Chapter 2

THE COMPLEXITY OF THE SYSTEMS APPROACH

"The world that we have made as a result of the level of thinking we have done thus far creates problems that we cannot solve at the same level as they were created".

Albert Einstein

2.1 INTRODUCTION

In this chapter, the complexities of the systems approach are introduced to provide the reader with the required insight into the complex issues governing the systems approach and associated problem solving methodologies which will be discussed in Chapter 3 and Chapter 4. More specific, it is the interrelationships which these entities have with hard and soft systems methodologies, which emphasises their importance to virtually become pre-requisites to the understanding the internal functionality of hard and soft systems approaches. Furthermore, the concepts making up the complexities of the systems approach cover a range of diverse (and often unrelated) topics. This will only become clear as the research progresses into Chapter 5 and Chapter 6, where the entities surface as integral components of the approach to model conceptualisation to address unstructured complex phenomena and viewed in context of the overall research.

The following concepts are investigated and where appropriate, defined:

- The concept system.
- General Systems Theory.
- The concept systems approach.
- The concept cybernetics.
- Closed and open systems.
- The role of models.
- The notions '*Weltanschauung*' and Appreciative systems.
- Causal loop diagrams and Reinforcing and balancing processes.

➢ Science and Technology impact

The analytical process followed thus far, is graphically depicted in Figure 2.1, which places the chapters in context with the overall thesis objectives, and furthermore indicates the relative positioning of this chapter.

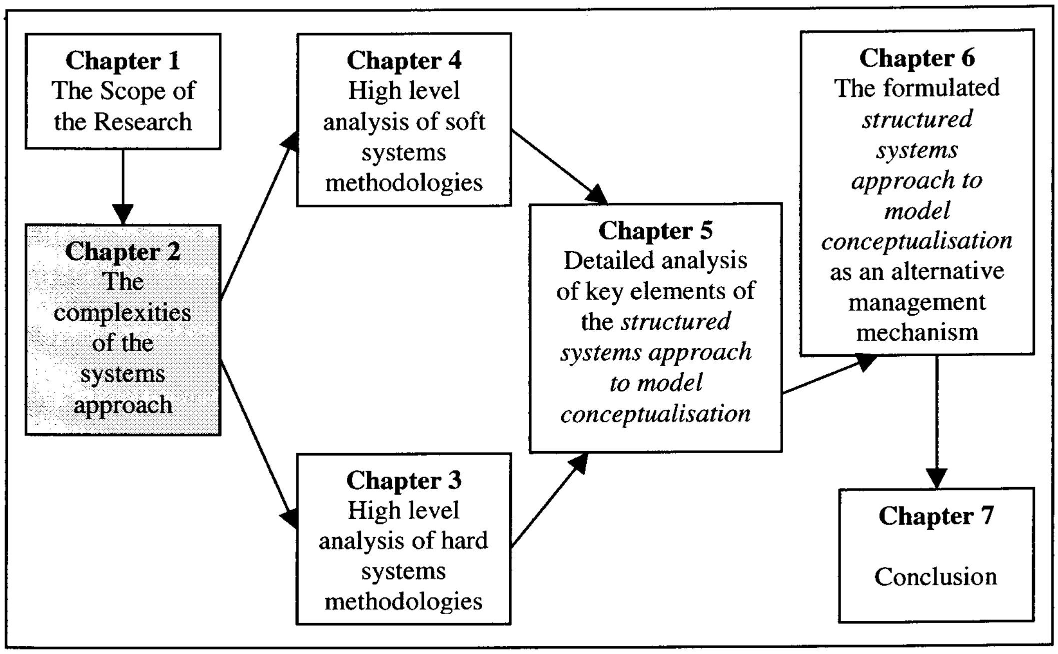

Figure 2.1: Chapters in context of the overall research

An analysis of Figure 2.1[1], shows Chapter 1 as the overall research approach to the thesis. Within the ambit of this chapter, a number of key elements (complexities), are explained in lieu of the high level analysis of 'hard' systems (contained in Chapter 3), and the high level analysis of 'soft' systems, (contained in Chapter 4). Key elements from the high level analysis of hard systems and soft systems methodologies, will serve as preliminary input mechanisms to Chapter 5, where the elements will be further analysed in detail to ultimately culminate in a formulated *structured systems approach to model conceptualisation*. Chapter 6 will depict the *structured systems approach to model conceptualisation* as an alternative management mechanism in practice, while Chapter 7 will contain a summary of the thesis content.

In addition, to provide the reader with a navigational roadmap to understanding

[1] Arrows in Figure 2.1 represents 'information flows' (inputs) from one chapter to the other.

the complexity of the systems approach, the components of which is reflected in Figure 2.2, being adapted from Checkland [29] for this purpose.

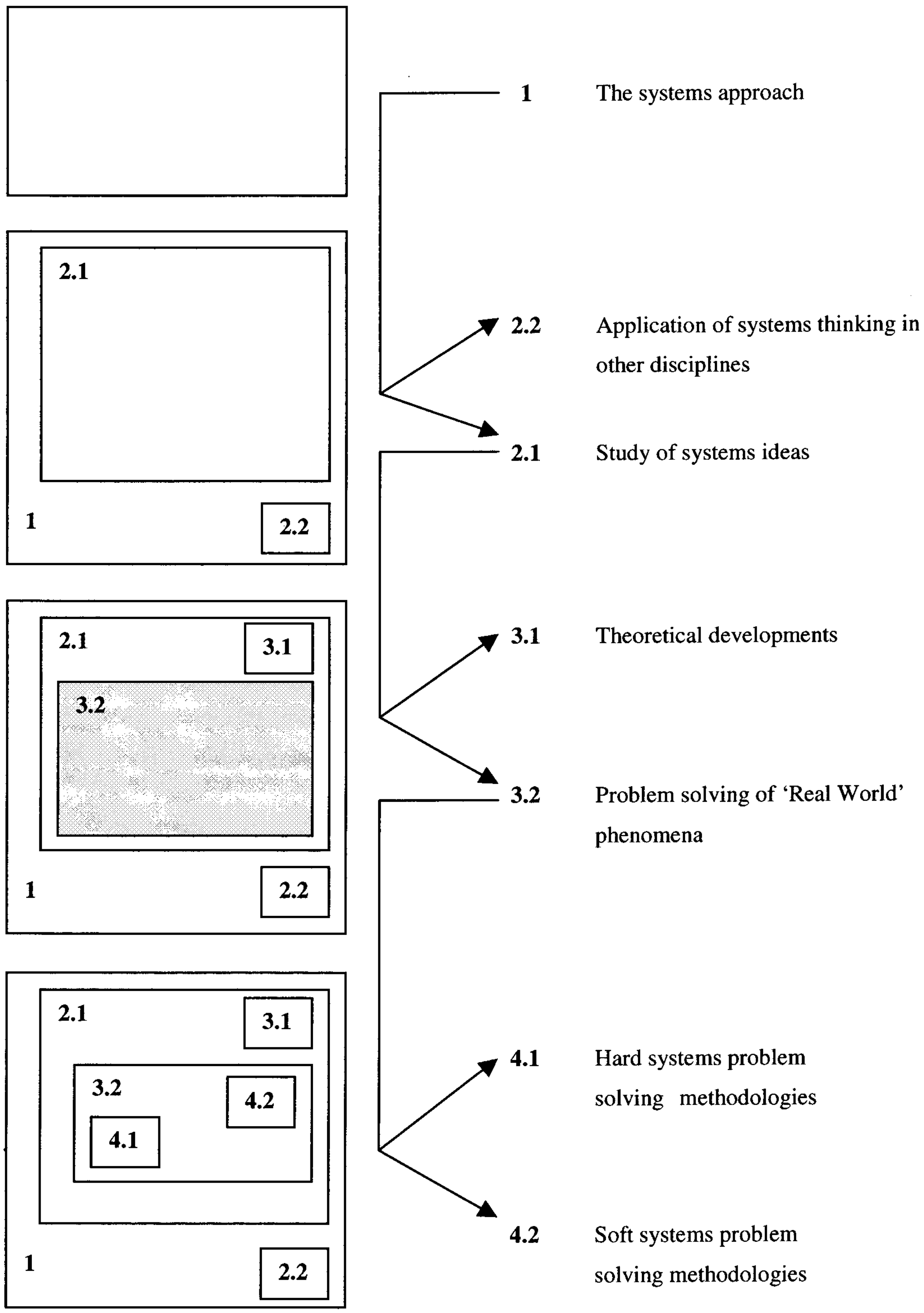

Figure 2.2: Classification of systems falling within the context of the systems approach [29]

It is acknowledged by the author that the classification of systems within the context of the systems approach as depicted in Figure 2.2, is merely 'one of many' such classifications in existence today. A more popular classification is provided by Jackson **[80]**, whereby system approaches are classified according to the assumptions they make where the terms, unitary, pluralist and coercive are used for describing the relationship between the various stakeholders with an interest in organisations. The classification as depicted in Figure 2.2, was selected specifically as the contents thereof map, to the general approach to the research problem set in this thesis.

Analysing Figure 2.2, the systems approach (shown as Frame 1), is presented as an all incumbent 'overall' problem solving methodology consisting of a multitude of different approaches to address complex phenomena. These different approaches led in the first instance to the 'application of systems thinking in other disciplines', (shown as Frame 2.2), of which the 1970's system revolution in geography serves as an example, and in the second instance, the 'study of systems ideas' (shown as Frame 2.1), which are split into two distinct fields namely:

- Theoretical developments (shown as Frame 3.1), of which the 'General Systems Theory' further discussed in Paragraph 2.3 serves as an example.
- Problem solving of real world phenomena (shown as Frame 3.2).

The hard systems approach (shown as Frame 4.1) and contained within the ambit of Chapter 3 is made up of the following problem solving methodologies:

- Systems engineering.
- Systems analysis.
- Operational research.
- Management cybernetics
- Systems Dynamics

The soft systems approach (shown as Frame 4.2) and contained within the ambit of Chapter 4 is made up of the following problem solving methodologies:

- The Viable Systems model of Beer (organisational cybernetics).
- Churchman's Social Systems Design.

- Mitroff and Mason's Strategic Assumption Surfacing and Testing Methodology.
- Ackoff's Social Systems Sciences.
- Checkland's Soft Systems Methodology.

It is this 'problem solving of real world phenomena', which gave rise to the very essence of the research contained within the ambit of this thesis

2.2 THE CONCEPT SYSTEM DEFINED

A philosopher once said he knew no two objects that were not related in some way, if only by the distance between them. This philosopher has broadly defined the concept of a 'system' **[141]**. This statement leads to the analogy that, "everything is related to everything else", which according to Beer **[21]**, is in line with the philosopher Hegel's enunciation of the proposition called 'The Axiom of Internal Relations'. In terms of this concept, the relations by which terms are related are an integral part of the terms they relate to. So the notion we have of anything is enriched by the general connotation of the term, which names it, and this connotation describes the relationship of the thing to other things. In fact, Hegel's Axiom entails that things would not be the things they are, if they were not related to everything else in the way that they are.

The term 'system' can be associated with a plethora of interpretations depending on the field one wishes to apply the concept to. The term is used in almost all sciences and in everyday language resulting in the term being associated with amongst others, system science, systems thinking, systems design, systems analysis, systems engineering and the systems approach.

According to Ackoff **[2]**, the term system is used to cover a wide range of phenomena, some of which are conceptual constructs, and others are physical entities. The following can be listed, namely:

- Philosophical systems.
- Number systems.
- Communication systems.

- Control systems.
- Educational systems.
- Weapon systems.

Against this background, Ackoff **[2]**, defines the concept as:

> *"Any entity, conceptual or physical, which consists of interdependent parts".*

Kauffman **[84]** and Sisk **[156]**, provide 'near' identical definitions of 'system' which are consolidated here to read as follows:

> *"a system is a collection of parts which interact with each other to function as a whole".*

Strümpher **[165]** citing Vickers (1984) defines a system as:

> *"a regulated set of relationships, and the key to its understanding is the way in which it is regulated".*

Strümpher **[165]** makes two important observations regarding the systems definition of Vickers of which the true impact will become clear only in Chapter 5 of this thesis where the *structured systems approach to model conceptualisation* will be formulated. These, rather lengthy comments, which are quoted *verbatim* as not to lose the true meaning of the author, reads as follows:

- *"The first aspect that Vickers' definition captures is that anything that we care to group together and label as an entity proves upon further investigation to be constituted from more relationships". "In fact why we care to label an entity as such is because the constituent relationships show resilience or stability through time, i.e., 'it' persists". "It is precisely because the relationships hang together through time that we observe them (it) in the first place". "One perspective on relationships then is this stability, which I* *will call the structure". "By structure I therefore mean those relationships that remain relatively unchanged through the period of interest to the inquiry".*

- *"A second aspect touched by Vickers' system definition is that there is a dynamic dimension to the relationships". "This perspective on systems relationships, which I will call the process dimension, refers to the altering or changing of relationships over the time frame of the enquiry". "Process refers to the matter/energy and/or information flow, and their transformations, which place within the entity, as well as between the entity and its environment, during the timeframe of interest in the inquiry". "Process describes the logical thinking of inputs to output(s)". "It should be borne in mind that definitions of input and output depend on how the systems boundary is drawn, which is by no means determined absolutely". "Whereas structure describe 'static' or (relatively) unchanged relationships, the process perspective describes the changes in relationships within the time frame of interest".*

The same author **[165]** also quotes the definition of Ackoff (1981) of a system. This definition portrays a system:

> *"as a set of elements where the behaviour of any part depends on the interaction with other parts. i.e., behaviour depends on interrelationships".*

Churchman **[35]** does not define a system *per se*, but provides nine conditions that determine a system. Briefly, the necessary conditions that something ***S*** be conceived as a system are as follows:

- ***S*** is teleological[2]. (i.e., a view that developments are due to the purpose of

[2] According to Churchman **[35]** design belongs to the category of behaviour called 'teleological', i.e. 'goal seeking' behaviour. More specifically, design is thinking behaviour, which conceptually selects among a set of alternatives in order to figure out which alternative leads to a designed goal or set of goals.

design, that is served by them.)

- ***S*** has a measure of performance.
- There exists a client whose interests are served by ***S*** in such a manner that the higher the measure of performance, the better the interests are served, and more generally, the client is the standard of the measure of performance.
- ***S*** has teleological components, which co-produce the measure of performance of ***S***.
- ***S*** has an environment, which also co-produces the measure of performance of ***S***.
- There exists a decision-maker who – via his resources - can produce changes in the measures of performance of ***S's*** components and hence changes in the measure of performance of ***S***.
- There exists a designer, who conceptualises the nature of ***S*** in such a manner that the designer's concepts potentially produce actions in the decision maker and hence changes in the measures of ***S's*** components and hence changes in the measure of performance of ***S***.
- The designer's intention is to change ***S*** so as to maximise ***S's*** value to the client.
- ***S*** is stable with respect to the designer, in the sense that there is a built-in guarantee that the designer's intention is ultimately realisable.

Churchman **[34]**, underwrites the above nine conditions that determines a system with the following definition:

"a system is a set of parts co-ordinated to accomplish a set of goals"

Very closely mapping this definition, is the description of a system as perceived by Thierauf **[170]** who describes the concept as, "an ordered set of methods, procedures, and resources designed to facilitate the achievement of an objective or objectives". Returning to the root meaning of the word, The Oxford English Dictionary **[169]** defines system as:

> *"An organized scheme or plan of action, esp. one of a complex or comprehensive kind; an orderly or regular method of procedure".*

According to Senge *et al* **[151]**, the word system, descends from the Greek verb *'sunistánai'*, which originally meant 'to place together', hence the view that a system is a perceived whole whose elements 'hang together', because they continually affect each other over time and operate toward a common purpose. This interpretation can be expanded upon if viewed against the definitions provided by Lannon-Kim **[95]** and the definition by Kramer and de Smit **[93]**.

- Lannon-Kim **[95]** and Kim **[89]** defines system as:

> *"a group of interacting, interrelated, or interdependent elements forming a complex and unified whole that has a specific purpose".*

- Kramer and de Smit **[93]** define a system as:

> *"a set of interrelated entities, of which no subset is unrelated to another subset".*

The definitions provided by Lannon-Kim **[95]** and Kramer and de Smit **[93]**, map in certain instances to the definition, which Kast and Rosenzweig **[82]** attach to the concept system namely:

> *"an organized, unitary whole composed of two or more interdependent parts, components, or subsystems and delineated by identifiable boundaries from its environmental suprasystem".*

Within this context, the term system covers a broad spectrum of our physical, biological and social world. This suggests the requirement for a 'General Systems Theory', which provides a broad macro view from which we may look at all types of systems given effect to the following words of Ashby (1964) cited by Kast and Rosenzweig **[82]**:

> *"So has arisen systems theory – the attempt to develop scientific principles to aid us in our struggles with dynamic systems with highly interactive parts".*

While the simplistic view of the concept system for Pascale **[123]**, 'only refers to how information moves around within the organisation', Churchman *et al* **[33]**, see system as, "an interconnected complex of functionally related components". The concept system is expanded by Achoff and Rivett **[5]**, to "a system's orientation", which they define as:

> *"deliberately expands and complicates the statements of problems until all the significantly interacting components are contained within it".*

This leads into the rather lengthy explanation by Johnson **[81]** of a system, provided in terms of the following fundamental characteristics:

> *"First, a system is a whole that consists of a set of two or more parts". "Each part affects the behaviour of the whole, depending on the part's interaction with other parts of the system". "In addition, the essential properties that define any system are properties of the whole, and none of the parts have those properties".*

The fact that a system is a whole that consists of a set of two or more parts' requires closer scrutiny. This implies that systems are composed of parts, which are themselves systems, according to Cleland and King **[38]** who cites the following example: "The human body is a system composed of various 'subsystems' (nervous, cardio-vascular, etc.)". "In turn, these sub-systems are composed of cells, each of which is itself a system". "Thus, systems typically exhibit a structure in which these are parts (sub-subsystems) imbedded within other parts (subsystems) within overall systems". This issue is deliberated further by Ackoff and Emery **[4]**, who look at, "human behaviour as systems of purposeful (teleological) events". Ashby **[16]**, is of the opinion that when a set of subsystems are richly joined, each variable is as much affected by variables in other subsystems as by those in its own. Furthermore, the imbedding of one system in another can go on through many stages and indeed go on endlessly.

In summary, Capra's **[27]** conceptualisation of system, in view of the author, draws together all the components of the concept. For Capra **[27]**, system means, "an integrated whole whose essential properties arise from the relationship between the parts which can be traced back to the root meaning of the word 'system' which derives from the Greek *'sunistánai'*, (to place together)".

In final conclusion, the controversial view of Weinberg **[181]**, who, when answering the question: What is a system? – retorts with:

> *"As any poet knows, a system is a way of looking at the world". "The system is a point of view – natural for a poet, yet terrifying for a scientist".*

2.3 GENERAL SYSTEMS THEORY

According to Kramer and de Smit **[93]**, Köhler a German physicist, was the first to give impulse towards the 'General Systems Theory' in 1924 with his book: *'Die physischen Gestalten in Ruhe und im stationären Zustard'*

Focussing on management, the earliest system models used in management according to Jackson **[80]**, studied organisations as mechanical systems in equilibrium. The idea of studying social systems in this way according to Jackson **[80]**, originally derived from Pareto (1919) and thereafter promoted in the United States by Henderson, a powerful figure at Harvard University in the 1930's.

According to Jackson **[80]**, citing Kast and Rozenweig (1981), three different models of management emerged from the 1930's onward namely, the Traditional Approach, the Human Relations Theory and the Systems Theory. The Traditional Approach was based on Taylor's Scientific Management, Fayol's Administrative Theory, and Weber's Bureaucracy Theory. Another theory, the Human Relations

Theory grew out of the critique of the Traditional Approach with theorists in the likes of Mayo, Maslow, Hertzberg and Mc Gregor avid supporters thereof.

Ludwig von Bertalanffy, in 1940 published in German his first discussion on open systems **[27]**, which was followed with an essay in 1950, entitled *'The Theory of Open Systems in Physics and Biology'* **[80]**. This according to Jackson **[80]** citing Emery (1969) and Lilienfeld (1978):

"establishes systems theory as a scientific movement".

This furthermore establishes von Bertalanffy rightfully as the founding father of the systems theory[3] **[80]**, who gave institutional embodiment to the concept by setting up the society for General Systems Research in 1954 with co-founders Boulding, Rapoport and Gerard **[93]**.

Capra **[27]**, citing from the work of von Bertalanffy (1968), provides the following definition of the 'General Systems Theory' from a holistic point of view:

> *"General system theory is a general science of 'wholeness' which up till now was considered a vague, hazy, and semi-metaphysical concept". "In elaborate from it would be a mathematical discipline, in itself purely formal but applicable to the various empirical sciences". "For sciences concerned with 'organized wholes', it would be of similar significance to that which probability theory has for sciences concerned with 'chance events'".*

Furthermore, according to Capra again citing von Bertalanffy (1968), the latter believed that a 'General Systems Theory' would offer an ideal conceptual framework for unifying scientific disciplines that had become fragmented:

[3] According to von Bertalanffy cited by Kast and Rosenzweig **[82]**: "The various fields of modern science have had a continual evolution toward a parallelism of ideas". "This parallelism provides an opportunity to formulate and develop principles which hold for systems in general".

> *"General systems theory should be . . . an important means of controlling and instigating the transfer of principles from one field to another, and it will no longer be necessary to duplicate or triplicate the discovery of the same principle in different fields isolated from each other". "At the same time, by formulating exact criteria, general systems theory will guard against superficial analogies which are useless in science".*

Caution in the use of the 'General Systems Theory' comes from Checkland **[29]** who is of the opinion that:

> *"The problem with General Systems Theory is that it pays for its generality with lack of content". "Progress in the systems movement seems more likely to come from the use of systems ideas within a specific problem area than from the development of overarching theory".*

It is of importance to note that while von Bertalanffy is commonly credited with the first formulation of a comprehensive theoretical framework describing the principles of organisation of living systems, the first papers on the general systems theory were formulated, not by von Bertalanffy, but by the Russian Alexander Bogdanov **[27]** twenty to thirty years earlier. According to Capra **[27]**, Bogdanov called his theory 'Tektology' from the Greek *'tekton'* (builder), which can be translated as 'the science of structures'. Bogdanov's pioneering book *'Tektology'*, was published in Russian in three volumes between 1912 and 1917, while the German edition was published and widely revised in 1928 **[27]**. Furthermore, according to Capra **[27]**, tektology anticipated the conceptual framework of Ludwig von Bertalanffy's General Systems Theory, and it also included several important ideas that were formulated decades later as key principles of cybernetics by Robert Wiener and Ross Ashby.

Kramer and de Smit **[93]**, acknowledge these parallel developments to the systems theory, namely contributions before 1950 pertaining to cybernetics citing Sziland, being in the forefront thereof with his book: *'Über die Entropieverminderung in* *einem thermodynamischen System bei Eingriffen intelligenter Wesen'*, and the work of Norbert Wiener in this respect, which led to the publication of his book *'Cybernetics'* in 1948, claiming that this was the most important impulse to the development of the General Systems Theory.

It was only during the 1960's, that the systems approach came to dominate management theory, due to the fact that the Traditional Approach concentrated on task and structure, the Human Relations Approach on people, and the systems approach was said to be 'holistic', because it focussed on organisations as a whole[4] **[93]**. This 'holistic' approach became a requirement according to Von Bertalanffy cited by Kramer and de Smit **[93]** due to the fact that in various academic principles, problems were becoming increasingly complex owing to progress in the respective sciences.

Vickers (1972) cited by Haines **[68]**, provides the following, rather lengthy, explanation of the General Systems Theory, in layman's terms, repeated here *verbatim* as to not lose the original meaning of the author:

> *"The words general systems theory imply that some things can usefully be said about systems in general, despite the immense diversity of their specific forms". "One of these things should be a scheme of classification".*
>
> *"Every science begins by classifying its subject matter, if only descriptively, and learns a lot about it in the process. . . ." "Systems especially need this attention, because an adequate classification cuts across familiar boundaries and at the same time draws valid and important distinctions which have previously been sensed but not defined".*

[4] The essence of the General Systems Theory can be expressed according to Kramer and de Smit **[93]** as: "the whole is more than the sum of its parts".

> *"In short, the task of General Systems Theory is to find the most general conceptual framework in which a scientific theory or a technological problem can be placed without losing the essential features of the theory or the problem".*

According to Haines **[68]**, this theory, then, is a marvellous vehicle for framing and describing universal relationships. Its basic precept is that, in our work in any problem, the whole should be our primary consideration, with the parts secondary.

2.4 THE CONCEPT SYSTEMS APPROACH DEFINED

It is the 'approach' to the concept 'system', which is encapsulated in the following definition from *The Oxford English Dictionary* **[168]**, which defines 'an approach' as:

> *"A way of considering or handling something, esp. a problem"*

This definition is identical to the definition provided by Checkland **[29]** who defines 'approach' as:

> *"a way of going about tackling a problem".*

Checkland expands this definition into a definition for the systems approach, which reads as follows:

> *"An approach to a problem which takes a broad view, which tries to take all aspects into account, which concentrates on interactions between the different parts of the problem".*

Lannon-Kim **[95]** defines the systems approach as:

> *"a school of thoughts which focuses on reorganizing the interconnections between the parts of a system and synthesizing them into a unified view of the whole".*

This definition maps to the systemic view of Palazzoli *et al* **[122]** where the authors make the observation that, "no phenomenon can be grasped unless the field of observation includes the whole context in which the phenomenon occurs". This definition leads into the requirement to understand the difference between systems analysis and systems synthesis, as Johnson **[81]** is of the opinion that, "the systems approach is more synthesis than analysis"[5].

Checkland **[29]** defines the process of management as being:

> *"concerned with deciding to do or not to do something, with planning, with considering alternatives, with monitoring performance, with collaborating with other people or achieving ends through others; it is the process of taking decisions in social systems in the face of problems, which may not be self-generated".*

The systems approach, since inception have been expanded upon and changed over the years and specifically applied to a world where complex phenomena are of the order of the day. The systems approach, as a regulated mechanism, specifically provides structure and order to any mode of inquiry within the context of such complex phenomena.

The complex phenomena associated with the art of management, and for the purpose of this thesis, executive management is encapsulated by the following extract from Goodman **[66]**:

> *"English, like most other Western languages, is linear – its basic sentence construction, noun – verb – noun, translates into a worldview of X causes Y". "This linearity predisposes us to focus on one way relationships rather than circular or mutually causative ones, where X influences Y, and Y in turn influences X". "Unfortunately, many of the most vexing problems, confronting managers and corporations today are caused by a web of tightly interconnected circular relationships". "To enhance our understanding and*

[5] See also Chapter 3, Paragraph 3.3 dealing with 'systems analysis'.

communication of such problems, we need a language more naturally suited to the task".

Goodman **[66]** suggests the systems approach as being the most suited language for communicating such complexities and interdependencies. This is supported by Dearden **[44]**, a Harvard professor, who referred to the systems approach as, "nothing more than good management". The systems approach is today the most popular problem solving technique **[103]**, which is to be expanded in this thesis to address specific phenomena pertaining to executive management over a spectrum of disciplines. The statement of Churchman **[34]** that: "the systems approach is not a bad idea", encapsulates all of the issues above.

While system analysis is useful for revealing *'how'* a system works – its structure **[159]**, system synthesis reveals *'why'* a system works the way it does, the latter the very essence of the systems approach, which is supported by Kramer and de Smit **[93]** who is of the opinion that, "The systems approach is a means of tackling problems, a methodology", which maps to the theme of this thesis, namely a *structured systems approach to model conceptualisation.* This is conceptually supported by Goodman *et al* **[65]** when discussing the power of systems thinking. The authors **[65]** upheld the opinion that, "the systems approach is especially useful for defining problems, formulating and testing potential solutions and implementing effective solutions that endure".

Oversimplified in its most basic format, and bordering on layman's terms, the systems approach to problem solving involves the following steps **[146]**, **[18]**, **[103]**, **[20]**:

- Define the problem.
- Gather data describing the problem.
- Identify alternative solutions.
- Evaluate these alternatives.
- Select the best alternative.
- Follow up to determine if the solution is working.

On the broadest level according to Churchman **[32]** and Senge *et al* **[151]**, the systems approach belongs to a whole class of approaches to managing and planning our human affairs with the intent that we as a living species conduct ourselves properly in this world. More in line with the theme of this thesis, Churchman **[34]** evaluates the systems approach from the point of view of the management scientist. In this respect, the systems approach entails:

> *"The construction of 'management information systems' that will record the relevant information for decision-making purposes and specifically will tell the richest story about the use of resources, including lost opportunities".*

Churchman **[34]** continues and draws the analogy that, "systems are made up of sets of components that work together as a whole, and that the systems approach is simply a way of thinking about these total systems and their components", which is in line with the view of Senge **[152]**, who is of the opinion that the discipline of the systems approach lies in a shift of mind:

- Seeing interrelationships rather than linear cause-effect chains.
- Seeing processes of change rather than snapshots.

An all incumbent analogy provided by Capra **[27]** is most appropriate when the author views a system as meaning an integrated whole whose essential properties arise from the relationship between its parts, and 'systems thinking'[6], the understanding of a phenomenon within the context of a 'larger whole'[7].

The concepts 'systems thinking' and 'larger whole' requires closer scrutiny. 'Systems thinking' according to Duhl **[46]**, as an internal mode of 'seeing' ordered patterns of relationships, processes and interconnectedness in and between objects, phenomena, and people, has perhaps existed forever in the minds of various disparate individuals. As a particular way of looking at the world that when extended, becomes a shared total world-view of a dynamically interacting model of the universe. According to Haines **[68]**, systems thinking, represents a

[6] See also Appendix C, Paragraph C2.8
[7] See also Appendix C, Paragraphs C2.8, C2.9 and C2.10.

new way to view and mentally frame what we see in the world; a worldview and way of thinking whereby we see the entity or unit first as a whole, with its fit and relationship to its environment as primary concerns; the parts secondary. This 'whole' view of the systems approach is supported by Senge **[152]** in the following philosophical approach to the concept, which is retained in the original text to ensure that the full impact of the wisdom can be appreciated:

> *"The words 'whole' and 'health' comes from the same root (the Old English 'hal', as in 'hale and hearty')". "So it should come as no surprise that the unhealthiness of our world today is in direct proportion to our inability to see it as a whole". "Systems thinking is a discipline for seeing wholes". "It is a framework for seeing interrelationships rather than things, for seeing patterns of change rather than static snapshots". "It is a set of general principles- distilled over the course of the twentieth century, spanning fields as diverse as the physical and the social sciences, engineering and management".*

The most generally known thesis with regard to 'wholes' is the following:

"The whole is more than the sum of its parts".

According to Angyal **[13]**, this is not a very felicitous formulation since – contrary to the concept of Gestalt psychologists – it may suggest that a summation of parts takes place and that, besides the summation, a new additional factor enters into the constitution of wholes. Feiblemen and Friend **[53]**, underpins the understanding of the concept of 'wholes' with this following powerful analogy of the concept namely:

> *"Wholes are not a level of analysis, but that from which analysis starts".*

This statement becomes more relevant if viewed against the background of the study at hand, in particular with respect to the analysis of complex phenomena.

Senge **[152]** concludes that the systems approach is a sensibility – for the subtle interconnectedness that gives living systems their unique character. According to Singer cited by Mitroff and Linstone **[108a]**, the fundamental notion of interconnectedness, or non-reparability forms the basis of the systems approach.

In final conclusion the views of Chestnut, cited by Silvern **[154]**, who stated that the systems approach is dedicated to emphasising the ideas, which are common to the successful operation of somewhat independent parts in an integrated 'whole'. A comprehensive analysis of the history and emergence of the systems approach is contained in Appendix C.

2.5 CYBERNETICS DEFINED

According to Checkland **[29]**, a part of 'systems theory' known as cybernetics, the word coming from the Greek word *'kybernetes'* meaning 'steersman', forms the link between control mechanisms studied in natural systems as opposed to those engineered in man made systems. According to Kramer and de Smit **[93]**, the Greek philosopher Plato used it in his discussions about the analogy between navigating a ship and governing a country or group of people, and was rediscovered in 1840 by Ampere in his classification of the sciences. The first application of the concept however can be traced back to Arabic and Greek manuscripts around 200 BC where it was according to Kramer and de Smit **[93]**, citing Verveen, used where control systems are mentioned.

It is Lerner **[96]** who draws the attention to the fact that cybernetics is generally associated with the date of publication (1948) by Norbert Wiener of his book *'Cybernetics, or Control and Communication in the Animal and the Machine'*, however in addition acknowledging valuable earlier contributions from Maxwell, Vyshnegradskiy, Shestakov, Gavrilov, Nakashimo, Pascal, Leibniz and Babbage. Checkland **[29]** and Kramer and de Smit **[93]** cites the studies of Wiener (1948), who defined cybernetics as:

> *"the entire field of control and communication theory, whether in the machine or in the animal".*

Checkland **[29]** further cites Ashby (1956), the latter considered the leading theoretician in the 1950's and 1960's, and who describes cybernetics somewhat different from Wiener, Ashby (1956) defines cybernetics as follows:

> *"Cybernetics is similar in its relation to the actual machine". "It takes as its subject matter the domain of 'all possible machines'..." "What cybernetics offer is the framework on which all individual machines may be ordered, related and understood".*

Another definition of Wiener, this time cited by Clemson **[39]**, defined the concept as:

> *"The science of effective communication and control in men and machine".*

Flood and Jackson **[56]** expand on this and describe cybernetics as:

"the science of organisation".

Wiener furthermore, according to Kramer and de Smit **[93]**, is of the opinion that cybernetics is not a science, which studies systems, but a science, which studies the behaviour of systems. From this the analogy can be drawn that the origins of modern cybernetics are diverse, but are to be found most concretely in the research of Wiener during the Second World War, particularly in the attempt to develop and refine devices for the control of gunfire **[114]**. This leads onto the notion that cybernetics has tangent planes to the control of processes, an analogy that is confirmed by Churchman **[34]**, when he defines cybernetics as:

> *"a mathematical method of evaluating and controlling a process on the basis of its experience".*

Churchman **[30]**, expands on this definition when he views cybernetics as the discipline concerned with the way in which individuals pursue – or ought to pursue – their goals. According to the author **[30]**, it emphasises the importance of equilibrium, of an internal state that is capable of responding to environmental change without the system's getting off its chosen course. Beer **[22]**, is of the opinion that, "the study of control is a science in its own right, known as cybernetics", while Beer **[23]** furthermore defined the concept as:

"the science of effective organization".

Quoting from an article by Beer entitled *'Towards the Cybernetic Factory'* in Heinz von Foerster and George Zoph (Eds) *'Principles of Self-organization'* (1962), Clemson **[39]** gives the following rendition of Beer's thoughts in respect of the above definition when, the latter thinks of systems with the following characteristics:

- **Complex:-** They have more relevant detail than the given observer can possibly cope with.
- **Dynamic:-** They are changing in their behaviours or structure or both.
- **Probabilistic:-** There are important elements whose behaviours are at least partly random.
- **Integral:-** They act in some important sense as a unity.
- **Open:-** They are embedded in an environment which affects them and which they affect.

From the above, according to Clemson **[39]**, the analogy can be drawn that:

> *"Cybernetics studies the difference between effective and ineffective modes/structures/methods of organization in certain classes of systems".*

It is of importance to draw a clear distinction between 'management cybernetics' falling within the ambit of hard systems methodologies discussed in detail in Chapter 3, and 'organisational cybernetics' falling within the ambit of soft systems methodologies discussed in detail in Chapter 4. The following descriptions according to Jackson **[80]** can be attributed to these two entities:

- **Management Cybernetics:-** This kind of cybernetics treats organisations as if they were actually like machines or organisms. The starting point for a management cybernetic model of the organisation is the input-transformation-output schema. This is used to describe the basic operational activities of the enterprise. The goal or purpose of the enterprise is in management cybernetics, invariable determined outside the system. Then, if the operations are to succeed in bringing about the goal, they must, because of inevitable disturbance, be regulated in some way. This regulation is effected by management. Management cybernetics attempts to equip managers with a number of tools that should enable them to regulate operations. Simplifying considerably (since in fact the cybernetic tools represent an interrelated response to the characteristics of cybernetic systems), extreme complexity can be dealt with using the black box technique, self-regulation can be appropriately managed using negative feedback, and probabilism yields to the method of variety engineering. These three entities will be discussed in greater detail in Chapter 3, Paragraph 3.5 (management cybernetics). Furthermore, whether based on machine analogy or on a biological analogy, management cybernetics can be criticised for exactly the same reasons as hard systems thinking. In this respect, see Chapter 3, Paragraph 3.6.

- **Organisational Cybernetics:**-This concept which is primarily the brainchild of the revered Professor Stafford Beer **[21, 22, 23]**, further supported by Clemson **[39]** and Espejo, the latter cited by Jackson **[80]**. Organisational cybernetics is a strand of cybernetic work concerned with management and organisations that breaks somewhat with the mechanistic and organismic thinking that typifies management cybernetics, and is able to make full use of the concept of variety. Stafford Beer's version of organisational cybernetics seems to have emerged from management cybernetics as a result of two breakthroughs. First, in his book, *"The Heart of the Enterprise"*, Beer (1979) succeeds in building his 'Viable Systems Model' in relation to the organisation from cybernetic first principles. This enables cybernetic laws to be fully understood without reference to the mechanical and biological manifestations in which they were first recognised. Second, more attention is given in organisational cybernetics to the role of the observer. Clemson **[39]**, makes a distinction between a first order cybernetics appropriate to organised complexity because it studies matter, energy, and information and a second order cybernetics (organisational cybernetics) capable of tackling relativistic organised complexity because it studies, as well, the observing system.

Organisational cybernetics, will be discussed in greater detail in Chapter 4, as part of the analysis of the soft systems approach.

2.6 CLOSED AND OPEN SYSTEMS DEFINED

It was von Bertalanffy **[175]**, **[49]**, who first made a clear distinction between two types of systems -'closed' and 'open' in contrasting biological and physical phenomena. Furthermore, he was important for establishing the notion of open systems on a scientific basis **[84]**.

Davis **[43]**, defines a closed system as a system which is self-contained, does not exchange material, information or energy with its environment and as an example of a closed system, cites a chemical reaction in a sealed, insulated container. It is for this reason then that Kremyanskiy **[94]** argues that the entropy of a closed system as a rule only grows, whereas the system as a whole, being subservient to the environment and incapable of renewing itself, is inevitable destroyed, without, moreover, leaving a successor.

Davis **[43]**, cites a biological system (such as man) as an example of an open system, as the elements exchange information, material, or energy with the environment. This exchange according to Kremyanskiy **[94]** serves as the basis for the perpetuation of this form of existence and as the basis for the decrease of relative constancy of entropy only when the system possesses certain features of internal organisation and interaction with the environment.

According to von Bertalanffy **[175]**, the following criteria distinguishes between closed and open systems:

Closed Systems:

- A system is closed if no material enters or leaves it.
- A closed system must, according to the second law of thermodynamics, and according to Koehler **[92]**, eventually attain a time-independent equilibrium state, with maximum entropy and minimum free energy, where the ratio between its phases remains constant.

- A closed system in equilibrium does not need energy for its preservation, nor can energy be attained from it.
- Closed systems cannot exhibit equifinality (The ability to reach the same final state from different initial conditions and in different ways).

Open Systems:

- From a physical point of view, the characteristic state of a living organism is that of an open system.
- A system is open if there is import and export, therefore, change of the components.
- An open system may attain a time-dependent state where the system remains constant as a whole and in its phases, though there is a continuous flow of the component materials.
- The character of an open system is the necessary condition for the continuous working capacity of the organism.
- The basic characteristics of self-regulation are general properties of open systems adapting to circumstances by changing the structure of processes of their internal components.
- Open systems which are exchanging materials with the environment, in so far as they attain a steady state, the latter is independent of initial conditions, is equifinal.
- Open systems can evolve toward states of greater complexity and differentiation, reversing the law of entropy.

Katz and Kahn **[83]**, identifies the following nine characteristics as definitive of all open systems:

- **Importation of energy:-** Open systems import some form of energy from the external environment.
- **The through-put:-** Open systems transform the energy available to them.
- **The output:**- Open systems export some product into the environment.
- **Systems as cycles of events:-** The pattern of activities of the energy exchange has a cyclic character.
- **Negative entropy:**- To survive, open systems must move to arrest the entropy process – they must acquire negative entropy.

- **Information input, negative feedback, and the coding process:-** Inputs are informative in character, and furnish signals to the structure about the environment and about its own functioning in relation to the environment. The simplest type of information input found in all systems is negative feedback. The general term for the selective mechanisms of a system by which incoming materials are rejected or accepted and translated for the structure is coding.
- **The steady state and dynamic homeostasis:-** The importation of energy to arrest entropy operates to maintain some constancy in energy exchange, so that open systems, which survive, are characterised by a steady state.
- **Differentiation:-** Open systems move in the direction of differentiation and elaboration.
- **Equifinality:-** Open systems are characterised by the principle of equifinality, meaning that a system can reach the same final state from differing initial conditions and by a variety of paths.

The view of von Bertalanffy **[175]** is that:

> *"The formal correspondence of general principles, irrespective of the kind of relations or forces between the components, lead to the conception of a 'General Systems Theory' as a new scientific doctrine, concerned with the principles which apply to systems in general".*

This statement by von Bertalanffy emphasises the importance of the concept open systems, in particular with reference to the research contained within the ambit of this thesis.

2.7 THE ROLE OF MODELS

This thesis is based on the system dynamics of a formulated *structured systems approach to model conceptualisation* specifically applied to the art of executive management, to structure the outcomes of paradigm shifts introduced into organisations as a result of unstructured complex phenomena. This high level role of the *structured systems approach to model conceptualisation* can be generalised to provide insight into the application of models in organisations as a tool to manage complex phenomena.

To create a deeper understanding of the importance of the concept 'model' within the ambit of this thesis, the following humoristic explanation thereof is offered by Cleland and King **[38]**: "The layman's idea of the meaning of the word 'model' probably concentrates on that sort which are commonly found in *Playboy magazine* and in fashion shows, however, if pressed to consider other varieties, most of us would react to the idea by describing a model airplane". "In doing so we would have brought to light the most important characteristic of models as they are used in management and in decision analysis namely that":

"A model is a representation of something else".

In the analysis of the definition of the concept model, Cleland and King **[38]** point to the fact that the 'something else' in the definition usually denotes some observable system or phenomenon existing in the real world, which is to be represented for purposes of display and analysis. They cite the examples of a child's model airplane being a representation of a real-world airplane and a schematic diagram, which represents the configuration of a large-scale electrical system. A basic, general descriptive definition of a model is provided by Takahashi and Takahara **[167]** as follows:

> *"Let A and B be two objects". "If B is considered to copy the features of A, B is called a model of A". "Then A is a prototype of B".*

There are many different kinds of models and there are many kinds of classification schemes, which have been applied to models. One of the taxonomies, which is most useful in understanding the structural differences in models is that given by Churchman *et al* **[33]**, when the authors categorise models as either 'iconic', 'analog', or 'symbolic'.

- **Iconic models:-** An iconic model is a simple scale transformation of the real-world system thus, the model airplane is an iconic model.

- **Analog models:**- An abstract variety of models as the properties thereof are transformed – i.e., one property is used to represent another. A graph is the simplest illustration of an analog model.
- **Symbolic models:**- The most abstract variety of model is the symbolic model. In such a model, symbols are substituted for properties. For example the equation $x = \frac{1}{2} gt^2$ is a simple physical model if x is interpreted to be the distance travelled by a body falling from rest, g is a constant describing the acceleration caused by the force resulting from gravity, and t is the duration of time which the body is allowed to fall. In management, symbolic models have long been used to describe simple phenomena. For instance, the model $P = R-C$ or, '*Profit* equals *Revenue* minus *Cost*', has long been recognised and used by managers. Only recently, however, have managers begun to use symbolic models for more complex phenomena.

According to Sterman **[161]**, one of the most useful classifications of models, divides models into those that 'optimise' versus those that 'simulate'. Clemson **[39]** provides an appropriate description of the requirement for models in organisation, which reads as follows:

> *"The manager is always faced with some 'thing' which he/she is trying to 'manage' into behaving in one sort of way rather than some other sort of way".*

This rather abstract description of the manager applies equally well to a cowboy herding steers, a teenager nursing along a jalopy, a teacher coaxing a class into learning, a doctor running a hospital, or the president of the United States trying to manage foreign and domestic policy. In all cases, the 'manager' acts on the basis of some framework that includes at least four elements:

- Some image of a preferred state, perhaps a goal or perhaps merely a way of behaving by the system (e.g. a low rate of crime is desired).
- Some image of the current state of the system (e.g. society suffers from a high rate of crime).

- Some image of the 'way the system works'. (e.g. the reducible system view of crime noted above).
- A belief based on the previous three images, that the situation might be improved by a given sort of 'managing'. (e.g. increase the penalties for criminal behaviour and criminals should be deterred).

The above maps to the description of 'mental models' as provided by Sterman **[161]**, who describes the concept as flexible, taking into account a wider range of information than just numerical data, and can be adapted to new situations and be modified as new information becomes available. Furthermore, mental models can be described as the 'filters' through which we interpret our experiences, evaluate plans, and choose among possible courses of action. Richmond **[137]**, is of the opinion that mental models are the dominant 'thinking paradigm' in most of the western world today.

Given that the situation to be managed is always more complex than the manager, the problem of choosing reasonable actions is quite difficult. To be precise, it is quite common for gross errors to occur in all four of the elements noted above. This means:

- The image of the preferred state may be in error. It is quite common that once achieved, the desired state turns out to be less valuable than was expected. In particular, the desired state may have unanticipated negative consequences that outweigh the beneficial results. Typically, desired states are seen as means to some other end and the assumed relationship to the higher end may be wrong so that achievement of the desired state does not, in fact, assist in reaching the higher goal.
- The image of the current state of the system is often seriously in error. The most common way in which this happens in large systems is that the manager is simply unable to remain informed about the relevant system aspects. Another common problem is that the manager may seriously misjudge critical aspects of the system. For instance, managers are frequently grossly wrong in their beliefs about subordinate's values, attitudes, desires and the need for communication.

- Our image of 'the way the system works' is almost always inadequate and is frequently wrong for social systems. Errors in the image of 'the way the system works', frequently lead us to undertake actions, which end up having an effect opposite to that which is desired.
- Our beliefs about the relationship between action and outcome constitute a model of 'the way the system works'.

Blake and Mouton **[23a]** provide the following specifications for designing a model based on systematic development[8], 'of what should be', which is repeated here *verbatim* to retain the original thoughts of the authors and to enforce the concept of formulating an 'approach'[9] as opposed to formulating a 'model':

> *"Clear-cut objectives are a prerequisite to the kind of development that takes place under the systematic approach". "An ideal model specifies what the result should be at a designated time". "To be systematic, the model must be based on theory, fact, and logic, uncontaminated in the status quo or by extrapolations from the past". "The model must be understood to represent the ideal, not the idealistic". "Ideal thinking can identify what is possible according to theory, logic and fact". "Ideal thinking can be tested against objective criteria to assess its practicality". "Idealistic thinking, on the other hand would have an unreal quality, probably rooted in self deception and expressing what is desired or what is wanted without having been tested against theory, logic or fact". "Ideal thinking is subjective and is based on criteria having little or nothing to do with the facts of the situation". "Ideal thinking has sometimes been suspect and rejected as idealistic". "Yet through history, some of what might qualify as among the world's greatest change projects – The Magna Charta, the Constitution of the United States – have probably come about through ideal-type formulations".*

[8] A more detailed presentation of the theory, techniques, and results of systematic development is contained in a book by the authors entitled: *Corporate Excellence Through Grid Organization Development: A Systems Approach.* Houston: Gulf publishing Company, 1968.
[9] For further discussion, see Chapter 5, Paragraph 5.1.

The above can be appropriately summarised by the view of Cook and Russell **[40]**, who in general terms, 'view a model as a representation or an abstraction of an object or a particular real world phenomenon'.

Although this thesis deals primarily with the formulation of a *structured systems approach to model conceptualisation*, an entity which will serve as input mechanism to the building of systems models[10], a discussion brief on models would not be complete without bringing to the attention of the reader, the works of Hall **[70]** and Morecroft *et al* **[109]**, to single out two of the most prominent academics, especially in describing the processes involved in systems model building.

2.8 IMPACT OF THE NOTIONS *WELTANSCHAUUNG* AND APPRECIATIVE SYSTEMS

According to Jackson **[80]**, the social world is seen as being the creative construction of human beings. It is necessary therefore, to proceed by trying to understand subjectively, the point of view and the intentions of the human beings who construct social systems. Hence the importance in 'soft' systems thinking (discussed in more detail in Chapter 4) of probing briefly the worldview or '*Weltanschauung*' of Churchman **[34]**, and the concept of 'appreciative systems' of Vickers **[174]**, that individuals employ in understanding and constructing the social world. In this thesis the above notions will only be discussed briefly as they relate to soft systems to create an understanding of the concepts.

- **The notion of '*Weltanschauung*'**

This notion according to Jackson **[80]**, carries the implication that an individual's interpretations will be far from random, they will be consistent in terms of a number of underlying assumptions that constitute the core of that individual's world view or '*Weltanschauung*'. Flood **[55]**, is of the opinion that world-viewism has several theoretically orientated scenarios, each one neglecting to recognise that no single position has or is ever likely to explain everything. The

[10] The reader's attention is drawn to the fact that 'the pilot', represented as Phase 8 in the process of model conceptualisation and described in Chapter 5, Paragraph 5.6.1, is considered to be a 'conceptual model'

'Weltanschauung' idea has been used by Churchman **[34]** and Checkland **[29]** in the development of methodologies to solve problems in systems.

Checkland **[29]** has suggested that this methodology can be applied to reveal any recurrent *'Weltanschauungen'* and that it therefore opens up the prospect of discovering 'the universal structures of subjective orientation in the world' (Luckmann, quoted in Checkland **[29]**). The notion of *'Weltanschauung'* is brought into context with the systems approach by Checkland **[29]** as follows: "A systems approach tries explicitly to avoid reductionism by viewing the world in systems terms". "It uses systems concepts in order to see the raw data of the outer world in a particular way, namely a set of systems". "It converts the raw data into a particular kind of information, and this is the process occurring in virtually all human thinking". Whether we realise it or not, we view raw data via a particular mental framework, or worldview (*'Weltanschauung'*). The hard systems methodology according to Checkland **[29]**, is concerned only with a single *'Weltanschauung'* – a need is defined or an objective is stated, and an efficient means of meeting the need or reaching the objective is needed. In soft systems methodology, we are forced to work at a level at which worldviews or *'Weltanschauungen'* are questioned and debated. Soft problems are concerned with different perceptions deriving from different[11] *'Weltanschauungen'*.

➢ **The notion of Appreciative Systems**

According to Vickers **[174]**, "the only way to understand decision making in human systems is to understand the different appreciative systems that the decision-makers bring to bear on the problem". Jackson **[80]**, explains the concept as follows: "An individual's appreciative system will determine the way he or she sees and values various situations and hence how he or she makes 'instrumental judgements' and takes 'executive action' – in short, how he or she contributes to the construction of the social world". It follows, according to Vickers (1973) cited by Jackson **[80]**, that if human systems are to achieve stability and effectiveness, then the appreciative systems of their participants need to be sufficiently shared to allow mutual expectations to be met.

[11] This particular principle of debating multiple worldviews forms a key component of Phase 4 in the process of model conceptualisation as described in Chapter 5, Paragraph 5.6.1.

2.9 CAUSAL LOOP DIAGRAMS AND REINFORCING AND BALANCING PROCESSES

Two of the most powerful systems approach tools are causal loop diagrams, and reinforcing and balancing processes. These two entities can be analysed as follows:

- **Causal Loop Diagrams:-** According to Kim **[87]**, 'feedback' is the 'transmission and return' of information, with 'return', the very characteristic that makes the feedback perspective different from the more common linear cause-and-effect way of viewing the world. The linear view depicted below as Figure 2.3, sees the world as a series of un-directional cause-and-effect relationships: A causes B causes C causes D, etc.

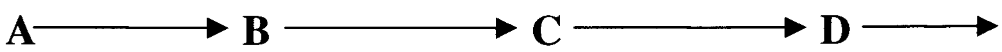

Figure 2.3: The linear view perspective (Single Loop) **[87]**

The linear view perceives the world as a series of events that flows one after the other **[19]**. For example, if sales should go down (event A), action can be taken by launching a promotions campaign (event B), sales rises (event D), and backlogs increase (event D). Should sales go down again, action can be taken by launching yet another promotional campaign . . . and so on. Through the lens of the linear perspective, the world is perceived as a series of events that trigger other events. The feedback loop perspective depicted below as Figure 2.4, on the other hand, sees the world as an interconnected set of circular relationships, where something affects something else and in turn is affected by it: A causes C causes A, etc.

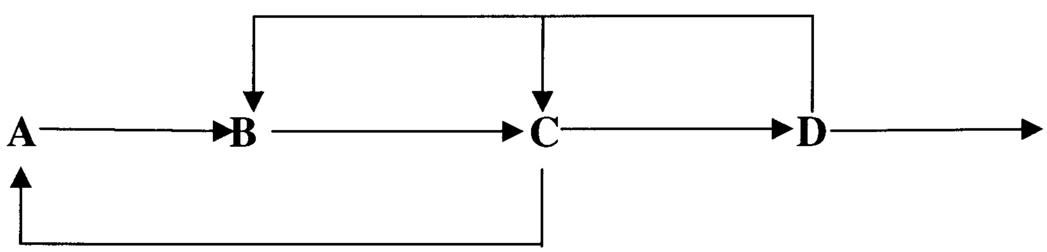

Figure 2.4: The feedback loop perspective (Double Loop) **[87]**

Using the same example as in the linear view perspective, the feedback loop perspective would demand that when sales go down (event A), action can be taken by launching a promotions campaign (event B). As orders increase (event C), and sales rise (change in event A), backlogs increase (event D), (another eventual effect of event B), which affects orders and sales (change in events C and A), which leads to a requirement to repeat the original action (event B). Mathematically, according to Capra **[27]**, a feedback loop corresponds to a special kind of non-linear process known as iteration (Latin for 'repetition'), in which a function operates repeatedly on itself. For example, if the function consists of multiplying the variable x by 3, i.e. $f(x) = 3x$, the iteration consists in repeated multiplication. In mathematical shorthand, this is written as $x \rightarrow 3x$, $3x \rightarrow 9x$, $9x \rightarrow 27x$ etc. Each of these steps is called a 'mapping'. If we visualise the variable x as a line of numbers, the operation $x \rightarrow 3x$ maps each number to another number on the line. More generally, a mapping that consists in multiplying x by a constant number k, is written $x \rightarrow kx$. An iteration found very often in non-linear systems, is the mapping $x \rightarrow kx(1-x)$, where the variable x is restricted to values between 0 and 1. This mapping is known as 'logistic mapping' and has many important applications of which the description of growth of a population under opposing tendencies serves as an example and also known as the 'growth equation'.

According to Kauffman **[84]**, feedback provides stability in a system that would otherwise be unstable. The importance of 'feedback' is emphasised by Skyrme **[157]**, when citing Davidson as follows:

> *"We are particular poor at appreciating the role of feedback structure in dynamics we experience in the systems we strive to manage . . ." "The possibility exists that management policy and decisions actually contribute to creating the dynamic problems they are intended to solve".*

The impact of feedback can perhaps best be described in terms of single loop and double loop learning using the same principle as explained above. The processes of single and double loop learning as advocated by Argyris (1992) and cited by Watkins **[177]**, are depicted in Figure 2.5.

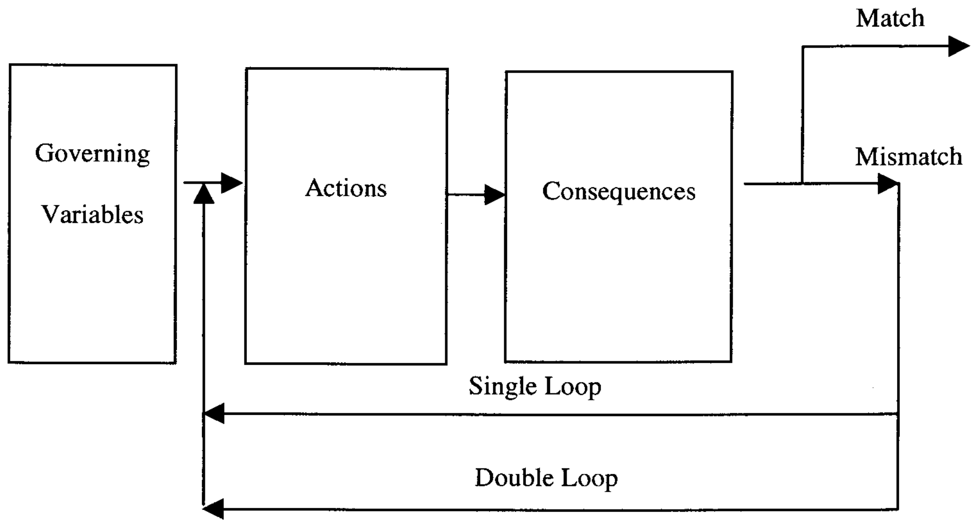

Figure 2.5:-Single-Loop and Double-Loop Learning **[177]**

The following rather extensive explanation of the above concept by Argyris (1992) cited by Watkins **[177]**, could not be improved upon, and based on the practicality of the example, is repeated here *verbatim* as follows:

"Single loop learning can be compared with a thermostat that learns when it is too hot or too cold and then turns the heat on or off". "The thermostat is able to perform this task because it can receive information (the temperature of the room) and therefore take corrective action". "If the thermostat could question itself about whether it should be set at 68 degrees, it would be capable not only of detecting error but of questioning the underlying policies and goals as well as its own program". "That is a second and more comprehensive inquiry; hence it might be called double loop learning". "When the plant managers and marketing people were detecting and attempting to correct the error in order to manufacture Product X, that was single loop learning". "When they began to confront the question whether Product X should be manufactured, that was double loop learning, because they were now questioning underlying organisation policies and objectives".

Specifically pertaining to solving unstructured complex phenomena, Richardson **[133]**, makes the observation that, "management rarely have the luxury of being able to make a decision in which causality goes only outward and does not generate repercussions that feedback to influence or affect management". Richardson **[133]**, continues his observation with the view that, "management plans and decisions alter the playing field, and consequently always have a hand in shaping the subsequent conditions to which management must respond".

- **Reinforcing Processes:-** According to Senge **[152]**, reinforcing feedback processes are the engines of growth. Whenever the situation occurs where things are growing, one can be certain that reinforcing feedback is at work. Furthermore, reinforcing feedback can also generate accelerating decline – a pattern of decline where small drops amplify themselves into larger and larger drops, such as the decline in bank assets when there is a financial crisis on the financial markets. Figure 2.6 represents reinforcing processes using a savings account as an example. Kim **[87]**, provides the following explanation of the two diagrams in Figure 2.6 to illustrate the mechanisms pertaining to reinforcing processes: If there is a positive balance each time there is an interest payment calculation, the amount will be slightly bigger than the preceding payment period. This is due to the fact that the balance has increased since the previous calculation. The time period after that, the interest amount will be bigger still, due to the fact that the balance has increased a little more since the time before.
- **Balancing Processes:-** According to Senge **[152]**, balancing feedback processes operates whenever there is a goal-orientated behaviour. If the goal is to be not moving, then balancing feedback will act the way the brakes in a car do. If the goal is to be moving at sixty miles per hour, then balancing feedback will cause the car to accelerate to sixty, but not faster. The goal can be an explicit target, as when a firm seeks a desired market share, or it can be implicit, such as a bad habit, which despite disavowing, we stick to nevertheless. Figure 2.7 represents balancing processes using a thermostat in a house as an example.

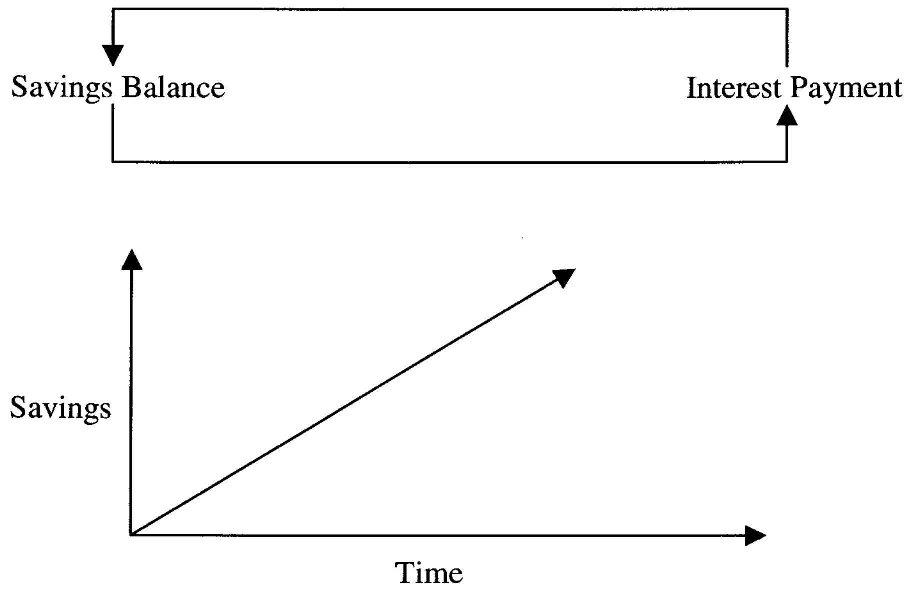

Figure 2.6: Reinforcing Processes **[87]**

Kim **[87]**, provides the following explanation of the two diagrams in Figure 2.7 to illustrate the mechanisms pertaining to balancing processes: When a home thermostat detects that the room temperature is higher than the thermostat setting, it shuts down the heat.

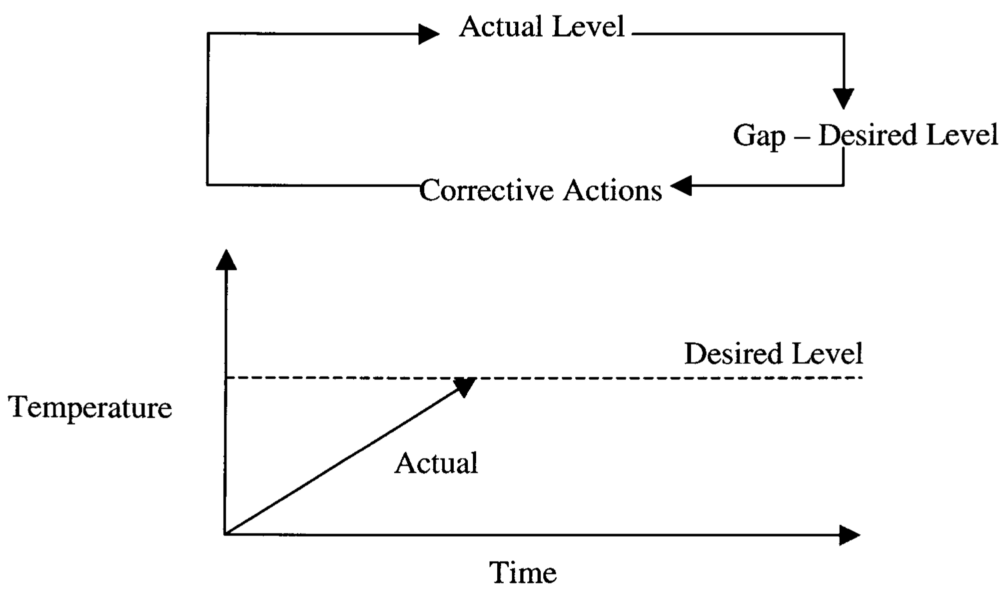

Figure 2.7: Balancing Processes **[87]**

There is always an inherent goal in a balancing process, and what 'drives' a balancing loop is the gap between the goal (the desired level) and the actual level. As the discrepancy between the two levels widen, the system takes corrective actions to adjust the actual level until the discrepancy decreases. In the thermostat example, gaps between the actual room temperature and the temperature setting of the thermostat (the goal) prompt the thermostat to adjust the heating and cooling mechanisms in the house to bring the actual temperature closer to the desired temperature. In this sense, balancing the processes always try to bring conditions into some state of equilibrium.

Although not falling within the research scope of this thesis, Kim **[88]**, in addition identifies other 'systems thinking' tools which are regularly employed as systems approach mechanisms, namely:

- Double-Q diagrams.
- Behaviour over time diagrams.
- System Archtypes.
- Graphical function diagrams.
- Structural behaviour pairs.
- Policy structure diagrams.
- Computer models.
- Management flight simulator.
- Learning laboratories.

2.10 SCIENCE AND TECHNOLOGY IMPACT

Science and technology, while not a direct consequence of the complexities of the systems approach, are considered very much part of unstructured complex phenomena, specifically if viewed against the following powerful statement by Halal *et al* **[69]**:

> *"Just as the medieval castle, the monarchy, and the institutions of an Agrarian era were transformed by the relentless advance of industrial technology into our present world, now the relentless advance of information technology is transforming society again".*

In essence, what is desired are the good, or positive benefits of technology and the elimination, or minimising of the negative aspects. To this purpose, according to

Roman **[139]** and Bond **[25]**, technological impact must be understood and technological change must be managed, which according to Feeny and Willcocks **[52]**, make them typical candidates for systems thinking. This implies in the words of Handy **[71]**, "that it is the things outside the organisation, the things that are beyond the manager's control that now become priorities".

The view of Schwartz **[148]**, encapsulates the importance of science and technology for executive management with the following extract:

> *"This force (for science and technology really comprise a single force) is one of the most important drivers of future events". "It literally shapes the future". "Politics can change, but a scientific innovation, once released into the world, cannot be taken back". "Nor can its impact be legislated away or forbidden by the chairman of the board". "Thus, keeping track of new developments in physics, biotechnology, computer science, ecology, microbiology, engineering, and other key areas is a special duty".*

Of all the authors cited in this section, it is perhaps only Beer **[22]**, who understands best the full impact of technology on management with the following powerful statement:

> *"Change – technological change – is happening all around us". "It could leave us managerially unadapted, and, in the end, extinct".*

The sudden explosion of networked electronic systems, their associated challenges and dichotomies **[11]**, which started in the 1970's with ever increasing momentum in the Year 2000 and beyond, will continue to add to the complexity of unstructured complex phenomena and thus to the complexity of the systems approach in dealing with such phenomena.

2.11 PUTTING THE SYSTEMS APPROACH INTO PRACTICE

In the following chapters, various methodologies of the systems approach and their application will be discussed in detail to ultimately culminate as the *structured systems approach to model conceptualisation.* The questions, which invariably arises, is why the concept is not commonly applied in practice and why has a *structured systems approach to model conceptualisation* specifically for executive management not previously been formulated?

These questions are echoed by Kim and Senge **[90]**, when they make the observation that, "diverse methodologies of systems thinking have been developed over the past decades, yet despite widespread recognition of the growing importance of interdependency and change, there has been relatively little penetration of these methods into the mainstream of management practice". Senge **[152]**, denotes that what is especially problematic in this respect, "is the inability to deal with dynamic complexity, when cause and effect are not closely related in time and space, and obvious changes do more harm than good". Senge **[152]**, continues his observation by viewing dynamic complexity as being more challenging due to the fact that it requires us to think in terms of complex causal interdependencies involving multiple sources of delay and non-linearity, and evolving patterns of change over time.

Kim and Senge **[90]**, provides a solution to the questions by suggesting that, "systems thinking can get into practice, through practice". This approach is based on the concept of 'managerial practice fields', which relate to settings where 'teams who need to take action together, can learn together'. This approach is deliberated further by Meadows **[105]**, who suggests that one way to remedy unsystematic, badly structured, difficult-to manage large scale social systems with persistent problems, is to bring more clear, accurate and inclusive systems concepts into public discourse, – the very objective of the author with the *structured systems approach to model conceptualisation.*

What is true about the concept systems approach in practice, can also be extrapolated to the *structured systems approach to model conceptualisation.* In spite of the existence of innumerable social system models, there is not much available literature, and probably not much existing knowledge about the process (approach) by which such models are constructed **[126]**, **[90]**, **[152]**, **[100]**, **[59a]**. Randers **[126]**, expands on the above with the view that the lack of information about the modelling process, particularly its 'first stages'[12], is probably due to the 'pre-scientific' state of modelling. The author **[126]**, maintains that model conceptualisation is especially difficult in the modelling of social phenomena because social systems are more complex and less well understood than physical systems, and because the modeller must represent aspects of the real world that are not easily observed or measured. Furthermore, the view is upheld that, "because there is no educational text on model conceptualisation, the sequence of presentation are commonly mistaken for the actual steps in the creation of these models". In addition, these findings of Randers **[126]** maps to the findings contained within the ambit of the limited survey contained in Appendix B. In the understanding of why the systems approach have not exploited to its full potential, the 'wisdom' of Churchman cited by Jackson **[80]**, underpins all of the above arguments with the aphorism, "there are no experts in the systems approach", hence the failure of the systems approach considered to be comprehensive **[32]**.

It is however Randers **[126]** himself who suggests some guidelines on model conceptualisation, and in the process provide a more balanced view of the situation described above. The guidelines on model conceptualisation as provided by Randers **[126]**, are contained in Appendix D.

2.12 CONCLUSION

Complex phenomena associated with the art of management is encapsulated by the following extract from Hesselbein **[73]**:

> *"Five hundred years ago, Renaissance man discovered that the world was round". "Three hundred fifty years later, organisation man*

[12] It is these 'first stages' or 'inputs' to the modelling process, which forms the core of the *structured systems approach to model conceptualisation*, proposed for executive management in this thesis.

> *developed the practice of management". "But, as this practice evolved he forgot that the world was round, and he built a management world of boxes and pyramids"*

Hesselbein **[73]**, continues that this new created world worked well for a long time, until a period of massive historic change began, of global competition and blurred boundaries, of old answers that did not fit the new realities culminating in complex phenomena associated with modern management. This is supported by Strümpher **[165]**, who is of the opinion that 'systems thinking' has emerged as the dominant basis for modern managerial thinking in the last few decades, and furthermore rapidly gaining acceptance as a basis for the management of complex phenomena. These statements are evaluated against the *caveats* of limited penetration of the systems approach into mainstream practice **[90]**, **[152]**, **[105]**, and the limited literature and expertise available on the subject of model conceptualisation **[126]**.

In this chapter, the complexities of the systems approach were introduced to provide the reader with the required insight into the complex issues governing the systems approach and associated problem solving methodologies which will be discussed in Chapter 3 and Chapter 4. More specific, it is the interrelationships which these entities have with hard and soft systems methodologies, which emphasises their importance to virtually become required pre-requisites to the understanding the internal functionality of hard and soft systems approaches. In addition, the complexities of putting the systems approach into practice was explored and expanded to include the concept of model conceptualisation.

In Chapter 3, the major hard systems methodologies, selected especially for their particular applicability to the research in this thesis will be contextually analysed at a high level in terms of literature reviews. The analysis will cover the following hard systems methodologies:

- Systems engineering.
- Systems analysis.
- Operational research.

- Management cybernetics.
- Systems dynamics.