Systems and Management: A Review

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THIS article seeks to serve several purposes, first to present a brief statement of the evolution and philosophy of modern systems analysis and then, to relate this to the operation of the managerial function in a modern firm. This first objective is necessary to explain the great variety of interpretations to be found in the literature. It is also hoped to demonstrate that the great challenge of the approach and the attendant excitement is no mere passing fad but rather based on the realisation that systems analysis is one of those new ways of looking at familiar things which in all ages have resulted in real advances in the level of scientific understanding.

I—THE EVOLUTION AND PHILOSOPHY OF SYSTEMS ANALYSIS

In the modern world there is a heightened awareness of the influence of current guiding metaphors and processes of conceptualisation on the development of knowledge,[1] and on the way people view their world, organise their information and plan their actions. This leads analysts to identify the inherited and environmental factors in the formulation of individual theories. The thought process of any generation and its underlying philosophy are seen as the outcome of a fertile exchange between inherited wisdom and the requirements of the new environment. The greater the degree of change in the basic philosophy, technology, economic circumstances and social organisation of an era the greater the challenge to adopt new methods for organising thought. This insight into the

[1] A well known populariser of this viewpoint is Marshall McLuhan.

processes by which knowledge grows has had two outcomes relevant to our discussion. First it had led analysts to search for the underlying factors which gave rise to the traditional or classical statements in each discipline and to question both the adequacy of the concepts and their relevance for modern analysis.

Thus critics of classical economics see it as borrowing from the nineteenth century science—from Darwinian theory and Newtonian physics for its analogies, Benthamite philosophy for its hypotheses and calculus for its methodology—to meet the *laissez faire* requirements of the industrial revolution in its struggle against state monopolies. The developments in science, philosophy, mathematics and methodology since that time mean that the classical statements can be reformulated in a manner more appropriate to the requirements of modern times with its recognition of the important role of State planning for economic growth and stability. New ways of conceptualisation do not render inherited knowledge obsolete. Rather they require a reorganisation of old knowledge into patterns more in tune with current requirements. As we shall see much of systems analysis is a search for such patterns, or "gestalten" as they are sometimes called.

The second consequence, therefore, springing from the study of knowledge accumulation is the desire to speed up the process of adapting the accumulated fund of inherited knowledge to current requirements. This process requires both familiarity with the existing store of knowledge and identification of the needs of modern society, both formidable requirements. Specialisation, which has resulted in great advances in knowledge in recent decades, now needs the corrective of a general synthesis if the growth of knowledge is not to be hampered by the growing inability of the specialists to communicate their findings to those needing the results, be they fellow scientists or decision-makers elsewhere in society. Thus one of the objectives of general systems theory has been the search for a body of systematic theoretical constructs which present the general relationships of the empirical world. Given such a framework, specialists in one discipline could catch relevant communications from those in other fields. The search has been prompted by the recognition of similarities in the theoretical constructions in different disciplines and at the initial stage at least the task is seen to be the development of theoretical models which have application in at least two fields of study. Just as the chemists were able to infer the existence of yet undiscovered elements from their knowledge of the pattern and then proceed to discover them, general systems theory seeks to discover the patterns and make a conscious drive for the missing elements. Frequently such a search can only be fruitful if the investigator is prepared to jump the traditional demarcation lines between disciplines. The increasing willingness of scientists to do so has resulted in the growth of interdisciplinary research, the birth of hybrid disciplines and the founding of interdisciplinary institutes based on a common empirical field (e.g. industrial relations) or a common methodology (e.g. group dynamics).

The "phenomenon" approach to systems

The search for a general systems theory has proceeded along two complementary lines. The first of these seeks to identify general *phenomena* which are common to many different disciplines in the empirical universe and to develop general models relevant to these phenomena. The second line of attack sets out to develop a *hierarchy* among the empirical fields based on the complexity of organisation of the individual or unit of behaviour in each field and then to develop a level of abstraction appropriate to each field. An illustration, borrowed from Boulding [1], will help clarify the difference in these approaches. The "phenomenon" approach might seek to study the phenomenon of *population* by developing a general model which would explain among other things how units are added or subtracted, how they age, what the important dynamic movements and the dynamic interactions are and whether relationships were competitive, complementary or parasitic. Such a model might be based, for example, on simple systems of difference equations and could be used to study ecological systems in biology, populations of machinery in the capital theory of economics, social ecology and statistical mechanics. Another phenomenon is the *individual interacting with his environment.* Here the model would seek to identify what "states" of the individual are "preferred" and describe "behaviour" in terms of the restoration of these preferred states subsequent to their being disturbed by changes in the environment. The individual in the model would be composed of a structure and arrangement of lower individuals, changes in which would also influence behaviour and perhaps the preferred state. Similarly a general theory of *growth* might develop out of research into the complex interrelationships between growth and form. Models describing a fourth phenomenon, *information and communication,* were first developed in electrical engineering and accordingly dependent on that discipline for their concepts. If they are to handle the semantic level of communications more appropriate models must be developed from which general notions of structure and abstract measures may ultimately be developed. Such an outcome could conceivably add a third basic dimension in addition to mass and energy.

The "hierarchy" approach to systems

The ultimate outcome of the phenomenon approach would therefore be a general field theory of the dynamics of action and interaction. The "hierarchy" approach focuses attention on the complexity of the individual in the various empirical fields and arranges these fields in an ascending order which roughly corresponds to the complexity of their respective individuals. Boulding [1] identifies nine major categories in this hierarchy.

First, static structures or *frameworks.* Since the dawn of science it has been recognised that for all organised theoretical knowledge, an accurate description of the appropriate framework must precede any theorising. Accordingly, emphasis over the centuries has been placed on the study of the anatomy of plants and animals; on mapping the earth, the solar system and the astronomical universe. As methodology and observation techniques improved this mapping extended to the cell, the gene, the atoms in a molecule, atoms in a crystal, electrons in a nucleus. This task of descriptive cataloguing is fundamental and ongoing.

The next level of systematic analysis, the level of *clockworks,* studies simple dynamic systems with predetermined motions. Identification of these motions makes prediction possible. The earliest applications were made by astronomers predicting the course of the sun and other heavenly bodies. Subsequently however, these simple equilibrium models also came to form the basis on which the theoretical structures of physics, chemistry, economics, etc. were developed. They are now seen to be the limiting case of the dynamic.

The third level, called the cybernetic system, introduces the notion of a control mechanism. It is more complex than the clockwork system since equilibrium is not determined simply by the equations of the system but requires the transmission and interpretation of information. Differences between observed or recorded values of a variable and its ideal value cause the system to make adjustments to maintain any given equilibrium within limits. While the most popular illustration of this system is the thermostat it also provides the conceptual basis for the homeostasis model so important in physiology and pervades biology and the social sciences. It is becoming increasingly important in economics and management.

The fourth level is that of the self-maintaining or "open" system, (i.e. open to matter-energy exchanges within an environment). At this point we reach the blurred boundaries between life and not-life. Some pre-life open systems occur but do not possess the property of self-reproduction. Other systems reproduce but are not open. A living system is characterised by being both open and self-producing. The least complex level of living systems is that of the cell.

The fifth level of system, that of the plant, or the "genetic societal" to use Boulding's terminology, is the second level of living system. It is more complex than the cell since the system consists of differentiated and mutually dependent cells. The genotype is sharply differentiated from the phenotype. It is less complex than higher levels since it lacks specialised sense organs. Information receptors are diffuse and cannot cope with a large throughput of information.

The transition to the sixth, or animal, level is characterised by increases in mobility, teleological behaviour and self-awareness. The development of specialised information receptors (such as eyes, ears, etc.) greatly increases the volume of information processed as we move to higher forms of life. Nervous systems become more complex until we reach forms possessing a brain which not only receives information but structures the inflow into a knowledge pattern, or "image", which is essentially different from the information itself, a view of the environment as a whole.

The relationship between information inflow and image formation is complex. Clearly the image ultimately depends on the information received by the organism but what is not clear is how the image changes. When the image is well established most information received has no effect on it. Sometimes however, special significance is attached to what appears to be a very small piece of information and a reorganisation occurs. The changed image will have far-reaching effects and produce radical changes in behaviour. Since behaviour is determined by the interaction of the stimulus with the image, rather than by a simple stimulus-response situation, prediction of the behaviour of these systems becomes very difficult.

The seventh level, the human level, regards the individual human being as a system. Man differs from other animals in his being self-reflective and self-conscious. *Cogito ergo sum*. He has a capacity for language, an ability to produce, absorb and interpret symbols as distinct from mere signs such as the warning cry of an animal. His images are of a higher order and include an awareness of time and mortality. Thus his behaviour is profoundly influenced by his view of his position in the whole life span.

The next level is that of social organisations or systems. Here the unit is not the person as such but his role, that part played by the person in the system being examined. Indeed social systems might be defined as a set of roles tied together by channels of communication. There is clearly a two way interaction between the individual and his role and the individual's perception of his role is affected by the personalities of those who played this role in the past. At this level the study of the system includes examining "the content and meaning of messages, the nature and dimensions of value systems, the transcription of images into historical record, the subtle symbolisation of art, music and poetry, and the complex gamut of human emotion".

The final levels are the transcendental systems—the ultimates, the absolutes, the inescapables and the unknowables which also exhibit systematic structure and relationship. Clearly, as the title of Boulding's paper—"General Systems Theory, the skeleton of science"—indicated we have here a blueprint for research over the entire spectrum of scientific investigation. This survey helped to highlight what was known and what was unknown in scientific knowledge. If we take the hierarchical approach it was recognised that the most adequate concepts, knowledge and methodology were to be found at the first level—the level of frameworks; but this level was as yet not fully mapped out. Knowledge and methods were accumulating at the second level—the level of clockworks—but these were still inadequate. Some initial ideas were being formed on the cybernetic level and tentative concepts being developed about open systems. Apart from these, existing concepts and methodologies were totally inadequate.

Systems and gestalten

The blueprint for research outlined above has already served to heighten the awareness among scientists of the inter-relatedness of their tasks. Individual workers continue to research their own specialities only now some new perspectives have been added. Some new reorganisations of the existing knowledge have occurred which help to spur on the general growth of knowledge. A new emphasis has occurred with the emergence of the systems idea. These discoveries and changes of stress are evident in many areas.

One such insight has been the recognition that the whole, or system, is more important than the parts. Wholes are not aggregates of parts. In aggregates it is significant that the parts are added; in a system it is significant that the parts are arranged. It is this arrangement, this pattern, this Gestalt that the system approach emphasises, this *unitas multiplex*. The system is an arrangement in which the parts do not participate by means of their inherent characteristics but by means of positional values though the parts may need certain attributes to enable them to fill the positions required by the system. The system cannot be derived from the parts: the system is an independent framework in which the parts are placed.

Every system has only one construction or system principle which may be perfectly or only approximately realised in a given whole. While some systems have all their significant principles occupied in accordance with the system principles, in others only a limited number of positions, sufficient to suggest the system principle, are occupied while other members are either out of position or else positions are not filled.

Having demonstrated the existence of static systems—i.e., where the system imparts to its elements a positional value which the given element does not have in itself but only when it forms part of a given whole—some writers [4] have gone on to postulate dynamic systems where the element functions differently, depending on the whole to which it belongs. The system in this case would also have its own characteristic dynamics. It is in this context that Boulding's scheme can be best understood.

Systems and classical science—a new logic

The development of the systems approach with its stress on the whole departs radically from the classical, or Newtonian approach to science with its stress on causal relationships. In Newtonian investigations all relationships, however complex, can be reduced to direct relationships between two and only two members which enter into the relationship by virtue of their inherent attributes. The method seeks to derive various properties of the whole directly from the properties of the parts without considering possible interactions between the parts or at most by deriving them by superposition of pairwise interactions. In the systems approach in certain respects the members cannot be analysed into pairwise interactions. The members derive their significance not from inherent characteristics but from their position in the system. It may be possible to establish secondary relations between the members of the system based on positional values but the system itself cannot be described even in terms of such relationships. To do so it is necessary to have a dimensional domain over which the members are arranged. Since systems cannot be deducted from relationships while the reverse is conceivable, some writers have argued that the studies of relationships should be regarded as a subset of the study of system.

Further progress in science now calls for a new logic, new languages and new methodologies. The main demand for such a change has come from the fields of biology and psychology where the writings of von Bertalanffy and Angyal have been particularly influential. Since the classical approach provides fairly good results at level two in the "hierarchy" scale—where mechanics tend to dominate—scientists at this level have tended to misunderstand the problem so obvious to those studying higher levels in the hierarchy, be they biological, psychological or social. It is also noticeable that where they do perceive a need for the systems approach the language and methodology of those engaged in the design of complex engineering systems differs considerably from those who seek to transfer concepts developed in the study of biological systems in general to social systems. In management studies the former have given rise to operations research and cost benefit analysis while the latter stress human organisations. An important activity in systems research is to integrate both approaches.

As indicated earlier some scientists are unhappy with this new development.[2] This uneasiness was anticipated by Angyal, who was prominent in the development of the approach:

"The possibility of the dynamic action of a system would probably be rejected *a priori* by many students. Although in the last analysis causality is just as inexplicable as a system action, still many students would feel more comfortable and would be willing to give credit for greater scientific validity to the formulation of the dynamics of a given happening in terms of causality than to its formulation in terms of system action. Causal thinking has been used in science for such a long time and, in certain fields, with such success that it is almost generally considered as *the* scientific thinking, although it may well be only a subvariety of it. Relational thinking is so firmly rooted a habit that the transition

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[2] See editor's introduction [4].

to system thinking is at least as difficult as the transition from a three-dimensional to a four-dimensional geometry" [4].

In so far as the study of complex systems which display purposive or adaptative behaviour has not sought to develop rigorous predictive theories misunderstandings have occurred. It has been necessary to resolve these by showing that the maps which are made of systems constitute scientific advances if the guiding metaphors and mapping principles used improve the internal coherence, implicative structure, freedom from clutter and comprehensiveness of these models of the real world. This need will diminish as the issues involved become more widely appreciated.

New languages

A new logic must be accompanied by a new means of communication, a new language. Systems workers have found both natural language or mathematics inadequate to cope with system description. For example Zemanek (in Ross [6]) reports that he and his co-worker, the Hungarian neurologist A. J. Angyal, were unable to communicate effectively the results of a study of conditioned reflexes using an artificial turtle. In the experiment 40 out of a potential 64 states actually occurred and in each the reaction of the model to the stimuli, light, sound and touch was different. In trying to overcome difficulties such as this, research workers have modified existing mathematical concepts, e.g. extended topological space, or created new ones, e.g. the Zadeh concept of fuzzy sets. However, other students have maintained that nothing short of a new language, or meta language will suffice. In the search for such a language computer and simulation languages are the subject of intense study.

A new methodology

Given that a language exists to describe patterns, a methodology must be developed to identify them and also to determine interactions between the members where these cannot be reduced to pairwise interactions. Traditional methods of hypothesis testing are of limited value whenever there is strong interdependence between a number of variables. Alternatives such as convolution and simulation techniques have been proposed but present many thorny problems of sampling and validation [6]. Furthermore, it is clearly impossible to investigate all the interactions of a system. Appreciation of this limitation has given rise to the idea of a *minimal simplification*—minimal in the sense that the problem can be solved and the essential properties of the original system preserved to the greatest extent possible. This is obviously a relative rather than an absolute level. The advent of electronic computation (10 million times faster than the mechanical calculation at this writing), the techniques of using stored logic programme steps in the computer's memory to automate problem solution and data processing, (the devices) on a microsecond, or "real time" basis; and the programmer's ability to make his machine duplicate, or simulate other operations (by means of appropriate logical design) have transformed the old methods of "pattern seeking" and testing into revolutionised potentials for system analysis which are yet to be realised.

The search for general systems theories

This desire for simplification has given the spur to the development of general systems theories to supplement the collection of concepts, views, principles, tools, problems, methods and techniques associated with the study of general systems. The approach here has been for the theorist to search among the disciplines to find analogous (geometric, kinematic, thermodynamic) systems where a similarity in the algebraic or differential equations describing them enables them to be classified into equivalent classes. Results from the study of the representative system can be transferred using an isomorphic relation to each system in the class. At this level of abstraction the theorist is working with contentless (mathematical) representatives (models) of equivalence classes.

The purpose of such research was vividly outlined by Boulding [2] who applied the analogy of the growth of wealth through specialisation and trade to the growth of knowledge. Specialisation without trade would mean naked farmers and starving tailors. Trade without specialisation is meaningless. Together they form the basis for the growth of wealth in the modern world. However, he argues, much of this progress was due to some people specialising on neither farming or tailoring but on facilitating the exchange between farmers and tailors i.e. the merchants etc. If the growth of knowledge through the increasing specialisation is not to break-down in a modern tower of Babel people are needed to facilitate the trading among specialists. People are needed to specialise in generalising the work of specialists—the general systems theorists. These have been called specialised generalists. Their function, as we have indicated, is not to supplant the specialist by doing his work any more than a trader grows wheat but to provide an easily assimilated set of basic concepts and principles which enable some specialists to become generalised specialists. These latter are essentially specialised in a discipline but familiar with general systems concepts. This enables them to communicate the complex system-type problems in his discipline to the systems theorists and to interpret correctly the results obtained from them.[3] The rapid technological development of the research industry in recent decades makes this skill increasingly crucial.

[3] Boulding makes some fascinating comments on the revolution in education which would result from the recognition that a basic requirement for further growth in knowledge is the development of better methods for learning the languages of specialists given that the content is expanding too rapidly to be imparted in a few years.

Other developments in systems studies

Not everyone has viewed with equanimity the growth of general systems theory. Some writers have maintained that the energy that should have gone into the development of concepts for the analysis of cybernetic and open systems, which would have enriched current methods of analysis, have been diverted into the relatively unprofitable search for general systems principles. One of these, F. E. Emery, writes: "It is perhaps unfortunate that this impact (i.e. von Bertalanffy) gave rise to a movement for General Systems Theory along with its search for dynamic principles common to all kinds of systems living or mechanical. This movement has been attractive to those with a systems engineering orientation, but has so far failed to further its unifying mission and has tended to overshadow the early recognition by Ashby and Sommerhoff that if living systems are to be treated as open systems we must be able to characterise their enviroments." [4, pp. 8-9]

This is not to say that all workers in the field have sought the grail of general systems theory. Many have confined themselves to particular aspects of the field which they have on occasion made synonymous with systems studies. Thus one major textbook stresses information as the universal flux of system. "Only recently have we recognised that to manage complex systems we must understand how knowledge is obtained and how knowledge can be transferred." If we interpret information processing in its widest connotation then this viewpoint is understandable since all systems in the hierarchy from the cybernetic upwards process information. However, there are more dimensions to systems than that of information processing. Where information is interpreted more narrowly we often find systems equated with Management Information Systems and frequently associated with computer systems.

Other workers stress other aspects. Some isolated "patterns" of operations (such as the theory of queues), others, methods of analysis (dynamic program) and yet others, strategies of test and evaluation (such as measures for systems noise and variety) that have wide application.

Without going into further details we can discern three main strands in the overall developments depending on whether we are dealing with the sciences (natural, behavioural or social), engineering or the arts. Some workers, especially in the engineering branch have concentrated on systems design, or systems synthesis as it is sometimes called. Here the task is to construct a system within which available resources can be mobilised to optimise certain objective criteria. For others—and this is especially true of the study of living systems—the system is given and the task is to discover the pattern and interconnections of its elements. These interests are, however, by no means mutually exclusive.

Summary

To sum up then the area of application of the system concept is the entire field of knowledge. The approach has caused a ferment of reappraisal in the scientific world and led to a rich variety of new concepts and new insights. The fields of biology and psychology have been foremost in promoting this growth to meet a real need arising from the inadequacy of the classical approach to the analysis of phenomenon in living systems. Engineering has also developed systems concepts but these tend to be rather different in language and methodology from those developed for living systems. Indeed even within these major areas the development of system studies is proceeding on many fronts with each worker contributing his own concepts and methodology—not to mention terminology—and as yet little in the way of a synthesis. The absence of a common framework has not inhibited the accumulation of rich concepts nor prevented these insights from being readily translated into the different terminologies currently employed. Nor does it prevent the approach from having a considerable impact on the science of management to which we now turn.

Developments in management

Although management is a component of all systems from the cybernetic upwards our interest will be restricted to human organisations especially, but not exclusively, those concerned with the management of materials, men and markets. In the earlier texts these organisations have been analysed in terms of clockworks as an extension of the technological structure which determines the nature of the task to be done and the types of relationships required for task performance. It is now appreciated that the system is a total integrated organisational unit and to isolate one aspect, such as the technological, from the other psychological, social or economic aspects is to do violence to the whole. In the search for an integrated approach interstitial disciplines have developed, e.g. socio-technical analysis, social psychology and socio-economic theory, which provide different points of departure in the quest for a bridging or unifying discipline.

In the area of business engineering this trend towards a synthesis is also visible. Here the investigator finds he must cross historical boundaries of knowledge and functions if he is to achieve major improvements in systems operation. Moreover, to understand and improve such systems by utilising the relationships that result when diverse components are combined he must be able to follow and exploit the chain of work flow, information flow or material flow—the connecting links that tie the systems together. The improvement of the business system *for the enterprise as a whole* requires him to disregard or cross at will the formal boundaries between organisational functions such as purchasing, production, distribution, research and product design, finance, sales, legal and tax departments and the like. This new approach has been reflected in the educational field by the development of mixed disciplines which likewise have crossed the boundaries of educational disciplines. These have made rapid progress through the conscious exploitation of the gaps between the historical categories of knowledge.

Systems and managerial models

If theory was adequately developed, the seventh or eighth level in Boulding's hierarchy would appear to be the most appropriate source of concepts for managerial sciences. However, as was mentioned earlier, theoretical knowledge has only formulated models of any significance as far as level four—self maintaining or open systems. Empirical knowledge is incomplete at all levels but most advanced at level one—the description, indexing and cataloguing of complex systems. Considerable knowledge has accumulated at level two—the level of clockworks, and a beginning made to the study of level three systems—the cybernetic or feedback systems. In the theory of organisation and control, social science which should be at level seven, is now moving away from the overly simple mechanical models of level two towards models which emphasise communication systems and organisational structure and the principles of homeostasis and growth. Decision processes under uncertainty tend to replace the simple models of maximising behaviour. Although this advance to level three is not as far as might be desired it is bound to result in more powerful and fruitful systems.

II—APPLICATIONS TO MANAGEMENT

The remainder of this paper considers how the system approach effects the basic functions of management, presents a model based on the cybernetic approach and indicates how the concepts of open systems might be applied to management.

The basic functions of management

After a period of rapid expansion since its founding about fifty years ago the role of management has come to be regarded as comprising the administrative functions of planning, organising, controlling and communicating [5]. Following Simon we can regard the organisation as composed of three layers: an underlying system of physical production and distribution processes, a layer of programmed (and probably largely automated) decision processes for governing the routine day-to-day operation of the physical system and a layer of non-programmed decision processes (carried out in a man-machine system) for monitoring the first level processes, redesigning them and changing the parameter values.

(*a*) *Planning*

The complexity of modern organisations operating in an environment characterised by rapid technological change and uncertainty make planning essential. In the systems context planning begins with the selection of the objectives of the organisation and further the policies, programmes, procedures and methods for achieving these objectives. Once made these decisions are not immutable but require continuous modification if the changing resources of the organisation are to remain adapted to both internal forces and those in the environment in any optimal sense. Planning must be adaptive.

Successful planning must also be able to cope with the obstacles to change, such as the inflexibilities associated with large-scale investment (including automation) and agreements with labour unions and the inertia resulting from the scale and complexity of the operations. This calls for innovation and creativity in the recognition, development, proposal and implementation of new and more effective ways of solving the problems posed by change. Rational decisions therefore call for the integration of numerous decision making subsystems rather than the concentration of decision-making at top management level. In this the systems approach, with its emphasis on the achievement of organisational goals, differs from the bureaucratic approach which is more concerned with the internal distribution of power and status. Planning in the systems sense aims at an organisational structure which promotes the creativity of the individual participants by involving them in the decision-making process.

Three basic types of planning can be identified. The first type, the planning of goals and objectives, is of a vital importance in that it provides a basis for unified and integrated planning and the premises within which more specific planning can occur. In particular it facilitates the delegation of authority and the decentralisation of detailed planning to those best equipped to do it. Given such decentralisation it provides a criterion by which the various, often diverse, functional operations can be controlled and a measure by which their achievements can be gauged. The existence of rationally defined goals also promotes the commitment of the members to the organisation by providing a source of motivation and pride in achievement. This sense of commitment will be in proportion to the extent that individuals feel their opinions have been considered in defining the overall objectives. The literature contains many works on management by objective and the problems of decomposing goals within an integrated plan.

The second type of plan comprises the standing plans, the plans for repetitive action. These have as important a role for the organisation's behaviour as habits in human behaviour since they permit management by exception. This means that the decision-making is defined and uniform with only the unusual cases referred to a higher authority. These rules require constant scrutiny during a period of rapid change to avoid the adverse aspects of bureaucracy.

The third type of planning are the plans for non-repetitive action—the one-off situations which nevertheless require a predetermined course of action within an integrated system. Not being recurring they do not warrant standing methods or operating procedures.

(*b*) *Organising*

The second function of management is organising. The system approach stresses administrative leadership and differs from other organisational theories especially the traditional approach with its emphasis on sheer legal authority. The latter ensures compliance but does not encourage employers to exert effort, accept responsibilities or exercise initiative. Traditionally management has broken down responsibilities into a hierarchy of clearly defined tasks rather on the analogy of a machine and with an emphasis on specialisation. Subsequent theories reacted to this mechanical approach by highlighting the role of human limitations, motivations, and aspirations. The systems approach retains, or even increases, the specialisation but seeks to interrelate the specialists horizontally to accomplish the objectives. The vertical relationship remains, only now it is a hierarchy of specialised planning functions aimed at coordination, adaptation and goal achievement. The human angle remains since the organisation is viewed as an adaptive goal-seeking social system with many mutually dependent interest groups integrated into a loose federation which develops mechanisms for avoiding uncertainty, engages in problemistic search, learns by experience and seeks satisfying rather than optimal decisions. The organisation is seen as composed of individuals, informal groups, a formal organisational structure and function sub-systems, all of which must be harmonised into a "steady state" which permits a continuous adjustment of the elements of the system to meet the demands made on the system by the changes in the environment.

As mentioned earlier all systems from level three upwards are characterised by a communications or information network which serves to integrate the elements of the system. The systems approach seeks to strengthen this integrating process and to eliminate noise and distortion in the communication channels. In this way the various groups can participate in the processes of identifying those changes in the environment which require the organisation to adapt and also assist in the adaptation process. Given the goal orientation of the systems approach it is essential to prevent the operation of Parkinson's law[4] by an organisational design which promotes homeostasis[5] and ensures adaptation and growth.

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[4] There is an ever increasing trend towards hierarchies of staff and functional personnel who are self perpetuating and often do not contribute significantly to organisational effectiveness and may stymie progress.

[5] The process which in living systems corresponds to the cybernetic mechanism of the engineer and involves balancing the parts of the internal system to meet changes in the environment.

(*c*) *Control*

The third task of management is control. In cybernetic systems the control function provides direction in conformity to the plan..Thus it is preventive rather than punitive and aimed at flexibility and effectiveness. The first step in the design of control systems is to determine the relevant characteristics, which when controlled, will prevent variations in the operations of the system exceeding the limits permissible. This implies first, some means by which to measure performance, a procedure to compare the measurement against some predetermined standard of performance, and a correcting mechanism capable of bringing about the changes necessary to restore the operations of the system to the desired level. This seemingly simple task is nevertheless fraught with problems. The characteristics most easily or most economically measured are often not those most related to the objectives. (Education is a good case in point.) The measurement procedure may not be entirely appropriate. The feedback from the measuring unit may be distorted. The standard must be as precise as possible and easy to communicate to all concerned. The significance of reported variations must be evaluated and over-reacting avoided. Is a drop in sales random or indicative of a new trend? The selection of the appropriate corrective action may be futile if it meets opposition or if those concerned have no clearly defined responsibility to take action. Thus leadership and motivation become important factors in control situations involving cooperation and initiative from people.

(*d*) *Communicating*

The final task of management is communicating. Clearly both planning and control depend on the exchange of information which in turn is dependent on effective organisation. At first it would appear appropriate to adapt the modern theory of communications developed by Shannon and other engineers. In its original form this considers such matters as the nature of the signal source, whether the signal is continuous or discrete, the nature and transmission capacity of the communication channel, the nature of the noise and the fidelity criteria by which the adequacy of the transmission is judged. Adapted to management these questions consider if the information source is adequate and unambiguous, if the message is fully, accurately and effectively coded, if transmission is accurate and timely, if the message is properly decoded and whether the recipient of the message can use the information to effect the result desired.

However, there are important problems in the living sciences which are not adequately dealt with by using an engineering analogy. Information theory deals with the transmission of messages and not with their meaningfulness to the user. It has been suggested already that all the higher forms of life interpose an image of the world between the external stimulus and the activating agency. This image interprets the information and as yet very little is known about the process by which the image rejects information as noise or contrarily uses it to revise the image. All action is related to this image and not to the original information. Similarly the motivation and behaviour of individuals is related to their perceived role in the organisation with all that implies.

Another aspect of information related to the above is that although people are constantly clamouring for information one of the greatest problems with information is that it can be supplied to excess. If information is to be useful to the organisation redundancy must be kept down and information gathered must be related to the purposes of the organisation. It must also be timely. In this connection the analogy of entropy and thermodynamics is often used.[6] Associated with information theory these concepts can make an important contribution to the systems approach but, I submit, only a partial contribution. As we shall see more work needs to be done before this function of management can be analysed adequately. This is true to a considerable degree of the other functions also.

Integrating the basic functions in a system

It will be clear from the discussion above that the former managerial functions, planning, organising, control and communication, are interrelated and cannot be performed in isolation. The literature is full of the complaints of planning groups which feel that their plans are ignored. A major contribution of the systems approach is its stress on the importance of integration. The four functions remain but are subservient to the general objectives of the system. The orientation is different and this has consequences for all the functions.

Planning is spread over the entire organisation. At the centre a key decision-making group selects project managers and decides on general policy matters based on internal and external information. Since decision-making here is non-programmed, unstructured, novel and consequential major reliance is placed on the mature assessment of the entire situation by experienced innovative top executives. The new techniques of management science are more prominent at the next stage where planning is done by resource allocation and operating committees which allocate facilities and manpower and supply technical assistance for individual systems design. They are even more important at the third level—planning the individual project where they can in some organisations make decision-making almost automatic.

Given this concept of planning, organisation is less concerned with the traditional approach of line, staff and function management and more orientated to efficient subsystem performance within the general planning context. The development of project management has an important role in the integration

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[6] Especially in the writings of R. H. W. Johnston of Trinity College, Dublin.

of the organisation's activities where such integration is very desirable. It devolves responsibility and ensures flexibility since resources must be reorganised on the completion of the project. Thus the operation of Parkinson's law is impeded. The devolution of responsibility facilitates the control function and the systems approach ensures that control is operated to ensure the attainment of the objectives set out in the central plan and not for any other purpose.

Communications provide a basic ingredient of planning at all levels. The purpose of the information is clear and tendency of departments to keep information to themselves is obviated since the approach favours integration of functions for goal achievement rather than the traditional hierarchy of authority. Decentralisation provides a new focus. Higher level planning need not be bothered with the minutiae of a lower level plan.[7] On the other hand the project manager must have access to all the relevant information irrespective of the department to which it "belongs".

A cybernetic model for management

There is no standard system just as there is no standard plant or animal. Every organisation must devise its own system in the light of its objectives, its resources and its environment. This paper will now briefly consider one of the approaches by which this can be done but before doing so it might be well to ask: "Has the approach been found to be fruitful in actual practice?"

Apart from the benefits of its new viewpoint conscious efforts have been made to implement it in many areas. These have had to face the difficulty that adequate systems concepts have not been developed to analyse or design socio-technical systems. Recently Charles Hitch, currently President of the University of California but formerly Asst. Secretary, US Department of Defense, reviewed the US government's experience with PPBS—Planning-Programming Budgeting System first, when it was applied to military applications, and later when it was extended to all government departments by an Executive Order of President Lyndon Johnston in 1965. In the military field "There is no question that this effort has paid some high dividends. It has produced successes as well as failures . . . we have learned that some military problems are tractable: easy to structure, with definable and acceptable criteria of performance and with empirical data available that are sufficiently reliable and adequate for computation and solution. We have learned that other problems, while apparently intractable at first because deficient in one or more of these respects, become tractable with the exercise of sufficient effort, time and intellectual ingenuity. Still others have so far defied attempts at solution. . . . We haven't learned how to structure limited war problems, to define criteria or to get the data we need. . . . The pervasive

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[7] See M. Ross [7].

uncertainties of the process have turned out to be too subtle for our tools. . . . We have also learned that even in some cases where the problems have proved tractable and the solutions satisfactory from the analyst's point of view, political considerations (in the broad sense of 'political') have thwarted their adoption."

Outside the military field there have been successes—e.g. the space programme but frequently "given the scale and complexity of the problems the effort was ludicrously small and discontinuous. There was nothing remotely comparable to a Rand Corporation or an Institute for Defense Analyses to provide multi-disciplinary terms, or, even more important, the kind of institutional continuity necessary to permit a cumulative learning process over a period of time. . . . President Johnson 1965 Executive Order . . . was well intentioned but hopelessly premature. It may yet prove to be a disaster. The skilled and trained manpower did not then and does not now exist to apply our techniques across the board of civilian government. What manpower did exist has been spread so thin, much of it over precisely the kinds of problems which were found intractable in the military, that the result has been disillusionment and some cynicism."

Hitch concluded that it was necessary to demonstrate the power of the method in an area such as conservation where the problems were tractable and thereby earn the right to tackle problems requiring more intensive effort. "Otherwise research would involve either sub-optimising where the results are relatively easily obtained but may be inconsistent with higher level objectives; or else grand optimisation where the problem is so difficult that the research worker either gets lost in the complexities or aggregates to the point where he loses his head in the clouds. To avoid the charge frequently and rightly levelled at my economics profession—casual empiricism . . . we must devise better models with a larger number of disaggregated state variables which will allow experts in various fields to provide inputs. . . Then we might have a model which would provide useful guidance for operations researchers working on all those essential sub-optimisations." (in Ross [6])

Other writers also emphasise the 'political' problems of systems analysts who are not themselves the decision-makers. They must earn the right to be heard by solid work on tractable problems if they are to obtain the confidence of management when seeking to research more complex issues. If they do so they are likely to chalk up significant successes.

In a recent review Moiseev vividly portrayed how the independent evolution of Russian thinking has resulted in many striking parallels with developments in the West. He has many very interesting observations to make on future developments: "The fact that the future . . . is determined to a large extent by our ability to succeed in uniting mathematical formalism and the non-formal faculty of thought using the profound possibilities of the human brain . . . is not due to the weakness of mathematics or of calculating techniques. In reality this fact reflects the complexity of the real world in which we live. Mathematical procedures constitute only one way of knowing the truth. . . . At present more and more efforts are being made to find procedures making it possible to combine in a rational manner mathematical formalism and non-formal methods which may make use of intuition, associations, and quite simply man's natural talent. The heuristic principle, the method of intermediary goals, non-formal aggregation and, of course the organisation and processing of experts' reports—all these are links in the same chain. In the course of the last decade the theory of expertise developed very rapidly".

The complexity of Soviet planning and experience with earlier plans has led to a new emphasis. "Qualitative changes have been taking place. . . . Analysis is becoming more and more oriented towards operations which put into effect actions with a precise aim such as make up complicated social, socio-economic and economic systems. . . . We have seen the appearance of a new and sufficiently general approach, which has been named in the Soviet Union imitator systems i.e. any system which includes the following elements at least:

(*a*) Systems of models. It is impossible to describe the functioning of the Siberian oil bearing complex with a single model . . . .

(*b*) Experts and Procedures. One of the ideas is to replace the classification of all possible variants by the analysis of certain variants chosen by the experts. Consequently, the experts and the rules of their behaviour constitute a biological element inseparable from the system.

(*c*) Language. The experts are generally not mathematicians. . . . It is therefore necessary to have a language which is . . . . sufficiently easily learned by all the experts and by the electronic computer since the latter will have to receive the experts' instructions.

(*d*) Operational system. It must control the functioning of the whole imitator system and must be linked to the operational system which controls the calculating complex". (in [6])[8]

Both in Russia and in the West the approach is still at the development stage. This does not mean that there have not been many successful applications or that applications should be shelved pending further developments in the basic concepts. Many studies have benefited from the application of ideas gleaned from the study of cybernetic systems, to which we now turn.

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[8] Translated from the French.

The cybernetic approach

The word, cybernetics, is based on the Greek word, *cybernes,* a helmsman, in the sense of captain, whose task it is to get the ship to port on time. He operates in an environment set by the weather, the wind direction, the pattern of the waves and has at his disposal some resources of men and machinery. These are organised into tasks—the engine-room mission, the maintenance mission, the galley mission etc. He has an information system which evaluates performance and tells him when deviations occur which may require changes. He has to decide how quickly he should get this information and also react at a speed that avoids problems of reacting too slowly or too quickly in rough water.

In this general context a number of methods of analysis have been proposed. One method defines the objectives or purpose of the system and how it is managed. This leads to an examination of the elements of the system both quantitatively and qualitatively. The method, then, analyses their organisation, their operating characteristics and the built-in mechanisms by which they achieve equilibrium. Finally, it examines how they respond to stimuli. The analogy to mechanisms, such as the motor car, is clear.

The model

For the purpose of the presentation here a slightly different approach, developed by C. West Churchman [3], will be discussed. Starting from a definition of a system as a set of parts coordinated to achieve a set of goals, the approach seeks to answer such questions as: What is the whole system? What environment does it operate in? What are its objectives? How are these objectives supported by the activities of the parts? In the search for an answer it examines five major aspects of the system:

1. The whole system objectives, and more specifically the performance measures of the whole system.
2. The environment, which defines in terms of the fixed constraints.
3. The resources of the system.
4. The components of the system—their activities, goals and measures of performance.
5. The management of the system.

1. *The objectives*

The identification of the real objectives may prove difficult since the apparent objectives may differ from it. These latter may have been put forward to win support prestige, or from a faulty view of the real purpose of the organisation. Even where the objective is correct it may be so vaguely stated as to be non-operational. In the first case it may be possible to determine the real objective as that objective for which the organisation is prepared to sacrifice other objectives knowingly in order to attain it, (e.g. profits sacrificed for growth). In other cases the investigators will have to delve deeply. For example, it may be stated that the objective of forecasting is accurate forecasts when the real objective is the best forecast obtainable in a specified time or a forecast adequate for the decision being taken. Where an objective is vague (e.g. "The objective of the University is to produce better citizens") the terms have to be defined and an objective selected which is not only correct but which can be monitored in some way.

But the question of the objectives also raises the question of whose objectives. In a firm is it the manager, the employees, the shareholders, the customers or the government? The strength of the case which can be made for each will depend on the environment of the firm. Similarly should a university be run for the benefit of students, staff, industry or society? It is by no means clear. In all probability it will be a case of multiple objectives which have to be given a definite weighting. Depending on the answer to this question a different emphasis will emerge.

Nor are objectives fixed once they are defined. In the words of Alain Enthoven, US Assistant Secretary of Defense: "Systems Analysis is a cycle of definitions of objectives, design of alternative systems to achieve these objectives, evaluation of the alternatives in terms of their effectiveness and costs, a questioning of the objectives and a questioning of the other assumptions underlying the analysis, the opening of new alternatives, the establishment of new objectives, etc."[9] In other words, a defined objective may on examination be less appropriate given the resources available than another objective not previously selected, or because the defined objective cannot be adequately measured. The use of surrogate objectives means that constant vigilance is required to ensure that the real objective is not forgotten, e.g., grades in an examination may be substituted for learning.

The objectives set the general orientation and must be decomposed into operational goals. Great care must be used at this stage to ensure that these goals do not lead to suboptimisation. If the objective is profit maximisation this does not mean that the goal of each mission is necessarily profit maximisation. Recognition of this truth has led to a swing away from narrow measures of performance—e.g. that typists should be fully employed almost all the time—and focused attention on those measures which, while they encourage morale, also can be integrated into the general objectives of the system. The selection of a set of integrated goals in a decentralised system requires very considerable thought and ingenuity. An earlier discussion illustrated the need for objectives and goals

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[9] Quoted by Hitch in Ross [6].

to be associated with measures of performance if they are to prove meaningful. There should be some direct relationship between the objective and the characteristic measured i.e. profit and the viability of a firm, grades and education. In many cases cost or other considerations prevent the ideal measure being used. The surrogate measure must then be interpreted carefully if distortions are not to occur.

2. *The environment*

The next aspect of the system for consideration is its environment. This is not something absolute but rather determined by the system being studied. The environment consists of those parts of the universe which are outside the system currently defined—and therefore the system can do relatively little about them —but which nevertheless determine in part how the system operates. For example a budget allocation or a worker's skill may belong to either the environment or the systems, depending on whether it is to be regarded as given or subject to change. Imaginative management may be able to include in the system some of what might normally be regarded as environment and thereby enhance the operation of the system.

3. *The resources*

The third aspect of the system is its resources—the means available to the system to use to advantage in achieving the objectives of the system. For firms the traditional catalogue of resources has been the balance sheet. However, this covers only a limited number and many of the important ones are omitted—goodwill, organisation, types of personnel, opportunities etc. Balance sheets have been designed for the specific purposes of accountancy and of necessity are based on conventions which are a compromise between the accounting principles of usefulness, objectivity and feasibility. Accounting concepts were evolved to facilitate the addition of complex elements together to provide a timely record of past activities. To supplement them, and to record all the relevant information for decision-making, management information systems have been developed. To be effective these must screen out unreliable, irrelevant and meaningless data and ruthlessly discard information where its cost of retention and retrieval exceeds its expected benefits. This can be best done if information received is not stored *in vacuo* but integrated into a system where its presence helps to improve the performance of the overall system. In other words, the costly process of collecting, storing, retrieving and interpreting information must be preceded by the design of an information system oriented to the achievement of system objectives which provides both criteria for data accumulation and means of analysis which facilitate decision-making. The disappointing results which have sometimes followed the introduction of management information systems can be traced to this lack of integration into the overall system.

Resources are not something static. Employees can be trained and educated. Other resources can also be changed and made to grow. Research and development may find new organisations of existing resources which are equivalent to an increase in the quantity of resources. For example, faster feedback may release part of inventories for productive purposes. Methods which ensure smoother production may have a similar effect through the elimination of bottlenecks.

All living systems have evolved methods by which they can grow and survive with a minimum consumption of resources. Growth and survival are no less important to social systems and for firms this objective is frequently recognised implicitly as taking precedence over the perhaps explicit objectives, such as profit maximisation.

4. *The components*

The value of organisation in promoting productivity of resources has been already discussed. As we have seen, in the system approach this organisation is based on a rational breakdown of the tasks, projects or missions, which the system must perform. This permits the contribution of the mission to the overall objective to be measured and avoids the rigidities and compartmentalisation of the traditional approach based on departments. However, its adoption is frequently opposed by those committed to the departmental approach, under which merit is gauged by success in obtaining finance and personnel. Frequently in the traditional approach the same missions are the responsibility of competing departments, each of which has several missions. The lack of integration and difficulties of measuring performance hinder the achievement of an optimal arrangement of resources.

5. *Management and Planning*

The final aspect of the system is its management. This has been discussed at length in an earlier section where it was seen that management generates the objectives and plans for the system, sets the goals for the missions, allocates resources and ensures that operations are carried out in accordance with the system's plan. In the discussion it was implicitly assumed that the management functions were all carried out by the one person or group of people. However, in many organisations planning is a technical service which reports to management just like any other service. Some companies have hit on a formula which permits a healthy symbiosis in these circumstances; but equally or more frequently the management-planning relationship is one of mutual frustration arising from poor communications, defective organisation and lack of organisational responsibility on the part of the planners. A recent review of corporate planning models suggests that this conflict is reinforced by the difference in goals, training and outlook between those who plan and those who direct. The former stress quality and seek to provide models which being non-trivial, powerful and elegant, will enhance their reputation in their profession. The latter emphasise applicability and therefore expect models to be relevant, valid, useful and cost effective aids to decision-making.

Given this dichotomy, planning is only likely to be effective if it is considered under three aspects—as a process of social interaction between the planners and the decision-makers, as a measurement process and as a testing procedure.

Planning: A process of social interaction

Like all system components planning must serve the objectives of the system. This requires that like other components its role be clearly understood, its responsibilities clearly defined and its performance accurately measured. Currently little is known about two factors critical to the success of the operation —where it should be located within the organisational network and what types of people make the best planners.[10] This latter factor is complicated by the fact that the methods by which the planners communicate the plan will differ with the organisational environment. In some the prestige and abilities of the planners merely require that they use persuasion to obtain acceptance. In others a process of mutual education is called for since the planners do not possess all the answers but must rely on the reaction which follows the manager understanding their plan. Documentary evidence shows that where both sides have been continuously interacting the planner is usually successful. Frequently however the plan will imply changes and shifts in the power structure, so that its adoption will call for political skills which planners notoriously lack. This requires that decision-makers, in the widest sense of change agents, be identified, and that a sufficient number of these be won over so that resistance to the plan can be contained.

Given the adoption of the plan, procedures need to be devised to smooth its implementation.

Planning as a measurement process

The measurement phase of planning relates to the specification of objectives and goals, the formulation of alternatives and the measurement of the effectiveness of each alternative in achieving the system's objectives so that an optimal strategy can be selected. This has been discussed earlier.

[10] For example, is it true that planner must be radical to be useful as Churchman maintains?

Planning as a testing process

The third aspect of planning is testing the plan once it has been defined. This may be done by computer simulation in which some players act as devil's advocates. This can be done by producing a counterplan which uses all the data that were used to build the plan but organises them using a different interpretation of what the system is about. If it can be made appear highly reasonable and plausable it may prevent errors in the basic assumptions of the plan and an overconfident acceptance of its conclusions.

Further testing will occur as a result of feedback in the control stage after implementation. This may require adapting the plan. Faced with the continuous inflow of information, the manager's sense of when to adapt the plan and when not to remains of paramount importance to the success of enterprise. The analogy with the reorganisation of the image in level six of Boulding's hierarchy is clear. It has been suggested that living systems probably learn and hence adapt because of their ability to react to the general and less variable properties of the environment rather than because of their sensitivity to the concrete events and objects which do after all yield a constant flux of stimulation. A greater appreciation of the processes involved would have obvious relevance for management.

The development of "open" models

This brings us to the final section of this review, the search for greater understanding of open systems. This search has renewed interest in the early work of Ashby and Sommerhoff, who stressed the importance of being able to characterise the environment in which the adaptative behaviour occurs. Emery [4] presents a challenge to the serious students of management to find ways to bridge the gap between the richness of the concepts and their application to business systems. As a starting place he presents six principles which Koehler enunciated thirty-five years ago, and also form a fitting conclusion to this brief review of systems and their application to management.

1. The primary task of management is to manage the boundary conditions of the enterprise. The boundaries of an enterprise are those levels of exchange with the environment which allow it to survive and grow. They can be managed only by managing the co-variation of internal and external processes. In so far as a manager has to co-ordinate or otherwise resolve internal variances then he is distracted from his task.

2. The goals or purposes of an enterprise can be understood only as special forms of interdependence between an enterprise and its environment. They cannot be identified with the state of equilibrium that is the end-state for closed systems. The state of equilibrium represents a minimum level of potential energy or capacity for

work. The enterprise seeks to establish and maintain those forms of interdependence that enable it to maximise its potential energy or capacity for work. As in Koehler's example of the flame, a steady state is achieved only at the level of maximum potential energy. The form of this potential capacity and the exchanges are determined by the special forms of interdependence into which the enterprise enters, but achievement of a steady state is the most general dynamic trend in an open system.

3. An enterprise can achieve a "steady state" only when there is (a) constancy of direction, i.e. despite changes in the environment or in the enterprise, the same outcomes or focal conditions are achieved. Put another way, the system remains oriented to the same end; (b) that with respect to that end, the system maintains a rate of progress towards it which is within limits defined as tolerable. A more precise statement of "rate of progress" might be that the enterprise achieves the required focal condition with lesser effort, with greater precision for relatively no more effort, or under conditions of greater variability. In any of these cases, the level of exchange would be more favourable to the enterprise. One implication of this proposition is that an enterprise can have no equilibrium state such as can be found in physical systems (because in the former case, the relevant internal and external variables are capable of independent variation—the state of one does not automatically determine the other). A positive implication is that an enterprise cannot hope to achieve a steady state (except accidentally unless it sets a mission for itself in terms of outcomes that are capable of achievement and yet are sufficiently beyond present performance to allow for some measurable degree of progress.

4. Given the last two propositions, the task of management is governed by the need to match constantly the actual and potential capacities of the enterprise to the actual and potential requirements of the environment. Only in this way can a mission be defined that may enable an enterprise to achieve a steady state. However, the actions of management cannot in themselves constitute a logically sufficient condition for achievement of a steady state.

5. A "steady state" for the system cannot be achieved by any finite combination of regulatory devices or mechanisms that are aimed at achieving a steady state for some partial aspect of the system such as input-output rates, internal change, or environmental contact. In a human organisation, the two requirements for a steady state, unidirectionality and progress, can be achieved only by leadership and commitment. The end-state of the system must be clearly enough defined and agreed upon to enable the system to be oriented toward it regardless of a wide range of changes in their relations. Secondly, the members of the organisation must be so committed to the end-state that they will respond to emergencies calling for greater efforts. The basic regulation of open systems is thus self-regulation—regulation that arises from the nature of the constituent parts of the system.

One corollary is that it is only within this framework that regulatory mechanisms, such as cost controls, can make an effective contribution. In creating these mechanisms it is essential to ensure that they do not run counter to, or undermine the requirements for self-regulation, and to remember that mechanisms which are appropriate in one phase of a system's existence may, with a change in location with respect to the mission, become inappropriate.

The measure of whether these processes of self-regulation are operating effectively, of whether the system is healthy and maturing, is to be found in the steady growth of potential capability with respect to the mission. In the case of any enterprise, the critical question at any time is whether it is more capable than before of fulfilling the tasks arising from its mission. A good record of recent performance, e.g. high profit yields, would not in itself exclude the possibility that potential capacity had in fact been reduced.

6. An enterprise can only achieve the conditions for a steady state if it allows to its human members a measure of autonomy and selective interdependence. This proposition is clear enough when applied to organisations composed of professionals. It is less clear that it applies to enterprises in general because it introduces an assumption which is new in this context, namely that individuals themselves have open-system characteristics and can be related to each other or to organisations only in ways that are appropriate to such systems. In particular, commitment presupposes that the individual has sufficient autonomy to exercise choice. The requirement that the co-ordination of components be maximally brought about by themselves (proposition five) requires some sacrifice of autonomy and to that extent threatens commitment. This threat can be lessened by allowing selective interdependence.

Conclusion

The rapid expansion of studies which sharpen systems concepts or which apply these in concrete situations makes this article as much a progress report as a review. Merely to mention systems is to have other work brought to one's attention.[11] A new book by two foremost writers in this field, R. A. Ackoff and F. E. Emery, [8] is a case in point.[12] What are we to think of these attempts? Are they yet another panacea that has been oversold and will fail to live up to its promises?

I think it is fair to reply that the interest in systems is somewhat different in that it springs from the observation that the manager in search of sound advice often finds a plethora of apparently competing disciplines offering a wide variety of prescriptions in a host of mutually incomprehensible mandarin languages. How is he to choose the correct formula (or should it be formulae)? It seeks to answer this question in a rather fundamental way. It does not offer "a theory

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[11] For instance the work of Professor J. J. Moore at University College, Dublin, [9].

[12] This book will not be treated in this article but reviewed in a later issue.

of behaviour nor a set of generalisations that explain why people behave as they do. Nor does it describe their behaviour. Nor is it another of the increasing number of efforts to mathematise or formalise the study of human behaviour. What [it] does attempt to do is provide *a way of looking at human behaviour as systems of purposeful [teleological] events.*" [8]

In the words of Ackoff and Emery it is not concerned with providing scientists and engineers with an "additional quantitative tools to put in their kit but to provide them with a new kit into which old and new tools can be replaced" [8].

This approach is of a fundamental type because it involves a re-examination of the principle functions of a philosophy of science, particularly its role as a potential synthesiser of the findings of the various scientific disciplines into one integrated corpus of knowledge about natural phenomena. This reappraisal, which has revived the debates of the last century between Marxists and others on the nature of science, arose when research workers studying types of phenomena which were not previously susceptible to classical scientific investigation found a way to surmount the barrier between living and non-living systems which had hitherto proved the major stumbling block in previous attempts to unify the sciences. These investigators found the prevailing mechanistic approach used by most scientists was inadequate for the behavioural sciences where the interest was focused on a teleological (goal seeking) study of *life*. By studying mechanisms that served a function—teleological mechanisms—it became apparent that it was often more profitable for designers of mechanisms to develop their conception of the parts by decomposing their conception of the whole rather than obtain their conception of the whole by assembling analyses of the parts.

Taking such a holistic viewpoint resulted in it becoming apparent that the teleological and mechanistic approaches were compatible rather than conflicting and a basis for unifying the sciences was perceived. This discovery was particularly important for the behavioural sciences since a convincing case could now be presented that a holistic approach to research can employ fundamental concepts which are as objective, as measurable and as capable of use in experimentation as any of the structural concepts used in the mechanistic approach of the "hard" sciences.

Traditionally it was necessary for the sciences to become more and more specialised to increase the depth of understanding in a particular discipline. The problem then became one of finding a means of synthesising the findings in each discipline given the growth of relatively unrelated conceptual systems in an ever-increasing spectrum of disciplines. Early attempts looked to evolution, dynamic equilibrium or structural isomorphism as the central concept around which to build the synthesis. The holistic approach begins with the recognition that disciplines were developed for the convenience of researchers and are not something that exists in nature itself. It sees the disciplines as points of view and suggests that if each discipline makes a conceptual analysis of the broad view its starting point for scientific analysis within, the discipline, and works down, integration is largely unnecessary. Problems of starting from the disciplines and working up to a synthesis which had proved so difficult are avoided.

The holistic approach to management likewise starts from the broad view. It recognises that successful management of complex modern systems is difficult in a period of rapid social change and intensive technological innovation. The new partnership between state and business calls for a reorientation of management in which the vision, ingenuity and administrative ability of the manager needs the support of the best that science can offer. If each discipline develops its own insights and methodologies on the basis of a perception of the whole which is shared across disciplines not only are the possibilities for integration greatly enhanced but the cross fertilisation will also prove fruitful for further scientific advances. In the process the practice of management stands to benefit considerably.

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