boundaries from a complex systems perspective, the main focus of this paper, will be discussed in the following section.

## THE NATURE OF BOUNDARIES

This section will discuss the nature of boundaries in a complex system. The nature of boundaries from a spatio-temporal perspective will be discussed first followed by an exploration of the boundary concept from a phase space perspective. These two perspectives will then be used to argue for a position in which no boundaries really exist in a complex system (except those defining its comprising components) but that a distribution of boundary (structure) stabilities does exist which legitimates a wide range of paradigmatically different analytical approaches (without the wholly rejection of natural science methods).

### Emerging Domains

If one were to view the spatio-temporal evolution of a complex system it would be observed that different structures wax and wane. In complex systems different domains can emerge that might even display qualitatively different behaviours from their neighbouring domains. A domain herein is simply defined as an apparently autonomous (critically organised) structure that differentiates itself from the whole. The apparent autonomy though is illusory. All domains are emergent structures that persist for undecideably different durations. A particular domain, or structure or subsystem, may seem to spontaneously appear, persist for a long period and then fade away. Particular organisations or industries can be seen as emergent domains that are apparently self-sustaining and separate from other organisations or industries.

Figure 1 illustrates the spontaneous emergence of order in a basic complex system (the mathematical details of which are not relevant for this discussion). Different domains emerge whose 'edges' (boundaries) change and evolve as the system evolves. Though a snap shot of the systems evolution would show clear structures it would be wrong to assume that such structures were a permanent and real feature of the system, the structures are emergent and temporary.

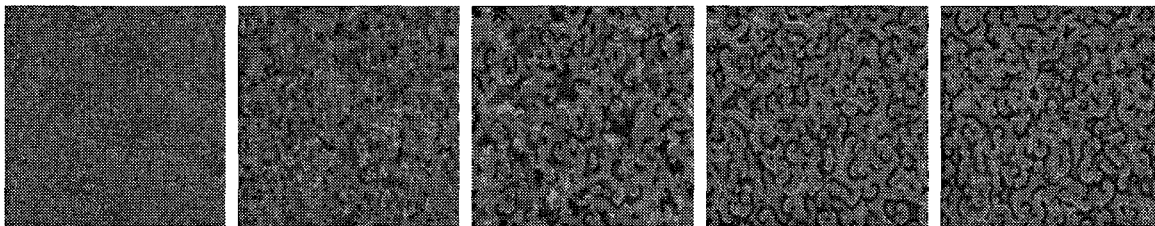


Figure 1: The Emergence of Domains (or Systems)

Though all boundaries are emergent and temporary some boundaries may persist for very long periods. For example, the boundaries that delimit a proton (which is arguably an emergent manifestation of the combined interactive behaviour of quarks, or superstrings) from its complement persist for periods theorised to be longer than the current age of the universe (possibly  $> 10^{33}$  s) after which the boundaries decay (through the emission of an X particle) and a new set of boundaries emerge (a positron and a pion which then decays into three electromagnetic showers). All boundaries are not so persistent. The boundaries that describe an eddy current in a turbulent fluid (which could be seen as the emergent property of the liquid's constituent molecules) are incredibly short-lived when compared to the proton. Most boundaries of interest in our daily lives exist somewhere in the middle of these two extremes. The boundaries that define the organisations we work within, those (conceptual) boundaries that define the context(s) for meaning, the boundaries that define ourselves



(both physically and mentally) are generally quite stable with low occurrences of qualitative change though quantitative change is rife.

It is also important to recognise that the observation of domains, and their defining boundaries, depends upon the scale, or level, one is interested in (which is often related to what one wants to do, i.e. one's purpose). An example of persistent boundaries and resulting levels again comes from the natural sciences. The hierarchy of quarks → bosons & fermions → atoms → molecules → cells → etc. is very resilient (especially at the lower ends) as well as displaying different levels of emergence. Choosing which level to base our explanations within is no easy task, particularly as any selection will be deficient in some way or another.

At the level of quarks (even if we could directly observe that level), say, it would be difficult to distinguish between two people, though at the molecular level this becomes much easier, and at the human level the task is beyond trivial. The level taken to make sense of a system depends upon the accuracy required or the practically achievable. Organisations (economic domains or subsystems) are very difficult, if not impossible, to understand in terms of individuals so they are often described as coherent systems in themselves with the whole only being assumed to exist (NB the general unhappiness of the modern employee is a testament to the dangers of over simplifying this particular organisational problem).

In short, the recognition of boundaries is problematic as well as being related to the level of aggregation we choose to view.

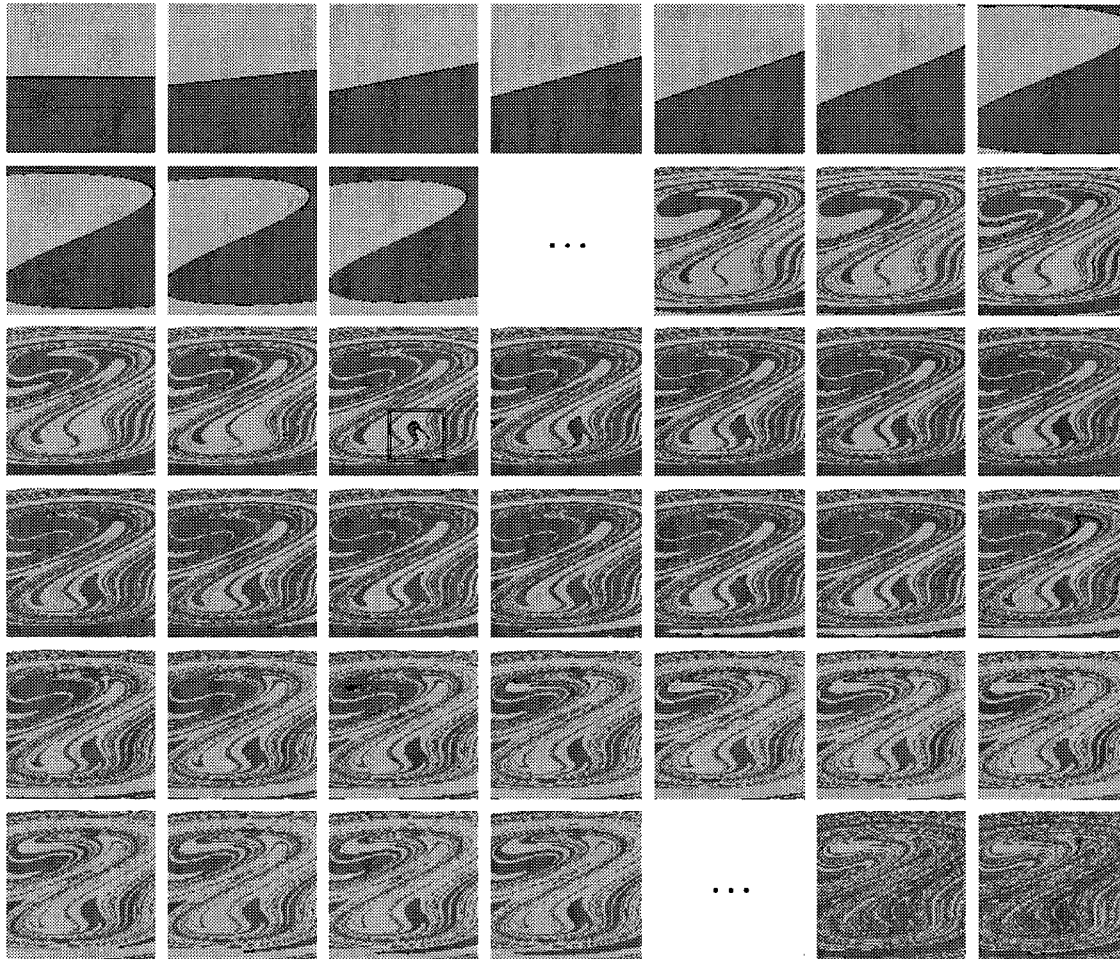
## Evolutionary Phase Spaces

This emergent domain aspect of complex systems is complexified further when the behaviours of different domains are included. Let's assume for the moment that we are interested in a particularly stable domain, an particular organisation for example. We might perform some kind of analysis, a cluster analysis for example, that allows us to proffer a number of order parameters (i.e. parameters that when changed, change the domain's behaviour) and their interrelationships that seem to characterise the observed domain's behaviour. We can then draw a picture of the domain's phase space, which will provide information regarding the qualitatively different modes of behaviour of that domain for varying time. Figure 2 shows the evolution of such a phase space for a very simple nonlinear system. The two order parameters are position (y-axis) and velocity (x-axis) and the two main shades represent the two main attractors for this system (black represents an unstable equilibrium attractor). So, on the first snapshot (taken at time = 0), depending on what the initial values are of the order parameters, the system is either attracted to the attractor represented by the light grey or the attractor represented by the dark grey.

The proceeding snapshots show how the phase space evolves with the two qualitatively different attractor spaces mixing more and more as time wears on. What we find for this particular system is that, though we know that there are two distinct attractors, after a quite short period the two attractor spaces are mixed at a very low level indeed. In fact, the pattern becomes fractal meaning that we require infinite detail to know what qualitative state the system will be in. So even with qualitatively stable order parameters qualitatively unstable behaviour occurs (Sommerer & Ott, 1993).

Despite this continuous mixing of states stable areas of phase space *do* emerge and persist. Figure 2 shows an example of this by highlighting the emergence of a stable region that persists to the end of the modelled evolution. This is of interest because it demonstrates that not only is quantitative prediction problematic but that qualitative prediction is also problematic (as opposed to being impossible). But remember that the example given is for a stable domain with qualitatively stable order parameters. For a domain, that is an emergent property of a complex system having other emergent neighbours, the order parameters will not necessarily be qualitatively stable. The defining order parameters might be *qualitatively unstable*. (This demonstrates that the order parameters are simply trends that offer a

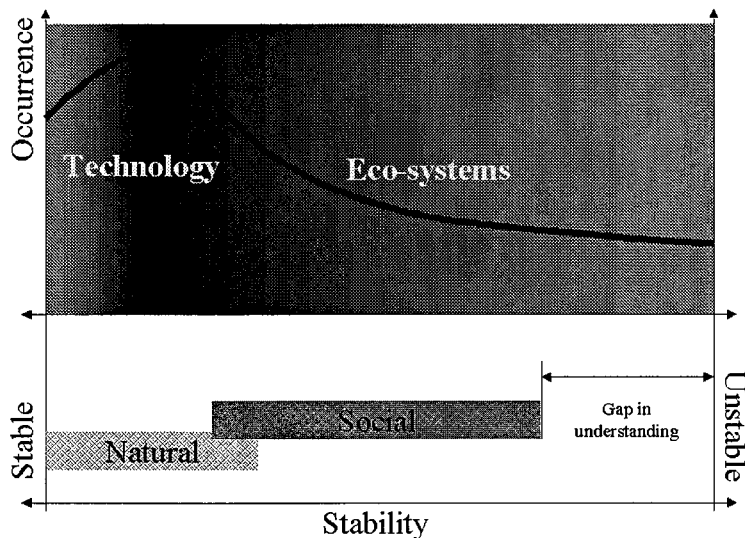
superficial (though often useful) understanding of any real system of interest.) The evolution of these phase variables will depend upon the interaction between the neighbouring domains, which is a manifestation of causal processes at the lower levels (an argument for meta-order parameters perhaps). This introduces nontrivial difficulties for any observer's attempts to make sense, i.e. derive robust knowledge. The fact that such change is not random, with the existence of stable structures as well as behaviours, means that the possibility of deriving useful understanding is not wholly undermined.



**Figure 2: The Emergence of Qualitatively Stable Behaviours**

## Boundary Distributions

The basic conclusion that the complexity-based argument given thus far leads to is that there are no real boundaries in any *absolute* sense (NB This by no way suggests that in certain instances assuming the *existence* of particular boundaries is inappropriate). How are we to do derive knowledge of particular systems then (particular if no systems really exist)? As mentioned above the situation is not as dire as it might immediately seem. There is no need to follow the radical holists to model the world, the universe and everything. In the field of complexity there is evidence that, though there may be no real boundaries, there are resilient and relatively stable emergent structures. In fact, there is a distribution of boundary stabilities. No evidence is given for what this distribution may actually be; it is simply argued that there is a distribution. Figure 3 illustrates a possible stability distribution (which has no theoretical or empirical basis).



**Figure 3: A Possible Distribution of Natural Boundary (Structure) Stability**

At one end of the stability spectrum there are boundaries/structures that are so persistent and stable that for most intents and purposes it can safely be assumed that they are in fact real and absolute. Boundaries that describe the objects of science-based technology exist toward this end of the spectrum. Such long-term stability allows a 'community of enquirers', e.g. the scientific community, to inter-subjectively converge on some agreed principles that might actually be tested through experiment. Under such conditions it is quite possible to develop quasi-objective knowledge, which for most intents and purposes (but not ultimately) is absolute. The existence of such persistent boundaries allow for a something other than a radically holistic analysis – this may explain why the scientific program has been in many ways so successful when it comes to technological matters. In many circumstances reductionism is a perfectly valid, though still approximate, route to understanding. In short, what is suggested here is that scientific study depends upon the assumption that natural boundaries are static, and that if one can 'prove' that the boundaries of interest are in fact stable and persistent then the scientific method is more than adequate.

At the other end of the stability spectrum we have essentially 'noise' in which the lifetime of apparent boundaries might be so fleeting as to render them unrecognisable as such and therefore unanalysable. Under such circumstances attempts to develop knowledge are strongly determined by the whims of the individual, with observed boundaries being more a function of our thirst to make sense, rather than an actual feature of 'reality'. To maintain a purely positivistic position, one would have to accept radical holism and consider the entire universe – a practical absurdity and a theoretical impossibility as has already been suggested. This is the only method by which robust knowledge could possibly be derived.

Fortunately though a vast majority of the perceived universe isn't quite so nebulous. This doesn't mean however that boundary recognition and allocation is a trivial exercise. In fact without the

ability to not only determine the stability distribution but also recognise where the objects of interest exist of the curve it is very difficult to determine how to approach them. Radical positivists might argue that a rigorous implementation of the scientific method is appropriate across the board. I have already suggested that the application of the scientific method makes clear assumptions about the ontological status of boundaries that I believe cannot be supported. I would argue that the social sciences with their willingness to work with a plurality of (possibly incommensurable) methods and perspectives is more suited to deal with a state of affairs in which boundary recognition and allocation is deeply problematic. This position reflects Cilliers (2001) concern that "[i]n accepting the complexity of the boundaries of complex systems, we are committed to be critical about how we use the notion since it affects our understanding of such systems, and influences the way in which we deal with them."

Before we move on to discuss possible solutions that mitigate the effects of this state of affairs I'd like to summarise the discussion thus far in relation to our observed reality.

## THE UNIVERSE AS ONE

The only real absolute boundaries in a complex system are those that define the basic constituents and their interrelationships. All other boundaries are emergent and temporary. In order to relate these arguments to the real world it is assumed in addition that the universe is a complex system, i.e. the one and only well-defined system. If we accept the current picture of theoretical physicists then the universe is a vast agglomeration of superstrings (see for example Greene, 1999). Defining the universe as a complex system suggests that it is a vast collection of nonlinearly interacting superstrings. As such, the only boundaries with any absolute ontological status are those boundaries that describe each superstring and their interrelationships (which would all be the same if the universe was a gigantic cellular automata experiment). All other boundaries are, as already asserted, emergent and temporary.

Regarding the universe in these terms has profound consequences for the status of all our knowledge including scientific knowledge. If we could find a theory of everything that would fully describe the universe at the superstring level (assuming them to be the ultimate fundamental constituents) then we might be able to develop absolute understanding. However, the emergent processes are intractable, i.e. there is no algorithmic shortcut from one emergent level of aggregation to another. The only way to quantify the emergent products is to run the system. This is quite obviously beyond us mere mortals. So though it may be a reasonable position to willingly accept that there is a theory of everything with which scientists might be able to claim absolute knowledge (though complete validation would be impossible) this does not lead to absolute knowledge of other emergent levels of aggregation. In short, scientists can never (and will never) have absolute (and therefore infallible) knowledge. Our knowledge is no more than a superficial and flawed account of what actually is (though this doesn't undermine the utility of such superficial knowledge).

The only route to absolute knowledge is through a theory of everything that, because of the inherent nonlinearity, would be severely limited. The resulting conclusion is that no single perspective can ever claim to capture the rich complexities and subtleties of *any* observed phenomena. However, as already suggested, there does exist very stable and persistent (critically organised) natural 'boundaries', or 'structures', so the creation of very stable and representative knowledge is also possible. However, given the problematic nature of boundary recognition and allocation the whole notion of knowledge is itself problematised.

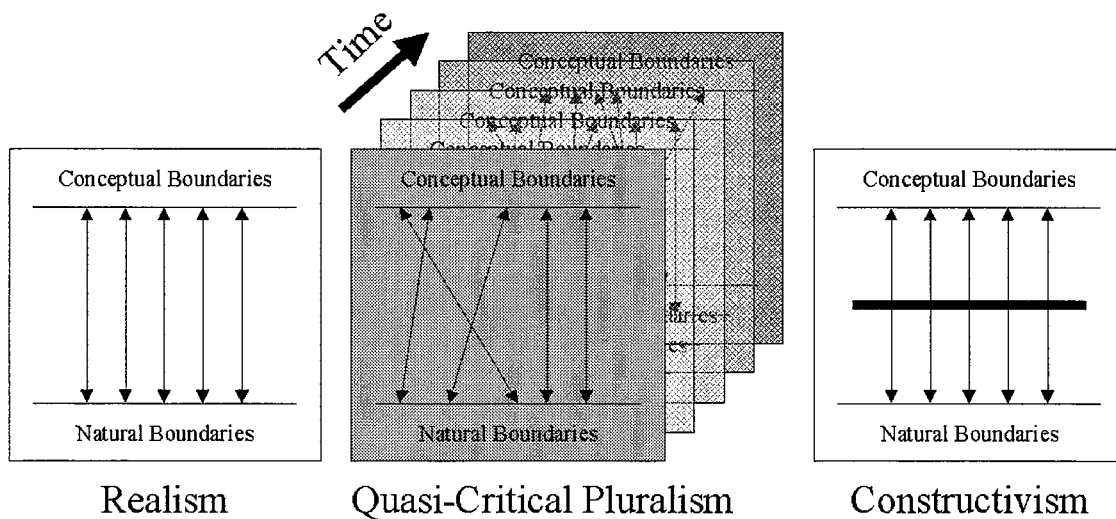
To mitigate the difficulties that complexity raises for our ability to know anything it has been suggested that a pluralist epistemology is developed contrary to the quasi-monist epistemology of science, the scientific method (Richardson, 2001a,b; Richardson *et al.*, 2001). Pluralism accepts that all conceptual perspectives (underpinned by conceptual boundaries) have the potential to shed light on a particular part of the universe. However, taking this position literally leads to a relativist philosophy

that more or less excludes the influence of the universe and yields a purely constructivist ‘anything goes’ position. In Richardson *et al.* (2000, 2001) it was argued that scientists must respect both the influence of the universe (as they already do) and the many explanatory possibilities of pluralism. Pluralism must go hand-in-hand with criticism – critical pluralism. Through criticism the strengths and weaknesses of different conceptual boundary configurations (perspectives) can be assessed in terms of the perceived context. This leads to an emergent philosophy in which a critical dialogue occurs between ourselves, the conceptual world, and the natural world (all of which are interrelated in non-trivial evolving ways). The relationship then between conceptual boundaries and natural quasi-boundaries is neither simple (realism) nor absent (constructivism).

## **The Relationship Between Natural and Conceptual Boundaries**

Given that there are no true boundaries we are forced to assume boundaries because of limited cognitive resources; our inherent human need to reduce the complex. Some of these boundary judgements will be reasonable, some of them will not be. Given that there can be no description other than the description of the whole (which is plainly impossible) it is straightforward to conclude that all descriptions must necessarily be metaphorical in nature. Even mathematical models are metaphors for reality. A metaphor is a partial description of one thing in terms of another. In the case of mathematics, the universe (one thing) is partially described in terms of selected mathematical constructs (i.e. other things). As all explanations must be by their very nature metaphorical then we must treat them as such rather than implicitly assuming that our explanations are homological with the object they claim to describe. As already suggested, this isn’t that big a disaster for knowledge. Though Truth might not ever be obtained in an absolute sense, our words, concepts and theories can point towards the Truth without ever fully expressing it.

This view undoubtedly denies (naïve) realism in that conceptual boundaries (that are implied by explanation) do not perfectly map to their espoused objects. There is no one-to-one mapping of our ideas to objective reality. However, this denial of realism does not *recoil* into an argument for constructivism. Constructivists, as has already suggested, argue that all boundaries are created in our minds and as such do not correlate with objective reality at all. The position argued for herein, which is based upon the problematic distribution of natural boundary stabilities, falls between these two extreme. Rather than having a fixed relationship with natural boundaries, or having no relationship at all, conceptual boundaries do have a complex and changing relationship to reality. Sometimes this link might be so tenuous as to be unusable. Sometimes this link is so strong as to give us the impression that we might actually have absolute Truth to hand. The key difference between this position, which has been called quasi-critical pluralism (NB The ‘Quasi’ is attached to acknowledge our inability to be absolutely unbiasedly critical as well as the resource limitations that prevent is from being truly pluralist), and realism is that it explicitly acknowledges the problematisation of boundary recognition, which is trivialised in most realist philosophies. The key difference between Q-CP and constructivism is that Q-CP acknowledges that the world does indeed play an integral part in the evolutionary relationship between reality and our ideas. Figure 4 illustrates the different relationships between conceptual boundaries and natural boundaries for these different philosophies.



**Figure 4: The relationship between natural and conceptual boundaries for different epistemologies**

## SUMMARY AND CONCLUSIONS

Most of the problems facing contemporary humanity, boundary recognition and allocation are at best problematic. Most of these problems are social (used in the broadest possible sense) in nature: how do we move forward with globalisation – do we regulate (homogenify) everything or do we learn to sustain and manage difference?; how can we develop a symbiotic relationship with our climatic environment (without simply turning every electrical device off)?; or more down to earth, how might we manage multi-culturalism without striving for mono-culturalism?

For these problems, as with many others, we will need to develop (relearn?) the skills to enable the development of local knowledge (through Q-CP) without always falling back onto prevailing dogmas – the status and value of scientifically derived knowledge needs to be put into question allowing, if the perceived (inter-subjectively agreed) context demands, the privileging of other types of knowledge. Even if we can fulfil this nontrivial task, we must still remember that much of the knowledge developed is certainly approximate and provisional often requiring radical revision as the future unfolds. This tends toward an evolutionary epistemology and away from a single coherent and universal epistemology. This is not the death of universals, but a levelling of the playing field. Furthermore this is not a move from naïve objectivism to naïve subjectivism. This is a middle way in which the ‘complex’ relationship between natural boundaries (as viewed from a complex systems perspective) and socially constructed boundaries (concepts and symbols – also seen from a complex systems perspective) is of central importance.

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# A System Framework for the Conceptual Design of Reconfigure-able Multi-Mission Unmanned Aerial Vehicle

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## ABSTRACT

*The mission effectiveness of Unmanned Aerial Vehicle (UAV) have been proven in civil and military operations. Several issues and challenges of the UAV systems have been identified and these needs to be addressed for system effectiveness of the UAVs. One of the major issues is the large inventory of UAVs and its associated operation and support challenges. This paper discusses a research framework that addresses the issues and challenges in UAV system by the development of methodology to conceptually design a multi-mission UAV with inbuilt design flexibility. A 'system approach' is adopted to develop a methodology that identifies the design parameters to facilitate the design of a reconfigure-able multi-mission UAV.*

*Keyword: System approach, System structure, System hierarchy, System Framework, Multi-Mission, Unmanned Aerial Vehicle, Design Reconfiguration.*

## INTRODUCTION

Unmanned Aerial Vehicle (UAV) system has played a major role in the last decade in the replacement of manned vehicle. UAV systems are placed on certain high-risk missions and on missions, where the UAV's system effectiveness is envisaged as greater than manned systems (Hewish 1998). UAV designs over the years have evolved as solutions to meet the growing mission requirements of the civil and military customers. In the race to find design solutions, the design aimed to address omni-mission requirements, resulting in the delivery of a large variety of UAVs in the market (Anon 2001). The large inventory of UAVs when assessed for fleet-system effectiveness, indicate a host of "issues and challenges" that face the UAV systems – design, development, operation and support (Franchi 2001). A more systematic methodology is required to address the issues and challenges from mission definition to the final induction of the UAV system in-service, coupled with logistic support.



The issues of mission payload have been addressed in past (Sinha et al. 1999, 2000, 2001). A system approach was adopted to study the operational needs and operational environment of UAV systems. The study initially resulted in the conceptualisation of the UAV system in a typical input-process-output configuration (Flood & Jackson 1991). A UAV system hierarchy was developed for the design of multi-mission payload. The research developed a system methodology for the design of multi-mission payload that addressed the mission expectations of UAV systems. The transformation process of multi-mission payload concept into a feasible futuristic UAV design is still at its premature stage.

A design methodology needs to be developed for a multi-mission UAV with inbuilt design flexibility, from a system perspective – one that will holistically (Flood and Jackson 1991) address all design parameter and constrains, including reconfiguration requirements (Sinha et al. 2001). The multi-mission UAV (MM-UAV) needs to be on an ‘open format’, to provide flexibility to reconfigure the vehicle for particular mission.

This paper presents a framework for the development of a system methodology to conceptually design a re-configurable MM-UAV.

## SYSTEM METHODOLOGY

There are several issues and challenges (I & C) of the UAV system that needs to be addressed. Several I & C have been listed from a general perspective (Franchi 2001). The I & C when summarised, fall under three aspects – Project, Technology and Operation. Project I & C ranges from the conceptualisation to cost effectiveness, technology I & C involves validation to logistic support and operation cover doctrines to support requirements. The I & C formatted under these three aspects is presented in Table 1.

**Table 1: Issues and Challenges of UAV Systems**

Issues	Challenges
Project	<ul style="list-style-type: none"> <li>• Customer needs, operational requirements and utility definition;</li> <li>• System thinking to capture the requirements holistically;</li> <li>• Technology acquisition process;</li> <li>• Application of available technology;</li> <li>• Not as a stand-alone asset; and</li> <li>• Cost effectiveness.</li> </ul>
Technology	<ul style="list-style-type: none"> <li>• Conceptual thinking directed towards technology convergence;</li> <li>• Induction maturity to avoid system re-design and modifications;</li> <li>• Development of autonomous technology for guidance, control and information management;</li> <li>• Application of stealth technology;</li> <li>• Sub-system technology; Launch and recovery (Land, Ship &amp; Space), Avionics and sensors;</li> <li>• EMI/ EMC ;</li> <li>• Power requirements;</li> <li>• New approach of signal processing for real-time information extraction; and</li> <li>• Multi-mission payloads: Greater capability in a single vehicle.</li> </ul>
Operation	<ul style="list-style-type: none"> <li>• Doctrines and concept of operation be fully developed;</li> <li>• Impact on traditional air power;</li> <li>• Operational acceptability test and validation;</li> <li>• Optimisation of mission performance and effectiveness;</li> <li>• Airworthiness and operation certification to meet internationally recognised regulations;</li> <li>• Communication integration in available bandwidth; and</li> <li>• Maintenance and operational support requirements.</li> </ul>

A system methodology to study the I and C of UAV systems was developed by Sinha et al. (2001), which was conceptualised in a conventional input-process-output configuration (Flood & Jackson 1991). The configuration identifies the keys inputs to the system, the components and attributes, the environment and the expected outputs, as a result of the process. The I and C formatted in Table 1 are transformed in a system configuration with the issues of project, technology and operation as components of the system. The challenges form the attributes, with the organisation, climate, economics, etc., forming the environment. The system configuration of the Is and Cs is presented in

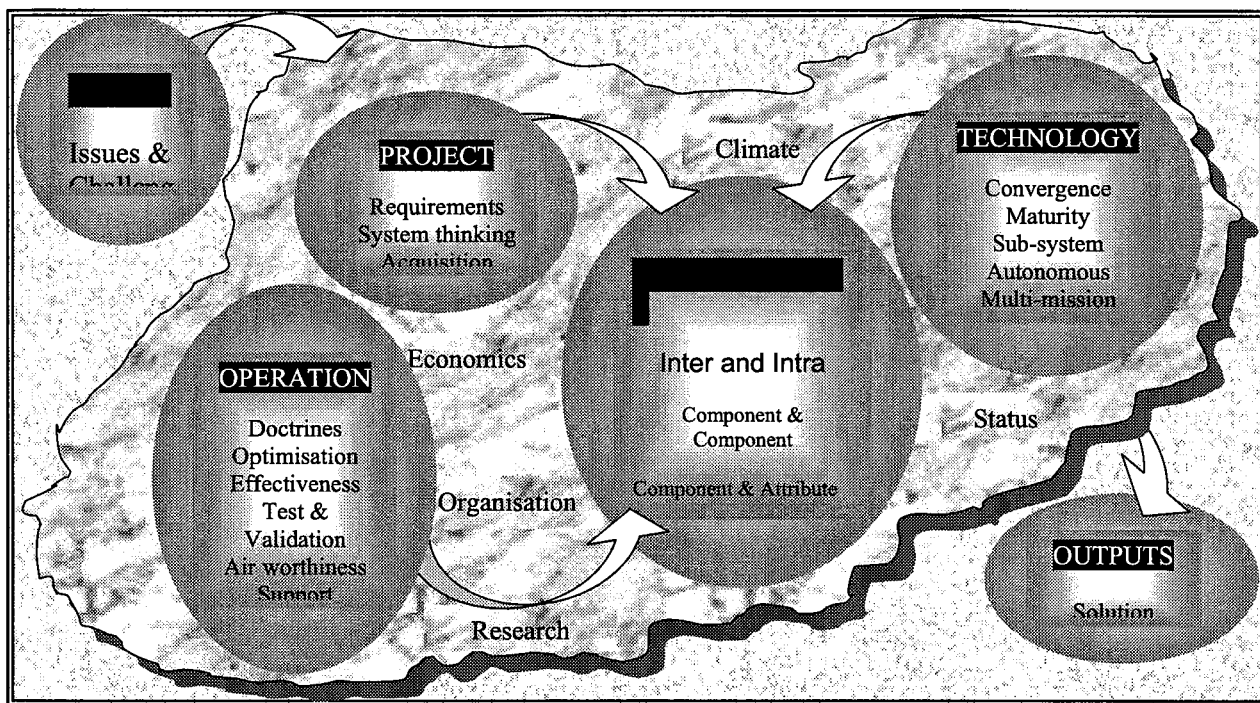


Figure 1: System Configuration of UAV Issues and Challenges

Figure 1.

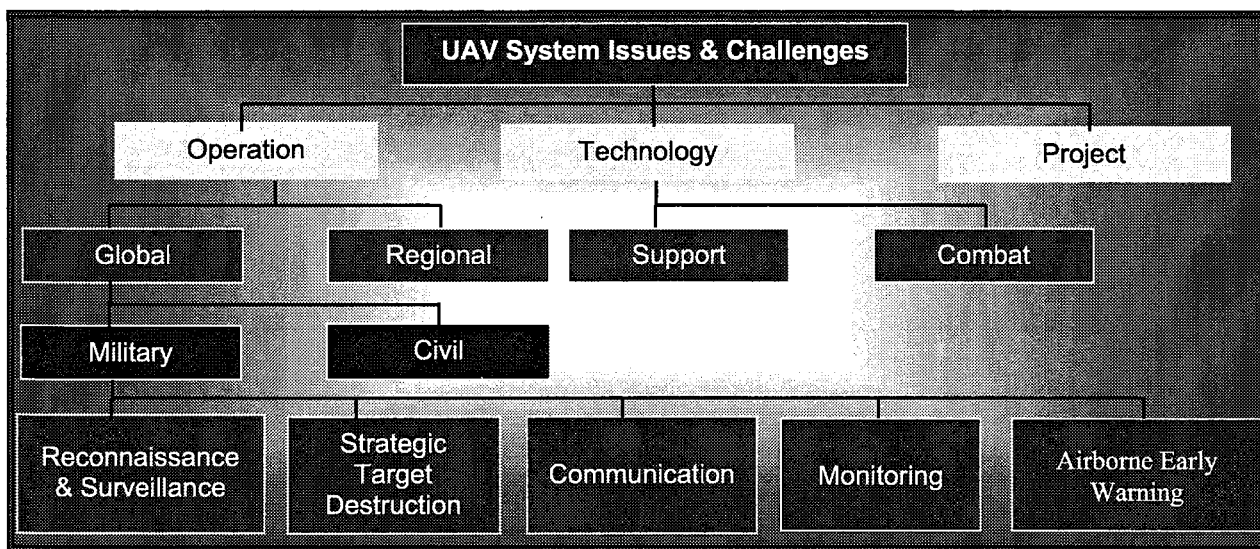


Figure 2: System Hierarchy of UAV Issues and Challenges

With the Is and Cs formulated from a system perspective, each component (project, technology and operation) are now considered as a system to identify their components. The study of the sub-systems provides an insight of the system hierarchy. Thus the Is and Cs are visualised in a hierarchy format to provide a holistic view. The UAV system I and Cs hierarchy is presented in Figure 2.

The system hierarchy of Is and Cs, provides the base to study the inventory of UAVs from an operational, technological and project perspective. A holistic perspective of the inventory will provide the guide,

to address the over-stretched inventory for a solution aimed at a narrowed inventory. Considering the operational and technological Is and Cs in the system hierarchy format, the operation needs and mission requirements of the customers are studied to classify the UAV inventory. The operational needs and mission requirements and the resulting technology classification by the study is presented in Table 2.

**Table 2: Operational needs, mission requirements and technology classification of UAV system**

Operational Needs	Customers	Mission Requirements	Technology Classification
Global	Military	<ul style="list-style-type: none"> <li>Distance &amp; large theater surveillance and reconnaissance;</li> <li>Monitor hostile emission;</li> <li>Destroy mobile missile launcher &amp; time-critical targets;</li> <li>Communication with covert formation;</li> <li>Ballistic missile defence; and</li> <li>Airborne early warning.</li> </ul>	<u>Support UAV</u> HALE HALO MAME  <u>Combat UAVs</u> UCAVs (HL) UCAVs (MM)
	Civil	<ul style="list-style-type: none"> <li>Meteorological monitoring;</li> <li>Disaster monitoring;</li> <li>Atmospheric telecommunication relay platform.</li> </ul>	<u>Support UAVs</u> HALE HALO MAME
Regional	Military	<ul style="list-style-type: none"> <li>Precise targeting &amp; terminal guidance;</li> <li>Force protection &amp; battle management;</li> <li>Attack &amp; suppress enemy ground targets;</li> <li>Combat Intelligence, Reconnaissance &amp; Surveillance;</li> <li>Battle damage assessment;</li> <li>Communication relay;</li> <li>In-situ chemical/biological agent detection;</li> <li>Airborne early warning;</li> <li>Anti sub-marine &amp; ship warfare;</li> <li>Electronic and information warfare; and</li> <li>Immediate vicinity surveillance &amp; reconnaissance.</li> </ul>	<u>Support UAVs:</u> MAME LALE VTUAVs (LE) VTUAVs (ME) VLAVLE (micro)  <u>Combat UAVs</u> UCAV (MM) UCAV (LL)
	Military	<ul style="list-style-type: none"> <li>Support Law enforcement;</li> <li>Search &amp; Rescue;</li> <li>Relief Operation in Natural disaster;</li> <li>Customs tasks; and</li> <li>Media &amp; entertainment.</li> </ul>	<u>Support UAVs</u> LALE VTUAVs
Regional	Civil	<ul style="list-style-type: none"> <li>Support Law enforcement;</li> <li>Search &amp; Rescue;</li> <li>Relief Operation in Natural disaster;</li> <li>Customs tasks; and</li> <li>Media &amp; entertainment.</li> </ul>	<u>Support UAVs</u> LALE VTUAVs

• **Abbreviation**

- |  |  |
|--|--|
| HALE : High Altitude Long Endurance                                      | UCAV(MM) : Unmanned Combat Aerial Vehicle (Medium Altitude Medium Endurance) |
| HALO : High Altitude Long Operation                                      | VLAVLE(Micro) : Very Low Altitude Very Low Endurance                         |
| LALE : Low Altitude Short Endurance                                      | VTUAVs (LE) : Vertical Takeoff Unmanned Aerial Vehicle (Long Endurance)      |
| MAME : Medium Altitude Medium Endurance                                  | VTUAVs (ME) : Vertical Takeoff Unmanned Aerial Vehicle (Medium Endurance)    |
| UCAV(HL) : Unmanned Combat Aerial Vehicle (High Altitude Long Endurance) |  |

The UAV inventory (Table 2) formulated from the technological classification consists basically of “support” and “combat” UAV systems. Each of these systems are driven by endurance, altitude and mission payload classifications. The endurance, altitude and payload design aspects are governed by the airframe and power onboard. In order to narrow the inventory, the avenue open in UAV project definition is to include the aspect of “flexibility” in design, by a base-line design on a common fuselage with changeable/bolt-on sections. The flexibility to re-configure the vehicle for particular mission with changed endurance, altitude of operation and payload, can be addressed as follows:

- Fuselage extension section : Provision for alternative payloads;
- Changeable wings : Provision for low/high altitude and endurance;
- Changeable tail units : Stability and control; and
- Alternative power-units: Provision for increased/decreased power.

The concept of MM-UAV with inbuilt design flexibility has provided the foundation to formulate a research program on design methodology for a reconfigure-able MM-UAV. The system methodology developed by Sinha et al. (2001) could be explored to conceptually design a UAV airframe with changeable sections and adjustable power for particular mission payloads.

To develop a methodology that holistically address the flexibility in UAV design, a system structure for design reconfiguration is to be formulated. The system structure is to facilitate the identification of system elements based on the concept of MM-UAV developed by Sinha et al. (2001). Keeping the provision of changeable airframe and adjustable power as the focus, the function of UAV design reconfiguration to be structured is as follows:

- Identify mission requirements for MM-UAV;
- Formulate reconfigure-able design requirements;
- Identify design parameters of omni-mission UAV; and
- Integrate reconfigure-able design requirements and omni-mission design parameters to identify the base-line design requirement of futuristic MM-UAV.

The system structure of the UAV design reconfiguration considering the above functions is presented in Figure 3.

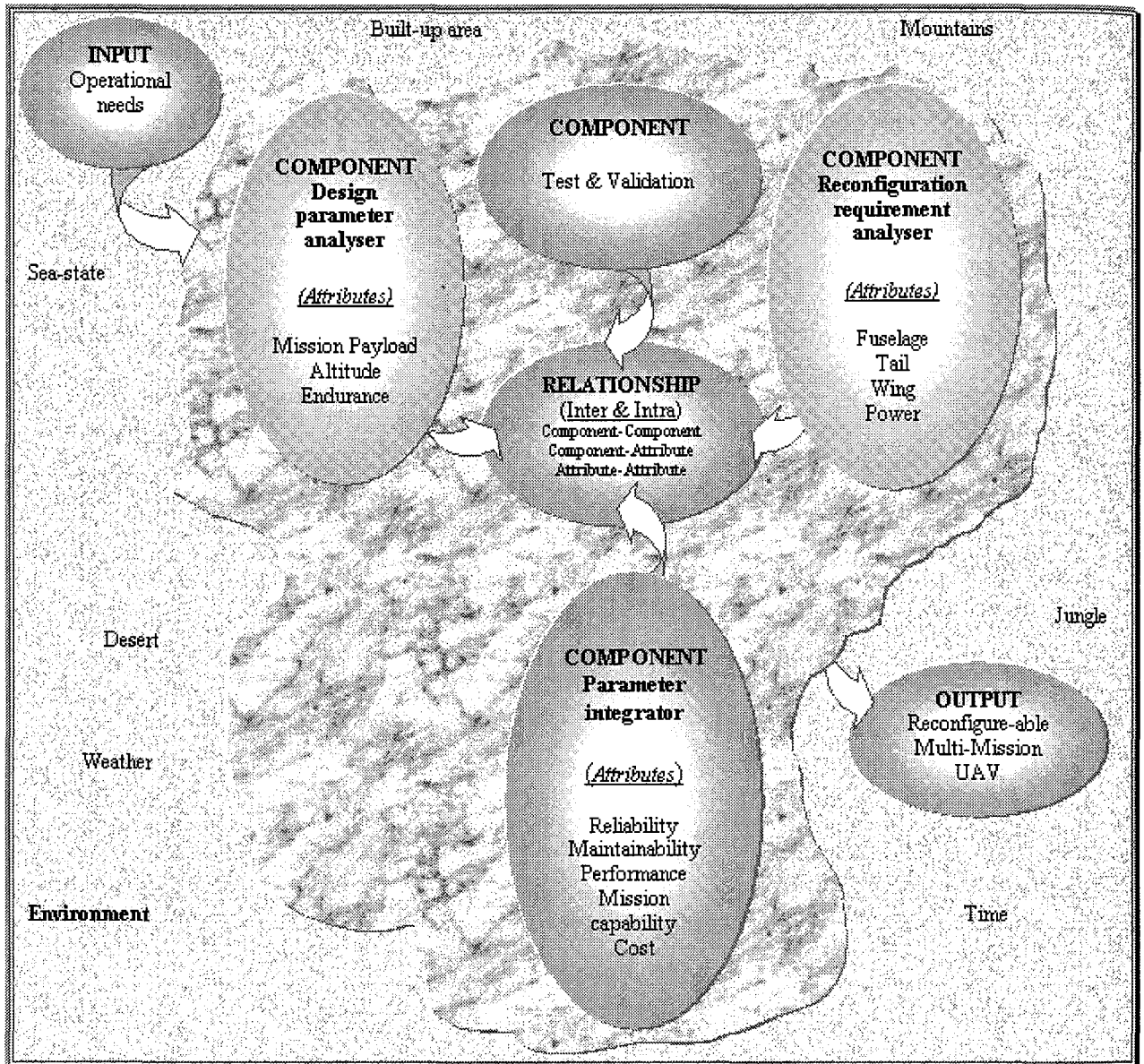


Figure 3: System Structure of UAV Design Reconfiguration

## SYSTEM FRAMEWORK

Having conceptualised the UAV design reconfiguration process from a system perspective, the framework for the conceptual design of reconfigure-able MM-UAV can be developed. The UAV design reconfiguration structure identifies the requirement of four components – two analysers, and integrator and a tester and validator – to aid design of reconfigure-able MM-UAV. The components and their slated functions are as follows:

- **Analysers:** To provide an analysis of the UAV design parameters and reconfiguration requirements for MM-UAV with inbuilt design flexibility;
- **Integrator:** To integrate the design parameter and design reconfiguration requirements for base-line design requirements of re-configure-able MM-UAV; and
- **Tester and Validator:** To test and validate the effectiveness of reconfigure-able MM-UAV design.

With the above modules and their functions identified, the system framework for the conceptual design of a reconfigure-able MM-UAV can be developed. The system framework with various modules and functional flow is presented in Figure 4.

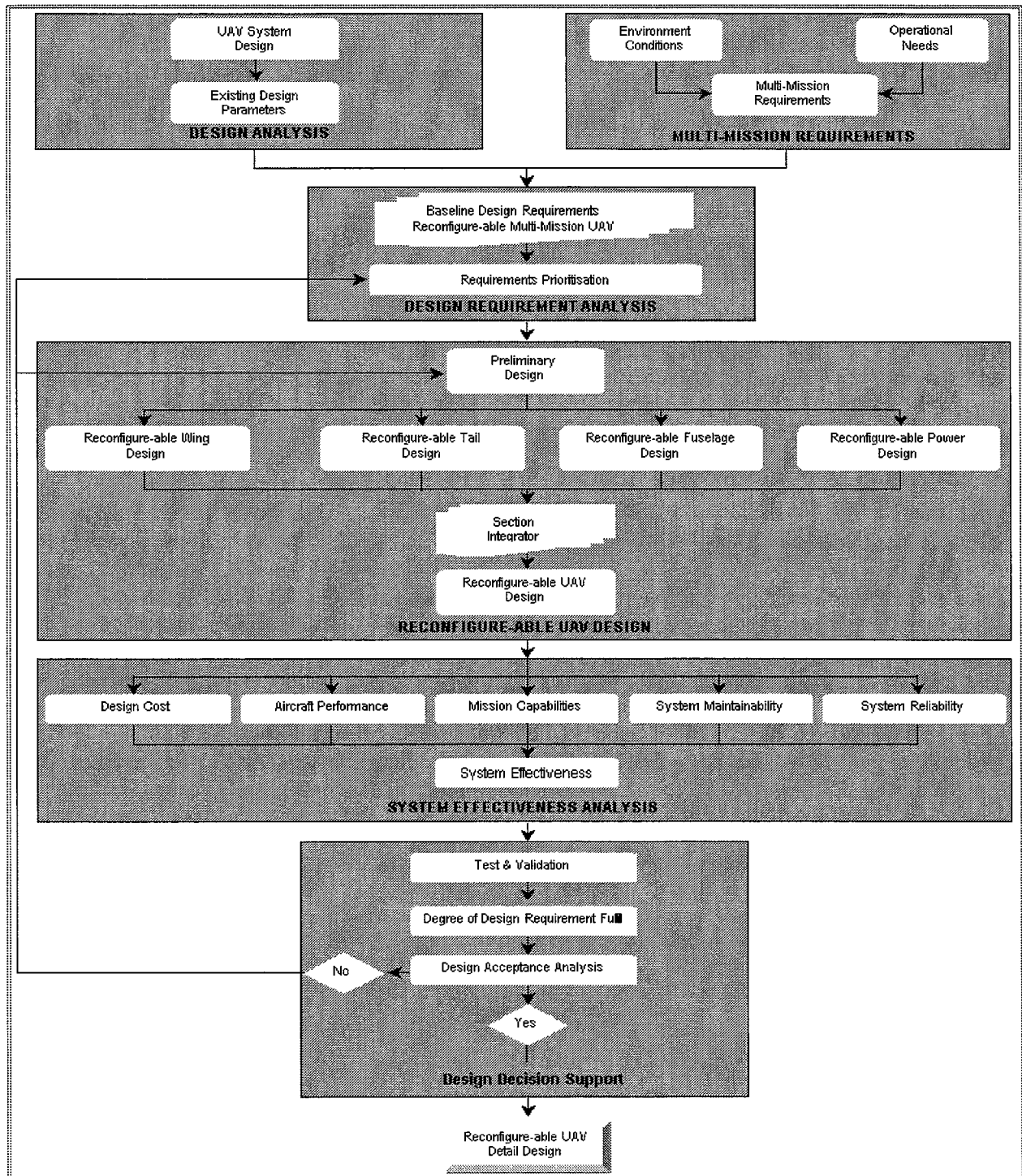


Figure 4: System Framework for Conceptual Design of Reconfigure-able MM-UAV

## RESULTS AND DISCUSSION

The application of generic system methodology to the design of MM-UAV with inbuilt design flexibility resulted in the following:

- Development of a “System Structure of an UAV design reconfiguration”; and
- Development of a “System Framework for the conceptual design of reconfigure-able MM-UAV.”

The system structure developed, provides a system perspective of UAV design reconfiguration process. It identifies the components of the problem and their functional requirements that need to be addressed for a holistic solution. An interrelationship analysis of the components and their attributes (functional requirements) provides the methodology to integrate the UAV design parameters and requirements for inbuilt flexible design.

The system framework developed, identifies six analysis modules – Design analysis, Multi-mission requirements analysis, Design requirement analysis, Reconfigure-able UAV design, System effectiveness analysis and Design decision support. Each of these modules comprises of various sub-modules that aids analysis and decision support. The sub-modules frameworks need to be further developed in detail for functionality of the modulus. The system framework caters for feedback loops to optimise the design.

## CONCLUSION

The issues and challenges in the design, development and operation of UAV systems, are many. System approach provides an avenue to holistically conceptualise the issues and challenges for analysis. In this process, the large inventory of UAV system, the prime issue and challenge, can be narrowed by the design of MM-UAV systems with in-built design flexibility.

The system approach adopted for developing the framework for the conceptual design of a reconfigure-able MM-UAV is the first step in formulating a futuristic MM-UAV to address the issues and challenges in UAV system. The methodology developed addresses all design parameters that needs to be considered in the design process.

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# A System Framework for Sustainability Analysis of University-Industry Aerospace Research Collaboration

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## ABSTRACT

*Consolidation and globalisation of aerospace industries have impacted on-going and future R&D programs. With the added impact of declining budgets, only optimum collaboration between university and industry will be able to garner enough resources to ensure "project sustainability." To formulate optimum collaborations, a holistic analysis of the R&D activities of universities and the industrial priorities is needed. In this paper the adoption of a system approach to develop a methodology for "Collaborative Project Sustainability Analysis" is discussed.*

*Keywords: System Approach, Sustainability Analysis, System Framework, Research Collaboration.*

## INTRODUCTION

The strategic importance of Aerospace industries have increased in the past decade owing to their all encompassing importance in economic, military and technological spheres. However, the continuing consolidation and globalisation in the industry have had a salutary effect on both military as well as commercial development programs. Declining worldwide budgets have further impacted negatively on resource allocation towards baseline Research and Development (R&D).

Under these conditions the R&D sector has to work cohesively with the industry to produce research results that will prove to be viable. Future research co-operation between university and industry will be vastly different from the past. While greater collaboration is vividly indicated, but the tangible gap between the two have limited the inter-action.

With well controlled and stabilised funding for dedicated R&D, innovative vitality can be brought to the industry. In order to achieve this, it is necessary to ensure that academic research and education is tailored to the industry needs. The need for the R&D sector to produce the appropriate research project results is a new challenge to be addressed in the context of "project sustainability."

Kainikara et al. (2001) developed a system framework to holistically address the issues of project sustainability. The framework conceptualised project sustainability as a system with the capability to process the aerospace programs and the business environment into the required research collaborative order. It also considered the inter and intra relationships between university and aerospace industry, in order to identify inputs for the development of a system framework to establish research collaboration.

The system framework provides the required foundation for the development of "Collaborative Project Sustainability Analysis" (CPSA) methodology to build optimum collaboration between university and industry. In this paper the adoption of a system methodology to identify and develop the sub-systems of the CPSA is discussed.

## **SYSTEM METHODOLOGY**

The sustainability of any university-industry collaboration on a long-term basis will depend on the research centre capability to meet industrial project requirements. The outline framework for mutual assistance in joint project initiatives can be arrived at by an analytical and holistic approach to "collaborative project sustainability." Accordingly a system methodology to study and analyse the capabilities of research centres and the project requirement needs was developed based on action research to establish the use of systems concepts in problem solving (Checkland 1981).

The methodology considered the stated requirements and evolved through the establishment of parameters, operational requirements and support policies (Blanchard et al. 1990). The following parameters were identified for analysis:

- Industry project requirements and in-house capabilities; and
- Academic research centre capabilities.

With the parameters clearly defined, the sub-modules of the CPSA are now formulated.

## **COLLABORATIVE PROJECT SUSTAINABILITY ANALYSIS**

Having defined the requirement and parameters involved, feasible design approaches are considered and the results evaluated in terms of specified effectiveness criteria. The preferred configuration is described through sub-module specifications (Blanchard et al. 1990).

Five sub-modules were identified.

- Research Centre Capability Analysis: To analyse the research centre resources and expertise for capability identification;
- Project Requirement Analysis: To identify project requirements of resources and expertise;
- Database: To store historical industry project and research centre data;
- Project Sustainability Analysis: To compare the "identified capabilities" with "identified project requirements", for "degree of sustainability" determination; and
- Shortfalls Provisioning Analysis: To identify shortfalls and provision them to increase project sustainability.

### **Sub-Module 1: Research Centre Capability Identification (RCCI)**

Research centre capabilities will be identified in terms of resource availability, expertise of personnel and on-going and future programs. Resources would include financial status and constraints if any, technical manpower availability and capability to induct sufficient numbers within stipulated time frames and laboratory infrastructure. A detailed analysis of the qualifications, experience and interdisciplinary qualifications of personnel will be done. Programs that are on-going at the centre as well as future plans regarding the disciplines that would be considered, the level of the program and time-frame will be considered. An analysis of these factors will clearly identify the research centre capabilities as well as drawbacks.

## Sub-Module 2: Project Requirements Analysis (PRA)

In order to identify the industrial project requirements, the resources, expertise, on-going programs and projects will be identified and then analysed. The analysis will clearly bring out the prime factors that are required in any given project. It will also identify the requirements for the successful completion of the program as well as the deficiencies in the concerned project profile.

## Sub-Module 3: Database

The database will utilise the oracle 8i function to allow data updating on a continuous basis through the RCCI and PRA sub-modules (Gennick et al. 2000). The database will store data on research centre resources, expertise and programs as well as project requirement resources, programs and projects. This sub-module will provide appropriate data suitable for the functions of other sub-modules and will be easily extractable.

## Sub-Module 4: Project Sustainability Analysis

This sub-module is the prime mover in the analysis. It integrates the identified capabilities of the research centre and the identified project requirements. This integration will produce a degree of project sustainability within the given parameters and would determine the quantum of mis-match between the two. The analysis of the mis-match will produce either sustainability of business enterprise or lead on to provisioning of short falls in the research centre.

## Sub-Module 5: Shortfalls Provisioning Analysis

If the sustainability analysis produces a mis-match, which would not permit the project to proceed further, the factors that contribute to the shortfall will be identified. Thereafter the factors will be analysed and remedial provisioning made at the research centre in order to meet the necessary degree of project sustainability.

## SYSTEM FRAMEWORK

The system framework can now be developed by considering the sub-modules, their functions and the data flow requirements. The system framework of a CPSA for university-industry aerospace research collaboration is presented in Figure 1. Depending on the database contents and university capabilities, the framework has the potential to cover a range of aerospace research areas.

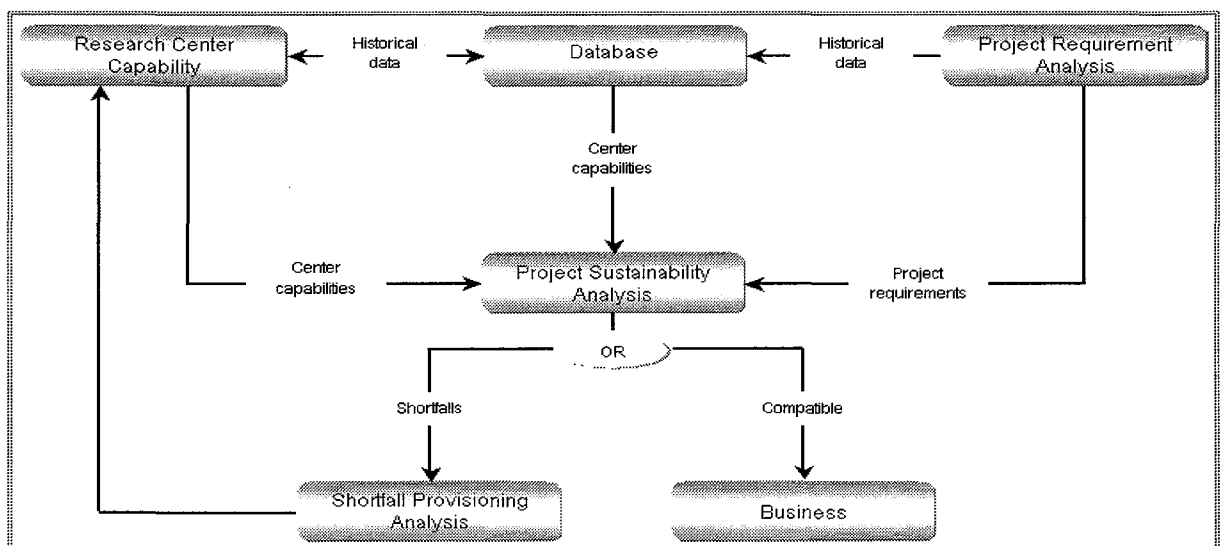


Figure 1: CPSA System Framework

## RESULTS AND DISCUSSIONS

The issue of collaborative project sustainability can be analysed holistically to ensure that adequate mutual assistance exists for the project to be viable. This study produced a feasible sub-module configuration for a base level analysis.

The modular structure developed provides a system perspective to the university-industry research collaboration. It identifies the components of the combination and also delineates the mis-match area. A project sustainability analysis provides the basis for the methodology to further collaborative project sustainability. The analysis identified five sub-modules of the analysis framework.

## CONCLUSION

The system approach adopted for the Collaborative Project Sustainability Analysis provides the avenue for a "holistic" analysis of the problem. The sub-modules and their functions for the development of the CPSA have been defined. The continued acceptance of research outcomes into the system, based on feedback from the operational "real world" will be largely dependent on the capability of research centres to meet stringent demands. The CPSA will be an appropriate tool to measure and analyse the capabilities vis-à-vis requirements.

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# A System Approach to Quality Evaluation and Enhancement of Educational Programs

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## ABSTRACT

*The quality of educational programs being delivered by academic institutions is vital to the sustainability and establishment of institutions credentials. The traditional "quality evaluation methodology" of educational programs that stems from students assessment of delivered programs, provides a uni-dimensional based quality evaluation. A more systematic feedback process is required to holistically evaluate the quality of an existing program on a multi-dimensional format to identify the shortfalls for quality enhancement. In this paper, a system framework for "Quality Evaluation and Enhancement of Educational Programs" is discussed. A system approach is adopted to identify the multi-faced inputs and the parameters on which rests the quality of educational programs.*

*Keywords: System Approach, System Structure, Feedback System, Educational Program, Quality Evaluation and Quality Enhancement.*

## INTRODUCTION

Educational institutions worldwide emphasise the quality of their educational programs as a key factor to attract potential candidates (Simpson & Siguaw. 2000, McKone 1999). The traditional "quality evaluation methodology" of educational programs provides a uni-dimensional analysis, that is scope limited. Quality being multi-parameter orientated, the results of uni-parameter analysis have in-built limitations to support crucial decisions on quality enhancement of educational programs. A systematic, process needs to be developed to holistically (Checkland 1981) evaluate the quality of an existing program on a multi-dimensional format. Additionally, quality shortfalls in the program, also needs to be addressed for quality enhancement.

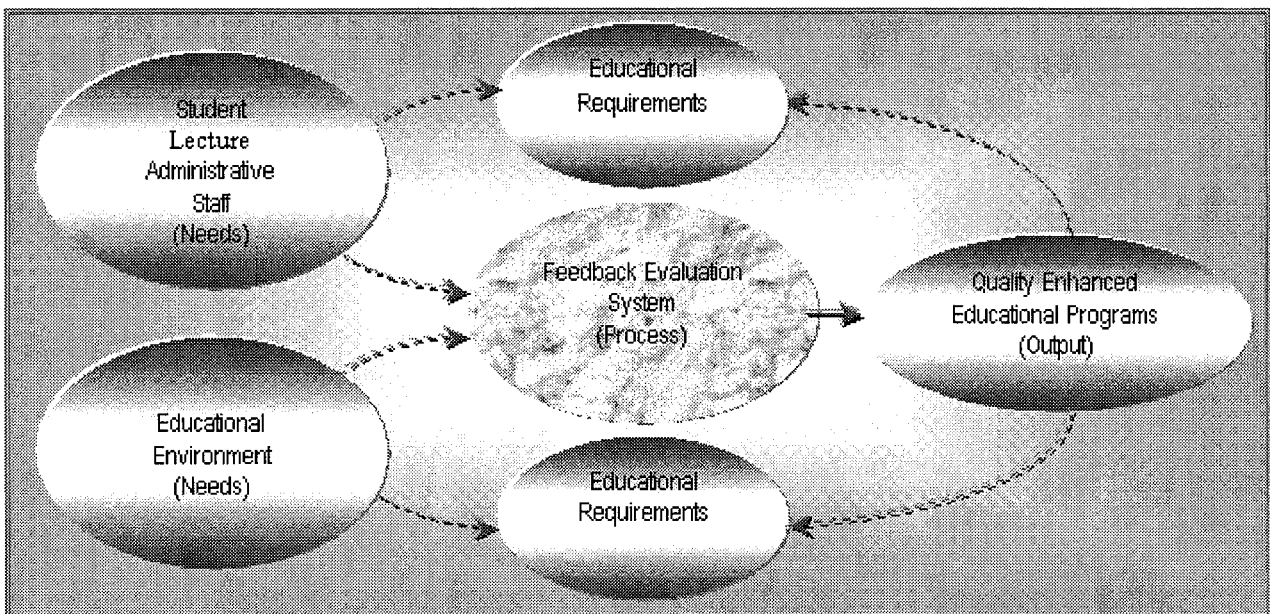
Guolla (1999) developed concepts to assess the quality of programs. The concepts based on uni-parameter analysis, needs to be expanded for a comprehensive multi-parameter analysis. To evolve a holistic process for quality enhancement of educational programs, an "Evaluation System" based on feedback from various agencies needs to be developed.

This paper presents a framework for the development of a "Feedback Evaluation System" (FES), with multi-dimensional inputs from students, instructors and administrators.

## SYSTEM METHODOLOGY

A methodology to evaluate the quality of an educational program on a uni-dimensional format was presented by Guolla (1999). The uni-dimensional evaluation methodology provides the development base for a FES framework, on a multi-dimensional format. The students' parameters considered for analysis on a uni-dimensional format though limited, can be expanded to cover the balance parameters.

To facilitate consideration of all parameters, a holistic analysis of educational programs are required. The FES thus needs to be conceptualised as a system in a typical "input-process-output" configuration (Flood & Jackson 1991), with multi-dimensional inputs from students, lecturers and administrators. The FES is to transform the inputs to "enhanced quality programs", as outputs of the system. The needs of the students, lecturers, administrative staffs and environment, drive the "educational requirements" of the programs. The educational program with enhanced quality, are to meet these requirements. With the inputs, processes and outputs clearly defined, the system configuration for quality evaluation and enhancement of educational programs is now developed. The configuration is now developed. The configuration is presented in Figure 1.



The conceptualised FES (Figure 1) is to facilitate quality enhancement of educational program, as system outputs. The outputs are to be fed-back in the system to validate the educational requirements are met to the required degree. For quality enhancement, a series of analysis are to be processed by the FES. The FES processes are to result in the following:

- Evaluation of current program's quality;
- Identification of quality shortfalls in current programs;
- Identification of remedial measures to enhance quality of current programs;
- Incorporation of remedial measures in current programs; and
- Re-alignment of current program with added quality for subsequent deliveries.

With the required processes of the FES established, the system structure of FES is developed, to identify the sub-systems (components), their attributes (functions of the components) and the inter-intra relationships. The components are identified from the processes stated above. The components are the following:

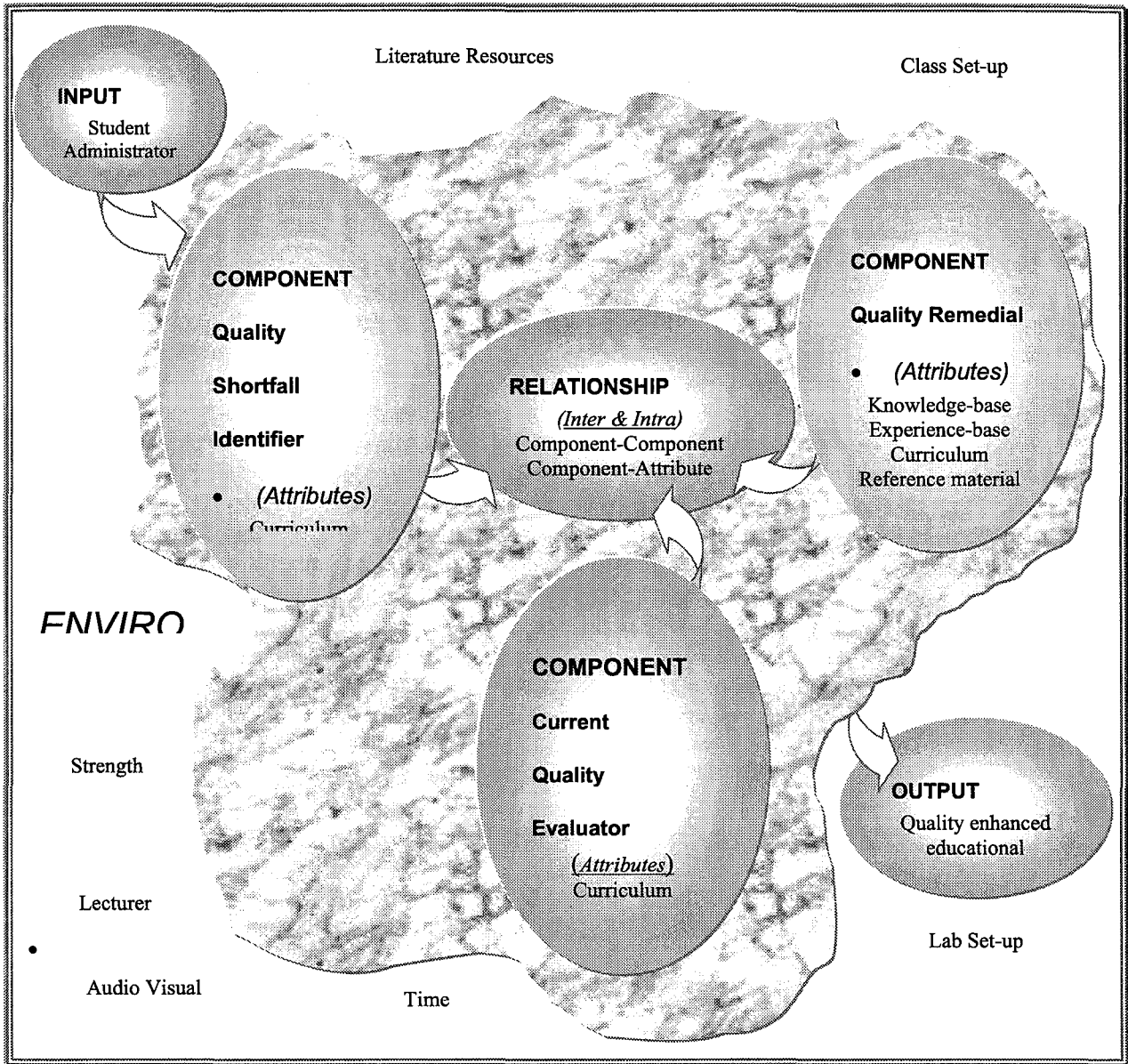
- **Quality evaluator:** To evaluate the degree to which the current course meets the set benchmark;
- **Quality shortfall identifier:** To identify the attributes and sub-attributes that require re-alignment and;
- **Remedial measures implementer:** To identify and incorporate measures to enhance the current course quality to reach the required benchmark.

The functions are the educational requirements of the programs. The educational requirements are transformed from the needs of the students, lecturers, administrative staffs and environment. These requirements are presented in Table 1.

**Table 1: Educational Needs, Requirements and Outputs of a Feedback Evaluation System**

Needs	Educational Requirements	Outputs
Student	<ul style="list-style-type: none"> <li>• Knowledge-base</li> <li>• Curriculum</li> <li>• Reference Material</li> <li>• Delivery Mode</li> <li>• Assessment mode</li> <li>• Support Infrastructure</li> </ul>	Quality enhanced educational program
Lecturer	<ul style="list-style-type: none"> <li>• Knowledge-base</li> <li>• Experience-base</li> <li>• Delivery Mode</li> <li>• Assessment mode</li> <li>• Support Infrastructure</li> </ul>	
Administrator	<ul style="list-style-type: none"> <li>• Program Integration</li> <li>• Material</li> <li>• Funds</li> <li>• Support Infrastructure</li> </ul>	
Environment	<ul style="list-style-type: none"> <li>• Lecture room/Lab Set-up</li> <li>• Literature Resources</li> <li>• Audio-visual</li> <li>• Time</li> <li>• Class strength</li> </ul>	

With the components identified and the educational requirements (functional characteristics of components) defined, the FES structure is developed. In developing the structure, the functional characteristics specific to each identified component are to be stated from the identified educational requirements (Table 1). The FES structure for quality enhancement of educational programs is presented in Figure 2.



In the system structure, the attributes (educational requirements) are obtained from the different agencies. This gives rise to a platform for analysis of the relationships between the attributes and the various components: quality shortfall identifier, quality remedial and current quality evaluator. This analysis leads to a quality enhanced educational program as its output.

## SYSTEM FRAMEWORK

The system structure provides an insight of the educational program for quality enhancement studies. The inputs to the system are the feedback from students, lecturers and administrative staff. The components of the system provide the tools to study the quality of current educational programs and enhance the quality based on the feedback inputs. The system framework, thus needs to be built on the following base modules:

- **Feedback Analysis Module:** To provide an analysis of feedback inputs from students, lecturers and administrative staff. The analysis parameters are the educational requirements identified in Table 1;



- **Quality Analysis Module:** To provide an analysis of the quality by evaluating the current quality, identifying shortfalls and providing remedial measures. The analysis parameters are the attributes of the components identified in Figure 2;
- **Quality Enhancement Module:** The output of the quality analysis is compared with the Quality Benchmark to be set by the educational institution. The shortfalls in reaching the benchmark are fed back to the current program. The quality enhancement module benchmarks the current program for acceptance or re-alignment and
- **Program Re-alignment Module:** The program is re-aligned to meet the benchmark and provide a quality enhanced educational program through a feedback loop to the quality analysis module. The re-alignment module derives inputs from the quality shortfalls and modifies the current program for enhanced quality.

With the base-modules and their functions identified, the system framework is developed. The framework displays how the inputs of the students, lecturers and administrative staffs based on the educational requirements (Table 1) are part of the feedback analysis that can be checked for quality evaluation, quality shortfalls and quality remedial measures as part of the quality analysis. Then, the quality of the current program can be measured against a set benchmark. If the benchmark is met, the current program is transformed into a quality-enhanced program. If the benchmark is not met, the program is re-aligned by looping through the quality analysis and quality enhancement analysis until the quality enhanced educational program is achieved.

The framework for quality evaluation and enhancement of educational program is presented in Figure 3.

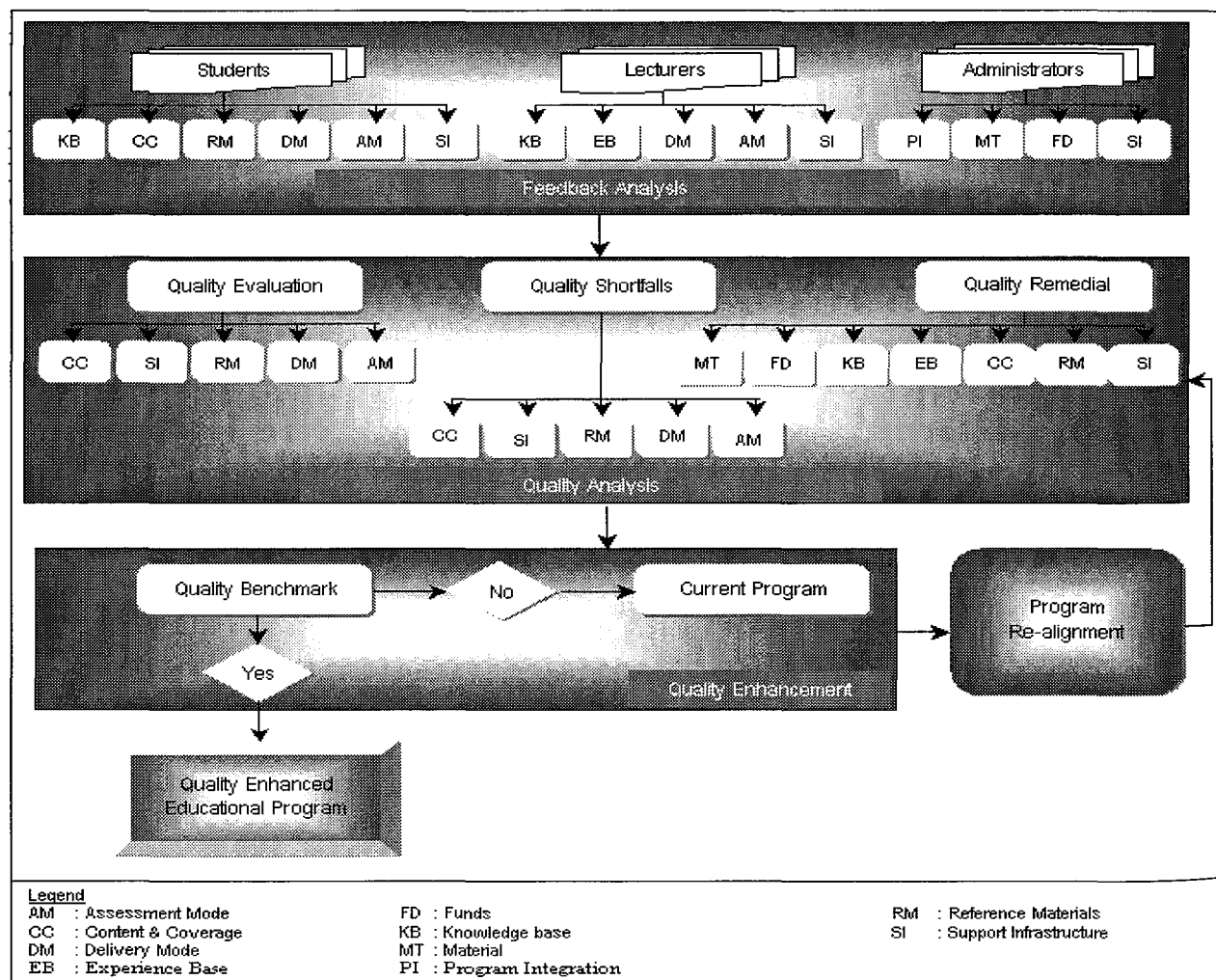


Figure 3. System Framework for Quality Evaluation and Enhancement of Educational Program

The system framework developed is generic and applicable to any educational program. The analysis parameters of each module of the framework need to be re-defined/modified as relevant to the program. The educational requirements of the program are to be appropriately defined from the needs of various agencies that have inputs in the program. In this case, the agencies were the students, lecturers and administrative staffs. The results of the studies are the following:

- **System Configuration:** Educational program can be conceptualised as a system in an input-process-output configuration. The configuration aids in identifying the inputs and defining the outputs of the system. The configuration also places the derived requirements of the program from the inputs in a loop, as a checkpoint to confirm the outputs have met the derived requirements.
- **System Structure:** Educational programs can be structured as a system to identify the components required to process the inputs into outputs. The attributes (functional characteristics) of the components are dependent on the educational requirements of the program. They are obtained from the inputs of the agencies in the program. The components are basically criteria to evaluate and enhance quality of the program, in order to provide a re-alignment/modified program with enhanced quality.
- **System Framework:** The system structure aids in identifying the modules of the framework. For quality studies of educational program, the modules required are for analysing, enhancement and re-alignment/modification. The analysis modules relate to feedback from the agencies involved in the program and the quality of current program. The quality analysis module comprises of quality evaluation of current program and identification of shortfalls. The quality enhancement module benchmarks the current program for acceptance or re-alignment. The re-alignment module loop the deficient program back to the quality analysis modules until it reaches the quality benchmark and can be implemented as a quality enhanced program.

## CONCLUSION

System approach provides an avenue to study educational program for quality. The program can be conceptualised as a system for the development of a framework to evaluate the quality of educational programs and add quality to improve the educational program for subsequent development and delivery. The framework developed is generic and may require modifications for application to a particular program. This approach can be used not only to evaluate the quality of educational programs, but it may also be used to evaluate and enhance any other programs or applications. The main advantage of such an approach is that it is based on multi-dimensional analysis.

The framework can be modified to suit the users. It is a very flexible structure with opportunities for improvement for future research. For example, some users might use a database to collect all the data and record the analysis. This framework has been tested on a continuing education and training program and was found to be very effective for quality analysis and enhancement as it has a multi-dimensional approach.

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# Occupational Health and Safety Systems and Viable Systems Diagnosis

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## ABSTRACT

*OHS (occupational health and safety) Management Systems are a key component of providing corporate governance processes for OHS. However, the paper system must be supported by the human and information infrastructure to enable it to be acted upon. This paper explores the implementation of a computer system to assist in providing a corporate governance system for OHS in a large, diverse Commonwealth government department. Consultation with stakeholders was undertaken and their comments were used to define the changes needed in the OHS system. Viable System Diagnosis was used to suggest an appropriate human and information infrastructure.*

*Keywords: OHS Management Systems, Viable Systems Diagnosis, Action Research, Systems Thinking in Organizational Structures, OHS Corporate Governance*

## INTRODUCTION

A large, diverse Australian Commonwealth Government Department (the Department) recognized that their OHS computer system was being underutilized and commissioned a study to examine how the system should be improved. While investigating the computer system, it became apparent that the compensation costs of this organization were increasing dramatically. In addition, the senior management and the OHS professionals were becoming concerned about the corporate governance (OECD, 1999) of OHS in this complex Department. The initial study was expanded to include discussion with stakeholders about the OHS performance of the Department and to recommend modifications to the computer system and to OHS management practice in light of these concerns. Viable System Diagnosis (VSD) (Beer, 1985) was used to assist in understanding the appropriate human and information infrastructure necessary to provide adequate information flow and to implement the OHS management system.

This paper focuses on the application of Viable Systems Diagnosis to the OHS information system of the Department.

## METHODOLOGY

Key stakeholders were defined as those who had influence over the OHS performance of the organization. Within this group, interviews were organized with individuals or groups of strategic, operational and functional personnel of various levels of authority, in order to ensure that the widest range of opinions were canvassed. Interviews were semi-structured, with the key question being, 'What information do you need to fulfill your safety obligations?'

Several private and public sector organizations were interviewed to benchmark their safety processes and information flow. A report was prepared describing the wishes of the stakeholders, comparing these wishes to the best practice benchmarking and then recommending modifications to the safety computer system to reflect this input.

A qualitative Viable Systems Diagnosis was applied to the OHS system within this Department. VSD was deemed to be an appropriate technique for analysis because it focuses on organizational evolution rather than structure and it was observed that the Department had an evolutionary nature (Flood and Jackson, 1991, Schwanger, 2001). VSD is mainly concerned with information flow and control processes (Flood and Jackson, 1991), which the OHS system was attempting to provide. In addition, the issue in question was determined to be *complex* in its systems, due to the large number of elements and their interactions, yet *unitary* in the goals of the participants, or at least so it appeared at the time. These factors combine to make VSD an appropriate technique for analyzing the OHS computer system (Flood and Jackson, 1991).

A simplified model of the organization and its OHS information flow was prepared based on information acquired during the discussions with stakeholders. This information was supplemented by consultation with the OHS professionals within the corporate OHS agency and further refined by discussions within the wider organization. The organizational/information model was compared to the 'text book' Viable System (VS) of Stafford Beer (Beer, 1985). The findings below indicate the discrepancies between the 'text book' VS and the model of the existing processes.

## FINDINGS

Initial preparation of the VS model involved aligning the Department organizational structure with the structures of Beer's Viable System. The first step is to define the '5 Systems' as described by Beer in 1985 (Beer, 1985). For this Department, the Systems were defined as:

System 1: System 1 is construed as the system that 'does' what the system does (Flood and Jackson, 1991). The original viewpoint for this analysis was through the corporate OHS service of the Department. This was decided to be inappropriate because the OHS service was a support agency and not 'viable' in itself. To overcome this, System 1 was deemed to be the OHS human infrastructure within each Group that makes up the Department. They are the OHS implementers (they 'do' OHS) and thus became the 'system in focus' as required by VSD. These people should have feedback on their performance and should be held accountable for achievement of the Departmental goals related to OHS.

System 2: System 2 is used to co-ordinate the various System 1 Groups by providing stability and conflict resolution (Walker, 1999). The corporate OHS agency was deemed to be System 2 for the Department. However, at the time of the analysis, this agency had a mixture of roles, including policy development, provision of expert advice to two of the Groups, provision of the computer reporting system and preparation and analysis of data derived from the computer system. VSD would describe these as a combining System 5, 4 and 2.

In the 'text book' model, System 3 is construed as the system that provides internal regulation, optimization and synergy (Walker, 1999). For this Department, System 3 was deemed to be the senior OHS managers from the various Groups, meeting on a regular basis to consider OHS issues for the whole of the organisation. They would be responsible for coordinating the implementation of OHS policy and management system within their group, obtaining group resources for OHS and would be held accountable for the OHS performance. At the time of the analysis, the senior group OHS managers did not meet on a regular basis and as such each group within the Department had their own way of implementing OHS policy without regard to the lessons learned in the other groups.

System 3\*, the audit function, did not exist. At the time of the analysis, there was debate as to whether the audit function should belong to the Corporate OHS agency or to the line management. Stafford Beer would say it reports its information to System 3, the meeting of the senior OHS managers. (Flood and Jackson, 1991, Leonard, 1994).

System 4, the function that gathers intelligence from the environment (Flood and Jackson, 1991), did not formally exist. There was some attempt by the corporate OHS agency to look for 'over the horizon' issues, but it was not officially empowered or resourced to do this. An 'algedonic signal' where significant events are immediately reported to senior management in the time of a crisis (Flood and Jackson, 1991, Leonard, 1994), was available, but functioned straight from System 1 (Operations) to System 5 (Senior Management). This seems appropriate in this department. However, an algedonic signal for OHS events in the external environment may need to be established.

There was difficulty in recognizing the role or existence of System 5. System 5 is generally equated with the Board of an organization (Schwaninger, 2001) or the Management Group responsible for establishing policy. Government Departments seldom have formal Boards, but this Department had a 'most senior managers' committee. This group occasionally received reports on the status of OHS in the department, but did not receive any regular reporting on performance. At the time of the analysis, this Committee was becoming very concerned about the ability to prove that they had adequately governed the Department with respect to their OHS responsibilities.

The whole system had some components of being recursive, particularly System 1, but all levels had gaps with respect to System 4.

## **INTREPRETATION**

As this is an initial interpretation of this VSD, it appears that:

Senior management will have to take more responsibility for OHS by regularly receiving status information and actively forming OHS policy. Recommendation: establish an OHS System 5 by including OHS performance and policy on the agenda of the very senior managers meetings.

Responsibility for monitoring the OHS external environment will need to be assigned and the communication channels for this reporting must be established. This could belong to the existing corporate OHS agency in addition to its System 2 role as long as the remit is clear. Recommendation: establish System 4 for environmental scanning and commit to regular reporting of issues to Systems 5 (senior management) and System 3 (the senior group OHS managers).

An audit function that reports its findings to the combined group OHS manager committee (System 3), will need to be established. In addition, the audit data will need to be regularly summarized and reported to very senior management (System 5). Recommendation: establish System 3\* audit function. The personnel may be part of the corporate OHS function (System 2) or some other location if appropriate, but they must be able to provide reliable audit information to the senior OHS managers committee.

The information system coordinated by the corporate OHS agency will need to be enhanced to address the needs of the OHS staff in the groups and to provide reports for the senior managers. Recommendation: enhance System 2 to be able to provide these reports. This was the original scope of the study, but upgrading the computer system was clearly not sufficient to fix the corporate governance and system implementation issues.

The OHS function in the operational Groups will need to be 'beefed up' to fill the gaps in the structure. This does not necessarily require additional personnel, merely recognition of functions that need to be performed and assignment of this responsibility. Recommendation: reinvigorate the System 1 operational areas so that there are personnel assigned to provide OHS information. Hold group managers responsible for implementation of OHS policy and for reporting on performance.

## CONCLUSION

The Viable System Diagnosis was a useful technique for the author to use in determining a recommended organisational structure for this Department. Convincing the corporate OHS agency that this was an appropriate process for analysis involved extensive exchange of information and learning on both the part of the agency and the author.

The Department is large and complex with differing goals relating to safety. It will remain to be seen as to how the recommendations from this study are incorporated into Departmental practice.

This project has raised questions about the relationship between hierarchical organizational structures and their ability to provide the information flow necessary for an evolving, viable system. In addition, this project questions the appropriate model for the construction and control of diverse, autonomous operating systems such as OHS systems. Both these issues will need to be explored with further research.

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# System thinking – the power behind social learning: reflections on research in the Australian Defence Organisation

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## ABSTRACT

*This paper reports on the methodologies used and the findings to date of the research done by the Enterprise Social Learning Architecture (ESLA) Task into learning processes occurring in two diverse environments within the Australian Defence Organisation (ADO), tactical and strategic. The research focused on identifying tools that enable social learning and these are discussed in view of the proposed preliminary architecture and in view of the socio-technical environment within which people work and learn. The paper concludes by suggesting that system thinking is one of the important elements in effective social learning as well as an understanding of the cultural issues prevalent in work environments.*

*Keywords: Knowledge management, organisational learning, systems thinking, sociotechnical system*

## INTRODUCTION

Researchers and practitioners have long been concerned about improving the successful development and implementation of information systems projects. As the industry evolves, the search for the factors influencing success and failure has intensified. While the definitions and the exact rate of success may remain debatable, no-one in the industry would deny that too many delivered information systems fail to meet users' expectations and too many delivered systems are 'shelved' or 'bypassed' by clients and not used optimally.

In the past decade, there has been an increasing emphasis on investigating the social and organisational factors that may help the industry build more successful systems. Investigation of these issues necessitates a sound understanding of organisational culture, human social interactions, communication and relationships. This signifies an increasing awareness of the importance of the social aspects of socio-technical design.

The Enterprise Social Learning (ESLA) Project is researching social aspects of systems within which people work in organisations. The task is a four-year research study, currently in its third year, investigating social learning within the Australian Defence Organisation (ADO). Social learning, in this context, refers to learning occurring within a group, an organisation, or any cultural cluster and includes: the procedures by which knowledge and practice are transmitted across posting cycles, across different work situations and across time; and the procedures that facilitate generative learning – learning that enhances the enterprise's ability to adjust to dynamic and unexpected situations and to react creatively to them.



The immediate aim of this research is to understand the issues inherent in building learning, adaptive and sustainable organisations. The long-term objective, however, is to develop architectures that will support the development of information systems that guide and enhance organisational learning.

Although the research is still in progress, the results to date point to a tightly coupled relationship between knowledge management, systems thinking and effective social learning. The team has identified a number of processes and strategies, or 'tools', that, when positively applied, facilitate social learning within the ADO. However, the findings are equally applicable to all types of organisations. Many of the 'tools' identified by the study require systems thinking to be effective.

## **SYSTEMS THINKING**

In his seminal work on organisational learning, Senge (1992) states that in order for organisations to maintain a competitive edge, they must be capable of continuous learning and he outlines the five models, or disciplines, that will enable this: personal mastery, mental models (or assumptions); shared vision; team learning; and systems thinking. According to Senge (1992:3) learning organisations are:

*organisations where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning how to learn together*

There are many similar definitions of learning organisations. For instance (Garvin 1993), states that learning organisations are organisations that are skilled at five primary activities: 'systemic problem solving, experimentation with new approaches, learning from the experiences and best practices of others, and transferring knowledge quickly and efficiently throughout the organisation' (Garvin 1993:81). Hoffmann and Withers (1995) say that learning is an autonomous, largely uncontrollable function of being human, however, the culture in which this learning occurs is the compelling determinant of the quality of that learning. Furthermore, they believe that successful learning organisations must operate in an environment of trust and the reduction of fear, teamwork and sharing. Learning organisations need leaders to act as champions of people and their ideas as well as the encouragement of constant change.

The common theme in most of these definitions and characterisations is the belief that the key to an organisation's success and longevity is in its ability to effectively adapt to its changing environment and to efficiently nurture the growth, sharing and sustenance of the corporation's historical and dynamic knowledge (Warne 2000).

## **THE ESLA STUDY**

The ESLA study began in June 1998 and has acquired data from several different ADO settings. The first setting was a 'tactical' single service headquarters, where a pilot study was conducted to determine the feasibility of the project's aim and methods. The research team returned to this headquarters in April and May 2001 to validate that the findings remained stable over time. The second setting was a joint (all three services and civilians) 'strategic' headquarters within the main Australian Defence Headquarters. Currently, further studies are underway in a single-service strategic headquarters.

Given the exploratory nature of the research as well as the importance of the context and the need to understand the social process of learning, ethnography was the appropriate methodological tool to adopt. Generally speaking, ethnographers 'immerse' themselves in the situation for a sufficient time so as to gradually see and understand the key factors that influence the setting being studied. Prior to the commencement of the research study the team members were thoroughly briefed on the principles and

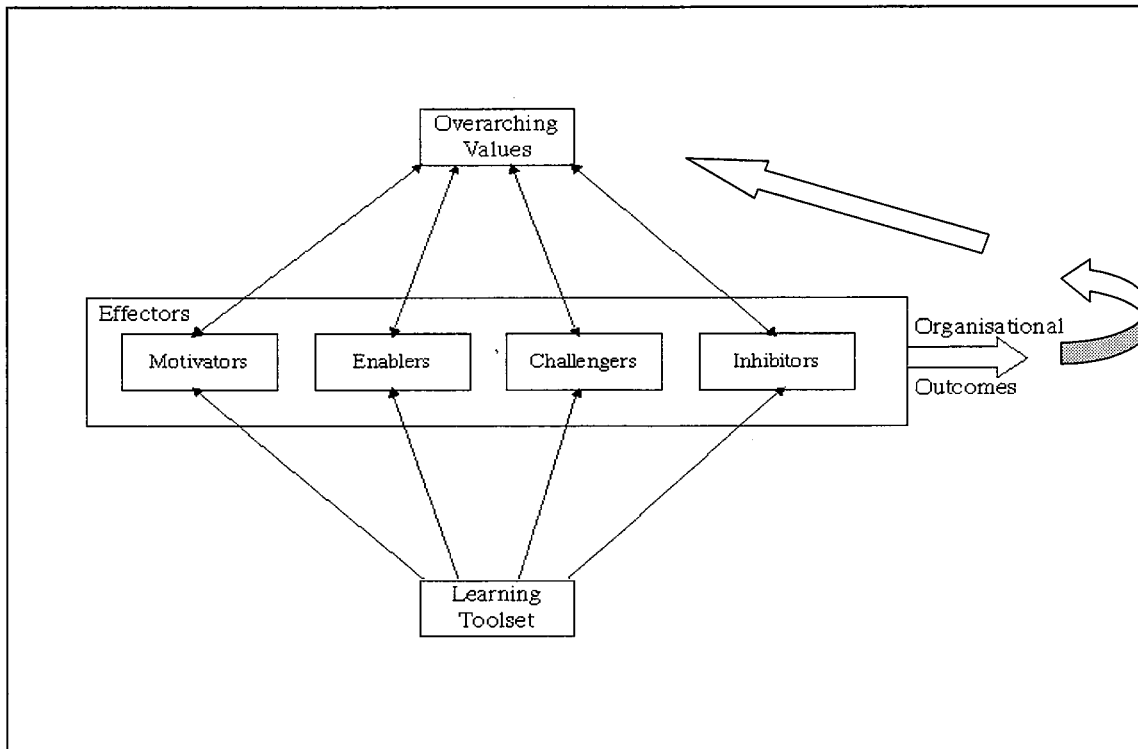
ethics of ethnographic research by Gitte Jordan (then from the Institute of Research and Learning associated with Xerox Parc) who helped to popularise the use of ethnography in industrial settings.

The primary form of ethnography used in the ESLA study was 'field work', which entailed observing the work taking place in different settings, and using directed questioning to clarify issues. As the study proceeded to different work environments it became useful to augment the ethnographic observations with other research methods. For instance, in the more recent settings, quantitative surveys were constructed based on the observations and the team undertook extensive unstructured interviews with a stratified sample of personnel. Careful consideration is given to ensure validity of this research study. The research study is subject to triangulation by data source (different times and places) and by method - observations, interviews, and, quantitative surveys. The survey succeeded in moving attention from the researcher to the participants, and had the added benefit of validating the ethnographic research already conducted. In this way, the reliability of the qualitative findings was validated by quantitative techniques (Bailey 1982).

All data is coded according to a thesaurus developed for this purpose and the team uses N'Vivo, a qualitative software database package, for data storage and analysis. The methodologies used and research conducted has been reported on in more depth elsewhere (see Agostino, et al. 1999; Ali, et al. 2000; Warne 1999).

## **STUDY FINDINGS**

The progressive findings of the ESLA studies represent the collective research results of all the different settings studied, to date. The focus is on the findings that are likely to be relevant to all organisations, not just military ones. These findings are multilayered and allowed the research team to pinpoint a number of environmental and cultural issues, processes and strategies that facilitate effective social learning. These results have been conceptualized into the architecture represented in Figure 1 below.



**Figure 1: An architecture for social learning**

The ESLA findings can be collectively conceptualised as a Learning Toolset of actions, processes and strategies which we refer to as the 'tools' that the organisation can use to facilitate its activities to achieve organisational outcomes. Examples of the tools in the Toolset include induction, training, records keeping, reward and recognition, and performance management.

Each of the tools in the Toolset can impact on social learning in four distinct ways collectively called effectors. The tool can act as a motivator, enabler, challenger or inhibitor of social learning, or indeed a combination of these, depending on how effectively it is applied in the organisation. Each tool can have a greater or lesser impact on each of these effectors of social learning. The organisational values arise from the balance of outcomes from these organisational effectors, but in turn, the values inform these effectors.

This recursive relationship is characteristic of the architecture that is emerging from the findings of this research. While motivators form a sound foundation and enablers provide the bricks or building material, the values are the mortar that binds them all together. Challengers and inhibitors are environmental or personal factors that impede or erode the organisation's continued robustness.

Based on the ESLA research, the tools in the Toolset have been categorised into seven social learning constructs: Common Identity, Problem Solving, Team Building, Access to Information, Development of Individual Expertise, Communication, and Induction and Enculturation.

*Common Identity* – a common ground/understanding to which many people/groups can subscribe, and requires a shift from seeing ourselves as separate to seeing ourselves as connected to, and part of, an organisation or organisational sub-unit. Based on our research issues impacting on *Common Identity* are: goal alignment, cultural identity, gendered identity, language, morale, and workplace design (spatial and physical design).

*Problem Solving* – Problem solving was a core activity in all of the settings studied and it was seen as one that fosters social learning, because each instance of problem solving represents an opportunity to generate knowledge. Issues associated with this enabler are: networking, improvisation, perceptions of the organisation, systemic understanding, and a time for inquiry and reflection.

*Team building* – working together and understanding what each member was trying to do was seen to be essential to organisational success for effective social learning and problem solving. Issues associated with this enabler are: leadership, team-based morale, performance management, public recognition and reward systems, use of humour, and workplace design.

*Access to information* – the easy availability of corporate information, in whatever format, was observed to have a direct input into knowledge acquisition and generation of new knowledge and thereby, social learning. Issues associated with this enabler are: record keeping, networking, meetings, and information technology (IT) infrastructure.

*Development of individual expertise* – the acquisition and development of expertise was seen as an integral part of social learning and issues associated with this enabler are: career trajectories, professional currency, professional training, postings and promotion, and mentoring.

*Communication* – this enabler was observed to be essential to effective learning within an organisation, and to effective social learning. Issues associated with this enabler are: overall communication climate, formal and informal information flows, time for inquiry and reflection, use of humour, language, and workplace design.

*Induction and enculturation* – they facilitate social learning by providing a foundation upon which an individual can become fully productive more quickly and is more likely to generate new knowledge. Issues associated with this enabler are: timelines and comprehensiveness of the process, buddy/mentoring system, handovers and information packages, and training.

## **VALUES**

In terms of organisational values, the findings suggest that social learning will flourish where the influences of empowerment, trust, forgiveness, cultural cohesiveness, and sharing are feed into organisational effectors. These values provide a fertile ground for learning by allowing people to speak honestly, share information and offer suggestions without fear of ridicule or retribution (Hoffmann and Whithers 1995).

## **CONCLUSION**

While the research is continuing, and new findings may emerge, it is possible to reach some conclusions about organisational learning in the ADO, as identified to date. The results indicate that a tightly coupled relationship between knowledge management, systems thinking lead to effective social learning. Systems thinking is central in this relationship of interdependence as it allows for deployment of different strategies for learning, each dependant upon nature and perspective of an organisation. The team has identified a number of tools that, when effectively applied, facilitate social learning leading to positive organisational outcomes influencing organisational values. Although some of these issues are specific to a military organization, most are equally applicable to any organization that is attempting to improve its learning capability and knowledge management.

The results strongly suggest that the interplay between human, social and organisational issues must be considered first, to effectively facilitate social learning and supporting information system design. Technology alone, however well designed it may be, is unlikely to produce effective solutions fin the absence of appropriate attention to such issues.

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# Changes to Theory Making about Systems Involving People: Meta-theoretical Analysis and Brain Research

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## ABSTRACT

*The paper describes how a meta-theoretical approach developed in Design Research points to weaknesses in systems theory. It identifies ways that new findings from brain research help address these weaknesses in systems involving humans. The paper suggests that including the findings of brain research marks the beginning of a new direction in Systems theory making.*

*Keywords: Systems, Cognition, Affect, Meta-theory, Brain Research, Epistemology*

## INTRODUCTION

There are many similarities between Systems and Design Research since their inception at a similar time and from similar origins (Love, 1995). Both fields are multi, cross and inter-disciplinary and focus on identifying future states involving humans, objects, environments, thoughts, motivations, intentions, decisions, perceptions, intuitions and actions. A large number of theories of Design Research are underpinned by systems theories, and this paper explores the reciprocal relationship: the implications *for* systems theories of developments in Design Research. The analyses in this paper are based on the author's earlier research into theories about designing and designs (see, for example, Love, 1999, Love, 2000d, Love, 1996, Love, 2000c, Love, 2000b, Love, 2000f, Love, 2001b, Love, 1995).

Many changes in Design Research reflect changes in Systems initiated by Flood and others (see, for example, Ackoff, 1991, Churchman, 1991, Flood and Carson, 1988, Flood, 1990, Flood and Jackson, 1991, Flood, 1995), perhaps most clearly evidenced in the writing of Coyne and associates (see, for example, Coyne, 1997, Coyne et al., 1992, Coyne and Snodgrass, 1992a, Coyne, 1991, Coyne, 1990, Coyne and Newton, 1992, Coyne and Snodgrass, 1991, Coyne and Snodgrass, 1992b, Coyne and Snodgrass, 1992c, Coyne and Snodgrass, 1993).

In the last 3 years, a substantial shift has seen Design Research increasingly founded on a more detailed understanding of how individuals function, and how this shapes interactions between humans and with artefacts and environments. Previously, Design Research, like Systems, had mainly used the epistemologies of the Physical Sciences and the Humanities, deriving models and theories from generalised observations of human behaviour, processes and observable properties of objects and environments. The new direction is evident in the increasing use of protocol analyses of designers: a change from constructing theories exclusively on the basis of external objectively observable processes to including knowledge of human internal processes.

Systems methodologies and theories have moved from 'machine age' thinking to include sociological epistemologies (Churchman, 1991, Flood and Carson, 1988, Flood, 1990, Flood and Jackson, 1991, Flood, 1995, Ackoff, 1991, Checkland and Scholes, 1990). This paper points to reasons for a further change for Systems to include findings from brain research relating to the ways that human cognitive-affective mechanisms shape people dependent systems.

## SYSTEM THEORIES

This section sketches briefly those aspects of Systems that provide a context for this paper.

Four considerations differentiate systems theories from theories of other disciplines:

- A focus on boundaries and the flow of effects across boundaries
- Emphasis on targeting complex situations with definable elements inside and outside system boundaries
- Analyses aimed at difficult, ill-structured, ill-defined, or indeterminate problems
- The use of theories, methods, perspectives and analyses from any discipline in whatever ways suit the purpose in hand.

The field has a tradition of internal critique by experienced researchers and practitioners, and a history of new theories and perspectives being promptly developed in response to these critiques (see, for example, Beder, 1993, Churchman, 1991, Coyne et al., 1990, Flood, 1990, Flood and Jackson, 1991, Hubka and Eder, 1988, Joseph, 1996, Rastogi, 1992, Probert and Stephens, 1998). Researchers and practitioners have drawn on the findings and theories of other disciplines, especially Sociology, to enable systems analyses to be validly extended into new areas.

In early years, most systems theories, including those of associated fields such as Operational Research, were similar to engineering theories, e.g. the cybernetic Viable Systems Model of Beer (Espejo and Harnden, 1989). This presented epistemological difficulties because many theories targeted systems that depended on human activities and values, and human subjective factors are explicitly excluded by the epistemologies of the Physical Sciences. The need for a shift towards interpretive epistemologies and methodologies of Sociology and to some extent Psychology was argued Cassandra-like by researchers such as Churchman (1991) and Ackoff (1991), and became actualised and mainstream through the work of Flood and others (see, for example, Hutchinson et al., 1995) after increased attention to epistemological issues.

Systems theories and analyses apply to a wide variety of practical situations that separate into two streams.

- Stream A: 'Soft' systems approaches aimed at situations in which human behaviour impacts strongly, e.g. human organisations, human decision-making, management, ethics, designing.
- Stream B: 'Hard' systems approaches aimed at situations whose functioning is not strongly impacted by human activities, e.g. chemical process plant systems.

Broadly, the distinction is between 'human organisational systems' (Stream A) and 'engineering systems' (Stream B).

## META-THEORETICAL ANALYSIS

In the mid-1990s, the author developed a meta-theoretical method for analysing the structure and development of theories in a single field and across fields. This method was based on earlier work by Reich (1994), Popper (1976), Franz (1994), Stegmuller (1976), Indurkha (1992), Ullman (1992), Konda & associates (1992) and others (see, for examples, Love, 1998, Love, 2000e, Love, 2000d, Galle, 2001). The method was developed to address the unusually wide breadth of fields of theory associated with Design Research, and, hence, likely to be well suited to analysing theories of Systems. Analyses using this meta-theoretical approach locate theories in a human context, especially focusing on human skills involved in addressing wicked problems and creating new knowledge and artefacts.

The meta-theoretical method consists of a generic hierarchical structure with a family of different forms for analyzing theory in different contexts and fields. Versions have been published for designing and designs, cognition, information systems, e-business education, and the inclusion of qualitative social, environmental and ethical factors in quantitatively based activities (see, for example, Love, 2001a, Love, 2000b, Love, 2000e, Love, 2000a, Love, 2001b). The core is a table with nine layers of abstractions that form a theoretical chain at one end grounded in the concreteness of reality and at the other end bounded by assumptions, beliefs and values about existence and reality. The lowest level focuses on the initial conversion of sensual perception of the world into concepts by naming phenomena: the first level of abstract cerebral processing. The highest level contains the human ontological or religious beliefs about existence and the nature of the core entities on which theory is made. Between these two—the conceptualisation of direct perceptions of 'reality' and beliefs about 'what is fundamental about existence'—are the co-dependent layers of theoretical and everyday abstractions that are stock in trade of communication and reflection in diverse occupations such as journalism, management, art, science, technology and academe.

The universality of this family of meta-theoretical hierarchies is in part due to theories and abstractions having generic properties that are relatively independent of what each theoretical abstraction represents, and in part due to the ubiquitousness of 'designing' (creating a plan for future action) and 'researching' (gathering information to support such planning) in most human endeavours. A relatively generic form of the hierarchy (Love, 2001b) is outlined in Table 1:



**Table 1: Meta-theoretical hierarchy of concepts and theories about situations involving human activities**

Level	Classification	Description
1	Ontological issues	The ontological basis for theory making. This level includes the human values and fundamental assumptions of researchers, designers and those involved in critiques of theory.
2	Epistemological issues	The critical study of the nature, grounds, limits and criteria for validity of knowledge. This is the level that contains the relationships between ontology and theory
3	General theories	Theories that seek to describe human activities and their relationship to designed objects and human environments.
4	Theories about human internal processes and collaboration	Theories about the reasoning and cognising of individuals involved in designing and researching, of collaboration in teams, and socio-cultural effects on individuals' behaviours.
5	Theories about the structure of processes	Theories about the underlying structure of processes of designing and researching based on domain, culture, artefact type and other similar attributes and circumstances.
6	Design and research methods	Theories about, and proposals for, methods and techniques of designing and researching
7	Theories about mechanisms of choice	Theories about the ways that choices are made by designers and researchers between different elements, designed objects, processes, systems or other types of possibility.
8	Theories about the behaviour of elements	Theories about the behaviour of elements that may be incorporated into designed objects, processes and systems
9	Initial conception and labelling of reality	The level at which humans' descriptions of objects, processes and systems are coined, e.g. 'a vacuum cleaner', a 'database', 'sitting' at a 'desk', 'hearing' 'noise', and 'watching' 'sunsets'.

This meta-theoretical approach gives rise to several inferences/axioms:

- A theory at any level of abstraction describes patterns in theories at lower levels and depends on theoretical abstractions at higher levels.
- For a theory to be well justified it should be possible to identify it as a part of a complete chain with elements in all of the levels. (Theories and concepts often have possible relationships with more than one abstraction at neighbouring levels, and this usually results in a cascade of relationships increasing with the distance between levels.)
- Different disciplines have different distributions across the hierarchy. (e.g. Engineering theories are mainly found in levels 7 and 8). All disciplines, however, would be expected to contain elements at all levels if they are to be complete in terms of the structure and dynamics of their theories.

## **META-THEORETICAL ANALYSIS OF THEORIES IN THE SYSTEMS FIELD**

The above methodology was originally developed to address problems that resulted from the uncoordinated development of theories about designing and designs which occurred because theories were developed in different domains and many theories were implicitly and explicitly domain specific (Love, 1998). The body of systems theories suffers from similar problems (Love, 1995, Flood and Carson, 1988, Flood, 1990, Hubka and Eder, 1988). The similarities between Systems and Design Research imply that meta-theoretically analysing theories of Systems may offer useful insights. An alternative meta-theoretical analysis of systems theories was described by Flood (1990), but his analyses focused almost exclusively on epistemological perspectives rather than the structure and dynamics of theory making. The meta-theoretical hierarchy described in this paper helps answer question such as 'What would a complete and well justified body of theory about systems look like? The weakness of Flood's approach (and its strength in its context) is the way his approach answers more limited questions such as 'Which epistemological/ontological theories are appropriate to particular classes of systems problems?'

Table 2 below sketches out the distribution of systems theories in the meta-theoretical hierarchy of Table 1. The contents of Table 2 are illustrative only and not meant to be complete. Streams A and B refer to whether systems are dependent or independent of subjective human behaviour.

**Table 2:A Meta-theoretical Taxonomy of Systems Theories**

Level	Description	Systems Theories
1	The ontological basis for theory making. This level includes the human values and fundamental assumptions of researchers, designers and those involved in critiques of theory.	Stream A: Values that underpin human action, research creativity, theory making and analysis. / Ethical and aesthetical positions Stream B: Axioms/fundamental characteristics of 'objects' in systems theories and in reality, e.g. 'system', 'relationship', 'object'.
2	The critical study of the nature, grounds, limits and criteria for validity of knowledge. This is the level that contains the relationships between ontology and theory	Stream A: Epistemologies of Sociology, Social Theory. Stream B: Epistemologies of the Natural Sciences and Engineering
3	General theories that seek to describe human activities and their relationship to designed objects and human environments.	Stream A: General theories about human activities are defined in terms of the standardised models of input and output vectors and connections of elements that form part of a system representation of a situation involving humans, e.g. General Systems Theory/ Viable System Model/Soft Systems Methodology. Meta-theoretical representations such as the Total Systems Intervention model offer a model of relationships between other general theories. Stream B: Not relevant – see level 8
4	Theories about the reasoning and cognising of individuals involved in designing and researching, of collaboration in teams, and socio-cultural effects on individuals' behaviours.	Stream A: Usually tacitly rely on undefined representations of internal human processes. Social processes are defined in terms of inputs and outputs of system elements that represent individuals, groups or organisational roles mediated by understandings furnished mainly by sociological constructs. Stream B: Human cognition ignored or tacitly defined in terms of properties of objects, e.g. theories involving web form designs that assume that the users cognition is isomorphic with the way the form is laid out and the ways a form interacts with other web pages.
5	Theories about the underlying structure of processes of designing and researching based on domain, culture, artefact type and other similar attributes and circumstances.	Stream A: Information-based processes described in systemic terms. Theories of information acquisition and use based on sociological and psychological epistemologies. Stream B: Defined in terms of the properties of and relationships between non-transcendental objects.
6	Theories about methods and techniques (of designing and researching)	Stream A: Information based methods of information creation and sharing that take into account social theories and focus on empirically accessible properties of the objects, processes and systems being researched. Stream B: Information based to automating designing and researching that focus on the empirically accessible properties of the objects, processes and systems being researched.
7	Theories about the ways that choices are made by designers and researchers between different elements, designed objects, processes, systems or other types of possibility.	Stream A: Theories about choices include human social factors that shape decision-making processes and often also are defined in terms of rational and bounded rational, deterministic, logical and fuzzy-logical and search-based processes that primarily focus on object and system properties. Stream B: Rational and bounded rational, deterministic, logical and fuzzy-logical and search-based decision making processes that primarily focus on object and system properties.
8	Theories about the behaviour of elements that may be incorporated into designed objects, processes and systems	Stream A: Interpretive, post positivist, subjective, human constructed cognitive and affective theories: commonly defined in terms of the gross empirical characteristics of social arrangements and interactions and object properties. Stream B: Scientific, engineering, positivist and 'hard' systems theories
9	The level at which humans' descriptions of objects, processes and systems are coined, e.g. 'a vacuum cleaner', a 'database', 'sitting' at a 'desk', 'hearing' 'noise', and 'watching' 'sunsets'.	Stream A: Labelling of human situations, relationships, factors acting on relationships, arrangements between humans and organisational types based mainly on scientific and social constructivist epistemologies. Stream B: Scientifically-based labelling of objects, categories of objects and relationships between objects and classes of objects.

The above meta-theoretical sketch points to three characteristics of systems theory making:

1. Systems theories presume and depend on theories of human cognition but these are rarely explicitly defined.
2. There is little attention given to the internal human systems that provide the mechanisms that implement (and hence shape) cognition in individual humans. This lack of attention to theories at this level in the hierarchy suggests a systemic weakness of systems theory making – especially for Stream A theories.
3. There is a lack of attention to systems that relate human affect, cognition, intentionality and agency. These issues form the systemic foundations for theories that involve management, incentive, motivation, judgement, choice, peer-pressure and other processes that depend on human feelings.
4. The lack of theories in relation to individual human internal cognito-affective systems has resulted in distortions in other areas of systems theory to cover this omission.

Systems theories have adapted to circumscribe the lack of adequate theories in relation to human cognito-affective processes. This has occurred, for example, through the development of tacitly held models of individual human cognition implicitly defined by observations of humans en masse, or by tacitly defining human cognition in terms of properties of and relationships between objects, (e.g. defining thinking about a situation in terms of the logical relationships embedded in it). There is a spectrum at one end of which are rational, deterministic, and behavioural models of human cognition and action, and, at the other, interpretive theories that assume human understanding and associated cognitive processes and actions result from internal individual-specific constructed systems whose development has been strongly shaped by social factors. In both cases, these address human cognition issues in a second-hand manner, and at a significant distance.

## **NEW DIRECTIONS IN SYSTEMS THEORY**

The above meta-theoretical analyses suggest that Systems would benefit from greater attention to human cognition. This is not straightforward, however, because theories of cognition are themselves undergoing radical revision. This is partly a consequence of the trend away from the mechanistic rationalist theories that formed a cornerstone of early Artificial Intelligence and Cognitive Science theories (e.g. Newell and Simon, 1972, Newell, 1990) and towards the inclusion of affective processes (Picard, 1997). More significantly, radical changes are due to new findings from brain research that potentially render irrelevant and obsolete many theories of cognition inferred from human behaviour. This has ramifications for systems theories that implicitly or tacitly depend on such theories.

A practical example of the ways these new findings impact on theory is brain scanning in the area of early childhood education. The findings of brain research completely replace many education/child development theories that previously informed the choice of pedagogical approaches to address developmental delay. Brain scanning shows immediately and directly which approaches are successful because it immediately reveals detailed changes in brain structure and function, rather than having to infer these internal changes second-hand from observations of behaviour. Another example is their effect of brain research findings on musical education theories based on the theory of music (similar to the way that mathematics education theories are based on the structure of mathematical theories). Early steps in brain research in music skill development suggest that focussing on tone skills (rather than for example, skills in rhythm, playing or music theory) is the key educational factor that results in brain changes that are characteristic of competent musicians (Ohmishi et al., 2001). This finding provides a useful heuristic, but, more importantly, it potentially renders obsolete the body of existing theory and epistemology relating to this aspect of music education.

The implication is that similar outcomes to those in Education would be expected in Systems. Both are deeply dependent on human cognition and affective processes, and in both existing theories address these issues second-hand by inferring them from externally observable behaviour – a process recognised as epistemologically problematic (Phillips, 1987). In these and similar fields, it is likely that new findings from brain research will replace inferred theories of cognition with directly observed and measured models of neural mechanisms.

These new developments in brain research and the associated implications for cognito-affective theories offers the possibility of addressing areas of weakness in systems theories relating to the ways that they represent situations that depend on the feelings, values and thought systems of individual humans. This does not, however, imply a move to biological determinism. Understanding the mechanisms – even of cognito-affective processes that actualise the relationship between an individual's thoughts and their feelings and values – does not offer a one-to-one correspondence between context and action. These new understandings do, however, potentially allow the boundaries of systems involving humans to be located at some theoretical distance inside the humans involved. This change has additional ramifications for cybernetic systems theories because it allows the variety in human internal systems to be included in systems analyses that utilise Ashby's Law.

The above changes mark a significant move onward in systems theory development as existing theories are replaced with new theories based on new and epistemologically different forms of knowledge. It represents a step in the progression of system theory development: 'machine age' → 'sociological epistemologies' → 'cognito-affective human activities'.

## SUMMARY

This paper has sketched out a meta-theoretical analysis of systems theories and pointed to potential weaknesses likely to be addressed by new knowledge emerging as a result brain research.

This change is more than superficial because it is likely to result in epistemologically different foundations for substantial areas of systems theory. It implies the start of a new era in Systems theory making.

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# A System Approach to Automate Decision Support in Aircraft Upgrade for System Effectiveness

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## ABSTRACT

*The mission systems on-board a military aircraft undergo technological advancements at a rate that outpaces the service life of the aircraft. The replacement of mission systems with state-of-the-art technology, termed, as 'Aircraft Upgrade', to enhance mission capabilities, is cost-effective, compared to new aircraft design. To holistically analyse the decision governing factors of a mid-life upgrade process, an automated 'Decision Support System' is required to simulate the process. In this paper, an overview of an 'Integrated Decision Support System' developed by adopting a system approach is discussed. The IDSS provides an automated analysis of mid-life upgrade process. The overview is followed by detailed discussions on system effectiveness of the upgrade that is studied as a system of system methodologies.*

*Keywords: System Approach, System of System Methodologies, Mid-life Upgrade, Integrated Decision Support System, System Effectiveness.*

## INTRODUCTION

The service life of military aircraft spreads over two to three decades. During this period, the systems onboard the aircraft that aid the missions, require replacement by more advanced systems (Hobson 2001a, 2001b). The design of a new aircraft with such systems is a costly venture (Mulholland 2000). To circumvent the cost factor, aircraft in service, undergo an "upgrade program" that involves the identification of appropriate advanced systems, followed by a detailed engineering process to replace the systems on board the aircraft (Bostock 2001).

Sinha et al. (1996a, 1996b, 2000a, 2000b) adopted a system approach to develop a 'Mid-life Upgrade System' (MLUS) to facilitate the mid-life upgrade process. The MLUS was conceptualised in an 'input-process-output' configuration (Flood & Jackson 1991). The approach considered the operational needs and the environmental conditions of the aircraft as the key 'inputs'. The 'process' identified the advanced systems for aircraft upgrade; and the 'outputs' were the mission capabilities derived from the systems. The engineering process was considered as a 'system of systems methodologies' (Flood & Jackson 1991) to evaluate the following design parameters on which design decision were dependent: (a) mission capability; (b) flight performance; (c) reliability; (d) maintainability; and (e) cost.

The upgrade process is a major engineering task and thus requires detailed pre-analysis for an appropriate design decision. A 'Decision Support System' is required to automate the MLUS process for a time-based-robust upgrade analysis and decision support. Kusumo et al. (2001a, 2001b, 2001c) explored the development of an 'Integrated Decision Support System' (IDSS), to automate the MLUS for maritime helicopters. The IDSS framework consisted of seven sub-models, of which the upgrade analysis and decision support was facilitated by the following sub-models: (a) Mission System Identification; (b) Mission Payload Design; (c) Multi-Parameter Analysis; (d) Upgrade Decision Support; and (e) Decision Robustness Analysis.

The Multi-Parameter Analysis (MPA) sub-model to evaluate the design parameters, needs to be conceptualised as 'System of Systems Methodologies' (S of SM) to study the disparate design parameters. In this paper, the conceptualisation of MPA sub-model as a S of SM is discussed.

## INTEGRATED DECISION SUPPORT SYSTEM

### System Methodology

The 'Mid-life Upgrade System' (MLUS) developed by Sinha et al. (2000a) for maritime helicopters was conceptualised in a conventional input-process-output configuration (Figure 1) to broadly identify the inputs, the process required and the outputs. The MLUS inputs were a set of operational needs and environmental conditions that were transformed to mission requirements; and the outputs were the mission capabilities derived from the system (Table 1 and 2). Based on the operational needs, environmental conditions and the mission requirements, Sinha et al. (1996b) developed a system structure to identify system components and attributes for upgrade. The system structure is presented in Figure 2.

The MLUS was then arrayed in a hierarchical structure by Sinha et al. (2000b) to identify the sub-systems (hardware components) that could fulfil the designed functional characteristics (attributes). The partial system hierarchy is presented in Figure 3. The last level of the hierarchy identified the advanced systems to replace the obsolete systems on the aircraft; and required an upgrade engineering process.

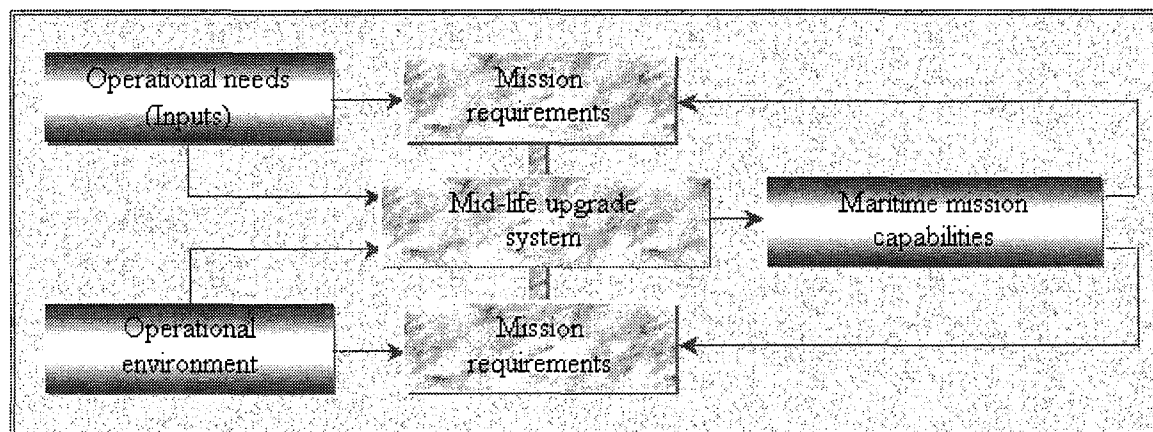


Figure 1: Mid-life Upgrade System Configuration

**Table 1: Maritime Missions – Operational Needs**

Operational needs (Inputs)	Mission requirements (Attributes)		Mission capabilities (Outputs)	
Offensive	Fire power	<ul style="list-style-type: none"> <li>• Light weight attack of submarines.</li> <li>• Shadowing and targeting of surface contacts.</li> <li>• Provide support information to aircraft or missile system.</li> <li>• Limited forward air control for air attack.</li> <li>• Battle damage assessment.</li> <li>• Self defence.</li> </ul>	Offensive warfare capabilities	
	Tactical flying	<ul style="list-style-type: none"> <li>• Terrain flight/ Nap of earth flight.</li> <li>• Aggressive low level manoeuvring.</li> <li>• Day/ night/ all weather</li> </ul>		
	Communicating	<ul style="list-style-type: none"> <li>• Air traffic communication.</li> <li>• Tactical communication.</li> </ul>		
	Operator activity	<ul style="list-style-type: none"> <li>• Interpret inputs.</li> <li>• Weaponry.</li> <li>• Dispense EW counter measure.</li> <li>• Human stress.</li> </ul>		
Defensive	Fire power	<ul style="list-style-type: none"> <li>• Support boarding or search parties.</li> <li>• Self defence.</li> </ul>	Defensive warfare capabilities	Maritime mission capability
	Reconnaissance & Surveillance	<ul style="list-style-type: none"> <li>• Detect, identify, classify, locate and prosecute targets.</li> <li>• Combat search.</li> </ul>		
	Aerial assault & extraction	<ul style="list-style-type: none"> <li>• Insertion of boarding or search party.</li> <li>• Extraction of boarding or search party.</li> </ul>		
	Tactical flying	<ul style="list-style-type: none"> <li>• Terrain flight/ Nap of earth flight.</li> <li>• Aggressive low level manoeuvring.</li> <li>• Day/ night/ all weather.</li> </ul>		
	Communicating	<ul style="list-style-type: none"> <li>• Air traffic communication</li> <li>• Tactical communication</li> </ul>		
	Operator activity	<ul style="list-style-type: none"> <li>• Interpret inputs.</li> <li>• Weaponry.</li> <li>• Dispense EW counter measure.</li> <li>• Human stress.</li> </ul>		
Logistics	Search	<ul style="list-style-type: none"> <li>• Over land and sea for survivors or debris.</li> </ul>	Logistic support capability	
	Aerial replenishment	<ul style="list-style-type: none"> <li>• Cargo to personnel or ships.</li> <li>• Delivery of rescue personnel or survival equipment.</li> </ul>		
	Transportation	<ul style="list-style-type: none"> <li>• Transport combat troops.</li> <li>• Transport personnel and supplies.</li> <li>• Transport light stores on ships.</li> </ul>		
	Aid civil authorities	<ul style="list-style-type: none"> <li>• Visits and displays.</li> <li>• Support firefighting.</li> <li>• Support police operations.</li> </ul>		
	Evacuation	<ul style="list-style-type: none"> <li>• Evacuate stretcher cases with attendants.</li> </ul>		
	Tactical flying	<ul style="list-style-type: none"> <li>• Terrain flight/ Nap of earth flight.</li> <li>• Day/ night/ all weather.</li> </ul>		
	Communicating	<ul style="list-style-type: none"> <li>• Air traffic communication.</li> <li>• Tactical communication.</li> </ul>		
	Operator activity	<ul style="list-style-type: none"> <li>• Interpret inputs.</li> <li>• Troop or cargo handling.</li> <li>• Casualty handling.</li> <li>• Human stress.</li> </ul>		

In the complete exercise of system conceptualisation to the identification of advanced system, the system effectiveness needs to be considered for design decision. (Sinha et al. 1996 b). To study the system effectiveness, the design parameters to be evaluated and further integrated were the following: (a) mission capability; (b) flight performance; (c) reliability; (d) maintainability; and (e) cost. The system effectiveness study was conceptualised by Sinha et al. (2000b), as a S of SM (Figure 4).

**Table 2: Maritime Missions – Environmental Conditions**

Operational needs (Inputs)		Mission capabilities (Outputs)		
		Maritime mission capabilities		
		Defensive sub-mission	Offensive sub-mission	Logistic sub-mission
Mission requirements				
Natural	Marine	<ul style="list-style-type: none"> <li>• Open ocean</li> <li>• All sea state</li> <li>• Salt laden air</li> <li>• Sea water spray</li> <li>• Wave wash</li> </ul>	<ul style="list-style-type: none"> <li>• Open ocean</li> <li>• All sea state</li> <li>• Salt laden air</li> <li>• Sea water spray</li> <li>• Wave wash</li> </ul>	<ul style="list-style-type: none"> <li>• Open ocean</li> <li>• All sea state</li> <li>• Salt laden air</li> <li>• Sea water spray</li> <li>• Wave wash</li> </ul>
	Confined	<ul style="list-style-type: none"> <li>• Ships</li> <li>• Vegetation</li> </ul>	<ul style="list-style-type: none"> <li>• Ships</li> <li>• Vegetation</li> </ul>	<ul style="list-style-type: none"> <li>• Ships</li> <li>• Vegetation</li> </ul>
	Terrain	<ul style="list-style-type: none"> <li>• Desert</li> <li>• Unprepared sites</li> <li>• Obstacles</li> </ul>	<ul style="list-style-type: none"> <li>• Desert</li> <li>• Unprepared sites</li> <li>• Obstacles</li> </ul>	<ul style="list-style-type: none"> <li>• Desert</li> <li>• Unprepared sites</li> <li>• Obstacles</li> </ul>
	All weather	<ul style="list-style-type: none"> <li>• Tropical</li> <li>• Hot</li> <li>• Wintery</li> <li>• Cyclonic</li> <li>• Rainy</li> </ul>	<ul style="list-style-type: none"> <li>• Tropical</li> <li>• Hot</li> <li>• Wintery</li> <li>• Cyclonic</li> <li>• Rainy</li> </ul>	<ul style="list-style-type: none"> <li>• Tropical</li> <li>• Hot</li> <li>• Wintery</li> <li>• Cyclonic</li> <li>• Rainy</li> </ul>
	All times	<ul style="list-style-type: none"> <li>• Day</li> <li>• Night</li> </ul>	<ul style="list-style-type: none"> <li>• Day</li> <li>• Night</li> </ul>	<ul style="list-style-type: none"> <li>• Day</li> <li>• Night</li> </ul>
	Situation	<ul style="list-style-type: none"> <li>• Hot and wet</li> </ul>	<ul style="list-style-type: none"> <li>• Hot and wet</li> </ul>	<ul style="list-style-type: none"> <li>• Hot and wet</li> </ul>
Natural and Manmade	Threat	<ul style="list-style-type: none"> <li>• Hostile</li> <li>• Non-hostile</li> </ul>	<ul style="list-style-type: none"> <li>• Hostile</li> <li>• Non-hostile</li> </ul>	<ul style="list-style-type: none"> <li>• Hostile</li> <li>• Non-hostile</li> </ul>
	Interference	<ul style="list-style-type: none"> <li>• Electro-magnetic</li> </ul>	<ul style="list-style-type: none"> <li>• Electro-magnetic</li> </ul>	<ul style="list-style-type: none"> <li>• Electro-magnetic</li> </ul>

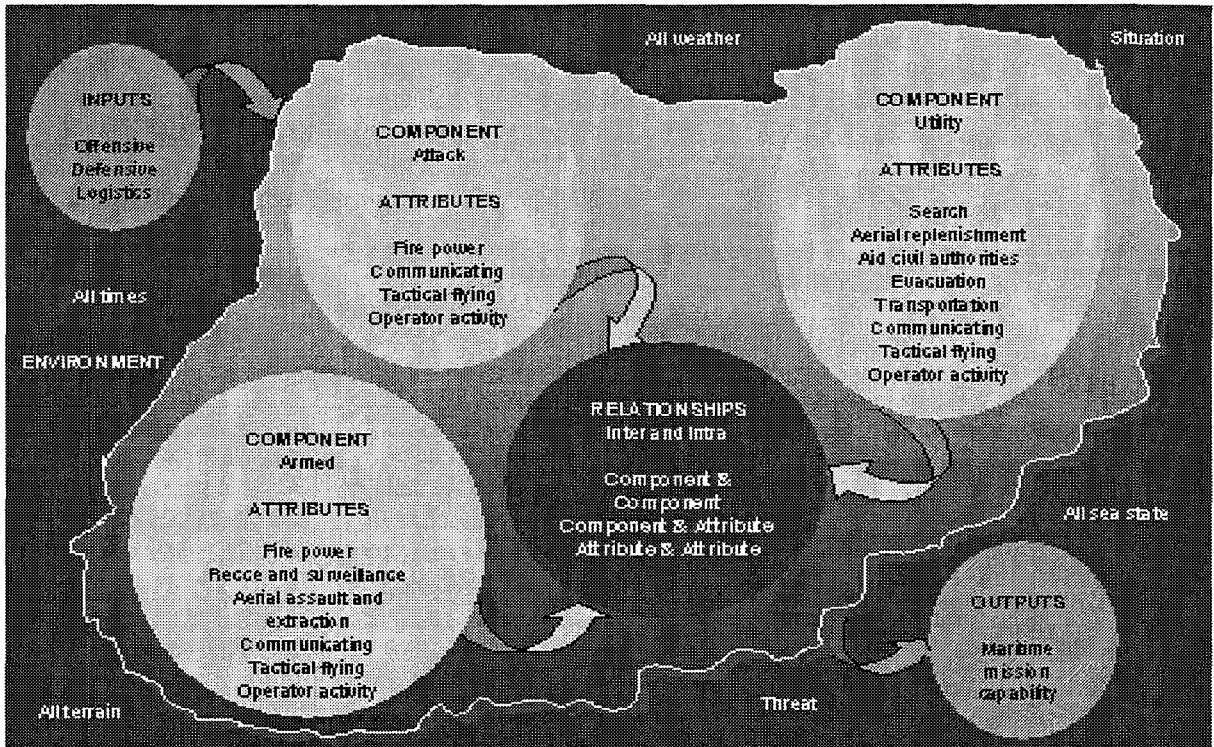


Figure 2: Mid-life Upgrade System Structure

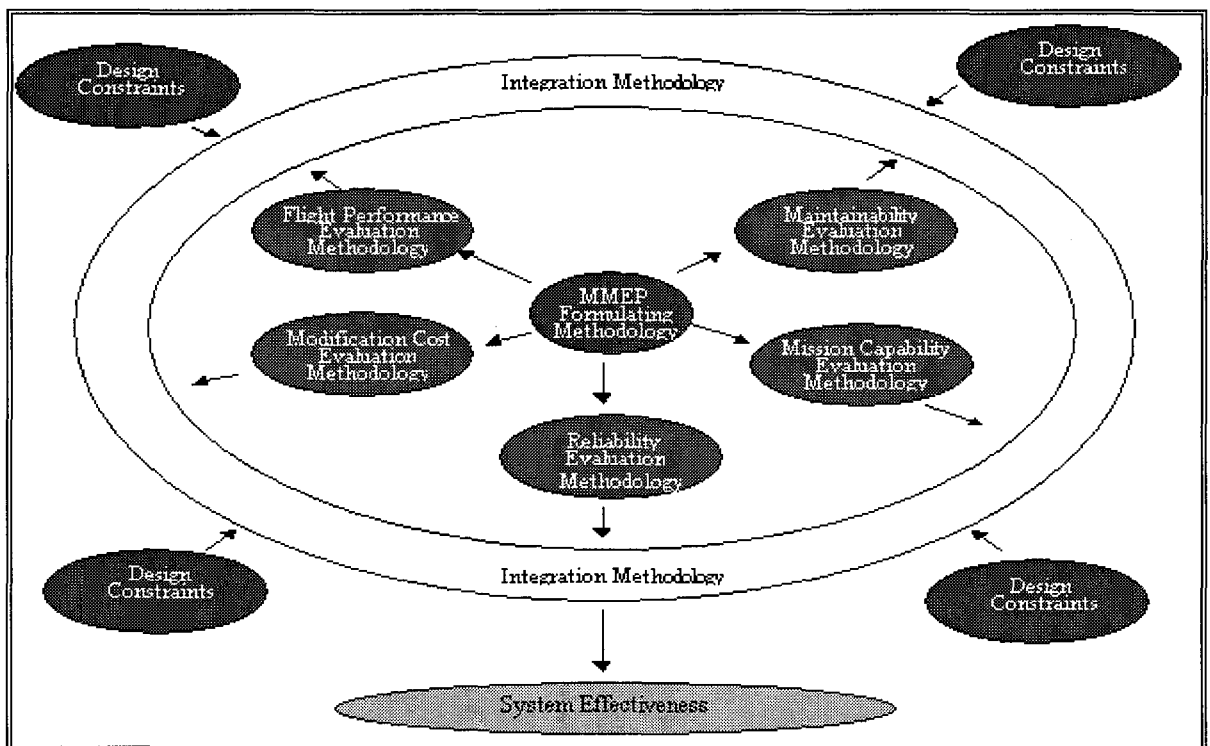


Figure 3: Partial System Hierarchy of Mid-life Upgrade System

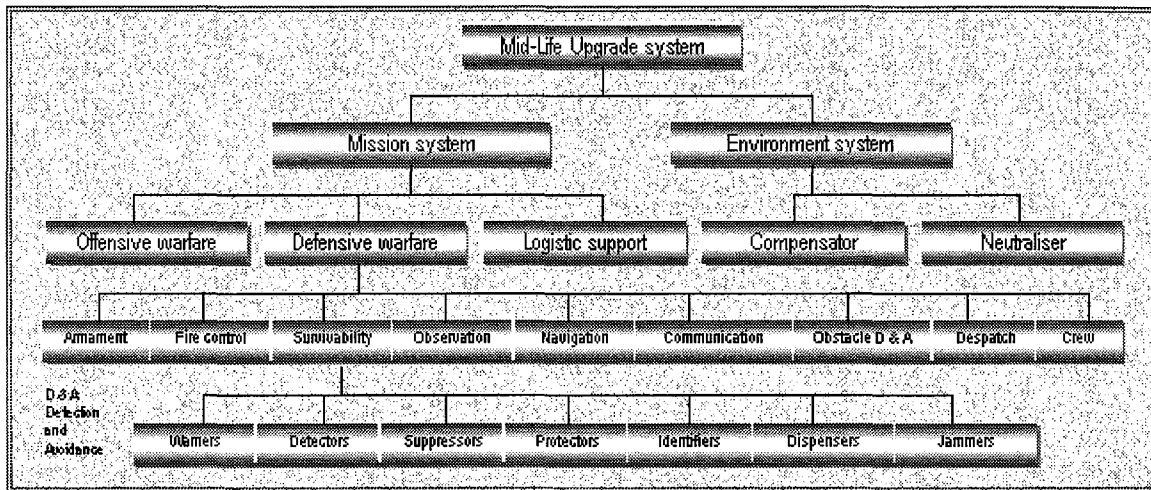


Figure 4: System Effectiveness as a System of Systems Methodologies

## AUTOMATION OF MLUS

To automate the system methodology (Sinha et al. 1996a, 1996b, 2000a, 2000b), an 'Integrated Decision Support System' (IDSS) was developed by Kusumo et al. (2001a, 2001b, 2001c). The IDSS consisted of three base-line sub-models with pre-designated functions as follows:

- **'Man Machine Interface' (MMI):** To provide user-system interaction;
- **'Analysis, Synthesis and Decision Support System' (ASDSS):** To identify state-of-the-art mission systems from defined operational and environmental needs and to evaluate system effectiveness of the upgraded helicopter for decision support; and
- **'Database' (DB):** To store and manage operational, mission systems and helicopter data.

The ASDSS base-line sub-model was further refined, with detail functions required for upgrade design decision. The ASDSS sub-models was to automate the process of mission analysis, requirement analysis, functional analysis, synthesis, test and validation. The sub-models of ASDSS and their desired functions were as follows:

- **Mission System Identification (MSI):** To translate operational and environmental needs to mission requirements, and identify state-of-the-art mission systems for upgrade;
- **Mission Payload Design (MPD):** To prioritise the mission systems based on their relative dependence and contribution in mission accomplishment and formulate alternative 'sets of mission systems' (mission payload) for upgrade options;
- **Multi-Parameter Analysis (MPA):** To evaluate the degree to which the system design parameters (mission capability, flight performance, reliability, maintainability and cost) are met by the alternative mission payloads;
- **Upgrade Decision Support (UDS):** To evaluate the system effectiveness of the upgrade options by considering the results of the MPA and to identify the optimal upgrade option for design decision; and
- **Decision Robustness Analysis (DRA):** To test the robustness of the design decision against temporal uncertainties and to validate the design.

The IDSS framework representing an automated system structure for mid-life upgrade of aircraft is presented in Figure 5.

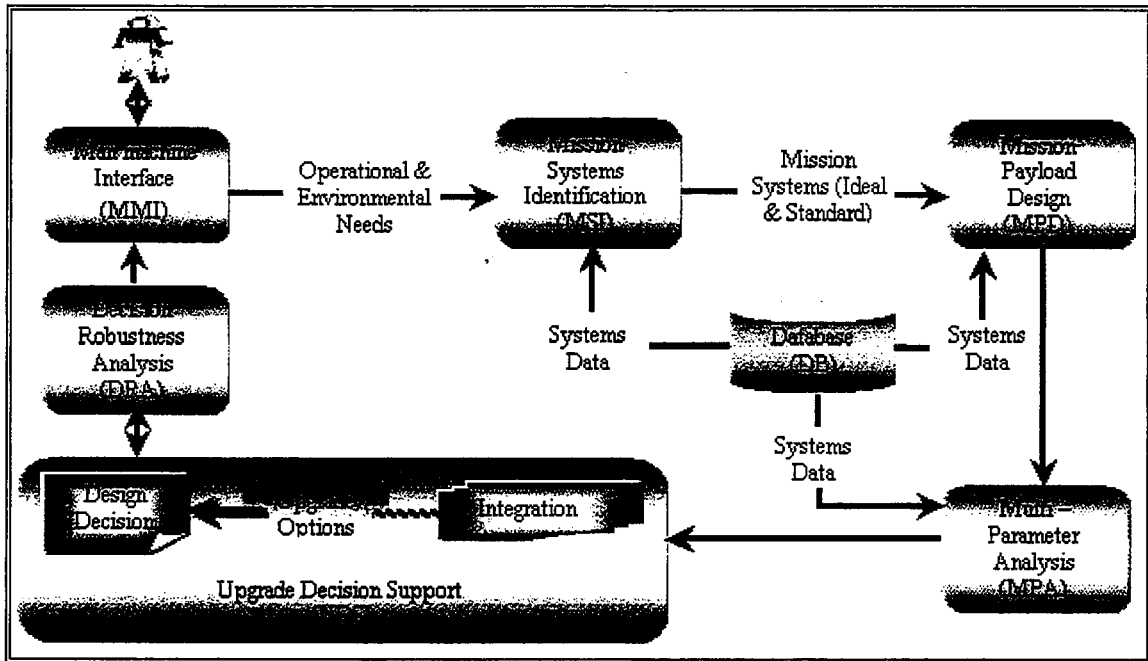


Figure 5: Automated System Structure for Mid-life Upgrade of Aircraft

## SYSTEM EFFECTIVENESS

The system effectiveness study is the function of the Multi-Parameter Analysis sub-model. As the effectiveness is governed by various parameters, the analysis is to be multi-parameter based. The engineering process is to consider all the design parameters and integrate these for system effectiveness acceptance; with the design constraints as the acceptance benchmark. To consider the upgrade engineering process for automation as a S of SM, the following methodologies are required to integrate the aircraft and the advanced system:

- **Mission capability Analysis:** The methodology for analysis involves a study of the defined mission capability and the derived mission capability from the upgrade. These two capabilities are to be integrated to evaluate the capability enhancement that is achieved by the upgrade;
- **Flight Performance Analysis:** The methodology for analysis involves a study of the flight performance of the upgraded aircraft with advanced systems. The degree of performance degradation is evaluated for operational acceptance;
- **Reliability Analysis:** The methodology for analysis involves a study of the re-configured system reliability with advanced systems. The system reliability is re-evaluated;
- **Maintainability Analysis:** The methodology for analysis involves a study of added maintenance requirements of advanced systems. The system maintainability is re-evaluated; and
- **Cost Analysis:** The methodology for analysis involves a study of the upgrade costs associated with the advanced systems.

The evaluated design parameters are compared to the benchmark of acceptance that is dictated by the design constraints of each parameters. The system effectiveness acceptance is governed by all design constraints fulfilment for appropriate design decision. The multi-parameter analysis sub-model as a S of SM is presented in Figure 6.

## RESULTS AND DISCUSSION

The multi-parameter analysis constitutes of design parametric analysis for system effectiveness. The disparate design parameters are considered as separate evaluation methodologies; and hence conceptualised as a S of SM. The various system methodologies are the following:

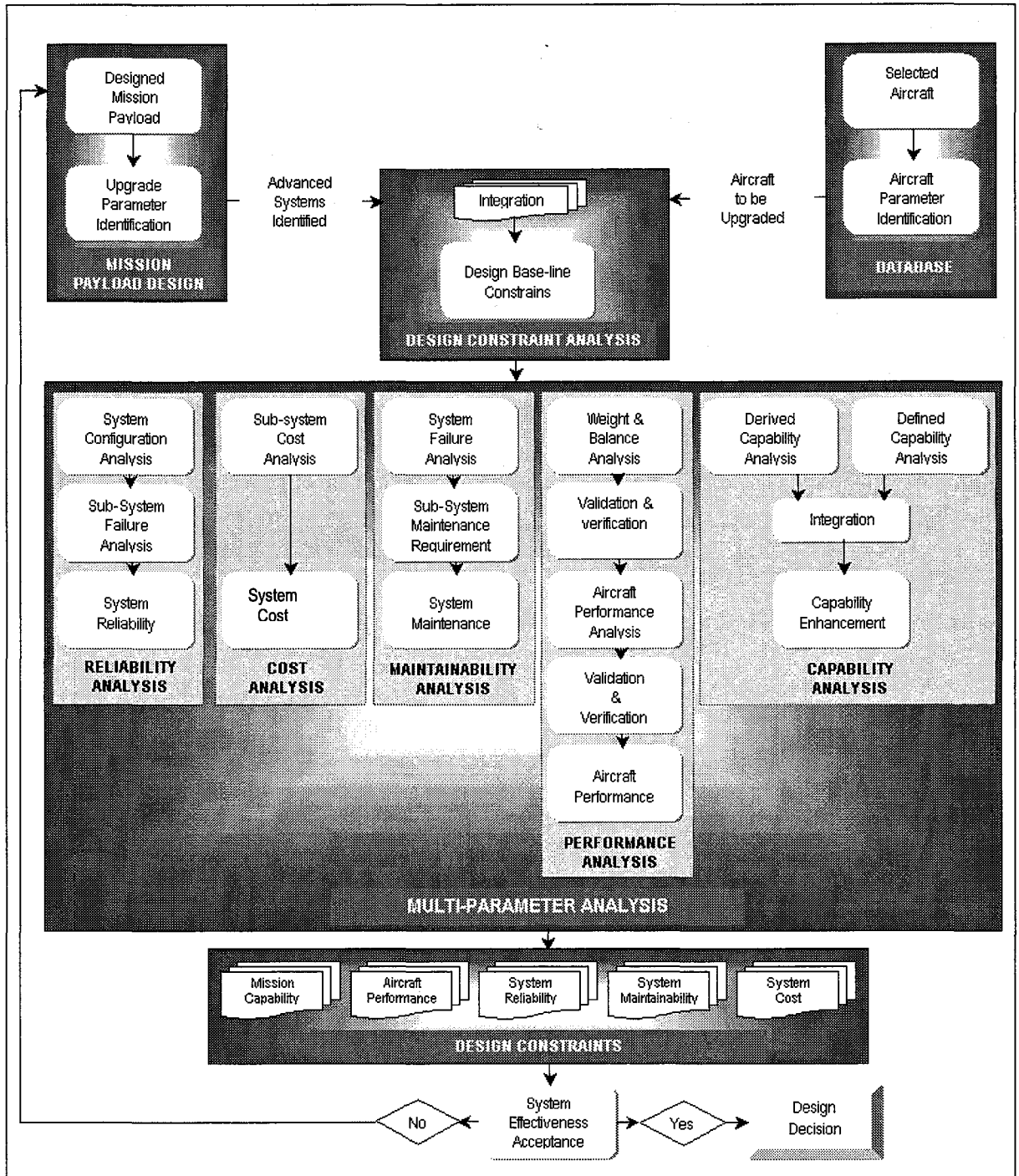
- Mission Capability Analysis;
- Flight Performance Analysis;
- Reliability Analysis;
- Maintainability Analysis: and
- Cost Analysis.

The evaluated design parameters are studied against the imposed design constraints for acceptance. The system effectiveness acceptance denotes all design constraints being met by the upgrade process. Design decision can thus be based on the degree to which the system effectiveness is met.

The Multi-Parameter Analysis sub-model for the automation of aircraft upgrade is to involve five design parameter evaluation methodologies. The automated evaluation of design parameters and comparison with design constraints; provides the benchmark for system effectiveness acceptance for design decision.



**Figure 6: Multi-Parameter Analysis as a System of Systems Methodology**



## CONCLUSION

System approach provides an avenue to address the engineering challenge of aircraft upgrade. The upgrade can be conceptualised as a system. The automation of the upgrade engineering process can be further conceptualised as a System of Systems Methodologies for system effectiveness studies.

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# Addressing Information Systems Failures through Design Research

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## ABSTRACT

*The ubiquitousness of failures in new information systems designs and implementations indicates that the design methodologies that the field has developed are inadequate or faulty. This paper points to the body of knowledge developed from design research as a potential source of expertise for developing design methods that are more successful. The paper describes a meta-theoretical method for classifying theories in the Information Systems field, and identifying areas that need further development.*

*Keywords: IS Research, Theory, Design Research, Epistemology*

## INTRODUCTION

There is widespread criticism that the designing and implementation of Information Systems (IS) solutions are frequently problematic in terms of late completion and being over-budget (see, for example, The Word, 2000, Lyytinen et al., 1998, Standish Group, 2001, Gladwyne Software Surety Inc, 2000). A primary purpose of Information Systems research is to facilitate the designing of information systems. These criticisms imply that the ways that information systems are designed are not sufficiently well developed: that the design methodologies devised on the basis of IS research are inadequate or faulty. These problematic approaches to designing information systems contrast with the more successful approaches used for designing other forms of artefact, many of which are considerably more complex and have greater capitalization than IS solutions.

This paper contributes to rectifying the above situation by describing theoretical approaches that have emerged in the field of Design Research: the main discipline that focuses directly on improving designing and designed outcomes across different domains. The paper draws attention to the close relationship that existed some 40 years ago between IS research and Design Research, sets out some key definitions, and maps out the different research and theory-making themes that have emerged as important in design research. The paper describes a method of meta-theoretical analysis to identify areas of weakness in the balance of theories in the literature of IS research, and concludes with suggestions for improving designed IS outcomes.

## BACKGROUND ISSUES

In the 1960s, a beneficial symbiotic relationship existed between the fields of IS and Design Research (see, for example, Simon, 1969, Jones and Thornley, 1964). Since then, the field of IS has developed its own design methodologies (see, for example, Adams et al., 1985, Astrom and Wittenmark, 1990, Bielawski and Boyle, 1997, Curtis, 1995, Long, 1982, Shneiderman, 1998), and the previously close theoretical relationship between the fields has declined, although IS theories have been used in design research (see, for example, Court, 1995, Coyne et al., 1990, Dasgupta, 1991, Eder, 1989).

Terminology relating to designing is problematic (see, for example, Hubka and Eder, 1988, Love, 2000c, Eder, 1966, O'Doherty, 1964, Liddament, 1996). Definitions used in this paper are based on the epistemological analyses of Love (2000b, 2001 (accepted)-b, 2001 (accepted)-a):

'Design' - a noun referring to a *specification* for making an artefact or for undertaking an activity. A *design* is the basis for and precursor to the making of an artefact (including systems, theories, methods). Creating an artefact does not necessarily depend on a design, for example, in Art and Craft)

'Designing' - non-routine human internal activity leading to the production of a *design*.

'Designer' - someone who is, has been, or will be *designing*, i.e. creates *designs*

'Design process' - any process or activity that includes one or more human acts of *designing* in association with one or more other sorts of activities.

'Design Research' – research and theory making about *designing* and *designs*.

Other meanings and uses of 'design' are avoided, especially the epistemologically problematic use of 'design' as an entity with agency, in, for example, "'design" creates better solutions'. The above definitions separate the activity of designing from other human activities, and identify acts of designing in many situations in which they have been overlooked.

## IS RESEARCH AND DESIGN RESEARCH

IS Research has two main foci: the activities of designing information systems (in some cases with their associated business case and plans), and analysis and prediction of the physical and theoretical characteristics of information systems. These equate in design research terms to 'research into designing' and 'research into designs for different forms of artifact'. Like the design processes of most products, successfully designing information systems goes beyond addressing purely technical issues. It relates to all of the three main themes of design research:

- Human aspects of designing - Research into designing as a human internal activity (including all human stakeholders).
- Methodological aspects of designing - Research focusing on design processes and developing of methodologies to improve design processes. This includes research into how the activity of designing co-joins with many other activities like calculating, programming, drawing, analysing data, collecting data etc
- Technical aspects of designing - Research into problems, designs for solutions, and the physical and theoretical relationships between them. This includes information about or from stakeholders.

**Research into human aspects of designing** - understanding and modelling designers' internal activities is important. Designing is a primary aspect of individual human functioning, underpinning how humans create change and respond to problems. This aspect of design research lies at the heart of understanding individual and group behaviour and motivation. It is relevant to understanding and reducing IS failures because it offers the greatest insights into including human social, environmental and ethical issues into designing solutions (Love, 1998b).

IS systems are increasingly likely to draw on research in this realm because of the increased use of affective mechanisms in information systems such as customer relationship management systems. Affective issues are involved in several other aspects of designing IS solutions including:

- Designing Information systems
- Designing hardware and software configurations
- Designing new business plans that include information systems
- Product design
- Corporate identity design, image management & business documentation
- Financial management strategies
- Buying
- Advertising and marketing

Traditional information systems for management focus on business process. The recent shift towards e-enabled customer-centric business processes indicates a need for a fuller understanding of customers. Design research can also offer some insights in this area because customers themselves are involved in designing, especially in the ways they use the products and services of others as design support tools to 'design' their lives. These design support tools include, e.g. using an online loan calculator, and using on-line catalogues and advice to design a new lifestyle. The way that customers *design* their lives points to a role for design research to helping IS professionals and researchers involved in building information systems to support advertising, marketing, corporate planning and organisational planning professionals who can be reconceptualized as managers to 'customers as designers'. This approach offers potential competitive benefits that complement traditional customer research methods.

**Research focusing on design methodologies** has been a major theme in design research over the last 50 years or so, particularly in the Design Methods movement from which the UK-based Design Research Society and the US-based Design Methods Group originated. Hundreds of design methodologies and models of 'design processes' that are potentially relevant to the design of information systems have been devised to efficiently and effectively address design problems across a very large number of sub-disciplines. These methodologies focus on different issues. Some focus on bringing together the necessary elements of a design for an artefact. Others are aimed at the 'public face', or the interface, of a designed artifact. In an IS context, the first sort of design methodologies might involve data types (name, address, company, transaction, date etc). In the second, the focus of the methodologies might be the answers to questions such as: "Who needs to know the data?" "Why?", "How will the system supply them with that data?", "How are the user's feelings affected by how the data is presented?", "Which parts of the systems are easier / more difficult to access?", "What is the most natural flow of events and tasks within the system?", "What alternative pathways are in the system?", "Why, and how are pathways signaled to the user?".

Other types of design methodology outcomes from design research that are relevant to praxis in the development, implementation and management of information systems are:

- Methodologies that support the designing of artefacts whose functioning is flexible and robust to allow them to be used with a high level of variance. These methodologies are important because users of designed artefacts are rarely a behaviourally homogenous group with a single and well-defined identity.
- Methodologies related to designing organizational processes for managing teams of people involved in designing solutions (including customer-designers).
- Methodologies based on Systems perspectives on designing that bring together processes and methodologies into a coordinated whole.
- Methodologies aimed at the management of design processes: an area broader than it first appears because many human involve some aspect of designing.
- Methodologies for aspects of designing relating to human communications, aesthetics, corporate identity, the representation of brand and identities through information systems, brand and identities in business planning, visual and socio-cultural aspects of designed solutions as reflected in identity and brand issues.
- Methodologies for designing interfaces that include praxical, ethical and aesthetic sensibilities.
- Methodologies whose focus is the targeted collation of supporting information.

In these latter methodologies, information is repackaged in forms that are 'designer-friendly'. Examples of such packages in a software environment are: high level languages, RAD environments and software toolboxes e.g. Delphi, C#, and Cognos, These are language and information system packages that support program designers to function at higher conceptual levels that are more effective and efficient. The underlying design methodologies consist of processes to develop these collations of programmatic and informatic elements into easily accessible and carefully structured products to support designers in creating solutions without them needing to reprocess primary knowledge structures and data.

**Research into technical aspects of designing** focuses on problems, designs of solutions, and the relationships between them. Research in this area follows these three themes:

Research focusing on *problems*: for example, formal ways of defining problems to help designers produce solutions to those problems effectively and efficiently.

Research focusing on *designed solutions*: for example, identifying the ways that humans interact with particular designed solutions, and how the characteristics of particular designed artefacts align or comport with the characteristics or behaviours of other designed artefacts.

Research focusing on the *relationships between problems and designs of solutions* to those problems. The aim is to automate problem-solution scenarios to move them out of the arena of designing and into routine processes. Design researchers have successfully undertaken this task across a variety of disciplines, perhaps most visibly in the engineering disciplines where many tasks previously requiring high-level human skills in designing and judgement are now automated via computer-based information systems.

The complex nature of human circumstances means that there is rarely a single right or correct solution to creating a design to resolve a particular problem: in most cases designing involves minimising the adverse compromises necessary to create a solution that is whole and functional. The findings and theories of design research offer support for IS professionals to more effectively use other relevant, bodies of knowledge, especially relating to the cognitive and informatic processes that are a part of designing.

## META-THEORETICAL ANALYSIS

So far, the focus has been on the topoi regarded as important in design research that may contribute to improving IS design methodologies and designed outcomes. Another way of exploring the interrelationships between the fields is to focus on the structure and dynamics of their theories (Stegmüller, 1976).

Different fields contribute theory to human understanding in different ways, in different areas, at different levels of abstraction, and with different amounts of coherency and justification. A structural meta-theoretical approach to analyzing theory focuses on categorizing theories and concepts in terms of their relationships at different levels of abstraction. The most abstract levels relate to ontology and epistemology, and the least abstract relate to individual humans' direct interactions with their environment and selves. Between, with different forms of hierarchical dependence to each other, are the day-to-day theories used by professionals and researchers.

Several meta-theoretical hierarchies have been devised to map out different categories and relationships between theories. These include: Giddens' (1987) subdivision of Social Theory into large, small and middle-range theories; Reich's (1994) three level model of theory in Engineering Design and Artificial Intelligence; Franz' (1994) four level structure for theories about designing in Architecture; Popper's (1976) three incommensurate 'worlds', Ullman's (1992) complex taxonomies of mechanical design theory, and Howard and Lazear's (1990) seven different areas of understanding. Each of these has been devised for a particular purpose.

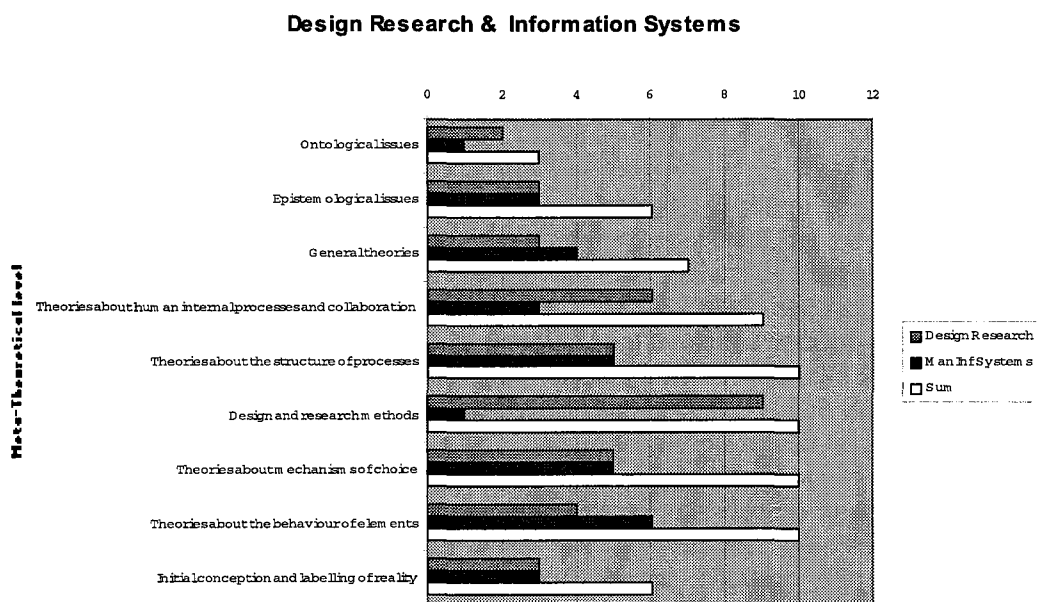
The nine level meta-theoretical abstraction hierarchy described below in Table 1 was developed to assist in clarifying the relationships between different fields of study associated with human agency (such as designing IS products), and for checking the coherency and sufficiency of general theories, theoretical perspectives and sub-fields of study (Love, 1998a, Love, 2000c, Love, 2000a, Galle, 2001). This meta-theoretical hierarchy locates theory in a human context in which designing (the skills at addressing wicked problems and creating new knowledge and artefacts) is included as a core aspect of human existence. The hierarchy consists of a generic structure that is modified for analyzing theory in different situations (see, for example, Love, 1998b, Love, 2000c).

**Table 1: Meta-theoretical hierarchy of concepts and theories**

Level	Classification	Description
1	Ontological issues	The ontological basis for theory making: human values and fundamental assumptions of researchers, designers and other theoretical foundations and axiomatic entities.
2	Epistemological issues	The critical study of the nature, grounds, limits and criteria for validity of knowledge.
3	General theories	Theories that seek to describe human activities and their relationship to designed objects and human environments.
4	Theories about human internal processes and collaboration	Theories about the reasoning and cognising of individuals involved in designing and researching, of collaboration in teams, and of socio-cultural effects on individuals' behaviours.
5	Theories about the structure of processes	Theories about the underlying structure of processes of designing and researching based on domain, culture, artefact type and other similar attributes and circumstances.
6	Design and research methods	Theories about and proposals for methods and techniques of designing and researching
7	Theories about mechanisms of choice	Theories about the ways that choices are made by designers and researchers between different elements, designed objects, processes, systems or other types of possibility.
8	Theories about the behaviour of elements	Theories about the behaviour of elements that may be incorporated into designed objects, processes and systems
9	Initial conception and labelling of reality	This is the level at which humans descriptions of objects, processes and systems are coined, e.g. 'a vacuum cleaner', 'a car body', 'a groyne', a 'database', 'sitting' at a 'desk', 'hearing' 'noise', 'smelling' 'fumes' from an 'exhaust' and 'watching' 'sunsets'.

The focus of this meta-theoretical hierarchy is on theory *qua* theory. Theoretical objects and elements are any things (not necessarily physically real or concrete) that are represented in theoretical terms. This is a position that aligns with many IS conceptualisations, e.g. object-oriented programming. The meta-theoretical hierarchy is reflexive and theories from one perspective may well be the objects or elements of theory for another and vice versa.

The balance of theories and concepts at different levels in the meta-theoretical hierarchy are different for different bodies of literature and different disciplines. Theories of IS can be mapped onto this meta-theoretical hierarchy in a fairly straightforward manner; made easier because of the organized nature of information systems. The diagram below demonstrates a hypothetical mapping of theories of Management Information Systems and Design Research across the hierarchy (The distribution of theories at each level is a personal estimate for demonstration only and is not based on any formal research).



An additional measure plotted in the above example is the sum of the contributions from the two fields.

The profile of this sum can offer increased understanding about the relationships between two fields. Where it is relatively constant in spite of the relatively uneven distribution of theories from each field it may indicate that the fields are complementary, and may have a symbiotic relationship in terms of research, theory building and solution creation.

Three axioms relating to the meta-theoretical hierarchy are:

- Any theoretical element at a particular abstraction level in the hierarchy describes patterns in and relationships between theoretical elements at lower levels in the hierarchy
- Any theoretical element at a particular abstraction level in the hierarchy depends on theoretical constructs at higher levels of abstraction. These are the 'assumptions' on which each theory element is based.
- For each theoretical element, coherence and validation criteria require that it should be possible to identify it as a member of a complete pathway of interrelated theoretical elements that together span all levels in the meta-theoretical hierarchy.



These axioms in conjunction with a meta-theoretical mapping of the distribution of theories for a field such as Information Systems offers an overview of the coherency of the theoretical developments in the field, and can indicate areas in which there is a shortfall or neglect of theory development.

In many technical fields, the application of the above method frequently indicates weakness in relation to levels 1, 2, 4 and 9. Compared to other technical disciplines, IS has a relatively strong theoretical presence at level 9 due to research on interface designing and other ergonomic issues. Disciplines close to the physical sciences are likely to be relatively light in levels 1 and 2 because the ontology and epistemology of physics (on which many scientific disciplines are based) is axiomatically defined at these levels. This does not apply to Information Systems because the development of IS solutions also requires addressing human subjective issues that involve human values, and hence the field of IS would be expected to possess a rich and detailed theoretical foundation in levels 1 and 2.

Theories about human internal functioning (level 4) are epistemologically important to ensuring theoretical coherency in many disciplines to which they may at first seem relatively irrelevant. Any discipline whose knowledge is intended to support the development of artefacts for human use presumes and depends on theory about human cognition, feelings and behaviour. For other theories to be coherent and fully justifiable in a discipline, this implies it is necessary to make explicit the tacit level 4 theories.

Design methodologies are limited to the extent to which they can be successful in commercial use when the focus is only the technical aspects of problems and designs for solutions, and does not include human subjective issues based on values and ethical and aesthetical sensibilities (Dilnot, 1982). For design methodologies of IS (levels 5, 6 and 7), the above meta-theoretical hierarchy offers the means of checking the external and internal aspects of design methodology models. It provides the basis for identifying the assumptions on which a method depends, and the lower level theoretical constructs whose relationships it models. It also enables each methodology or method (as an abstraction) to be understood in terms of its associated meta-theoretical pathway of associated theories on levels 1-9. These meta-theoretical 'pathways' in many cases can be envisioned in terms of metaphors. For example, theories that relate to the metaphor 'humans behave like robots' form a complete, identifiable and coherent set across all the levels. These 'human robot' theories form a different theory set from those related to for example, 'humans behaving as creative geniuses'. With the meta-theoretical hierarchy, this metaphoric approach forms an additional tool for creating appropriate design processes and methodologies, and identifying the weaknesses in methodologies.

## CONCLUSIONS

Information Systems activities of designing, understanding, managing and developing solutions all involve many acts, small and large, of designing that can be only partially described in terms of information and information flows.

In this paper, improving the design methodologies of Information Systems has been explored in terms of topic areas of design research, and through the use of a meta-theoretical hierarchy. The analyses suggest that the field of Information Systems might helpfully draw on findings, theories and theoretical perspectives of design research in relation to:

- Human internal and external activities involved in designing information systems solutions.
- How people *use* information systems to shape their lives and environment
- How people *manage* those using information systems to shape their lives and environments

Many of the factors that supported the original symbiotic relationship between the two fields remain and this suggests that it may be helpful to explore the benefits available through joint research and for reviews of literature to include new developments in both disciplines.

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# Goldratt's Thinking Process Approach to Developing Strategies in Supply Chain

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## ABSTRACT

*This paper describes an application of a system approach known as the thinking process (TP) of the theory of constraints (TOC) not only to identify critical success factors in supply chain management, but also to understand causal relationships between these factors. The study was conducted in a group-based model building environment with a group of students who specialised either in logistics management or e-commerce. The results suggest that understanding the dynamic nature of supply chain through cause and effect relationships is critical to the formulation of supply chain growth strategies.*

*Keywords: Logistics, Supply chain management, system approach, theory of constraints, thinking process.*

## INTRODUCTION

Although the interest in supply chain management, both in industry and in academia, has grown rapidly over the past few years, the concept can be traced as far back as Forrester (Forrester 1958, Forrester 1961). Using industrial dynamics technique Forrester tracked the effects of delays (material flow lead time and information flow lead time) and decision policies within a simple but representative supply chain consisting of a manufacturing plant and its warehouse, a distributor, and a retailer. In this seminal work Forrester (1961) demonstrated the importance of sharing information with partner organizations in the supply chain, delays across supply chain, strategic alliance and supply base management and vendor-managed inventory at a time when these vocabularies were not part of the business literature.

To date many attempts have been made to identify critical success factors in supply chain management (Holmes 1995; Power et al. 2001), investigate relationship between logistics strategy and business processes (Brewer and Hensher 2001); establish determinants of successful strategic supplier alliances (Monczka et al. 1998); assess the impact of TQM practices on logistics and supply chain performance (Anderson et al. 1998; Tan et al. 1999) and the effect of supply management orientation on supplier performance (Shin et al. 2000); examine the role of communication in supply chain management (Ellinger et al. 1999), and investigate the impact of information technology on logistics capability (Cross et al. 1997). These are quantitative studies which applied rigorous statistical analysis including factor analysis (Power et al. 2001; Tan, et al. 1999; Anderson et al. 1998), structural equation modelling (Shin et al. 2000; Anderson et al. 1998), canonical correlation analysis (Brewer and Hensher 2001).

In this study we applied a system approach known as thinking process (TP) to identify critical factors of effective supply chain management, determine the causal relationships between these factors and investigate their interrelationship with supply chain performance.

## THEORY OF CONSTRAINTS AND ITS THINKING PROCESS

In this section we will give an overview of the theory of constraints (TOC) and its thinking process (TP). For a complete description readers can refer to Goldratt (1990) and Cox and Spencer (1998). Rahman (1998) gave a detailed description of the TOC methodology including its concepts, principles, tools and performance measures and provided a comprehensive review of the TOC literature.

Developed by Eli Goldratt in the mid-1980s (Goldratt 1988) TOC evolved from the Optimized Production Timetables (OPT) system (Goldratt, 1980) and was later known under the commercial name of Optimized Production Technology (OPT®). As part of a marketing tool for the OPT system, Goldratt illustrated the concepts of OPT in the form of a novel, *The Goal* (Goldratt and Cox 1984) in which the theory is gradually unravelled through the context of an everyday production situation. A second book, titled *The Race* (Goldratt and Fox 1986), was written to overcome difficulties encountered in the implementation. Gradually, the focus of the TOC concept moved from the production floor to encompass all aspects of business. By 1987, the overall concept became known as the theory of constraints (TOC) which Goldratt viewed as 'an overall theory for running an organisation' (Goldratt 1988, p.453). This refinement recognised that the main constraint in most organizations may not be physical but managerial-policy related. To address the policy constraints and effectively implement the process of on-going improvement, Goldratt (1990, 1994) developed a generic approach called the 'Thinking Process' (TP). This is the current paradigm of TOC. Experts believe that it is the TP of TOC which will ultimately have the most lasting impact on business.

The concept of the TOC can be summarised as:

1. *Every system must have at least one constraint.* If it were not true, then a real system such as a profit making organisation would make unlimited profit. A constraint therefore, 'is anything that limits a system from achieving higher performance versus its goal' (Goldratt 1988, p.453).
2. *The existence of constraints represents opportunities for improvement.* Contrary to conventional thinking, TOC views constraints as positive, not negative. Because constraints determine the performance of a system, a gradual elevation of the system's constraints will improve its performance.

The TOC has two major components. The first component is a philosophy which underpins the working principle of TOC. It consists of the five focusing steps of on-going improvement, the drum-buffer-rope (DBR) scheduling methodology, and the buffer management information system, and is usually referred to as TOC's 'logistics' paradigm. The second component of TOC is a generic approach for investigating, analysing, and solving complex problems called the 'Thinking Process' (TP).

### The Thinking Process

The Implementation of the working principle of TOC to a typical production environment can quickly yield substantial improvements in operations and in profits (Noreen et al. 1995). However, this process of continuous improvement takes the production operations to a point where the constraint shifts from factory floor to market. In such a case, constraint could be market demand (insufficient demand) which is a managerial/policy constraint rather than a physical constraint. Policy constraints are generally difficult to identify and evaluate, and frequently require involvement and cooperation across functional areas.

Goldratt (1994) developed a generic approach to address policy constraints and create breakthrough solutions for them using common sense, intuitive knowledge and logic. This procedure is referred to as the Thinking Process (TP). According to Noreen et al. (1995, p.149) 'the TP may be the most important intellectual achievement since the invention of calculus'.

According to Goldratt (1990), while dealing with constraints managers are required to make three generic decisions. These are:

1. Decide what to change.
2. Decide what to change to.
3. Decide how to cause the change.

The TP prescribes a set of five tools, which basically are cause-and-effect diagrams, to get answers to these questions. The questions, associated tools and their purposes are summarised in Table 1. The TP process starts with the first decision question, 'What to change', *i.e.* to identify core problems. The Current Reality Tree (CRT) is used for this purpose. Dettmer (1997) defined a CRT as a logical structure which has been designed to depict the state of reality as it currently exists in a given system. Once a core problem has been identified, the decision question becomes 'What to change to'. The second step in the process is therefore to search for a plausible solution to the core problem. Answering the second question requires other tools such as Evaporating Cloud (EC) and Future Reality Tree (FRT). According to Dettmer (1997) FRT is a strategic tool in which major changes can be outlined. The implementation of these changes is likely to bring desired outcomes in a system. Once the 'what to change to' question is decided, then the organisation is left with the question 'How to do it' or 'how to change'. The Prerequisite Tree (PRT) and Transition Tree (TT) diagrams are used to identify obstacles to implementation and devise detailed plans for overcoming these obstacles.

Generic questions	Purpose	TP tools
What to change?	Identify core problems	Current reality tree
What to change to?	Develop simple, practical solutions	Evaporative cloud Future reality tree
How to cause the change?	Implement solutions	Prerequisite tree Transition tree

**Table 1: TP tools and their roles**

It is not the purpose of this paper to discuss these tools in great detail. For a detailed discussion readers are referred to Goldratt (1994), Noreen et. al. (1995) and Kendall (1998). The purpose of this study is to address the first question: what to change, *i.e.* to identify core problems which deters organisations achieving effective supply chains. We will use CRT for this purpose.

### **Guidelines for constructing CRT**

The CRT provides the most likely chain of cause and effect of a system under consideration. It is constructed from top-down: from identified undesirable effects, and depicting probable causes for those effects (effect-cause). It is however, read from bottom-up (cause-effect), when it is constructed. The following are the steps for developing a CRT (Noreen et al. 1995, p.156):

*Step 1:* Identify a list of Undesirable Effects (UDEs) that describe the area being analysed. It is recommended to begin with a list of five to 10 UDEs.

*Step 2:* Connect one or more UDEs to other UDEs, if they are causally related. Scrutinise each entry and place an arrow along the way via the Categories of Legitimate Reservations (CLR).

*Step 3:* Connect all other UDEs to the result of Step 2, scrutinise each entry and place an arrow along the way via CLR. Stop when all UDEs have been connected.

*Step 4:* Read the tree from bottom up, scrutinising again each arrow and entry along the way via CLR. Make any necessary corrections.

*Step 5:* Ask yourself/group if the tree as a whole reflects your/group's intuition about the area being analysed. If not, check for each arrow for Additional Cause Reservations.

*Step 6:* Don't hesitate to expand the tree to connect other UDEs that exist but are not included in the original UDE list.

*Step 7:* Present the tree to someone or a group who will help you surface and challenge the assumptions captured within.

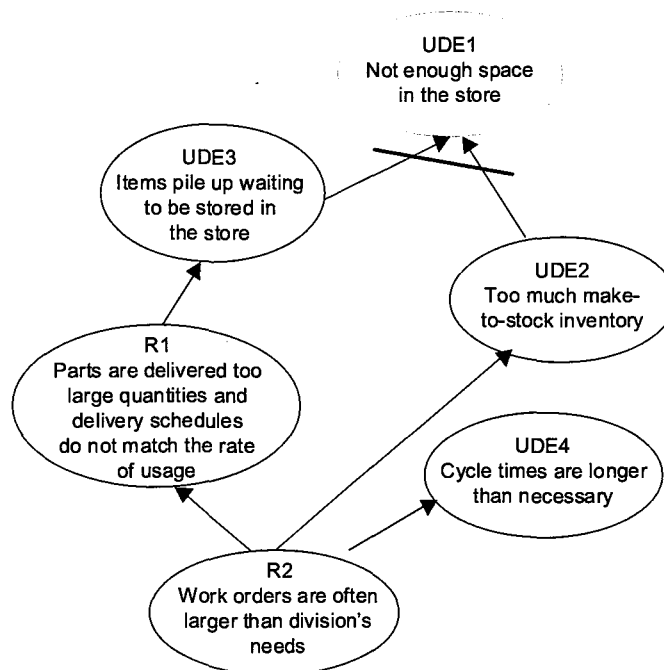
*Step 8:* Decide that the CRT is complete. Identify the core problem or problems.

### A simple example

To illustrate how a CRT is constructed we have chosen a simple storage problem with UDEs given in Table 2 (adapted from Noreen *et al.*, 1995). The corresponding CRT is presented in Figure 1.

No	Undesiabie Effects
1	Not enough space in the store
2	Too much make-to-stock inventory
3	Items piled up waiting to be stored
4	Cycle times are longer than necessary

**Table 2: List of Undesirable Effects**  
(Adapted from Noreen *et al.*, 1995)



**Figure 1: A current reality tree**

Suppose the management of a company is concerned with problems in stockroom and have identified four UDEs. These UDEs can be used to construct a current reality tree in a way of deducing a number of possible causes. The management believe that the lack of space in the store (UDE1) is due to excess inventories that resulted from making parts to stock (UDE2) and items that were piled up waiting to be stored (UDE3). So, UDE2 and UDE3 were connected to UDE1. UDE3 was suggested to be the result

of parts being delivered to the store in large quantities and delivery schedules not matching the rate of usage. (This has been identified in Figure 2 as R1 which has no significance, it is simply a reference number). Therefore, R1 is connected to UDE3 and is read "if R1 then UDE3". The management suggested that the main reason why parts were delivered in too large quantities (R1) was that work orders were larger than division's needs (R2). It was also suggested that cycle times were longer than necessary (UDE4) and UDE2 were related to the size of the work order (R2). Therefore, R2 was connected to R1, UDE2 and UDE4. That is how all the UDEs were linked in the form of a tree or conceptual map. Note that of all UDEs and Rs only UDE1 is linked to two UDEs (UDE2 and UDE3). This must be read with a 'logical AND' in the thinking process of TOC. Thus, the relationship between UDE1, UDE2, and UDE3 should be read as follows: If there is excess inventories that result from making parts to stock (UDE2) *and* items that are piled up waiting to be stored (UDE3) then there is not enough space in the store (UDE1). We have constructed the tree (Figure 2) starting with the UDEs and working down. However, the tree must be read 'bottom-up'. The management confirmed that the tree (Figure 2) represented the issue at hand and identified R2 (work orders are often larger than division's needs) as the core problem.

We illustrated the process of building the current reality tree (CRT) using a simple problem. It has to be remembered that TP of TOC should be applied only in a complex problem situation where solution is not intuitive and the relationships between effects and causes are not clear.

## **DEVELOPING GROWTH STRATEGIES USING TP**

### **Group Model Building Process**

Students undertaking a course in International Logistics management at the Institute of Transport Studies (ITS), University of Sydney were invited to participate in a group-based model building exercise in supply chain. The purpose of this exercise was to:

- Identify the consequences (effects) of failing to organise and run efficient supply chains.
- Determine possible causes of these consequences.
- Develop causal relationships between causes and effects.

The course was offered in February 2001 and was taught by the author of this paper in an intensive mode. 44 students who enrolled in this course were pursuing masters in either Logistics Management or E-Commerce at the University of Sydney. About 35% were international students (mainly from Asia) and the rest were local students. Some 15% of the students had very little or no experience (mainly Asian), 40% had 2 – 5 years experience and about 45% had more than 5 years of experience. Two students had more than twenty years of experience. About 35% of the students had experience with logistics companies. About 30% students took logistics management course prior to taking the International Logistics Management course.

Six groups were formed. Although it was difficult, a conscious attempt was made to ensure that groups were composed of both local and international students, with moderate and extensive experience as well experience with logistics organizations.

The group-based model building exercise was run in two sessions. In the first session, students used nominal group technique (NGT) to brainstorm the problem and identified five to ten UDEs of failing to organise and run an efficient supply chain. Groups then identified factors most likely to cause such effects and developed cause-effect relationships in the form of a casual diagram.

The actual models were developed in the second session. The thinking process (TP) of TOC was applied to develop the casual relationship between causes and effects. Since the students had no prior knowledge of TP and its analytical tools such as the CRT, the author of this paper developed the causal trees on white board with feedbacks and suggestions agreed by the groups.



## Results of the brainstorming sessions

The number of UDEs identified by these groups in the first session of the exercise ranged between 4 and 8. The first task in the second session was to decide which UDEs were to be considered for model building purposes. The groups agreed on the following UDEs:

1. Long cycle time
2. High cost of managing inventory
3. Low customer service
4. High distribution cost
5. High cost of supply chain.

It is interesting to notice that the list of identified UDEs can be considered as the performance metrics of supply chains which include both cost and non-cost measures. Many authors have suggested these items in the literature as measures of performance in supply chain models (Lee and Billington 1992; Christopher 1998; Mason-Jones and Towill 1999).

We chose one UDE at a time at random and developed the branches of the CRT following the guidelines mentioned earlier. When all the UDEs were considered and the branches were constructed, the branches were joined to develop a CRT for the entire supply chain system. In the following paragraphs we will discuss the construction of these branches. Due to space limitations, we will discuss only two of these branches.

### UDE: High inventory management cost

The group identified high inventory management cost as one of the major consequences of failing to organise and execute an efficient supply chain. This includes cost related to both over stock and understock of inventory. These costs are quite high and for a typical retail company it could range anywhere between 10 – 20% of product cost. That's why, we see that the main objective of the production technologies and strategies developed over the last four decades (such as MRP, JIT and TOC) have been to manage inventory. The major causes for high inventory cost as identified in the second session are lack of communication, long cycle time and low usage of information technologies (IT). The CRT is shown in Figure 2.

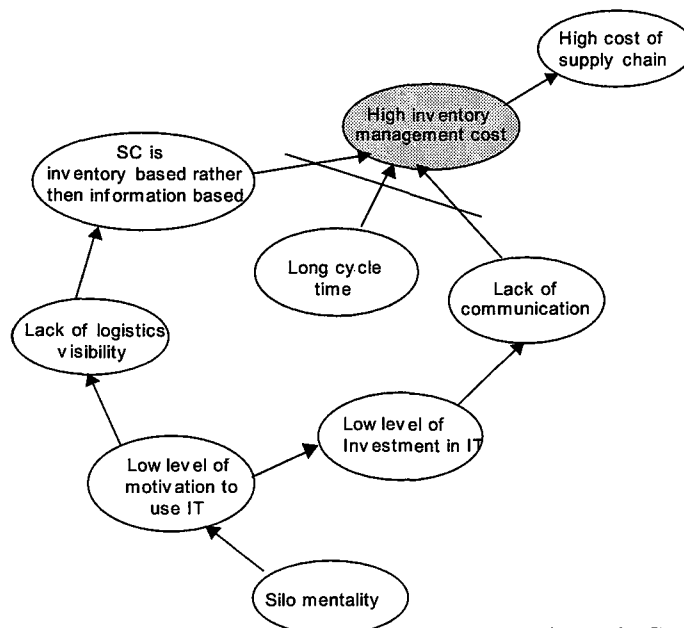


Figure 2: Causal relationships based on inventory cost

## UDE: Long cycle time

The criticality of cycle time or delay in a supply chain which includes both product flow time and information flow time was highlighted by Forrester (1958) some forty years ago. Recently, Stalk and Hout (1990) and Mason-Jones and Towill (1999) have emphasised the importance of reduction of total cycle time. In order to avoid what is now called 'bullwhip effect' (Lee et al. 1997) or 'Forrester effect' (Hines et al. 2000) total cycle time must be reduced by improved coordination and communication among supply chain partners and by aligning product-process design with appropriate supply chain structure (Figure 3).

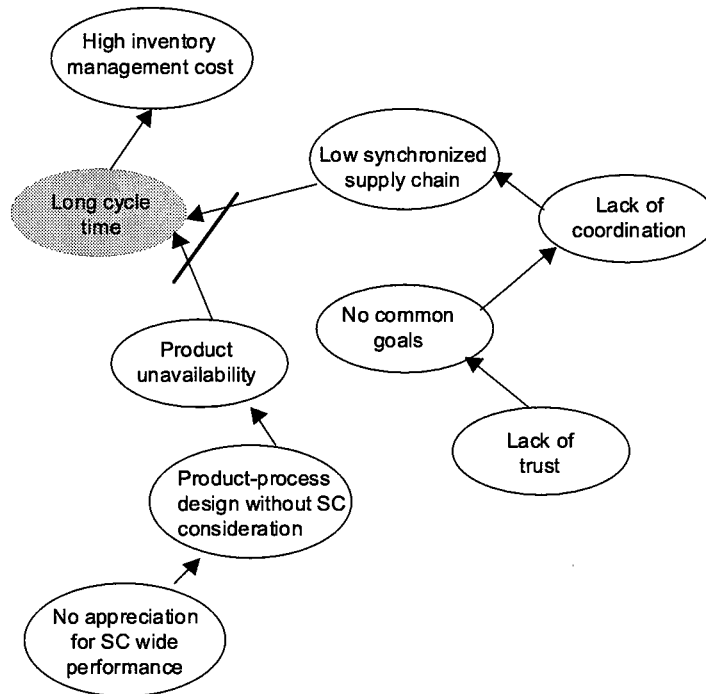


Figure 3: Causal relationships based on cycle time

In the similar manner we could develop CRT for the UDEs such as low customer satisfaction, high distribution cost, and high cost of supply chain.

## DISCUSSION AND CONCLUSION

Most of the studies conducted to understand different issues of supply chain management are generally quantitative involving rigorous statistical methods. The main objective of many of these studies had been to identify a list of success factors in SCM or determinants of successful strategic supplier alliances. This research describes an application of a system approach called TP not only to identify elements of successful SCM but also to understand causal relationships between these elements. Understanding the dynamic nature of supply chain through cause and effect relationships is critical to the formulation of supply chain growth strategies.

During the second session of the group-based model building exercise two important aspects of SCM emerged which were not identified by the groups during the nominal group discussions. These are supply base management and environmental policy. In the following subsections we will describe the impact of these two aspects of SCM and develop branches for the CRT.

## Supply base management

The low supply base management is the result of mistrust and having no common goals amongst the partner organizations in supply chains. These in turn are the outcomes of not sharing information and unwillingness to share risks and rewards (see Figure 4). The importance of supply base management on supply chain performance has been reported for many companies. Recently, Shin *et al.*, (2000) suggested that a better supply base orientation improves both the suppliers' and buyers' performance. The critical elements that improve the supply base management among others are long-term partnership with channel participants (Choi and Hartley 1996; De Toni and Nassimbeni 1999), reduced number of suppliers (Dyer 1996; Hahn et al. 1983; Kekre et al. 1995), sharing risks and rewards (Handfield and Nicholas, Jr., 1999), suppliers involvement in product development (Dyer, 1994) and trust among channel partners (Newman, 1988).

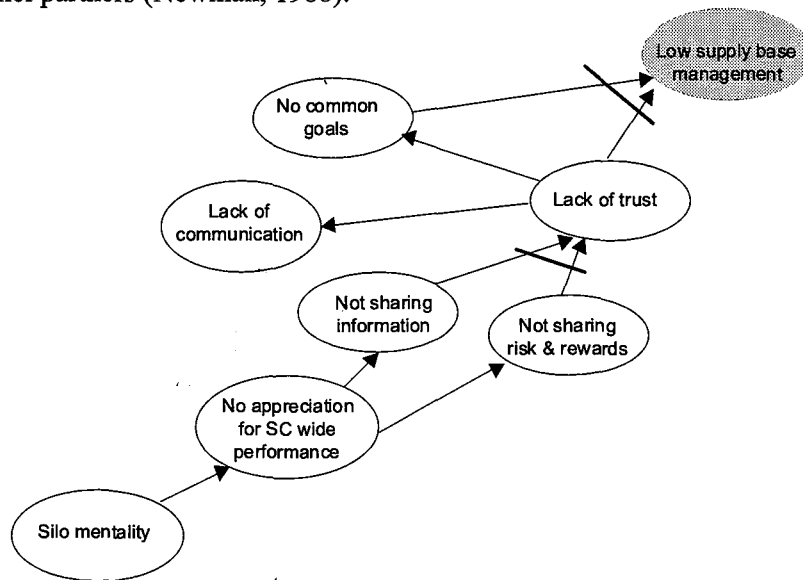


Figure 4: Causal relationships based on supply base management

## Environmental policy

Two adverse effects may result due to lack of environmental policy. One is the direct effect on cost of running businesses through low usage of recycled resources and the other is the indirect effect of degrading the local and global environment on customer satisfaction and market share (see Figure 5). Today, many researchers are in agreement that the environment makes a good business sense, it's an opportunity rather than a threat (Porter and Van der Linde 1995; Shivastava 1995, Hutchinson 1996). Using numerous case studies, Eden (1994) demonstrated that there is compatibility between environmental and business goals. By considering the environment in the design stage of its products, Xerox improved its ability to recover and reuse parts for future equipment. Implementing an end-of-life equipment take-back policy, Xerox's European operations saved over \$80 million in 1997 (Maslennikova and Foley 2000). Recently, several European countries have enforced environmental legislation, making producers with responsibility to take-back products at the end of their life cycles (Cairncross 1992).

A pressure to take environmental aspects into account through legislation is not the only concern for companies, a 'green' image has become an important marketing opportunity. Thus, it is imperative for companies to revisit their supply chain performance metrics in response to growing external institutional pressure and customers' environmental requirements.

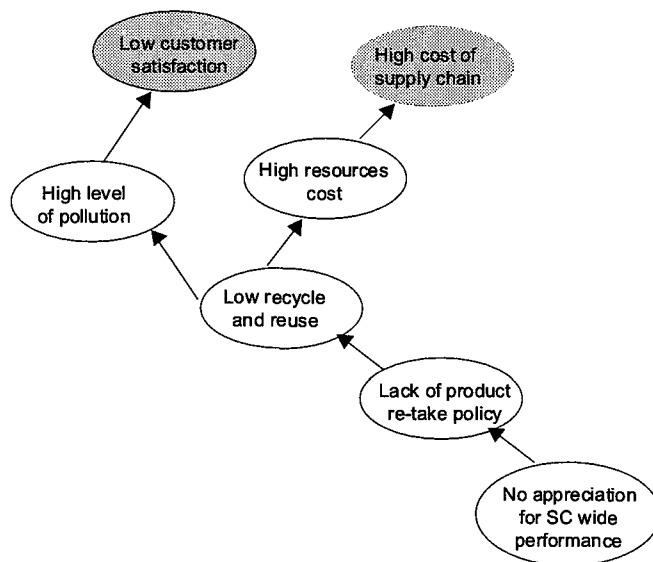


Figure 5: Causality due to lack of product re-take policy

## The big picture

The conceptual map called CRT immersed out of the group model building exercise is shown in Figure 6. In addition to the five undesirable effects (UDEs) identified by the groups, four other UDEs have been identified the model building exercise. These are responsiveness, flexibility in supply chain, incomplete orders, and percentage of products recovered, recycled and reused. All four measures are non-cost measures of supply chain performance and are related to customer satisfaction.

Responsiveness and incomplete orders have frequently been suggested in the literature as measures for supply chain performance (Altiok and Ranjan 1995; Cook and Rogowski 1996). Responsiveness can be considered in terms of response time and on-time delivery (Beamon 1999) whereas incomplete orders can be considered as fill rate (Beamon 1999).

The measures such as flexibility, and recovery and reuse rates are seldom used in supply chain analysis. Flexibility can measure a supply chain's ability to accommodate variety, volume and schedule fluctuations from the chain participants such as suppliers, producers, and customers. Since the supply chain exists in an uncertain environment, Beamon (1999) emphasised that 'flexibility is vital to the success of the supply chain' (p. 284). The use of recovery and reuse rate as supply chain performance measure is a recent phenomenon (Maslennikova and Foley, 2000). Countries of European Union (EU) have enforced environmental legislations, charging manufacturers with responsibility to take-back products at the end of the life cycle. The EU Producers Responsibility Obligations (packaging waste) Regulation, 1996, is required governments to ensure that they recover 60% of packaging waste by 2001 (McIntyre et al. 1998). Researchers identified two types of motivations, for companies to engage in product take-back process: economical and environmental (Fleischmann et al. 1997). These issues are intertwined, as Fleischmann et al. (1997, p. 3) pointed out that 'increasing disposal costs make waste reduction more economical, and environmentally conscious customers represent new market opportunities'.

The core problem seems to be lying with management (Figure 6). Due to their silo vision, management of many organizations fail to see and appreciate the importance of system wide performance measures. Several other factors (causes) which may effect the performance of supply chains include communication, trust among channel participants, investment and usage of IT, common goals, coordination, product-process design without SC consideration, lack of appreciation for SC wide performance measures, sharing risks and rewards, supply base orientation and inadequate definition of customer service. Many empirical and case studies have identified some of these factors. For instance,

Power et al. (2001) found that ‘more agile’ supply chains are more customer focused, have greater involvement with suppliers and better utilise information technologies compared to the ‘less agile’ supply chains. Many have suggested channel-wide management of inventories (Cooper and Ellram 1993), coordination, shared visions, reduced supplier base (Cooper and Ellram 1993; Shin et al. 2000), and fair sharing of risks and rewards (Handfield and Nichols, Jr. 1999) as characteristics of integrated SCM.

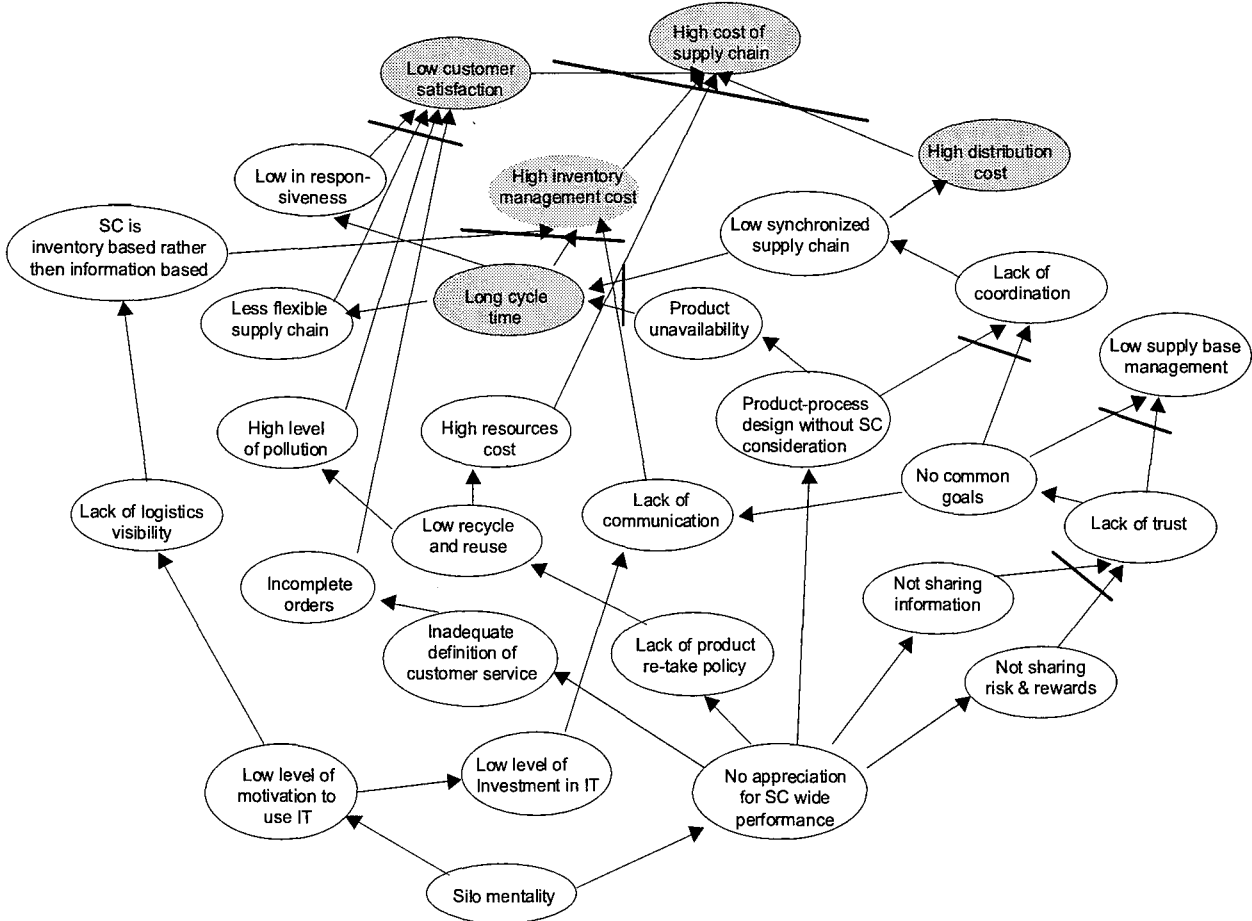


Figure 6: A CRT for a supply chain system

This study identifies not only the critical success factors in supply chain, but also the causal relationships between these factors. Management can use these relationships to develop growth strategies for their companies. However, these relationships need to be tested by large-scale empirical studies (Dunn et al. 1995; Mentzer and Flint 1997).

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# Complex Clusters in Local Environments: Investigating Triggers for Engagement

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## ABSTRACT

*This research investigated the early stages of research as experienced by both students and staff. The aim was to capture the complex clustering patterns of triggering factors associated with students' migration from a state of confusion to a state of knowledge. A methodological model, Context-dependent Cluster Model (CDCM) has been derived from Soft Systems Methodology (SSM) and complexity theory. CDCM was used to develop and interpret a conceptual model of the system at the micro level of the initial phase of the research process for students. A qualitative study was conducted and descriptions were gathered from individuals across three groups: new staff researchers and two distinct postgraduate student groups. Content analysis of the descriptions indicated that individuals in each group display multiple triggers that are context-dependent.*

Keywords: Complexity Theory, Soft Systems, Systems in Education, Student Research Process, Emergence

## INTRODUCTION

This paper explores initial reactions to undertaking research in a formal study program. It is aimed at capturing triggers associated with students' migration from a state of *confusion* to a state of *knowledge*. The theoretical underpinnings for this study are based on the seven-stage soft systems methodology (SSM) (Checkland & Scholes, 1990) and the application of complexity theory (CT) (Stacey, 1996) to human activity systems (HAS). Traditional SSM fails to capture emergent properties at the local environment. CDCM in both the theoretical and application domain has the ability to capture these emergent properties. In this particular study, the emergent properties are the trigger factors that are associated with students who are new researchers.

The catalyst for this study is the need for research into the informal and complex issues surrounding new researchers. There are numerous prescriptive texts available providing advice to students on the early stages covering such topics as what is research, research problems, topic definition, research ethics and research questions. There is literally a plethora of tools, techniques, structures and processes available to students with the explicit intention of guiding or facilitating the process (Bouma, 2000, Creswell, 1994, Locke, Spirduso & Silverman, 2000 & Zikmund, 1997). There are also a number of studies in recent years concerned with the question of how to support research students through the process in either the manner in which we teach research or the manner in which we structurally support the process. These studies are attempting to identify how academic staff can improve teaching or how institutions can improve infrastructure support.

In 1997 major US survey was conducted on all research institutions offering masters postgraduate courses to the nursing profession (Bower et al, 1999). The premise for the study was that postgraduate students indicated a general fear and dread of the research component of the course.

This study provides both an institutional and a faculty perspective for a large sample engaged in formal research. The study takes the approach that what is delivered to the students is the research process. Standard research tools techniques and methods were surveyed. However, a review of the key professional organisations and education organisations which influence nursing education indicated that there is no agreement on how master's level students should be taught the research process. There was general agreement on many of the key issues, such as defining a topic, but a lack of agreement on the issues at the micro level. This study commented on the key differences between program delivery that included supervision, individual/group work and participation. This study is silent on the voice of the student in the research process. These differences are only identified and not considered in light of the fear of conducting research. We are left wondering if any nurses ever move from dreading the subject.

The predominant culture enveloping postgraduate research students in educational institutions is designed around a system that has formalised the research process. Improving the quality of research and research training is increasingly becoming an important part of an institution's strategic direction. Not only is it a faculty or department concern but institutional wide postgraduate centres dedicated to improving the research experience are a common organisational unit in a University. The formal structures are typically designed to monitor the progress of higher degree research students during their period of enrolment. They attempt to develop a research culture and provide support services for student conducting research in masters and doctorate programs, often through various courses, seminars and workshops designed to improve research skills. Institutional assistance for postgraduate research is grounded in the formalities of rules, policies, structures and ethics.

There seems to be a paucity of research in understanding how students can improve their own research inquiry process. Much of the research process is largely about students working through issues from their own perspective – it is self-directed inquiry. Central to this paper is the way in which the new researcher experiences the early stages of research. The various tools, techniques, strategies and support mechanisms are all catalysts. There is a lack of understanding in the research community about the combination of these catalysts and their impact to enable students to understand their own research inquiry.

### **Soft Systems Methodology Modified - Context-dependent Cluster Model (CDCM)**

CDCM is underpinned by both SSM (Checkland & Scholes, 1990) and CT (Stacey, 1996).

The following summarises the changes to the 7 SSM steps:

Step 1 *problem situation unstructured* remains the same.

Step 2 *problem situation expressed* remains the same.

Step 3 *finding root definitions for relevant systems* is applicable for a macro view of systems. In CDCM this step is modified to *explore local clusters* of responses.

Step 4 *extracting conceptual models from the root definitions of relevant systems* also needed to change to align with these local clusters. In CDCM local peaks of responses to perceptions are regarded as individual conceptual models. The formation of these local clusters has been informed by an interpretation model based on the idea that clusters occur in local peaks within complex systems. More importantly, core systems concepts - communication, control, structure and emergence (Checkland, 1984) also underlie these local clusters.

Step 5 then becomes interpretation of step 2 with the model devised in step 4.

Step 6 Results of this interpretation expose the emergent and possible changes of step 6.

Step 7 then becomes the possible multiple actions to improve the problem situation some of which may be in conflict. This is described in CT (Stacey, 1996) as 'walking on the edge of chaos'.

### **Research Context - The Problem Situation Unstructured (step 1)**

Higher learning institutions including universities, polytechnics and institutes of technology are currently undergoing many changes with regards to postgraduate research. In many cases improved support for postgraduate students has become an institutional wide issue. A study by Ballantyne (2000) collected information to enable institutions to improve decision-making in postgraduate research. The findings are useful for an institution attempting to improve its structural support, for instance in facilities, funding and department staff. This study did not peel away at the layers of the research experience from the student's perspective- it was asking students to focus on the macro environment and do not consider the micro environment. In many ways the study was about the physical and tangible support mechanisms and very little was aimed at understanding the intangible. This study did not differentiate the stages of students' experience. Respondents of the survey were at all stages of the research process; there were those who were still in the very early stages, those who had come through presentation of early concepts and their proposal, those who had begun fieldwork and those who were almost finished. There is enormous variability of student experience and this is not reflected in the study.

This type of study is indicative of the current focus on developing formal policies and procedures within research management and strategic plans to indicate that support, facilities and research training is forthcoming. Such a formal system is inextricably linked to the current grants, scholarship and funding models. Blum (1995) suggests that the pervading culture in the US does not support fundamental discovery and challenge in the early research process. The dominant research culture is a formal structure aimed at grants and peer reviewed journal articles and therefore many of the 'real' research questions are not being asked. Such formal structures reflect a macro or top level approach to improving postgraduate research experiences and are an important part of the total system. However the micro level that considers student-centred experiences and the research process is often neglected.

The research training within this paradigm has flowed from these structures. According to Bawden (1985) when discussing the Australian system of undergraduate education our 'entire formal education system has been grounded in the belief of learning as the passive accumulation of preserved quanta of knowledge, generated from experiences often long forgotten and certainly remote from the contemporary student. The model forces an awful reliance on both the aggregation of specialised and selective packages of second-hand information and on those who disseminate it to us in the name of teaching'. Although speaking about education in the generic sense and particularly the undergraduate student system – it is suggested that the same belief patterns appear in the education of researchers in postgraduate degree programs, particularly the coursework postgraduate degrees and the research thesis or project.

Although there is much guidance as to what the steps are and what tasks are to be completed it is essentially not a task-oriented problem. Each research study is typically different and is associated with a different research problem within its own complex environment. Each study has complex concepts to be dealt with. Flower (1993) describes the writing of a thesis as a problem-solving task. As such it forces a self-directed approach to learning upon students.

The relationship between self directed learning and research performance in higher degree students is an interesting concept taken up by Kenley (1998). Although he has no empirical evidence to support the proposition, he provides an interesting model of students who flow from disinterested to motivated researchers. He suggested that 'the flow of students through to higher degrees would be enhanced through the provision of self directed learning prior to teaching research skills.' What is interesting is that the premise that students move from being disinterested research students following undergraduate degrees, through to disillusioned research students after some research training to motivated research students following the completion of their higher degree. This migration pattern is an important concept and not dealt with in the literature in any empirical manner. An important part of the research process of a research project is the early stages whereby the nature and aim of the research problem is established. Defining exactly what is to be studied and the significance of the phenomenon requires intensive critical thinking.

An experienced researcher has an intensive period grappling with the many constructs even although they have a skill base upon which to draw. Inexperienced researchers are learning both skills in research and how to train their mind to think as researchers. The combination of teaching and developing both research skills and critical thinking abilities is important in the early stages of the research process. Kiley & Austin (2000) note that students should have mastered research skills including reasoning and critical analysis during their undergraduate years, although many do not.

Many writers have noted what a difficult and unpleasant experience the research process has become. Little is understood about the struggles from the student's perspective. Baja (as cited by Bower et al, 1999) argues that the expectations of supervisors from the thesis and the lack of experience of students in research methodology and thesis preparation makes it an unpleasant experience for students.

### **The Problem Situation Structured (step 2)**

To begin to understand the problem within a particular institution, research has been carried out in a medium-sized institute of technology in New Zealand eager to attain University status. Much organisational emphasis and effort has been exploited in providing a Graduate School within the institution, postgraduate degrees, upgrading staff qualifications and attracting large numbers of postgraduate students. Staff are present in large numbers as students in postgraduate classes. Teaching staff from other institutions also swell the postgraduate student numbers.

This study investigated the early stages of the research process as experienced by both postgraduate students and staff at this institution. Data for this study was gathered using a one-page *survey questionnaire* that was distributed to two cohorts of students enrolled in a postgraduate course and to new staff researchers. The students were from either the Masters of Computing or the Masters of Business Innovation and Entrepreneurship in the Faculty of Business. The research project was between 50-65% of the total course assessment. The early staff researchers were employed in the School of Information Systems and Computing.

The sample included 63 new researchers. The term questionnaire survey is used loosely in the context of this research as no statistical analysis was carried out. The written response was considered appropriate to gather reflections from the early researcher. It was also considered a useful mechanism to assist the consistency across the two investigators. The research is concerned with capturing rich descriptions or key phrases from the respondents. The comments from each study participant were then extracted and a content analysis was conducted on the responses of individual students.

### **Research Methodology - Forming Relevant Theoretical Systems (step 3)**

In CDCM each individual is considered within their own local domain. This is a major departure from developing root definitions for relevant systems as is done in SSM. In CDCM it is more appropriate to consider individuals in their local context as opposed to the macro level for HAS.

Theory development and data analysis and interpretation for this study was complex cognitive task. As the number of interpretative content analyses increased with attempting to apply the original SSM model so the frustration level grew in failing to elicit the expected results. It therefore became necessary to develop CDCM to consider clusters of individual responses within a local domain. This theory formation was informed by the content analysis method used, repeated attempts at trying to interpret the problem situation expressed with domain-grouped responses and intuition. There was some trial and error to discover what theoretical framework would apply best. Initially it was thought that applying SSM to the problem situation would show the emergent triggers. When individuals' triggers did not emerge from the initial content analysis states of confusion and frustration were experienced. The cognitive process of developing a new theoretical model mirrored the obstacles being experienced by new researchers in the study. From a process of searching, analysing, reflecting and distancing the new model began to emerge for the writers. When CT principles were also considered CDCM finally emerged as an intuitive whole. Looking at the use of CT applied to HAS (Stacey, 1996) led to considering the use of multiple factors as triggers. Chait (2000) suggests that CT

is more suited to considering systems at the micro level. Applying content analysis (Potter, 1999) to clusters of words and/or phrases in the data allowed inferences to be made by the writers about these new researchers. Emotional state, level of learning maturity, position in the continuum from disengaged to engaged in the research process and the number and nature of obstacles and triggers to engaging in research emerged from the content analysis. Earlier work (Fielden, 1996) on depth learning and intrinsic motivators also informed the theory formation and interpretation. The content analysis performed on groups of words and phrases showed that it is clusters of intrinsic motivators that are the triggers for engaging in the research process. An individual's cluster is dependent on her/his local research community, and may be different from one person to the next both within local environments and in the population of new researchers as a whole. McKenna (1999) suggests that individuals draw their own inner complexity maps. This is consistent with individual clustering of obstacles and engagers. When the total number of clusters is greater or equal than the total number of obstacles for an individual then engagement has happened. One postgraduate class was motivated by talking with people while the other postgraduate class was more motivated by interacting with technology and following literature threads. New staff researchers were struggling with the perception that research was an onerous task for them and that they did not have the time to put into the activity. They were ready to place responsibility for their inability to engage in research on others.

Not only has the data been used to inform the theory-making process, but also to look for possible actions within this particular problem situation for individual new researchers within their own research community.

#### **Conceptual Models from Complexity Theory and Systems Core Concepts (step 4)**

In the original SSM Checkland (1984) draws on formal systems concepts (control, communication, hierarchy and emergence) and other systems thinking to extract the core ideas from step 3 to develop conceptual models. In CDCM conceptualisation is informed by the application of CT to HAS as well as core systems theory (ST) concepts. The most important core concept from both ST and CT is emergence since it is emergence that flows through into subsequent steps in CDCM.

One of the key issues in SSM is the construct of emergence as an explanatory construct (Bechtel & Richardson (1993). Emergence is the principle that whole entities exhibit properties that are meaningful only when attributed to the whole, not to its parts. Every model of a human activity system exhibits properties as a whole entity that derive from its component activities and their structure, but cannot be reduced by them. In the study of complex systems, the idea of emergence is used to indicate the arising of patterns, structures, or properties that do not seem adequately explained by referring only to the system's pre-existing components and their interaction.

Complex systems are when:

the organisation of the system, i.e., its global order, appears to be more salient, and of a different kind than the components alone;

the components can be replaced without an accompanying decommissioning of the whole system; new global patterns or properties are radically novel with respect to the pre-existing components; thus, the emergent patterns seem to be unpredictable and non-deducible from the components as well as irreducible to those components.

The applicability of emergence as an explanatory construct forms a continuum. On one end, the system can be sufficiently understood by an appeal to the components and their interaction alone. Whereas, at the other end, an appeal to components and their interactions is simply not very useful in understanding the dynamics of the system as a whole. Most systems fall somewhere between these two extremes, it is usually not the case that turning to emergence entirely supplants the need to also take into consideration the components and their interactions. Issues involved in using emergence as an explanatory construct include:

How causality is to be understood in such systems;

The question of whether emergence is ever more than a provisional heuristic device to be replaced when there is more knowledge of the components and their interactions; and  
 What general laws or principles can be discerned in the emergent patterns, structures and properties.

Kelly(1999) suggests that many intricate and fascinating patterns emerge from a few simple maxims such as 'Going with the flow is easier than swimming upstream' and 'Where fear exists deal with that first'.

Group rules for emergence that have been observed in this study include: generating collaborative energy or trust; openly sharing information and learning; deep personal commitment to aligning the individual with the group; co-ordinating co-evolution; self-discipline and self-responsibility and emerging synergy. Chait(2000) identified that CT has more application at the micro level. In this study on new researchers for this particular problem situation it was discovered that at the micro level there were local peaks of responses that could be extracted from step 3 for the emergence of both engagers and obstacles to the research process. Table 1 summarises the responses into those respondents who migrated from disengaged to engaged in the research process by their category. For this particular problem situation it was discovered that there were local peaks of responses that could be extracted from step 3 for the emergence of both engagers and obstacles to the research process.

**Table 1**  
**From Disengaged to Engaged in the Research Process**

Obstacles>Engagers	SISC	MCom P	MBIE	Engagers>Obstacles
Not Engaged		3	3	
Overwhelmed	4	3	1	
Onerous	1			
Overwhelmed+Onerous	1			
Confused, Daunted, Panic		1	10	
Frustrated		4		
Disengaged->Frustrated		3		
Excited->Overwhelmed	1			
Confused->Learning	1	2		Confused->Learning
Confused->Interacting			3	Confused->Interacting
	1			Confused->Application of ideas
		2		Frustrated ->Learning
		1	1	Frustrated->Action
				Frustrated->Interaction
		1		Ignorance->Learning
		1		Disengaged->Learning
	1		1	Learning
			4	Learning+People interaction
	4			Excited+Overwhelmed, Nervous, Worried, Afraid
		1		Overwhelmed->Own system
	3			Excited, Intrigued, Enthusiastic
	1			Linked research->Industry
	1			Linked research->literature
			1	Enthusiastic->application of ideas
			3	Excited by people
		1		Engaged with literature+people
		4		Totally Engaged

## **Findings - Interpretation of the Problem Situation Expressed with Theoretical Conceptual Models (step 5)**

In CDCM the *problem situation expressed* is interpreted with the *conceptual model developed at step 4* rather than *comparison of step 2 with step 4* as in the original SSM.

The research process was triggered as shown in table 1 above when:

The number of engagers on a cluster are greater than the number of obstacles (see table 1 above);  
Recognising the importance of engaging with initial confusion;  
Becoming aware of the learning process from disengaged to engaged as a complex process;  
Recognising that clusters of engagers are context dependent;  
Recognising that while there are context dependent patterns that an individual's cluster may lie outside the context-dependent cluster;  
Clusters of intrinsic motivators are the engagers; and  
Individual as well as whole class engagement is important to boost self-esteem in a complex learning process. Individual research proposal meetings were held in one of the postgraduate groups but not in the other groups. These meetings appeared to boost individual self-esteem.

New staff researchers describe in their cluster of inhibitors to engaging in the research process a lack of research skills coupled with time. Those new staff members who had engaged in the research process displayed multiple intrinsic motivation factors. Bower & Timmons (1999) in their survey on nurses engaging in the research process also found that nurses were overwhelmed at the thought of engaging in research. In all groups the researchers who had engaged in the research process displayed multiple intrinsic motivation factors.

## **Emergent and Possible Changes (step 6)**

In CDCM Step 6 becomes emergent and possible rather than feasible and desirable changes. This allows for diversity at the micro-level. Emerging and possible changes are to:  
Expose new researchers to chaotic situations as part of the learning strategy. For instance, expose new researchers to many research tools, techniques and strategies;  
Raise the level of awareness for individual new researchers to chaotic states in the early stages of research;  
Facilitate early stages of research through the stages outlined in figure 1 from overwhelm through confusion to frustration;  
Normalise negative emotional states to chaotic states in the facilitation process;

Experiencing chaos is essential for the research process to start. Engaging in chaos-inducing exercises, a supportive learning environment and developing skills to deal with negative emotional states all form part of the new researcher's individual tool kit to start to engage. New researchers thus develop their own cluster of intrinsic motivators and the own cluster of obstacles.

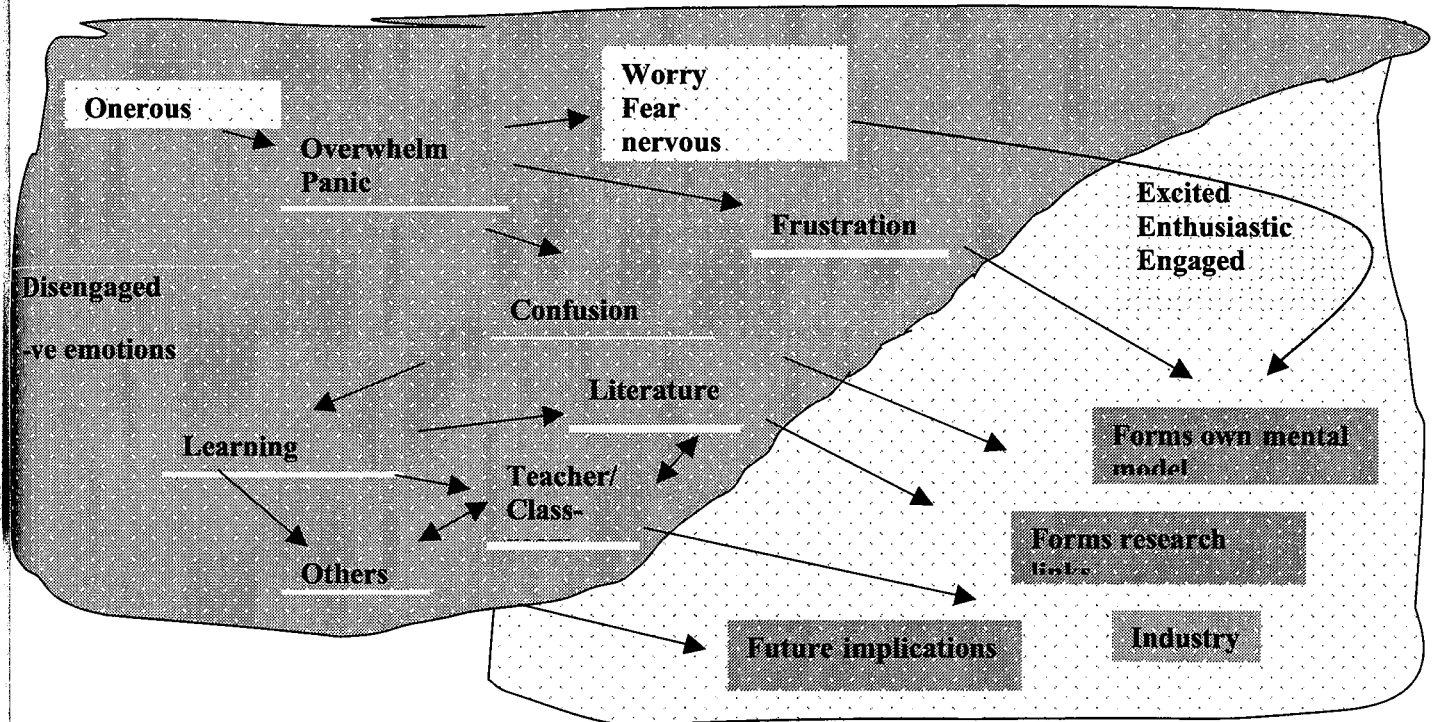
Full and rich engagement with the complexity of the research process occurred for those new researchers who engaged in multiple ways (had larger clusters of engagers) and who learnt in community with others. Those students who remained in isolation and who did not utilise the multiple communication channels provided had fewer intrinsic motivators and they were more likely to stay in a state of chaos overlaid with negative emotions

## **Future Implications - Possible Multiple Actions for Problem Improvement (step 7)**

In CDCM the emphasis is on possible multiple actions for problem improvement. These may be in conflict and may induce or encourage states of confusion and chaos. In CT (Stacey, 1996, Merry, 1995, Plsek, Lindberg & Zimmerman 1997) all stress the importance of initial conditions for multiple actions to emerge. In establishing an environment conducive to allowing the research process to be triggered, exposure to chaos through process design is essential. From the facilitator's point of view it is important to realise that new researchers will be overwhelmed, confused and frustrated. They will have negative emotions. This is a normal part of the process. Being aware of the complex patterns of

engaging in research allows for these early stages to emerge. Stacey (1996) also stresses the importance of allowing the shadow (informal) system to operate. This is supported in a community of new researchers by an environment in which multiple communication patterns may occur. Whole-class discussions and small group interactions are all provided within the research environment as a safe medium in which the shadow can operate. Realising that each learning community has context-dependent clusters of triggers to engage means that the facilitator can adapt both the learning style and environment to encourage local emergence.

Figure 1



## CONCLUSION

In this paper CDCM has been developed in which there is better alignment at the micro level for a HAS than in the original SSM model. Exciting results from applying this modified SSM to a problem situation suggest that becoming engaged in the research process is complex, context-dependent and happens in community with multiple communication channels. Four important findings are that intrinsic motivators are primary engagers, entering into a state of confusion should be viewed as an important early step in engaging in research, engagement is more likely to be triggered in community and individual, context-dependent clusters of triggers are required.



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# Consensus Building through Systems Thinking The Case of Policy and Planning in HealthCare

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## ABSTRACT

*This paper discusses a methodology and a case study using qualitative system dynamics to create consensus, team learning and shared vision in a public organisation. The case involves determining planning priorities for a Division of the Ministry of Health in New Zealand, leading to the creation of a business plan.*

*The methodology involves Systems Thinking using Group Model Building (GMB) - A three-step process starting with structured brainstorming using the partial KJ (Jiro Kawakita) technique to identify priority areas and then clustering them into 'affinity' groups. Next, the priority clusters are used by the participants to construct causal loop diagrams representing 'systems of priorities' (in contrast with list of priorities). Finally, through a group process, leverage points or key priorities are identified as the basis for a business plan. While the above process was well agreed upon by the participants at the outset, strong group resistance was encountered when managers attempted to reduce the number of priority areas. Systems thinking approach was used to create consensus and the commitment to the outcome.*

*The GMB approach offers significant promise in using qualitative system dynamics with non-systems experts. The methodology can be applied to change management initiative and complex decisions such as restructuring, reengineering, and supply chain design. The expected outcomes are greater commitment and shared vision.*

*Key Words: Group Model Building, Team Learning, Consensus Building, Qualitative System Dynamics, Change Management, and Planning*

## INTRODUCTION

The case study reported here is based on a Ministry of Health (MoH) project involving operational and business planning for one of its Divisions. The Division employs staff with diverse professional and policy backgrounds and varying periods of tenure with the Division.

The main question of the planning exercise was the selection of key priority areas (6-7) to focus the limited resources and efforts of the Division. While the project brief required the use of systems thinking approach, it also specified that this had to be conducted in an indirect and implicit manner. Given the short time periods allotted for planning workshops and the lack of familiarity of the participants with systems thinking modelling, this posed a significant facilitation challenge. Therefore, in consultation with Division manager, a series of workshops were designed to accommodate Division's requirements. This paper describes the policy and priority setting process for this Division and highlights the use of Systems Thinking modelling to transform contentious issues into mutual agreement and commitment. Before the process is described, a brief review of relevant literature follows.

## LITERATURE REVIEW

Lack of commitment to decisions is often a key factor in resistance to policy change and organisational initiatives. As the experience has shown, Change Management projects are fraught with stories of resistance to change, sapping morale and adverse consequences in organisations. The likelihood and magnitude of the adverse consequence are greatest where divergent groups, ie, different Divisions, department or units are involved.

'Messy' problems are defined as situations in which there are large differences of opinion about the problem or even on the question of whether there is a problem (Ackoff, 1974; 1979). Messy situations make it difficult for a management team to reach agreement. System Dynamics (SD) modelling with groups known as Group Model Building (GMB) is a powerful tool for dealing with these. SD and GMB are especially effective in dealing with semi-structured and ill-structured decision situations.

GMB offers an opportunity to align and share piecemeal mental models (Huz et al. 1997) and create the possibility of assimilating and integrating partial mental models into a holistic system description (Vennix 1995; 1996). GMB and SD can help uncover 'illusions' that may occur due to the fact that the definition of a problem may be a socially constructed phenomenon that has not been put to test.

Vennix (1999) identifies two sources of messy problems, namely, the individual, and the group/team that give rise to the existence of messy situations. Limited information processing capacity (Vennix 1990), and perceptions and reality constructions (Schutz 1962) are the main contributors to the individual sources of messy problems. Increasing the information processing capacity not only affects the dynamics of a system but also its causal feedback structure (Dorner 1980). One of the implications of this individual source on GMB is that both qualitative and quantitative modelling are important (Coyle 1999; Vennix et al. 1993).

The group sources of messy problems relate to deficiencies in group interaction, and the self-fulfilling nature of reality construction in groups. People not only construct reality in their minds, but their behaviour also causes their mental model to become reality in their environment. Deficiencies in group interaction are in the form of mixing up of cognitive tasks (Rogers & Roethlisberger 1988), lack of critical investigation (Janis & Mann 1977), and the way team members communicate (Argyris, 1990).

The above points highlight the need for a group facilitator in the GMB process. A facilitator is a person who acts as a 'role model' for the group, a person who can avoid the common deficiencies in group interaction, which negatively affect the quality of the decision (Vennix et al. 1993). Systems

thinking interventions will be much more effective if SD and MB tools are skilfully combined with adequate facilitation (Senge, 1990).

Critical characteristics of an effective facilitator include a primary concern with procedure and process and only indirectly with the content, i.e. with the how rather than what. Both attitudes and skills are important characteristics of the 'ideal' facilitator (Vennix 1996,1999). Some of the facilitation attitudes are a helping and inquiring attitude (asks questions rather than provide answers), which, at the same time is neutral with regard to the content of discussion. A facilitator should be able to foster reflection and learning in a team by discouraging defensive communication, while maintaining his/her own integrity and authenticity.

Other important facilitation skills are a thorough knowledge of SD and MB as well as group process techniques. The latter requires an awareness of the existence of various cognitive tasks that a group can encounter. Conflict handling and efficient two-way communication are other important facilitation skills (Vennix 1999).

Group model building need not lead to model quantification and simulation. Vennix (1999) argues that, due to existence of persistent cognitive and social barriers to learning (Argyris 1990; 1994; Senge 1990), simulations are not ultimate solutions. In fact, quantification will either add to understanding the issue or will be dangerously misleading (Wolstenholme 1992; 1999; Coyle 1999). Active construction of the model is just as important as playing it. Thus, it is important to recognise that in a number of cases it is not always useful or even desirable to go through the whole model-building cycle.

In summary, when conducting interventions through GMB, one should be aware that cognitive limitations, differences in perceptions (leading to multiple realities) and ineffective communication patterns (which block productive discussion of these multiple realities) play a key role in the success of the intervention. At the educational level, this requires teaching facilitation skills and group dynamics in SD programmes to engender appropriate attitudes and skills for effective GMB facilitation (Haslett et al. 1999).

The following sections describe a case study using group model building and facilitation in a real life situation.

## **ISSUES IDENTIFICATION AND METHODOLOGY**

The first step in the Division's priority and planning process was to establish a common ground and create a *safe* space for group dialogue. This required a shared understanding of what the real and perceived barriers to progress were. The key issues arose out of an initial round of "Checking Ins" whereby the participants shared their thoughts and feelings about various issues. The methodology used in this step was a modified KJ or Affinity procedure. The methodology is described in Systems Thinking and Modelling (Maani and Cavana, 2000, p. 34):

The Affinity Diagrams method, also known as KJ, is a process of mapping creative group thoughts and ideas. The aim of this process is to allow new thought patterns and breakthroughs emerge naturally from a large pool of 'raw' ideas. The Affinity/KJ technique has three main applications:

- Formulation of vague problems
- Synthesis of non-numerical data (also called semantic or language data)
- Teamwork and consensus building.

There are 7 steps in constructing an Affinity Diagram.i

1. Assemble the right team
2. Phrase issues to be considered
3. Generate and record ideas (each on a separate card, or Post-it notes)
4. Randomly lay out completed cards
5. Sort cards into related groupings
6. Create header (or label) cards
7. Construct the Affinity Diagram by placing the headers and sub-headers (on top of the page) with all the cards beneath them. This should form a column for each cluster.

Using the KJ methodology the following question was posed for brainstorming.

**“What is preventing us from making faster progress?”**

A total of fifty ‘raw’ statements were generated (five per participant). The participants then clustered these statements into nineteen headings or key issues as shown in Figure 1. This exercise served as a lead or mental preparation for the next step, namely, identification of priority areas. The question of priority setting in organisations is often contentious as it implies trade-offs need to be made, hence creating winners and losers. Often, this results in open challenges and, even worst, silent resentments that lead to loss of commitment by individuals and groups. It is therefore critical that the issue of priority setting is managed in a systemic (holistic) manner.

## **PRIORITY SELECTION**

In the next step, a second workshop was devoted to the following question. The question was phrased as follows:

What are the priorities in health policy in terms of where the Division should be placing its greatest efforts?

Again the group used the KJ methodology to identify ‘raw’ priorities by each individual participant and then cluster these in fewer priority areas. The KJ method is very beneficial in this process. Not only it avoids awkward disagreements and contradictions, the method converges very quickly yielding visible group consensus. Furthermore, the participants often see the process as ‘fun’, adding another impetus towards teambuilding. Again as the group was diverse in terms of organisational hierarchies and professional backgrounds, it was important that no priorities were missed or reduced early on and prematurely. The KJ process thus ensured that all contributions were included. This process resulted in 42 ‘raw’ priority statements, which were clustered into 19 priority areas as shown in Figure 2.

As the management had desired to have only 6-7 priority areas, this seemed to be too large for any practical purposes. Therefore, it felt necessary to reduce the initial set of 19 to 6-7 areas. In order to proceed, a set of criteria was developed by the participants for priority selection. The group later refined these criteria. The final criteria list is shown in Table 1 below.

**Table 1 - Criteria for priority selection**

<b>1. Realistic – can we marshal the resources?</b> Is it reasonable and compatible with the Government’s direction/ political environment?
2. Impact – direct impact on Maori health
3. Quick visible results – within a few weeks or months (maximum 6 months)
4. Alignment – with Division's mission and other stakeholders
5. Fundamental cause – cause not symptom focus
6. Existing initiatives – capitalises on existing initiatives
7. Planning Horizon – short, medium or long

In order to minimise subjectivity, it was deemed pertinent to apply the above criteria objectively. It was agreed by the group to use a priority matrix to rank order the priorities. Thus, a scaled ordinal ranking of 1-5 was adopted where 1 indicated lowest priority and 5 denoted highest priority. It was also decided that, initially, relative weights should not assigned to the criteria. The group then proceeded to rank each of the 19 priority areas against the seven criteria stated above. The outcome of this process, or the priority matrix, is shown in Table 2.

According to the priority matrix, a clear set of rank ordered priorities emerged. As all the participants had agreed and freely contributed the process to this point, it was expected that top priority areas would be selected from the priority matrix. Contrary to this expectation, most participants showed strong resistance to this outcome! This was both surprising and enlightening. It is important to bear in mind that in groups where diversity of tasks and purposes are present this resistance exists whether or not it is voiced. In this case no individual participant was prepared to ‘let go’ of his or her area of work. Of course, at this stage it was possible for the manager to intervene and use her authority to ‘force’ or coerce the opposing ‘camps’ into acceptance. But it soon became apparent that any ‘reduction’ of priority areas would be counterproductive and damaging to the group’s integrity and unity.

## **FROM PRIORITY SELECTION TO A SYSTEM OF PRIORITIES**

To break this impasse, it was agreed to adopt *all* priority areas. However, this was an impracticable solution and contrary to management’s initial objective. At this stage, in order to resolve this apparent conflict we offered to use the systems thinking approach. The underlying philosophy of systems thinking is the primacy of the whole and relationships rather than the individual parts. It was explained that this concept was contrary to treating priorities as independent and isolated elements, as they were originally perceived. Rather, the group needed to view them as part of a priority *system*, where all priority areas were regarded as indispensable elements of the system (i.e., the business plan). In such a system, while all elements are important for the working of the whole, relative importance and ‘timing’ of the parts are nevertheless recognised and acknowledged. This is done through the identification of ‘leverage’ points in Systems Thinking. Thus, the group identified areas that were deemed to have a fundamental (or cause) effect on the whole as leverage areas.

In the implementation phase, the Division started with the ‘leverage areas’ first and as a team, thereby differentiating the priority areas by *timing* rather than perceived importance. These interventions in turn would introduce a positive chain effect in the system as a whole. This approach necessitated adopting a new mental model, which transformed the question of ‘priority selection’ from a reductionistic perspective to a systemic mind set. Having accepted this philosophy and approach, the group converted the priority matrix into several plausible causal loop diagrams (CLD) of priorities.

The group then chose one of the CLDs as their preferred one. This CLD is shown in Figure 3. It is interesting to note that the selection of the preferred CLD, unlike the previous priority selection case, was rather quick and unanimous. In this CLD (Figure 3), variables identified by 'L' indicate leverage points in the systems, where *earlier* attention and focus will be devoted.

## CONCLUSION

Contentious organisational issues, such as priority selection, program, policy and direction changes often create resistance to change and unspoken resentment. The conventional change management techniques are unable to cope with the dynamic complexity and unintended consequences of such actions. This paper illustrates the application of Systems Thinking and Group Model Building in a Division of the Ministry of Health in New Zealand. The driving question of the planning exercise was to determine a *reduced* set of priorities for the creation of the Division's business plan.

The methodology involved a three-step process: (1) brainstorming to identify key issues and priority areas, (2) developing a priority matrix, and (3) creating causal loop diagrams representing '*systems of priorities*' (in contrast with *list* of priorities). Using the priority CLDs leverage points or key priority areas were identified as input to the business plan.

The paper illustrates how Systems Thinking methodology could create consensus, team learning and shared vision in today's complex organisations. This approach helped transform 'piecemeal mental models' to shared understanding, acceptance, and commitment to resolving issues and the challenges facing the organisation.

Group Model Building offers significant promise in using qualitative system dynamics with novice users. The methodology can be applied to change management initiatives and complex organizational decisions such as restructuring, reengineering, and supply chain design. The expected outcomes are greater commitment, mutual acceptance and shared vision.

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Figure 1: Issues Clusters

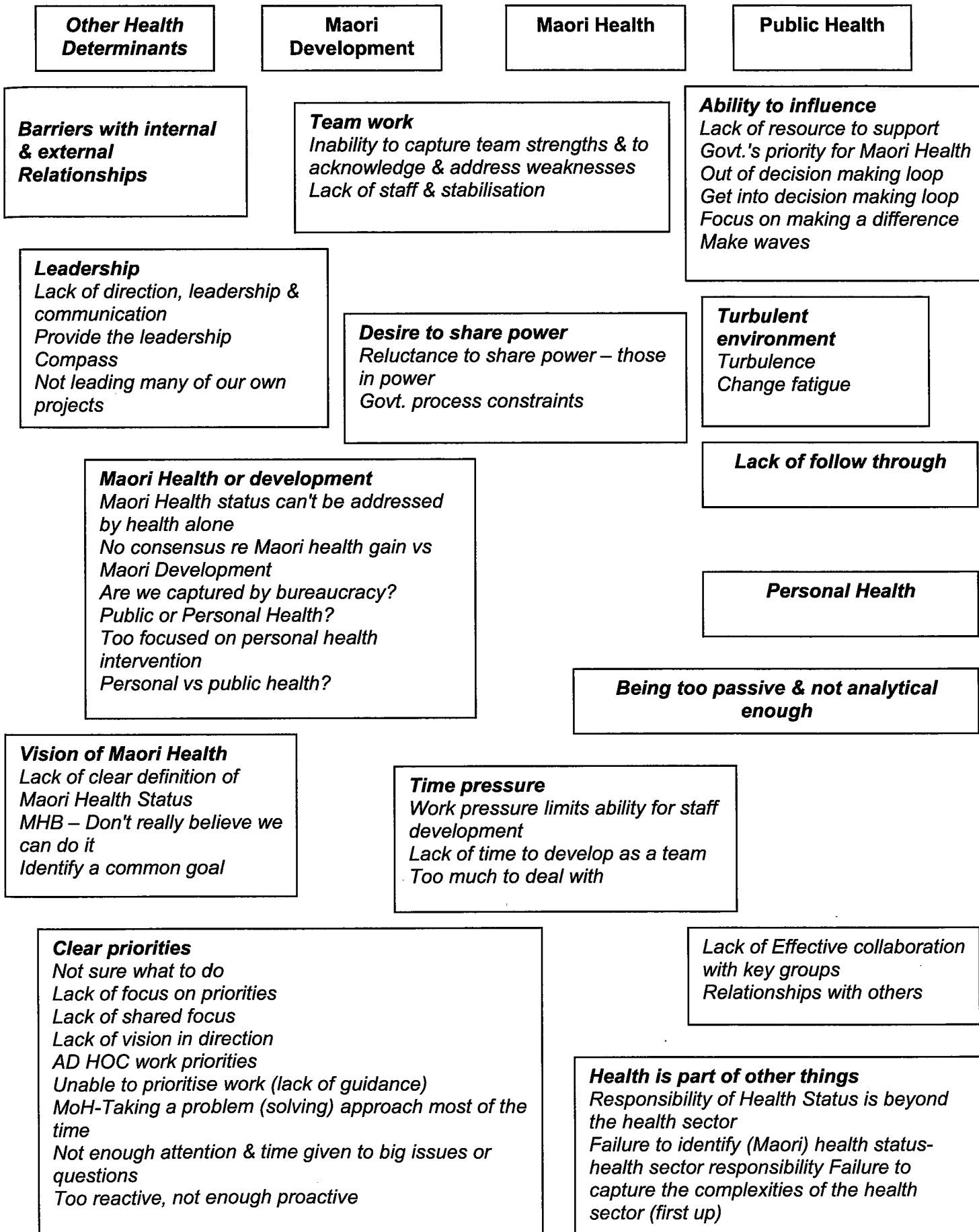
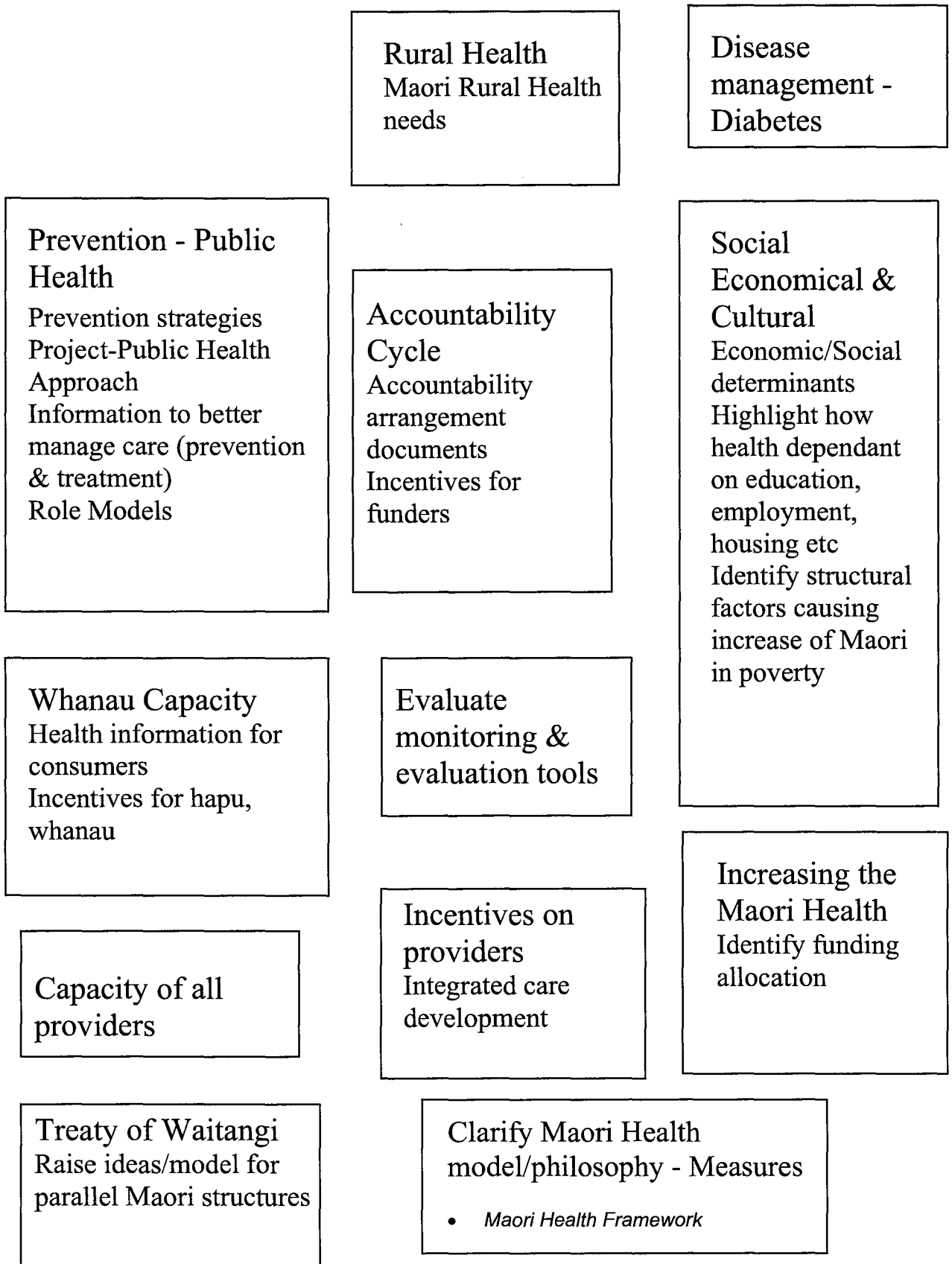


Figure 2 - Priority Areas



Maori Provider Development  
advocate funding (at least 5 years) for  
Maori Health providers  
Maori provider workforce development

Maori Workforce Capacity  
Maori Workforce  
NZMC Rep-MoH  
Establish Maori advisors in each  
Branch of MoH

High Priority Diseases  
Biggest Killers  
Most Common Morbidities  
Diabetes  
High Priority Health issues  
affecting Maori

Health Service-Access Barriers,  
\$, cultural, geographical  
-Research, Service utilisation by  
income levels

Child & Youth  
Youth Health  
Maori Youth, Mental Health,  
Suicide profile  
Child Health  
The Future - Nga Tamariki  
Tamariki Ora focus yr 1

Communication & Relationship  
& Collaboration  
Maintaining communication with  
Providers  
Support Maori Providers  
Manage relationship with HFA - on  
Maori Health  
Regular MoH Publications - Health  
sector developments  
Collaborate with HFA, TPK,  
Treasury, Social Services etc...  
Stakeholder collaboration  
(effective)

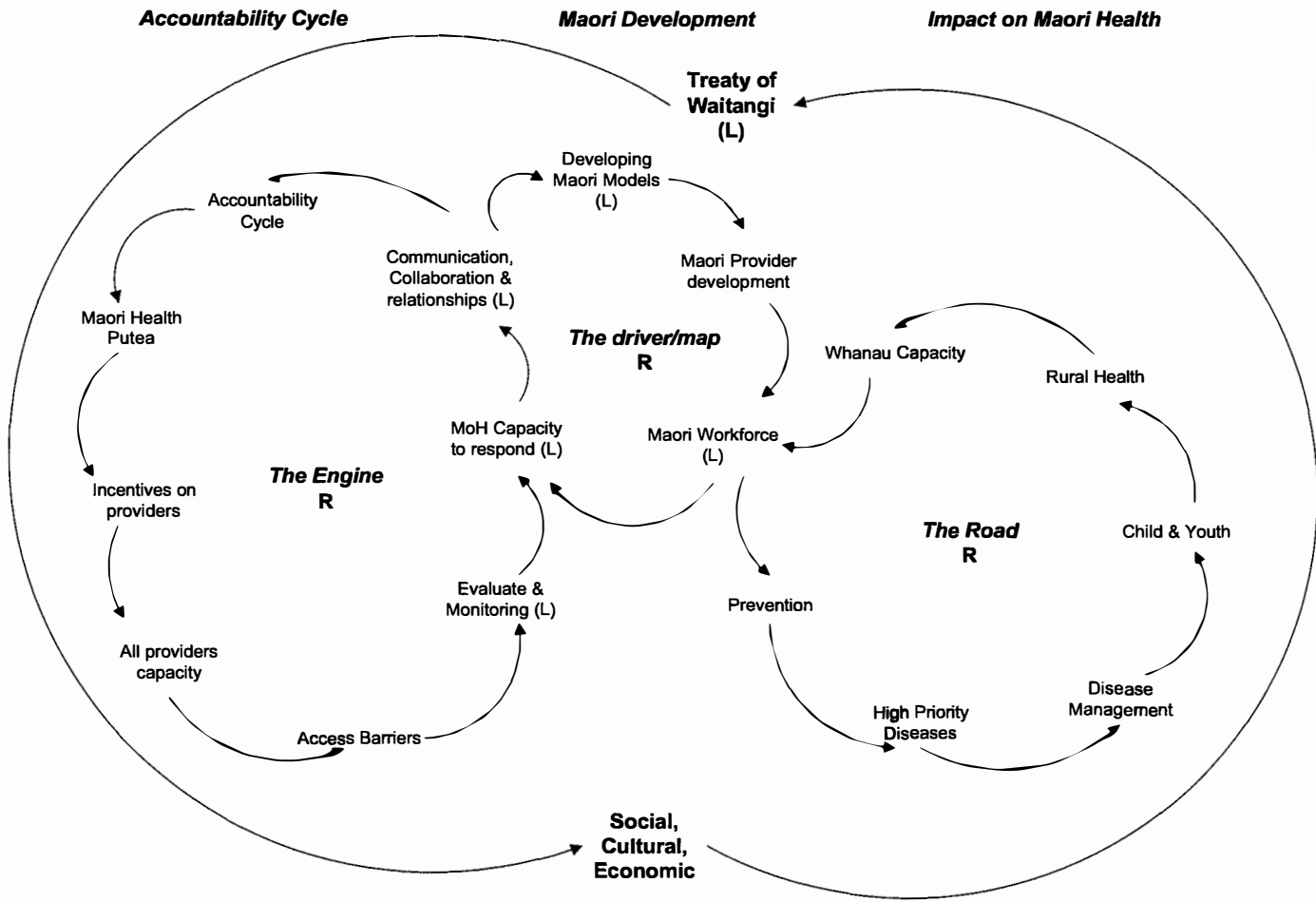
Capacity & Capability of  
MoH to respond  
TPK review of MoH

Table 2: Priority Matrix

Priority Area	Realistic	Impact on Māori Health	Quick Visible Results	Alignment	Fundamental Cause	Capitalise on other initiatives	Planning Time	Score
Accountability Cycle	5	4	5	5	2	5	s	26
Developing Māori Models	4	3	3	5	5	4	s	24
Evaluate monitoring & evaluation tools	4	4	3	5	2	4	s	22
Rural Health	3	4	2	3	3	4	l	19
Māori Provider Development	5	4	2	5	3	5	s,m,l	24
Māori workforce capacity	4	4	2	5	3	5	s,m,l	23
Communication, relationship & collaboration	5	3	5	5	2	5		25
Increase Māori Health Pūtea	3	3	1	5	4	4		20
Disease Mngnt	2	5	2	5	3	3		20
High Priority Diseases	2	5	2	5	4	3		21
Incentive on Providers	3	2	2	2	3	3		15
Capacity & capability of MOH to Respond	3	2	3	4	2	3		17
Social, Cultural & Economic	3	4	1	5	5	5		23
Child & Youth	4	5	4	5	5	4		27
Access Barriers	2	5	2	5	4	3		21
Whānau Capacity	3	3	2	5	5	3		21
Treaty of Wāhanga	3	4	3	5	5	3		23
Capacity of all Providers	3	3	2	3	3	3		17
Prevention, public health	4	4	3	4	5	4		24
								0

Scale  
 1=low 5=high  
 1=no 5=yes  
 s=short term  
 m=medium term  
 l=long term

Figure 3 - Priorities CLD



<sup>i</sup> Seven Management Tools, Goal/QPC, 19??

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