Scientific Inquiry, vol. 9, No. 1, June, 2008, pp. 3 – 18 *IIGSS Academic Publisher*

OPERATIONAL RESEARCH, SYSTEMS THINKING AND DEVELOPMENT OF MANAGEMENT SCIENCES METHODOLOGIES IN US AND UK

ALBERTO PAUCAR-CACERES

Manchester Metropolitan University Business School, Aytoun Building, Aytoun Street, Manchester, M1 3GH, UK

(Received February 05, 2007; In final form October 07, 2007)

The paper outlines the development of management sciences (MS) and systems thinking (ST) over the last few decades in the US and the UK, tracing the origins of systems thinking in Operational Research approaches developed in the UK and later on in the US. The paper argues that there are substantial differences in the way in which MS was conceived, and developed in both sides of the Atlantic and that this has marked the way ST has developed. ST in the UK has much more systemic edge which has resulted in the development of a number of systemic methodologies whereas in the US, MS and ST is still view as associated with a logical, systematic approach and heavily informed by the development of techniques and decision making aids. After revising earlier classifications of management sciences methodologies, a framework to classify its development identifying four stages is proposed: (1) problem solving methods located between 1940 and 1970; (2) situation-Improving methodologies in the 70s and 80s; (3) Intervention-empowering methodologies 80s and 90s; and (4) a multi-paradigmatic era in the 90s at to the present time. From the classification proposed, conclusions are drawn, highlighting the differences between US and UK systems thinking approaches.

Keywords: systems thinking; soft systems; management sciences, operational research, philosophy of OR.

1. INTRODUCTION

This paper aims to outline the historical development of Systems Thinking (ST), Operational Research (OR) and Management Sciences (MS) over the last 50 years in the US and the UK; the purpose being to assess the way in which MS has been conceived and understood and to ascertain how over the years the definition and scope of MS, ST and Systemic Methodologies (or Systems-based methodologies) have changed especially in the UK. Key literature from the period following Second World War and the years that witnessed the emergence of MS as a field of management will be examined to exemplify the view of MS in the US where OR/MS is still view as associated with a logical, systematic approach and heavily informed by the development of techniques and decision making aids. The paper discusses and contrasts these characteristics with the main features of the British OR/MS developments elaborating on the fact that in the UK, the preoccupation for using systems methodologies rather than methods has been a feature of the UK systems movement. By outlining the UK and US OR/MS positions and by reflecting on the different ways of labelling OR ('Operations Research and 'Operational Research') in the UK and US, the paper reflects further on possible reasons for the different paths followed by MS and ST in both sides of the Atlantic.

The paper revises earlier classifications of Management Sciences Methodologies (MSM), suggested by Checkland and Jackson and then proposes a framework to classify its development as part of the

endeavours of the Systems Movement identifying four stages: (1) an early problem solving stage is located between 1940 and 1970; (2) a situation-improving methodologies follows in the 70s and 80s; (3) an intervention-empowering methodologies appearing in the late 80s and 90s; and (4) a multi-paradigmatic era is identified in the 90s at to the present time. Finally, conclusions are drawn, highlighting different ways in which MS and ST are understood in the UK and the US, emphasising the usefulness of the management sciences methodologies classifications and the suggested framework proposed to assess the development of the systems movement.

2. OR/ MANAGEMENT SCIENCE – A BRIEF HISTORICAL ACCOUNT

Although there is evidence of the use of some mathematical modelling at the turn of the twentieth century (for instance the work of Erlang on waiting line problems, the work on war games by Edison and the work on inventory management Economic Order Quantity by Harris), the formal origins of MS are located in the early 1900s when Taylor proposed a scientific approach to management, aiming to improve operations and production. The rational approach and techniques proposed by him formed later the basis of the branch of engineering, called industrial engineering, an academic field that became well established and gained popularity in the latest 50s and 60s in the US and still is prominent today. However, the modern approach to management science as we know today grew out of successful applications of a 'scientific approach' to military operations during the Second World War, when, in order to maximize the war effort, the British government organised teams of scientists to work and assist commanders in the battlefield to solve the complex problems that the war presented and the term 'Operational Research' was coined. After the war, scientists on both sides of the Atlantic migrated to industry and government and with them the expertise to address complex problems. The first time the term Management Science was used it was in the US probably at around 1950 but it was formalised in 1953 when 'The Institute of Management Sciences' (TIMS) had its first meeting and later in 1954, and the Journal *Management Science* first issue was published.

Table 1 is adapted from Lawrence and Pasternack (2001) and Keys (1995) and highlights some of the crucial historical events leading to the development of MS to date. When the war ended and OR applications stated to be accepted, some events helped further facilitated the adoption of MS methods and techniques in industry in the US and because of the pervading influence that American business education started to exert from the 50s, one can argue that two important events marked the growth and acceptance of OR world-wide, these were: (a) the continued research on mathematical techniques culminating in the development of the Simplex solution to Linear Programming by Dantzig in 1947; and (b) the development and accessibility of hi-speed electronic computers in the late 40s which enable the rapid growth of OR applications in industry, especially in large companies.

The 30 year period starting with the end of the second world war is normally called the 'golden-era' of OR at least in its classical applications form; this era, as shown in Table 1, roughly comprises the years 1945 to 1975 and are characterised by emergence, growth and stability as regards OR applications in both sides of the Atlantic. This growth, according to Keys (1995) is manifested in three important events: (1) OR is accepted as support to management; (2) professional bodies started to become established in both sides of the Atlantic; and (3) the provision of academic programmes gained acceptance especially in the States where university degrees in OR started earlier than in the UK.

It is also worth mentioning that after the war, in the US, OR techniques were not easily accepted and operational researchers had to battle against the reluctance of industry to use these methods; whereas in the UK the nationalisation of industry contributed to its acceptance. Also, and as Jackson (2003) points out, the fact that the early OR thinkers had some sociological aspirations which could explain the fact that OR was more ready to be accepted in the British particular post-war social context. Cook and Shulter (1991) state that the impetus for the move from OR war applications to industrial was stronger in the UK; indicating three factors that have contributed to this: (1) the nationalization programme of the new labour government created large industrial corporations (coal, steel, gas road, trail and air transport) which brought unknown problems of large scale especially when Britain faced reconstruction in the post war years; (2) some of the leaders of these corporations

came directly from government and defence posts; and (3) the leading OR scientists decided to return to their original disciplines.

Table 1 Management Science/Operational Research time line
(Adapted from: Lawrence and Pasternack (2001); Keys (1995); and Informs website: http://w.w.w.informs)

Early history		
-1890	o	Frederick Taylor develops the field of 'scientific management' applying scientific approach to improving operations an production setting (industrial engineering)
-1900	o	Henry Gantt develops a control chart approach for minimising machine job completion times (Project Scheduling)
	o	Andrew A. Markov studies how systems changes over time (Markov Processes)
	o	The general assignment approach is developed (Networks)
-1910	o	F. W. Harris develops approaches to determine the optimal inventory quantitative order (Inventory Theory)
	o	E. K. Erlang develops a formula for determining the average waiting time for telephone callers (Queuing Theory)
-1920	o	William Shewart introduces the concept of control charts
	o	H Dodge and H. Romig develop the technique of acceptance sampling (Quality Control)
-1930	o	Jon von Neuman and Oscar Morgenstern develop strategies for evaluating competitive situations (game theory)
-1940	o	Second world war provides the impetus for the applications of mathematical modelling for solving mathematical problems.
Emerging OR era	o	After the war, OR was not easily accepted in the US whereas in the UK, due to the fact that many industries were nationalised, OR teams maybe with its social aspirations were allow to develop
	o	George Dantzig develops the simplex method for solving problems with a linear objective and linear constrains (linear programming)
	o	The first electronic computer is developed
-1950	o	H Kuhn and A.W Tucker determine required conditions for optimality for problems with a no-linear structure (Non linear Programming)
Growth era	o	Ralph Gomory develops a solution procedure for problems in which some variables are required to be integer values (Integer programming)
	o	Project Evaluation Review Technique (PERT) and Critical Path Network (CPM) are developed (Project Scheduling)
	o	In May 1952: The Operations Research Society of America (ORSA) and in December 1953: The Institute of Management Science (TIMS); two professional societies dealing with management science are established.
	o	November 1952: First issue of *Operations Research*
	o	October 1954: First issue of *Management Science*
	o	Richard Bellman develops a methodology for solving multistage decision problems (Dynamic programming)
-1960	o	John D. C. Little proves a theoretical relationship between the average length of a waiting line and the average time a customer spends in line (Queuing Theory)
Growth and stability in OR era	o	Specialised simulation languages such as SIMSCRIPT and GPSS are developed (Simulation)
-1970	o	The microcomputer is developed
Critique of OR	o	Ackoff, R. (1979), The future of OR is past, *Journal of operational Research Society*, 30, 2.
-1980	o	N. Karmarkar develops a new procedure for solving large-scale linear programming problems. (Linear Programming)
New debates in OR	o	The personal computer is developed; Specialised management science software packages that can run on microcomputers are developed.
	o	Checkland, P.B. (1981, 1999) *Systems Thinking, Systems Practice*, Wiley.

-1990	o	Spreadsheets packages begin to play a major role in modelling and solving management science models.
New debates in OR	o	January , 1995: TIMS and ORSA merge to form the Institute of Operations Research and Management Science (INFORMS)

The campaign led by some prestigious scientists, in the period immediate following the war, under the slogan 'science and reconstruction' also contributed to the rapid acceptance and spread of OR practices amongst UK industry especially in the coal and steel industry but also in some private companies.

This historical background might explain, in part, that the connotation of the term 'Management Science' over the last 50 years has changed, particularly in the UK, a review of the books and textbooks that use this term seems to indicate that views as to the nature and scope of MS appear quite different in both sides of the Atlantic. The terminology also differs, OR stands for 'Operations Research' in the US and 'Operational Research' in the UK; additionally, OR in the US tends to be more method and techniques oriented (despite the early efforts of Ackoff and Churchman) whereas OR in the UK has evolved into a movement that has fostered and encouraged the development of a plethora of fully fletched systems methodologies or to be more precise systems-based methodologies (Jackson, 2000, 2003, 2006). The next section elaborates further on these semantics differences when labelling OR/MS in the US and the UK.

3. AMERICAN 'OPERATIONS' RESEARCH AND BRITISH 'OPERATIONAL' RESEARCH

As it is well documented, in the US, during and after the second war world, OR techniques were called *Operations Research* by which name they are still know now whereas in the UK the name *Operational Research* originally used during the war has been kept. This apparent subtle difference has interesting implications concerning the emphasis and directions taken by OR/MS and ST in both sides of the Atlantic; and the difference of label (*Operations* and *Operational*) may help to explore some underpinning reasons that might explain the way OR has been conceived in both sides of the Atlantic. The Oxford Dictionary of English defines these two terms as:

- **Operations***: noun.* Action or method of working or operating; active process, discharge of functions; piece of work, esp. one in series.
- **Operational**: *adjective* of or engaged in or used for operations

The use of these two terms when labelling OR is not fortuitous: the term *Operations Research,* used in the US, comprises two nouns and that places the emphasis on the actual operations to be carried out, stressing the view of tackling reality directly and, as the definition of *operations* indicates, the weight of the label OR is on a*ction or method of working or operating*; the undertone of the term stresses the importance of the method as an important vehicle to 'uncover' reality; the focus being on reality itself giving an *ontological* bias to the term. On the other hand, the UK label *Operational Research* is composed of a *noun* (Research) and an adjective *Operational* (here modifying the noun) this gives the term a more subtle tone. The adjective *Operational* as the ODE defines it: '*engaged in or used for operations'* clearly stresses the 'importance' (in the term) of the process (the set of steps describing the 'actions' or operations to be carried out) rather than the task or action (operations) itself indicating an *epistemological* (giving supremacy to the method) bias to the term. It is interesting to note that, apart from Cook and Shulter (1991), there has been little discussion about these two ways of labelling the practice of OR:

> *The Americans adopted the idea [of OR practice] and the name, changing it only to 'operations research' because of their different usage of the adjectival nouns.* pp.3

Summarising, grammatical difference of the terms gives emphasis to different parts of the term: the emphasis in *Operations Research* in the action or operations that are carried out whereas in

Operational Research is in the process rather than the method itself which in a way explains the preoccupation of the UK systems community to develop a much more systemic and interpretative management science and hence the flourishing of the so-called systems based methodologies developed in this country.

4. AMERICAN HARD 'SYSTEMATIC' METHOD AND TOOLS MS/OR ORIENTED APPROACH

The different directions that OR/MS took in the UK and US has been reported as earlier as the late fifties when Ackoff (1957) discussed the differences in the way both countries approach OR. Some of these differences can be explained by the sociological preoccupation of the British OR practitioners and their pragmatism encapsulated in their endeavours to base their developments in real life cases rather than theoretical situations. The approach in the US was quite different; MS developments were theory driven, a feature that reached its peak in the late 60s and 70s which prompted the strong criticism from one of the founders of OR, Ackoff (1979) who indicated signs of OR being in crisis because of its obsession with theory.

Other commentators have indicated that these differences stem from the fact that in the US, the post-war development of OR took place mainly at the universities, and to some extent, this seems to be the case because OR departments of the US navy, army and air force were not dismantled as the was the case in the UK; in fact the opposite occurred, the US arms forces financed research in OR: the US army financed Johns Hopkins University; the US navy funded research mainly at MIT; and the Air force sponsored research at the University of California and the RAND corporation. This in many ways explains the tremendous impulse on mathematical and programming developments of the 50s. For instance, Dantzig, the 'inventor' of the Simplex method, a breakthrough in the field of mathematical programming, was working at the RAND corporation and had links with air force previous to this employment. In addition to this, the other major academic step was taken by Ackoff and Churchman who in the late 40s, funded the Case institute of Technology in Cleveland Ohio (where the 'academic' birth of OR took place) started to run courses in OR with the acceptance and support of industrial organisations. Although the main massage of Ackoff and Churchman was that OR is a 'basic method and approach' rather than a set of techniques, the book they produced (the first classic OR textbook) and the fact that the development of mathematical technique was at its peak meant that OR in the US became to be taken more a as set of technique rather that an approach. The book itself did not help because the description of a method was not clear and people started to pay attention to the techniques more easily than the general 'basic method or approach' proposed by Ackoff and Churchman.

Since the term 'management science' was defined and used around the early 50s the characteristics of MS in the US and its attachment to the scientific method have not changed substantially as the top part of Table 2 shows; the flavour of the definitions has not changed since they were originally conceived in the USA. These definitions indicate clearly the way that MS is still understood in the USA over the last almost four decades going back effectively to the very first definition of the OR process given in the first OR book by Churchman, Ackoff and Arnoff (1957; pp13):

...the following are the major phases of an OR project:

1. *Formulating the problem.*
2. *Constructing a mathematical model to represent the system under study.*
3. *Deriving a solution from the model.*
4. *Testing the model and the solution derived from it.*
5. *Establishing controls over solution.*
6. *Putting the solution to work: implementation.*

The same framework more or less is emphasised by Dennis and Dennis (1991), when they state that Management sciences presents the following characteristics:

(a) the scientific method, that is the, step-wise systematic method based on:
   a. observation,
   b. definition of the problem,
   c. formulation of hypothesis,
   d. experimentation, and
   e. verification.
(b) systems approach, here systems is described as a whole, comprising interrelated parts but clearly refers as to see systems 'out there';
(c) interdisciplinary/team approach;
(d) problem orientation using mathematical models and
(e) computer use.

As result of the overall US dominance on management education after the second world war, a great proportion of the management sciences textbook market for both undergraduate and postgraduate courses is heavily dominated by US authors. A cursory review of them (a sample of this is shown in Table 2) reveals that they tend to emphasise the 'systematic' nature of the approach and the benefits of MS as quantitative, logical oriented set of tools and techniques. This quantitative, scientific flavour is emphasised continually as the predominant approach that the American OR movement has followed, the statements in Table 2 corroborate the ever present quantitative, logical, systematic approach of American OR, which has made the terms OR and MS almost synonymous whereas in the UK the 'space' between classic OR and MS a bit wider: OR techniques might be associated with the label MS, but also some of the Systems based methodologies have been associated with OR.

Table 2: A sample of MS/OR definitions

Taylor III, B. (forthcoming 2007)	*Management sciences encompasses a logical, systematic approach to problem solving which closely parallels what is known as the scientific method for attacking problems. This approach […] follows a generally recognized and ordered series of steps: (1) observation, (2) definition of the problem, (3) model construction, (4) model solution, and (5) implementation of solution results.*
Lawrence, John A. Jr. and Pasternack, Barry, (2002)	*the discipline that adapts the scientific approach for problem solving to executive decision making in order to accomplish the goal of "doing the best you can with what you've got.". It involves:* • *Analysing and building mathematical models of complex situations* • *Solving and refining the mathematical models typically using spreadsheets and/or other software to gain insight into the business situation* • *Communicating/implementing the resulting insights and recommendations based on these models.*
Hesse and Wooley (1980)	*The use of logic and mathematics in such a way that it does not interfere with common sense*
Dennis, T. and Dennis L. (1991)	*Management science is a rational, systematic approach to problem solving that employs quantitative analysis to help managers make decisions. A variety of quantitative techniques have been developed to help solve specific types of standard problems. In this book, you will be introduced to some of these techniques. However, these techniques are only one component of a discipline that provides a logical framework for decision making. Therefore, this book is really about making decisions and solving problems, using a scientific approach and quantitative analysis*
Little, (1991)	*A scientific method of providing executive departments with a quantitative basis for decision regarding operations under their control*
Churchman, Ackoff and Arnoff (1957)	*…the following are the major phases of an O.R. project:* • *Formulating the problem.* • *Constructing a mathematical model to represent the system under study.* • *Deriving a solution from the model.* • *Testing the model and the solution derived from it.* • *Establishing controls over solution.*

- *Putting the solution to work: implementation.*

US army Pamphlet 600-3	*The use of techniques such as statistical inference and decision theory, mathematics programming, probabilistic models, network and computer science [to solve complex operational and strategic issues]*

5. BRITISH SOFT 'SYSTEMIC' METHODOLOGICAL ORIENTED MS/OR APPROACH

The direction that OR and MS has taken in the UK is quite different; the tendency has been to shake off the positivistic paradigm and to develop newer and broader methodologies that use systems ideas developed under a strong system movement fostered by the UK OR community. According to Jackson and Keys, OR's initial scope should be extended:

> *OR [operational research] is regarded by many as being in crisis. If OR is taken to be 'classical OR', this is indisputable……If, however, the definition of OR is widened to embrace other systems-based methodologies for problem solving, then a diversity of approaches may herald not crisis, but increased competence and effectiveness in a variety of different problem contexts,* Jackson and Keys (1984)

The development of OR in the UK has taken place in the context of a more robust Systems movement than in the US and it can be argued the whole concept of Management Sciences as a discipline has been revised in the late 70s when Peter Checkland questioned the validity of classical MS in one of his most influential papers *The Systems movement and the 'failure' of management science* and later on when his pioneering work on Soft Systems Methodology came to the fore in the late 70s and early 80s, Checkland (1972, 1976, 1978, 1980). As it was discussed in the previous section, in the US, MS/OR was still circumscribed to see MS methods as variations of the classical OR approach, articles and a number of textbooks in the UK take the view that MS is not only a quantitative oriented set of methods and tools but encompasses a much more varied set of methodologies: Checkland, Jackson, Mingley, Stowell, Flood, Mingers, and Keys amongst others have written and edited books that take this view. In particular, Checkland, Jackson and to some extent Mingers have been key figures in shaping the UK systems movement in this direction; we have studied somewhere else (Paucar-Caceres, 2003a, b) the important role of these three authors in shaping the systems movement in the UK and in disseminating the view that MS in the UK has developed a set of sophisticated systems based methodologies. All of these events have contributed to the establishment of the UK systems movement as one that is closely allied to the development of applied systems thinking, that is, to the original hard set of techniques, systems thinking in the UK has incorporated, what in some systems and OR circles is called 'soft OR' or 'problem structuring methodologies'. This is a phenomenon that, in our view, has affected only the UK systems and OR community.

So, the term Management Sciences, in the UK, is as Jackson argues, almost interchangeable with 'Applied Systems' (Jackson, 2000, 2003, 2006) because of the substantial number of Systems Methodologies available in the UK that have grown from the original systemic endeavours that the OR had back in the early 50s. Acknowledging that OR pioneers had wider and somehow 'heady' social aspirations, he states:

> *At their most ambitious they saw OR developing into an interdisciplinary approach, holistic in nature, addressed to strategic (as well as tactical) problems in social systems, and dedicated to social good***,** Jackson, 2006

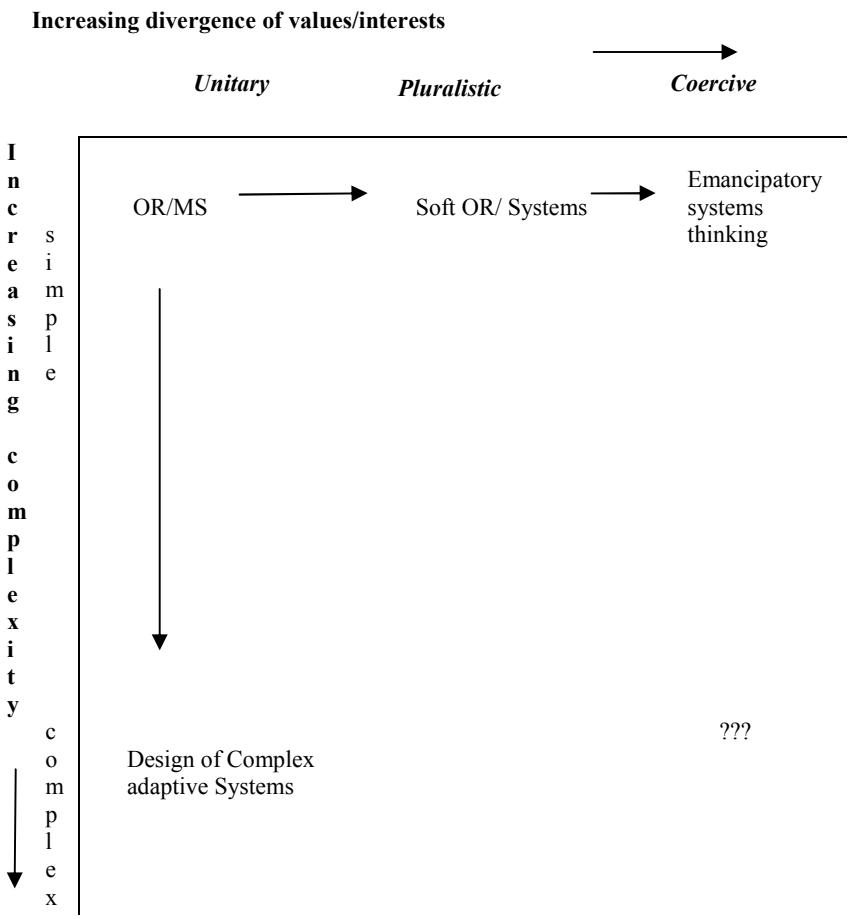

Figure 1. Progress in applied systems thinking (a UK perspective) from Jackson (2000)

Then the history of applied systems thinking in the UK can be presented in terms of efforts to overcome the weaknesses of hard systems thinking. Success in this endeavour has been hard won, and as a result over the last thirty years or so significant developments have taken place and the systems approach is now valued as making an important contribution to resolving a much wider range of complex problems than hard systems thinking was able to deal with, Jackson (2003, 2006). We can understand these developments best using a framework for classifying systems methodologies, developed by Jackson and Keys in 1984, called the 'system of systems methodologies' (SOSM). This framework helps us to 'travel in time' if we follow the north-west to south-east direction. Essentially, the devise depicted in Fig. 1 helps to map the development of management sciences on a two dimension framework that characterise problem situations. The horizontal (West-East) axis ***Increasing divergence of values/interests*** portrays situations in which the participants encounter themselves: the range goes from situations in which the values are shared representing three possibilities: (1) an 'unitary' situation in which all participants agree on the objectives; (2) pluralistic, a situation where certain values are shared and some are not nut dialogue and accommodation is possible; and (3) 'coercive' the case in which one group or person exerts power over the rest and no accommodation of values is possible. The vertical (North-South) axis ***Increasing complexity*** describes the increasing range of complexity of the situation as regards the elements (not people) that constitutes such situation; two possible states are identified: (1) simple; and (2) complex. This framework helps to depict the way that OR/MS has evolved in its efforts to cope with the problematic

situations. Jackson argues convincingly that the management scientists had to evolve accordingly and develop adequate answers for the combination of these two dimensions; i.e. classical OR/MS in the late 40s and early 50s dealt adequately with situations of 'simple' complexity and 'unitary' values whereas in the 70s soft approaches were needed to cope with the next combination of combination of 'pluralistic' values and 'simple' complexity. Yet unknown systems based methodologies are awaited to tackle situations where a coercive environment co-exists with complex situations as depicted in the cell at the bottom right hand corner, marked in Figure 1. as **'???'**. Jackson claims over the last three decades the UK systems movement has produced suitable systems based methodologies to tackle real world problem situations.

6. SYSTEMS THINKING IN THE US

In the US, Systems Thinking stems from the developments of MS/OR and it is perceived as becoming a discipline or an 'approach'. This, to a greater extent, stems from the early writings of Churchman, Ackoff and Arnoff` (1957), Churchman (1979). These authors pioneered the introduction of OR back in the late 40s but then became disillusioned by the directions that OR took in the US mainly because they argued that the technical, tools side was overemphasised as oppose to the method. It is interesting to note that the work of Churchman and Ackoff, two authors who were very influential in the UK systems movement (Jackson, 1982), never reached in the US the status of fully developed methodologies in which the systems approach was explicitly embedded whereas the work of Checkland (1981, 1999) and other influential systems thinkers in the UK were produced in the late 70s and 80s was embedded in proper systems methodologies. In the US it was not until the early 90s when the international bestseller book by Peter Senge, *The Fifth Discipline-The Art and Practice of the Learning Organisation* that the word *Systems Thinking* became popular in the States and indeed world-wide, Senge (1990). ST was the new buzzword and a vast amount f literature was produced reporting the benefits of the applications of ST to organisational problems claiming that systems thinking was the *fifth* discipline of every learning organisation need to embrace. Although this interest has faded somewhat, ST has become more established in the US and has started to be used becoming an emerging discipline. A recent text by Maani and Cavana (2000) defines ST as '*an emergent discipline for understanding complexity and change'.* This marks a subtle difference from the way ST is portrayed in the UK and although there is no agreement amongst the UK main systems commentators one can argue that essentially, in the UK, ST is considered a way of thinking and not a fully fleshed discipline whereas in the US is it considered the 'fifth' discipline of any company that aims to learn and survive by learning in an increasing turbulent environment.

7. SYSTEMS THINKING AND THE SYSTEMS MOVEMENT IN THE UK

In the UK , systems thinking is seen as a 'way of thinking' and regarded as a meta-discipline embedded in the efforts of those involved in the systems movement; this was stated in the early 80s when, according to Checkland (1981):

> *'The systems movement comprises any and every effort to work out the implications of using the concept of an irreducible whole, 'a system', in any area of endeavour. […]. Because systems ideas provide a way of thinking about any kind of problem, systems thinking is not itself a discipline.' page 99.*

One of the first people to map the development of the so called systems movement (defined as a loose amalgamation of people who claim to use systems ideas in tackling real-world situations) was Checkland. His map shown in Fig. 2 (from Checkland, 1976), makes explicit the difference between the hard and soft paradigms. This map also depicts the influences that informed the then emerging soft systems methodology. Although this map was extensively used by systems practitioners and was very useful in the 80s for making clear the difference between soft and hard approaches, it is however only a

snapshot of the development of systems thinking up to that time and it does not include the later developments in systems thinking in the 80s and 90s.

Jackson (2003), acknowledging the usefulness of Checkland's map as device to 'place order' on the Systems movement literature suggests that ST applied to problem-solving has become 'the most important achievement of the whole systems movement' and proposed to update Checkland's map. He emphasises the branch of the Systems Movement that he calls 'Applied Systems Thinking' where the Systems methodologies for solving problems are located as shown in Fig 3. This map indicates the richness of the systems movement developed in the UK over the last 30years or so in which there has been a prolific development of Systems Based Methodologies (SBMs). In this section we are merely signalling the richness of the UK systems movement.

8. MAPPING THE DEVELOPMENT OF MANAGEMENT SCIENCES METHODOLOGIES AND THE SYSTEMS MOVEMENT IN THE UK

In this section, a map of the development of some of the main systems based methodologies (SBM) associated with ST in the UK is proposed to further understand the influence between systems thinking and MS in the UK. A framework based on the paradigms underpinning the methodologies introduces four paradigms in the general development of management sciences and systems thinking in the UK: (a) Optimisation paradigm: problem-solving methods (1940-1960); (b) Learning paradigm: improving-situation methodologies (1960-1980); (c) Critical Paradigm: intervention-empowering emancipatory systems methodologies (1980-1990); and (d) Pluralistic and Multi-methodological Paradigm: use of multi-methodologies and pluralistic approaches (1990-present). Using time and the paradigms developed in management sciences and the systems movement over the last decades, a framework was constructed as shown in Fig. 1. It depicts the emergence and development of the main systemic methodologies in the UK, showing the major direct and indirect influences between them over the last six decades. The map depicts four main paradigms. The emergence of hard approaches is located in the late 50s and it has been associated with the developments of operational research (OR) in the UK and the USA and with the developments of systems engineering/systems analysis in the USA. During the 60s and 70s, a number of soft systems thinking methodologies emerged in the UK amongst them the more influential were Checkland's soft systems methodology (Checkland, 1981; Checkland and Scholes, 1990) and cognitive mapping developed by Eden *et al* (1983). In the late 1980s and 1990s, Critical Systems Thinking (CST) became prominent in the UK when 'total systems intervention' developed by Flood and Jackson embraced the CST commitments in systems practice, (Flood and Jackson 1991). Finally, the more recent debate in OR and systems communities in the UK is around the use of methodologies in combination and acknowledging various paradigms. The term Pluralistic/Multi-paradigmatic thinking has been coined to name the approaches under this approach (Jackson 1997, 1999, 2003; and Mingers, 1997a, 1997b, and 1999. These major methodological developments together with the main theoretical influences of the four paradigms over time are depicted in Fig. 4 (Appendix A); a brief description of the paradigms follows in the next sections.

8.1 The Optimisation Paradigm (1940-1960): Problem-Solving methods

Checkland (1981) locates the emergence and development of this paradigm in the late 50s and 60s. It was mainly an extension into management of what was the positivistic epistemology to natural sciences. The belief that organisations can be seen as objective worlds was certainly underpinning the early developments of classical OR/MS methods and techniques. Furthermore, these approaches relied on the assumption that the decision maker acts in full possession of rationality or 'bounded rationality', Simon (1947, 1960) and the ability to chose between different alternatives generated in full knowledge of what the problem is and where s/he wants to be. The Optimisation Paradigm and the development of 'solving methods' are generally associated with classic Operational Research techniques and the so called 'hard' approaches. Jackson (2003) places some of the systems-based methodologies of this paradigm in what he calls Systems approaches for 'Improving Goal Seeking and Viability'. The methodologies associated with this approach are:

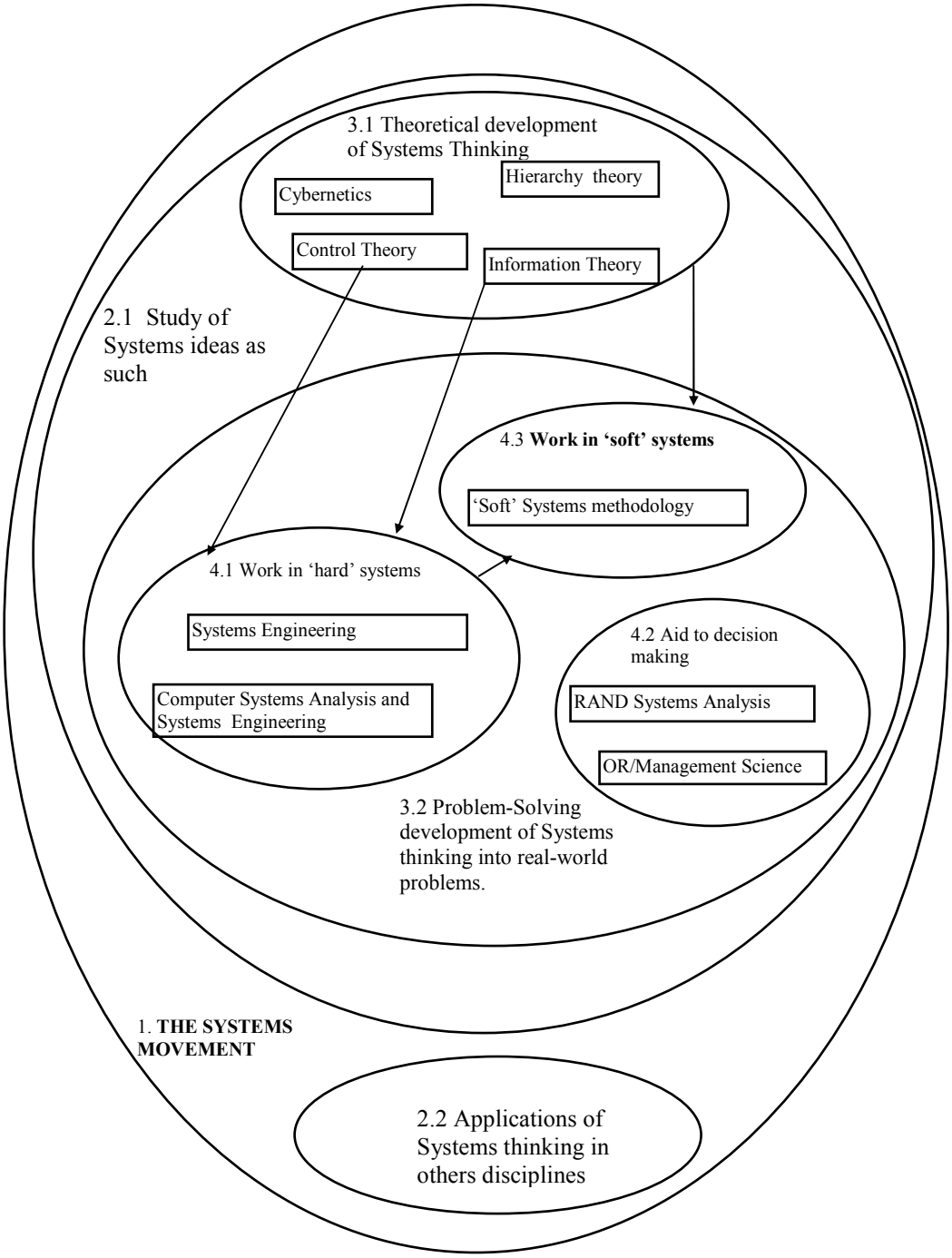

Fig. 2. The Shape of the Systems Movement (arrows indicate major influences) from Checkland, 1978, 1981

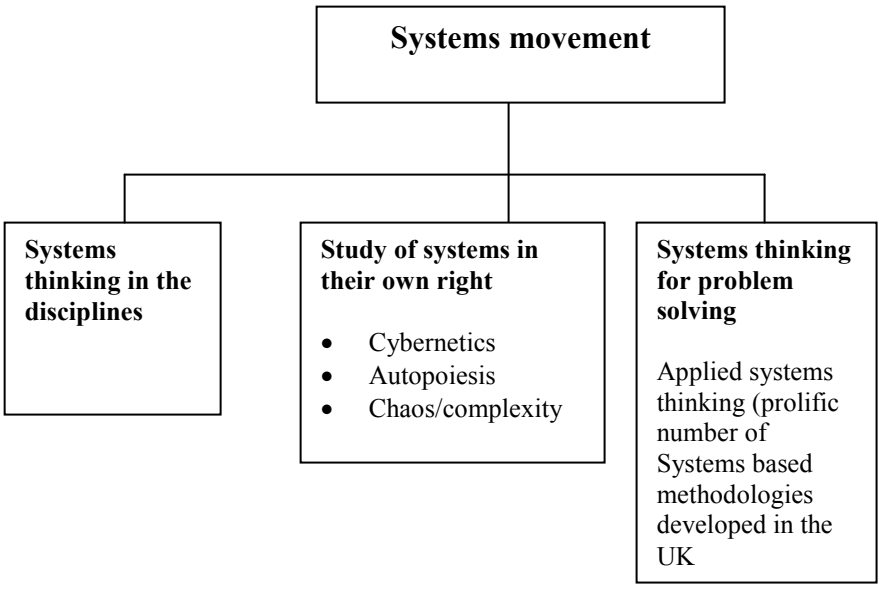

Fig. 3 The Systems Movement strands in the UK, adapted from Jackson (2003)

- Systems Dynamics;
- Organisational Cybernetics; and
- Complexity Theory

The classic OR or 'hard' approach has not been included in this group because this is a method that does follows a positivistic epistemology as oppose to the systemic approach prevalent in the other paradigms.

8.2 The Learning Paradigm (1970-1980): Situation-improving systems methodologies

The learning (Checkland, 1981), interpretivist (Jackson, 1982; Mingers, 1980, 1984) paradigm is the one that underpins the methodologies involved in this group. Ackoff (1993) calls this the 'design approach' comprising methods that attempt to dissolve *systems of problems* or *messes*. He argues that these methodologies differ substantially to those of the 'research approach' in that they aim to tackle the context or environment where the mess takes place and trying to alleviate or dissolve the systems of problems rather than solving it. Jackson (2003) groups the methodologies of this paradigm under Systems approaches that 'Explore Purposes'; here he includes 'Strategic Assumption Surfacing and Testing' developed by Mason and Mitroff (1981) and 'Interactive Planning' proposed by Ackoff (1981).

The most well known methodologies that have been developed in the UK and the US are:

(a) Soft Systems Methodology (Checkland's)
(b) Interactive Planning (Ackoff's)
(c) Strategic Assumption Surfacing and Testing, SAST (Mason and Mitroff's)
(d) Systems Intervention Strategy (Mayon-White)
(e) Social System Design (Churchman's)
(f) Cognitive Mapping, SODA (Eden's)
(g) Viable Systems Diagnosis (Beer's)

8.3 The Critical paradigm (1980-1990) Intervention-empowering systems methodologies

During the 1980s, a new set of methodologies based on Critical Systems Thinking (CST), Jackson (1992), Flood and Jackson (1991) appeared in the UK systems movement. It is a relatively new development in the systems movement; essentially its philosophy is based on the belief that social systems are oppressive and unequal therefore systems thinking should concentrate on the issue of inequality of the participants. The emergence of this paradigm has been mainly due to the work of Michael Jackson and Robert Flood at Hull/Humberside in the early 1980s. It can be argued that the main feature of these approaches is that they try to empower the actors in the intervention. The CST paradigm provides the philosophical underpinnings for the methodologies in this group. CST aims to provide a framework for those methodologies working in coercive context and in which the social and organisational world are oppressive and unequal. There are two main approaches that have been applied under the banner of CST:

(a) Critical Systems Heuristics (Ulrich); and
(b) Total systems intervention (as developed by Flood and Jackson)

8.4 The Pluralistic Paradigm (1990-): Multi-paradigmatic and Pluralistic thinking.

In the early 90s an interesting debate in the OR and systems communities in the UK emerged around issues concerning the use of more that one methodology (combining them or using parts of them); systems academics and systems practitioners have been debating the possibilities of using methodologies from different paradigms acknowledging and recognising the strengths and weaknesses of them. Two of the more fully-formed current approaches to multi-methodology are:

(a) Critical Systems and critical pluralism/complementarism as initiated by Flood and Jackson and lately developed into 'coherent pluralism' by Jackson (1999); and
(b) multi-paradigm multi-methodology/Critical pluralism developed by Mingers (1997a, 1997b).

9. CONCLUSIONS

- Modern-day MS grew out of successful British applications of the scientific approach to solving military operations during the Second World War. Originally known as Operational Research; after the war, the Americans shortened the name to Operations Research, and as managers were using OR approaches to aid decision making, the term Management science was coined in the States in the early 50s.
- In general, this paper takes the view that Management Sciences has taken a different route in the UK if compared with the US and continental Europe. In the States and, because of the influence of US business education, MS has kept its 'hard' or 'systematic' approach whereas in the UK the term has taken a much more 'systemic tone'. Management Sciences in the UK has broadened its scope and moved away from its positivistic/quantitative beginnings that seem still prevalent in US and continental Europe OR/MS communities of practitioners.
- In the UK the systems movement has nurtured and embraced a number of other approaches especially from the soft and critical traditions driven by the need to develop alternatives to the original Hard approach and to overcome its limitations; the history of MS development in the UK is the history of its endeavours to overcome the classical OR limitations; these efforts have been encapsulated in what it is called the development of the Systems movement that has been prolific in producing a plethora of Systems based Methodologies, that is methodologies that make explicit use of system thinking.
- The two different ways of labelling OR: 'Operations Research' in the US (and in continental Europe) and 'Operational Research' in the UK is not fortuitous. The term 'Operations Research' is formed of two nouns and places the emphasis on the Operations aspects of the investigation being more important. On the other hand, the term 'Operational Research' is formed by a noun

and adjective and that gives the term a much subtle tone where the emphasis is on the process of research. This, to some extent, explains the different routes that OR/MS and to some extent Systems Thinking have taken in both sides of the Atlantic.

- A paradigmatic shift widely acknowledged within the systems movement, has occurred in management sciences practice. From the optimisation paradigm of the 50s where solving problem methods flourish to the learning paradigm epitomised by soft systems methodologies of the 70s and then to the critical systems paradigm of the 80s where both the optimisation and learning paradigm were questioned.
- Systems thinkers from the USA (mainly Ackoff and Churchman) have made important contributions to support the theory behind many methodologies that later emerged in the UK. This contribution is depicted in Fig 4 (appendix A). It can be seen that an increasing number have of methodological approaches have been developed in the UK in the last two decades. The pragmatism embedded in British culture seems to have been evident in transforming theoretical developments into methodologies born and tested in practice.
- It has been argued that the UK systems movement has been a main contributor to the systems movement worldwide over the last three decades. The development in management sciences methodologies can be seen as a consequence of these developments. This paper has traced these developments over the last 50 years and mapped the main management science methodologies developed in the UK in those years.
- Four stages of the development of MSM have been proposed to further understand the evolution of MSM: (a) problem solving methods (1950-1970); (b) situation-improving methodologies (1970-1980; (c) intervention empowering methodologies (1980-1990) ; and (d) multiparadigmatic/pluralistic approaches (1990-). From the literature reviewed it is evident that during the first stage of these developments, the US management science practice was mainly involved whereas in the last three stages, the UK systems movement has been the major contributor.
- The paper suggests that US OR/MS journals have been reluctant to publish papers on methodologies from the last three management science paradigms advanced in this paper. This needs to be investigated further by surveying publications on the main MS/OR journals in the US that is '*Management Science'* and *'Operations Research'* (both published by INFORMS). We plan to do that in the near future.

REFERENCES

Ackoff, R. (1957) A comparison of Operational Research in the USA and in Great Britain, in Keys, P. (eds.) (1995) *Understanding the Process of Operational Research*, collected readings, Wiley, Chichester, UK

Ackoff, R. (1979), The future of OR is past, *Journal of operational Research Society*, 30, 2.

Ackoff, R. (1981), *Creating the corporate future,* Wiley, New York.

Ackoff, R. (1993), *The art and Science of Mess Management.* In Mabey, C., Mayon-White, B. *Managing Change*, Paul Chapman Publishing, London,

Checkland, P.B. *(*1972*)* Systemic, not Systematic*, Journal of Systems Engineering 3 (2), Lancaster, UK*

Checkland, P.B. (1976) Science and the Systems Paradigm, *International Journal of General Systems* 3 (2)

Checkland, P. B. (1978). The origins and Nature of 'Hard' Systems Thinking*, Journal of Applied Systems Analysis, Vol. 5, N.2*.

Checkland, P.B. (1980), The System Movement and the "failure" of the Management Science, *Cybernetics and Systems: An International Journal, 11*

Checkland, P.B. (1981, 1999) *Systems Thinking, Systems Practice*, Wiley.

Checkland, P. and Scholes, J. (1990), *Soft Systems Methodology in Action*, Wiley

Churchman, C. W. (1979) The Systems Approach, Dell, New York

Churchman, C. W., Ackoff, R. L. and Arnoff, E. L. (1957) *Introduction to Operational Research,* New York, John Wiley and Sons.

Cook, S.L. and Shulter M.F. (1991) The history of Operations Research, in *Operations Research in Management,* Littlechild S.C. and Shulter, M.F. (eds.) Prentice Hall.

Dennis, T, Dennis, L. (1991) *Management Science*, West Publishing.

Eden, C. Jones, S., and Sims, D. (1983), *Messing about problems,* Pergamon, Oxford.

Flood, R. and Jackson M, (1991), Crea*tive Problem Solving: Total Systems Intervention*, Wiley.

Jackson, M. (1982), The nature of soft systems thinking: The work of Churchman, Ackoff and Checkland, Journal *of Applied Systems Analysis, 9:17*

Jackson, M. (1992) *Systems Methodology for the management Sciences*, Plenum press

Jackson, M. (1997), *Pluralism is Systems Thinking and Practice,* in *Multimethodology*, Mingers and Gill (eds.), Wiley

Jackson, M., (1999) *Towards coherent pluralism in management science,* Journal of the Operational Research Society 50, 12-22.

Jackson MC (2000) *Systems approaches to Management*, Plenum, New York

Jackson MC (2003) *Systems Thinking: Holism for Managers*, Wiley: Chichester

Jackson (2006) Beyond problem Structuring methods: reinventing the Future of OR/MS, *Journal of Operational research* (forthcoming)

Jackson, M. and Keys, P. (eds.) (1987), *New Directions in Management Sciences*, Gower

Keys, P. (eds.) (1995) Understanding the Process of Operational Research, collected readings, John Wiley, Chichester, UK

Lawrence, John A. Jr and Pasternack, Barry, (2002), *Applied Management Science*, John Willey, Chichester, UK

Maani and Cavana (2000) Systems Thinking and Modelling, Prentice Hall

Mason, R., and Mitroff, I. (1981). *Challenging Strategic Planning Assumptions,* Wiley, New York.

Mingers, J., (1980) Towards an appropriate social theory for applied systems thinking: Critical theory and soft systems methodology, *Journal Applied Systems Analysis*, 7:41.

Mingers, J. (1984), Subjectivism and soft systems methodology-a critique*, Journal of Applied Systems Analysis*. 11:85.

Mingers, J., (1997a) Multi-paradigm Multimethodology, in *Multimethodology*, Mingers and Gill (eds.), Wiley.

Mingers, J., (1997b), Towards critical pluralism, in *Multimethodology*, Mingers and Gill (eds.), Wiley.

Mingers, J., (1999), A Comparative Characterisation of Management Sciences Methodologies, in: *Systemist,* Vol. 21(2), pp. 81-92.

Paucar-Caceres, A. (2003a) Measuring the effect of highly cited papers in OR/Systems journals: a survey of articles citing the work of Checkland and Jackson, *Systems Research and Behavioural Science,* **20**, 65-79

Paucar-Caceres, A. (2003b) Assessing the influence of systems thinkers in the UK: a survey of articles citing the work of Checkland, Jackson and Mingers; *Systemist*, Vol. **25**(1), June, 2003

Senge, P., (1990) *The fifth Discipline, the art and practice of learning Organization,* Century Business

APPENDIX A: Fig. 4. The Systems Movement 1940 - 2000, Emergence of Systems Methodologies: