

THE UNIVERSITY OF HULL

“Quality Management or Management Quality?”:
An Adaptive Model of Organization as the Basis of Organizational Learning
and Quality Provision

Minor Modifications Required by Examiners
and
Errata

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by

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*Thus shall ye think of all this fleeting world:
A star at dawn, a bubble in a stream;
A flash of lightning in a summer cloud,
A flickering lamp, a phantom, a dream.*

From "Vajrachhedika-prajnaparamita" or Diamond Sutra,
circa fourth century AD

Foreword

This document tells the story of the development of an approach to the management of quality management. Not the more usual “conformance to specification” version of product quality, but that of service quality. In telling this story two main sources have been used, cybernetic theory, and management practice. In telling the story is presented in a linear manner, which is intended to make it easier to follow. That is it begins with a problem, moves to a suggested solution and ends with an application and reflections thereon.

Although the project presented here *did* begin with the problem of service quality management and end with the successful implementation of a management tool, the development of the model that drives the solution was circular. Not unlike the serpent eating its own tail the process of model building was iterative, informed by the results of earlier research and consulting interventions. Because of its circuitous route the research draws on a broad range of theoretical sources, some more

obviously or directly relevant than others, but all of which served to enrich the understanding and applicability of the final model.

Because the theoretical model moves from cybernetical first principles the practical application it informs does not exhaust its potential. The constraints of the research questions, and the needs of the client, used as the basis for the case study, delimited the extent to which it was possible to comment formally on its content.

Although it has been possible to justifiably answer the questions set, almost by necessity some of the more esoteric elements of the theoretical model remain unproven in the strict sense. However, these elements provided invaluable *illustrative* insights and have hinted at a rich vein of future research, particularly in the field of computer simulation and the unification of science. The exploration of this potential is, however, beyond the boundary of this project.

The main practical outcome of the project is a rigorous approach for the integrated management of quality and organizational effectiveness in the professional service sector. Such an approach has been problematical in

the past and led to the situation where service quality was considered to be no different from production quality, evident in the “product and/or service” style of language adopted in the ISO literature. As I argue here (and (with Beckford) elsewhere) this approach is not tenable due to the fundamental differences in the manner of design, consumption and quality assurance between the two. And it is this that has tended to lead to the mechanistic approach to service quality management, e.g., the use of standard “scripts” to be followed during service events (e.g., “Have a nice day ...”).

Once this understanding of *service* quality management was established it was necessary to construct an organizational model to contain it. The basic model chosen was Beer’s Viable System Model. However several adaptations were made which allow for a more general, as opposed to strictly neurological, interpretation and to facilitate a more intuitive fit with the technological platform on which it was to be implemented.

Following this it was a relatively simple exercise to construct a database tool for the capture and manipulation of data to support organizational activities.

As the basis of the project was the development/derivation, through theory, of a practical solution to a 'live' business problem the burden of 'proof' lies in the application of the solution and reflection upon its utility. For this reason a case study is used to demonstrate the model which (and although it went through many formal and informal iterations) was 'signed off' by the client. In addition, the general model was accepted by both a professional body (as an appropriate tool for practice management) and a national standards body (as the basis for their auditor training).

With this final practical validation the story draws to a close. The practical problem of service quality management has been set within a demonstrably rigorous theoretical framework. The framework has provided the basis for, and informed the design of, a management tool. And the tool has been validated in practice.

Acknowledgements

There are a number of people to whom, for various reasons, I wish to offer thanks:

Dr Paul Keys, for agreeing at short notice to be my supervisor. This has been a complex and protracted project and I am especially grateful for the sound practical advice Paul has given, allowing me to turn a research project into (hopefully) a sensibly structured and coherent thesis.

Dr Robin Asby, for helping me to make sense of the eigenfunction, and preventing (my) excitement with the power and beauty of the idea from getting in the way of scientific reason.

Dr Robert Rutland, for his help in defining the problems facing the modern, independent dental practice.

Dr. John Beckford, for taking a chance on an unproven consultant, and so enabling me to both feed my family and complete this research. The

confidence he showed in the value of the research and the access he provided to professional and national bodies at home and abroad have been invaluable in both the development and validation of the model.

Finally, as with all undertakings of this nature, there are victims as well as participants — and they too deserve mention. The production of a work of this kind extracts a personal cost, not so much on the researcher/author themselves as their family. The sacrifices families make are more often taken than the occasion for them to be freely made is allowed to arise. Time that should be spent together is not and the repayment for this is usually a short temper rather than the gratitude it warrants. To my family — Mel, Kasenya, Ciara and Freyja — I offer apologies, thanks, and the hope that the result is worthy of their sacrifice and support.

Peter Dudley, June 2000.

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Chapter 1

Introduction

The aim of this project was to investigate the possibility of addressing the problems of managing quality (within the context suggested by the requirements of the International Standards Organization's (ISO) ISO 9000 family of standards) in the professional services sector. This was considered to be of interest for a number of reasons:

the difficulties encountered by clients in the services sector when dealing with quality management;

the apparent inability of the (then, i.e. 1994) International Standards Organization's quality management system requirements for service providers (ISO 9001:1994);

notification by the British Standards Institution (BSI) of the proposed introduction of a new set of quality management system requirements (ISO 9001:2000);

which led to the conclusion that there was both academic and commercial value in a formal study of the problems encountered and their possible solution.

At the practical level, i.e. at the level of the design and implementation of quality management systems, the most obvious problem appeared to be that of the overt manufacturing bias of the requirements of the standard (i.e. ISO 9001:1994). This led, in the client organizations visited, to either a disregard of formal (i.e. certifiable under ISO or similar standards) quality management as irrelevant to the provision of professional services or to *mechanistic* implementations that reflected the practices of manufacturing organizations in controlling output quality. These attitudes appeared to be based on the assumptions that either the provision of services is *irreducibly* different to the manufacture of products, and is therefore not susceptible to formal quality control, or that the provision of services is *exactly the same* (apart from the detail)

as the manufacture of products, and can be quality controlled in the same way.

The research carried as the basis of this project suggests that it *is* possible to construct a general model of quality management — one that is applicable to both services and manufacture — but that it is necessary to adopt a higher level of abstraction than has been evident in, for example, current versions of the ISO 9000 family of standards (see BSI, 1994; 1999a). This, it is suggested, is because there *is* an identifiable difference between service provision and manufacture, but that it is in the manner of their *consumption* rather than their *creation*. Physical products are consumed separately to their creation (and are, therefore, nominally susceptible to post production inspection), whereas services are consumed as part of their delivery.

The emphasis on *conformance* in the requirements of the quality management standards, i.e. ISO 9001:1994 and the committee draft two version of ISO 9001:2000 (BSI 1994 and BSI 1999a) strongly suggests that there is assumed to be some criterion of quality that is (and, therefore, *can be*) established in advance of the creation of the “product

and/or service”. However, for services, I believe this research to show that such criteria for quality as can be shown to exist are established as an integral part of the process of delivery. And that this is particularly evident in the case of *professional* services — where the ‘problem’ presented by a potential client is defined, by the service provider, in reference to some or other body of professional knowledge.

Because of the adoption of the notion of *conformance* as the criterion for the assessment of quality, the processes involved in service provision can be seen to be more *complex* than those in manufacture, both numerically (i.e. the extra element of specification) and, in the sense suggested by Flood and Jackson (1991, p. 34), by way of the nature of the interactions between participants in the process. This “conformance to specification” also implies the existence of a *single right answer* or solution to the quality question¹, which it is the goal of the quality seeking organization to achieve. And thus the operations of the organization must be *controlled* to achieve this goal.

¹ This is not to say that the answer must be the *same every time* (as would, e.g., be expected to be the case in a mass manufacturing run). indeed it could alter with every instance of the ‘problem’ being set or, in a social context, each instance may constitute a *different* ‘problem’ requiring a (more or less) individually negotiated solution (as would be the case in e.g., a professional service event).

These three elements of the ‘service quality problem’, i.e. complexity, a degree of unitarism and control led to the selection of the models of cybernetics as the basis of the approach to the project. In particular, because of their accessibility and the fact that they explicitly treat the possibility of ‘organizational change’, the “Viable System Model” of Beer (various) and the “Ultrastable System” suggested by Ashby (1960; and which forms the basis of some of Beer’s work) were selected.

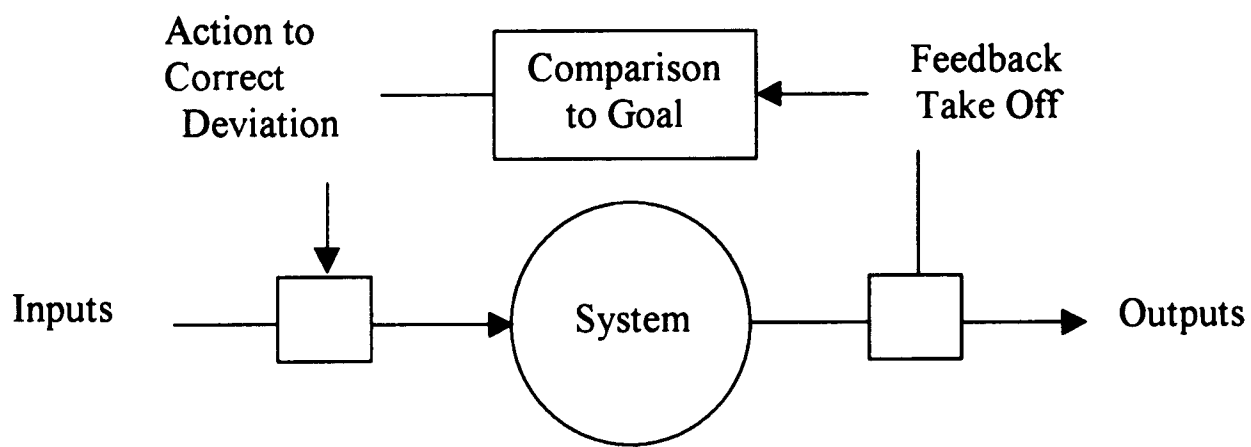


Figure 1a: A Simple Cybernetic Model (adapted from Shoderbek, et al, 1990, p. 86 and Wiener, 1961, p.112).

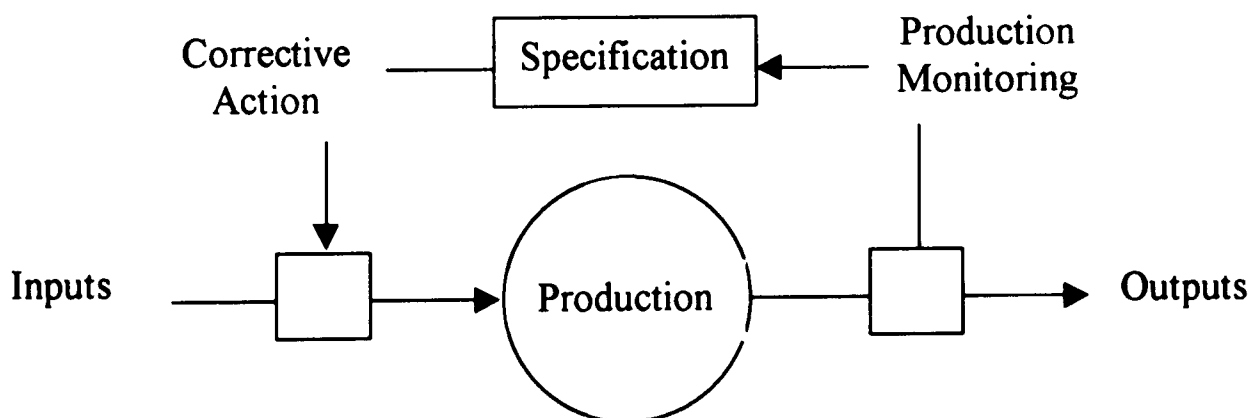


Figure 1b: a Simple Representation of Quality Control

Thus the questions asked as the basis of this research are:

“Is it possible to construct an effective model of quality management that is applicable to service quality management using cybernetic principles?”; and,

“If so, *what would it look like?*”.

The value this choice adds to the undertaking of this project can be seen in the direct comparison that is possible between the most basic of the cybernetic mechanisms (i.e., what Shoderbek, et al.(1990, p. 86), call a “first order feedback system”) and the operational view of quality control implicit in the “conformance to requirements” approach of the ISO standards (i.e., BSI, 1994; 1999a), given as figures one (a and b).

The comparability between the two models is not as trivial as it may at first appear, as will be come apparent in later chapters. This apparent utility is increased by the extension of this basic representation into Beer’s Viable System Model (VSM) which explicitly considers the form of the organization, and the functional provision necessary to support it, in relation to the *design* of organizations intended to achieve human

goals. Therefore the choice of cybernetics as the theoretical model for the project provides a body of knowledge sharing sufficient common ground with the problem at hand to begin fruitful study.

The formal adoption of a 'body of knowledge' *in general* as opposed to the adoption of cybernetics *in particular* brings two advantages. First, it provides a counterpoint to the apparently *atheoretical* approach apparently adopted by the standards designers² and could, therefore, be expected to allow sensible comment on the manufacture/service divide. And, second, it supports the *prototyping* approach necessary to the development and implementation of novel solutions to practical problems. This leads, when applied to a 'practical' problem, to a situation (represented in figure two) where the relationship between theory and practice is similar to the model of professional practice" introduced by Dudley and Beckford (1998). In this context the identification or statement of a problem (or "problem situation", see Checkland, 1981, p. 155) which (when interpreted through the body of

² Extended contact with persons involved in the drafting of the current (CD2) version of ISO 9001:2000 has given the very strong impression that a 'pragmatic' approach, dependent more on past experience and 'expert opinion' as to "what quality management is" has driven development. This may explain the absence of reflective consideration of the issues surrounding service provision and the possible differences between service and manufacture leading to some of the potential failings of the standard.

knowledge) drives the creation of a model of the situation (also informed by the body of knowledge) to be used for its ‘solution’. The model is, in effect, *tested* in its application to the situation and either modified or validated as a result and, when a satisfactory ‘solution’ is achieved the model can be said to be valid.

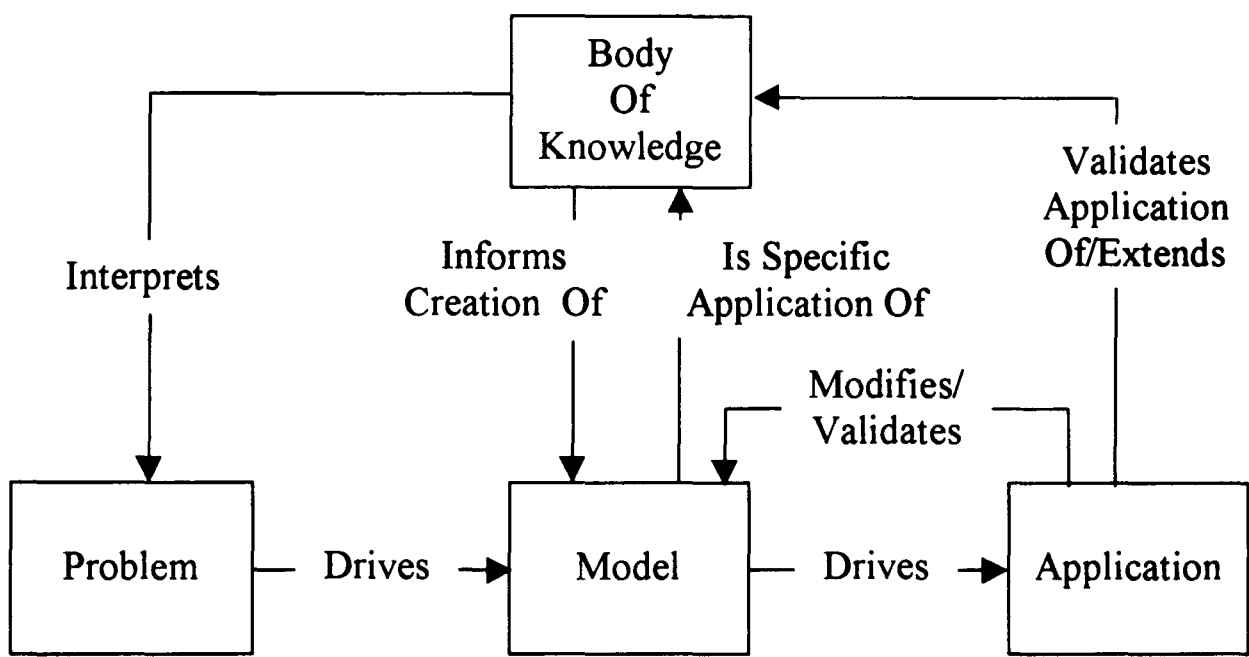


Figure 2: The Relationship of Theory to Practice

Thus the model can be seen to represent a specific application of the body of knowledge to a specific “problem situation”. And the extent to which it is ‘successful’ can also be seen, by association, to be a confirmation of the validity of the wider body of knowledge in application to that situation. Where the model represents a *novel* utilization of the body of knowledge (or where the “problem situation”/application is outside the accepted domain of the body of

knowledge) a valid application (defined as above) can be said to *extend* its legitimate domain of application.

As can be seen from figure two, the validation of the model (and therefore the legitimation of the application of the body of knowledge) lies in *practice* (i.e. the provision of a successful ‘solution’). And the eventual acceptance or rejection of the ‘solution’ arrived at in the application of them model rests in the hands of the *owner* of the problem situation, which provides the basis of Ulrich’s (1981) “Critique of Cybernetic Reason” (discussed later in this chapter).

By adopting cybernetic theory (along with a number of apparently related theories and disciplines) as the body of knowledge and Beer’s “Viable System Model” as the base model to inform the project, figure two becomes figure three. And the project, although originally conceived (and implemented) as the design of a ‘solution’ to a particular practical ‘problem’ becomes a *de facto* examination of the validity of both the VSM and cybernetic principles to the area of service quality management.

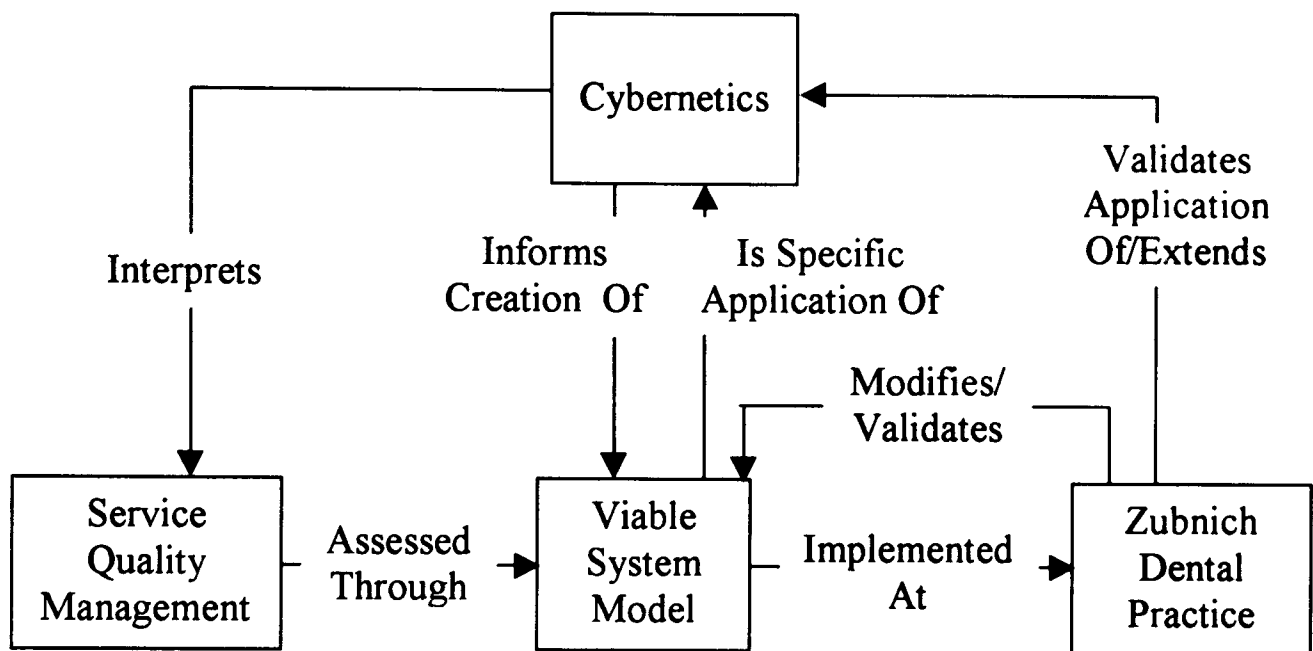


Figure 3: Using the VSM at Zubnich

The outcome of rendering the validity of the selected model, and its more general body of theory, contingent upon the ‘success’ of the ‘solution’ (however this may be defined) presents the process of enquiry with two legitimate options should the model not be validated in application. The first is to declare the model and/or the body of knowledge inappropriate to the area of enquiry — in effect to declare that the problem lies outside its legitimate domain. And the second is to modify the model — which is allowed for within the rubric represented by the diagrams — in order to allow it to more closely approximate an acceptable ‘solution’. As the primary aim of the project was the design of a ‘solution’ rather than a ‘test of the theory’ the second of these approaches was chosen. Thus the ‘pure’ form of the VSM (i.e. the one proposed by Beer) and, to some

extent, the relevant domain of cybernetics became provisional in the context of the project.

Even after allowing the selected model to be contingent the application of cybernetics to social groupings is problematic. From its inception the unreflected or malicious application of the principles (derived from observation and simulation of natural and mechanical systems) to the social arena was considered to have dangers. Norbert Wiener (considered to be amongst the founding fathers of the discipline), for example in his *The Human Use of Human Beings* (1959) warns of the outcomes of the misapplication (i.e. the socially irresponsible or despotic use) of cybernetic ideas as does Beer³ in *Designing Freedom* (1974) and *Beyond Dispute* (1994). Beyond this, Ulrich (1981), in his *Critique of Pure Cybernetic Reason* questions the limits of cybernetics in dealing with “practical reason” in the Kantian sense. Criticizing what he calls the “[substitution of] intrinsic control for intrinsic motivation” (ibid, brackets added) he (rightly I think, in the context of the commentaries from both Wiener and Beer) alleges that (in the social arena⁴) cybernetics contains

³ Implicitly in these cases, as the emphasis seems to be on the design of structures to *prevent* the subversion of socially desirable ideals.

⁴ There is a degree of arrogance in the assumption that the reliance on “extrinsic motivation” characteristic of the biological world, that Ulrich describes as characteristic of the cybernetic

no *intrinsic* protection against socially undesirable application, and as such becomes “... mere *tool design*” serving ends determined by “... acts of belief on the part of political decision makers” (ibid).

As it was conducted, the case study used in this project too is “mere tool design” — intended to provide a theoretically justifiable machine for the control of quality in the host organization. As such it assumed an (at least tacit) acceptance on the part of the other (i.e., non-owner) members of the organization, i.e. those that are “affected but not involved” of the legitimacy of the need to maintain and/or improve the quality of the output⁵.

There is a certain irony, then, in the recognition that it is the very:

“... contexts of meaning [which] are the basis of sensible orientation or selectivity vis-a vis a complex world, they represent a desirable kind of variety that is not to be reduced or ‘destroyed’, but rather to be maintained and interpreted as a potential source of new selections” (Ulrich, 1981, brackets added).

paradigm, places unjustifiable constraints on the social which seems to imply that the simple presence of a volitional capacity is sufficient to de-legitimate non-social control of social activity.

⁵ This is the question of *problem ownership* referred to earlier in this chapter.

which Ulrich considers to be beyond the legitimate scope of cybernetics because of the “...*one-dimensionality of its implicit rationality criterion*” (ibid, and which he uses as the basis of his critique) is a direct parallel of the logic that underlies the suggested model of professional competence. And, as such forms the basis of the variety management approach utilized in the (avowedly cybernetic) model⁶ proposed in this document.

Here it is also appropriate to address the definition of quality used in this project — because it is different from that generally applied in the quality literature and summarized by Flood (1993) in the first two of his ten quality principles:

“There must be agreed requirements for both internal and external customers...
Customer’s requirements must be met first time, every time ...” ibid, pp. 123/4).

The difficulty with services is that these requirements, except in the most general terms, are subjective. Thus the definition of *quality* used

⁶ This may, of course be a consequence of Ulrich’s (along with other commentators) use of the “picturesque” statement of Ashby’s law that “only variety can *destroy* variety” (Ashby, 1964, p. 202, italics added). Successful control (as is argued ad nauseam elsewhere in this document) relies on the *equivalence* rather than the *removal of relevant* varieties

throughout this project is a function of the perception of the service receiver. *Quality is good* if the client perceives and evaluates it as such. This problematizes the ‘agreement’ of requirements in advance and emphasizes the skill of the service provider in determining the correct (i.e. high quality) approach to the clients’ problem(s) (see Dudley and Beckford, 1998 for a full discussion) by necessitating that requirements are negotiated as an integral part of the service delivery event. Of course this, in its turn, problematizes Flood’s “first time, every time” principle, leading to even more emphasis on the skill of the service provider and the need for active management of the provision and availability of that skill. As these ‘advance specifications’ constitute a fundamental element of the models proposed in the quality literature (see, e.g. Beckford, 1998 or Flood, 1993 for a full review) a conscious decision was made to construct the model proposed here from cybernetic first principles, thus largely excluding previous writers from detailed consideration.

A final point, in the context of the above discussion, is the use of mathematical and/or physical models (chapters five to eight). Their inclusion and consideration as part of this project *is not intended to suggest* that human organizations or social groupings operate in this way.

Such models are used to illuminate the consideration of the dynamics of organizations in a manner similar to that of Parker and Stacey (1994) in that they:

“... might give us a deeper insight into how human organisations function ... [because] (w)e can certainly do with all the new insights we can get, bearing in mind how difficult managers seem to find it to design and sustain creative organisations ...” (ibid, pp. 11/2, brackets added).

Thus, *at the most*, the aim was to discover *analogical* patterns of ‘behaviour’ for which models already existed with a view to them informing possible behaviours (and the mechanisms that facilitate them). These models suggested pre-application modifications to the pure form of the VSM (which were added to in an iterative fashion *during* implementation), and led to the creation of the interpretation used in the abstract model developed in chapter eight. However, the examples, and the language, borrowed from the ‘hard sciences’ can be no more than *illustrative* when used in the context of the human organization or social grouping. They may have more formal utility in the field of automatic computer simulation of adaptive and/or learning systems, but even then will remain “models”, the utility of which, as Beer underlines in the statement:

Part 1

Part one (chapters two to four) introduces the project in the context of the client group, exploring the problems faced by firms attempting to manage service provision quality, reviewing the standard to which they were seeking certification and presenting a ‘first cut’ version of a suggested solution.

Chapter two identifies the core problem of designing and implementing quality management systems in the services sector as one centered around an inability to grasp the nature of the industry they intend to serve. That is, an inability to conceptualize, and, therefore to control the skills based characteristics of service provision. By implication this statement of the problem also forms a critique of the reductionist approaches to quality management in general — those which follow in the tradition of the “scientific management” movement and its tendency to alienating and deskilling task and role specifications.

Chapter three presents a description of and commentary on the contents of ISO/CD2 9001:2000 and the timetable for its implementation as a full international standard for the design and implementation of quality

management systems. Although it was not the intention, in this chapter to develop any form of detailed critique (that being the subject of the next chapter) references were made to areas where problems or weaknesses have been apparent in either the content, conceptual bases or in the promotion or dissemination of information relating to the standard or its implementation.

Chapter four undertakes a more critical review of the contents of the standard. This was then taken forward into a more detailed proposal of a model that is nominally capable of both satisfying the formal requirements of the standard, based on Ashby's "ultrastable system" and Beer's "viable system model". The mapping of the general elements of the standard onto the VSM demonstrate that it is feasible to attempt to design and build compliant quality management systems (i.e. which satisfy the requirements of the standards) based on these systems approaches to organizations.

Part 2

Part two develops the theoretical model used in the project using insights available from the mathematical, biological and physical worlds. It is

here in particular that the earlier comments regarding analogical and illustrative use have relevance.

Chapter five introduces some of the early influences on my thinking, i.e., those that led to the construction of the prototype of the model eventually proposed. As before, the chapter assumes the basic validity of the principles of cybernetics, and that they have a general applicability — whether formal or simply illustrative or heuristic.

Chapter six introduces four models of change (i.e. Darwinian natural selection, Kimura's neutral drift theory, Lamarckian inheritance of acquired characteristics and Bogdanov's podbor) that have, at different times and with differing degrees of (scientific) success, been applied to explain evolutionary change in biological systems. All, however, have potential utility in the design and investigation of organizations and of machines to simulate them.

Chapter seven introduces the last element of the model *in isolation*, the idea of the *eigen*-system, which was proposed as a structure for integrating the tools and models of change introduced in chapters five and

six and the requirements necessary for systems to be regarded as *adaptive*.

Chapter eight proposes a re-interpretation of the Viable System Model based on the explicit inclusion of a physical element alongside the informational elements defined by Beer. This re-interpretation is informed by the mathematical models discussed in chapter five and the notion of the “eigen-system”, a self creating entity based in the mathematics of quantum physics.

Part 3

Part three considers the application of the model developed in part two to the management of human organizations through the vehicle of a case-study of the Zubnich Dental Practice. Since beginning ‘writing up’ this project further credence has been added to the belief in the generality of the model by its acceptance as the core theory for the auditor training programme of the Hong Kong Quality Assurance Agency (HKQAA is the Hong Kong National Standards body largely equivalent to the BSI). A developed form of the database model (i.e., one which *includes* the effectiveness management and patient record modules) is under detailed

review by the Hong Kong Dentists Association with a view to developing a small practice management system for its members.

Chapter nine attempts to demonstrate how the adaptive model, completed in chapter eight, is able to fulfil the general requirements of ISO 9001:2000 and the principles of the guidance contained in ISO 9004:2000 as both stood as at CD2. This was achieved by taking the major clauses of ISO 9001:2000 and the associated guidance from ISO 9004:2000 as the base structure and considering the extent to which the elements of the model suggested were able to support them.

Chapter ten begins the case study analysis of the Zubnich dental practice, considering the extent to which the model (from chapter eight) provides the basis for “effectiveness management”. This was thought to be necessary because of the interaction between business survival and development and the adaptive maintenance of quality provision.

Chapter eleven details the model of quality assurance and control (based on the abstract model developed in chapter eight) implemented at the Zubnich Dental Practice and includes the data structures, search

procedures and decision points used to support it. The guiding principle was that quality at Zubnich, as a professional service provider, was dependent upon the skills of the individual professional clinical personnel. And therefore that in order to manage the quality of the service provided to patients it was necessary (with the exception of punctuality and the duration of treatments) for Zubnich to be able to monitor and manage the skills available to the practice.

Chapter twelve begins with a review of the method used and then presents the findings of the project as a whole. The review of method expands the detail of the process of this research. The findings of the project are discussed in terms of the extent to which the project can be considered a *practical* success, the theoretical considerations arising from this success (i.e., the extent to which the outcomes of the case study support the abstract model). And also identifies those areas where elements of the model, although not formally supported by the case study, merit further study and may be expected to provide practical and/or academic value. This section also examines the research questions, as originally asked, and the extent to which they have been answered by the research.

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able to do this it was necessary to enforce standards of design and manufacture that ensured that British manufactured ammunition would work in American manufactured firearms, etc., etc.. In more general terms, there was a need to ensure that remotely designed and manufactured components and semi-manufactures could be assembled into functional finished *products*.

The growth in material wealth that was brought about in western(ized) nations, and the very existence of the mass market/mass production economies they have developed since the end of world war two, can be directly related to the DEF STAN approach to production. *Conformance to requirements* makes the car you drive and the refrigerator that chills your food and drinks possible.

However economies mature and move on, and however much we may now be reliant on the principles of mass manufacture and conformance to specification the fact is that more than seventy percent (in money terms) of all organizations in mature economies are *service providers*. Even a cursory reading of BS EN ISO 9001:1994 and its related family of standards will show that they are far from sympathetic to service quality.

In a manner which parallels past experience in manufacturing, recent years have brought about an increasing pressure on the service sector to address issues of provision quality. However this drive to improve quality, which had varying degrees of success in the manufacturing sector, seems to have been even less so in the provision of services. There are two basic reasons for this:

The definition of "quality". Quality has been described in the literature (see, e.g., Beckford, 1998 for a review) as conformance to specification or fitness for (some assumedly pre-specified) purpose. Because of this, quality is often equated with standardization. Hence the level of quality is perceived as the inverse measure of deviation from a specification, rather than the warm rosy glow of the experience of a *good thing*.

The fact that *services are different*. There is often no tangible product as the result of a service. Service, and therefore service *quality*, is an emergent property of the process of its provision.

The interaction of these points has perhaps driven the proliferation of paper based "quality systems" for the control of service quality which are unusable. The attempt to capture the richness of service provision in flow-chart format makes them so large and complex as to be unintelligible. The fact is that no self-consistent system *can* completely capture all such complexity (see Gödel's incompleteness theorems, see Wang, 1996 for a detailed exposition), and so they are incapable of achieving the purpose for which they were designed. Thus such quality management systems are, by their own accepted definition poor quality.

What is needed is a re-conceptualization of quality and quality management appropriate to the professional service sector in order to allow the design and implementation of *effective* and *manageable* quality management systems for professional service providers.

Effective, in this context, means that it will provide the information necessary for the maintenance and improvement of service quality.

Manageable means, quite simply, (relatively) *small*.

The philosophy underlying the approach stems from the definition of *professional*, given below, and the fundamental belief that the complexities of quality provision and its improvement cannot be modelled in a *once and for all* manner. Therefore the traditional, documented procedure, approach to quality management is pre-destined to failure in the service sector and, increasingly given the *bundling* of services and products, in the manufacturing sector.

In order to be effective, any system designed to maintain professional service quality must address not only the nature of professionalism, but must use this nature to provide robustness in practice and embed it in a structure both sensitive and intelligent enough to *learn*.

In addition it must be small enough to be willingly used, and transparent enough to be understood (at least in principle), by those who use it and manage it.

Although it is accepted that ideal type organizations (i.e. either totally service or totally manufacture) do not exist, it will become clear that, at the level of implementation, they are considered to be different. This

difference arises from the methods by which the quality of their activities can be assessed and controlled. Here I shall state briefly why and how the proposed approach differentiates between manufacture and service provision and how this differentiation relates to quality management standards. In a later chapter I shall introduce the approach to the management of service quality — expanding the characteristics of services and service provision as I perceive them to be.

In manufacture the skills of the operators that carry out the processes which create the product form a meta-structure around the operation of the process. In service provision, on the other hand, the utilization of these skills *is* the product.

Because of this it is suggested that *all* services can be treated as "special processes" in the sense of ISO 9001, i.e., processes where :

"... the results ... cannot be fully verified by subsequent inspection and testing of the product and where, for example ... deficiencies may become apparent only after the product is in use..." (BSI, 1994, p. 7)¹.

Further, that formal quality *assurance* (rather than control) can be achieved by recognizing this and treating them as such.

Services are delivered *by people*, therefore process control in the context of service provision is the control of the behaviour of the people providing the service. How? Assuming (as a minimum) the absence of malice, appropriate behaviour (i.e. behaviour which is likely to achieve the purpose of the service being provided in the first place) is assured by ensuring that the provider of the service has the skills, knowledge and competence necessary to the provision of the service.

Services are also delivered *to people*, and they (especially clients, patients, passengers, customers) vary, therefore no two service provision events can ever be the same. Even assuming (the impossible situation) that the education of different service providers ensures that they are

¹ One should note in this quotation the evident manufacturing bias. However, if the word "product" is replaced with the word "outcome" it is apparent how the conclusion that services are, or are comprised

consistent in approach there will be as many variations on a single service as there are recipients (victims?), and this is why the complexities of service provision arise.

It is the potential variety of the situations that arise in service provision which, of necessity, defeat the mechanistic approach to quality management. It is not possible to model all possible situations in advance, therefore it is not possible to specify all activities and solutions in advance. Therefore it is not possible to chart the process fully in advance — not even with charts a mile long — and it is the very attempt that creates the bureaucracy.

This impossibility is a consequence of Gödelian incompleteness theory and an extension of Ashby's "Law of Requisite Variety" (Ashby, 1964, pp. 202 ff.) that states that only variety can overcome variety. In other words, a complex situation becomes uncontrollable when it becomes *more complex than the mechanism used to control it*. Hence robustness in the delivery of service quality (i.e. the control of the service process) cannot be achieved using mechanistic approaches as the machines (real

of, special processes was arrived at (see also Dudley and Beckford, 1998).

or otherwise) we are able to design are necessarily less complex than the situations they are designed to control (i.e. social interaction).

The Service Quality Problem

The Problem §1

Standardization, in the literal sense of conformance to standard, is a notion that is easily applicable to the assessment of a tangible product. It has grown as an integral part of the development of mass production and the derived need to manufacture complex items from components themselves (potentially) manufactured remotely.

Because it persists in a tangible form, independent of the process used to create it, a product can (within limits²) be described in terms of its critical characteristics in advance of its creation. "Critical characteristics" being those defined as affecting the performance of the product. This allows the extensional characteristics of the product to be *objectively measured* i.e., it has these dimensions, this volume, that weight or density. Products specified in this way can be quality controlled by means of

² Nb. that the aesthetics and ethics and/or morality of the manufacture of a particular product are considered to be beyond the realm of "specification" for the purposes of this part of the argument.

inspection, i.e., "*Do they have* those dimensions, that volume, that weight or density?".

The process of the assembly of components produced in isolation, for example, brings, the need for standardization. Significant variation in the size of the components will cause them not to fit together. In this case standardization is used to ensure commonality of size (usually within stated tolerances). The notion of measurement can be extended to the determination of all performance characteristics of the item in question that are dependent on the *physical properties* of that item, e.g.

item α must weigh j units

item β must have k tensile strength

item χ must have l melting point

item δ must have m electrical conductivity

item ε must be capable of processing n logical instructions per second

item ϕ must provide p calorific value

The logical extension of this approach is that, assuming that you can state fully the performance requirements of the item, it is possible to *specify* it in its entirety. The major advantage of this is that it provides a parsimonious statement of the desired characteristics of the item. That is, only those elements that relate to the ability of the item to perform the task/role assigned to it are taken into account in its design and production. This is obviously a highly desirable state of affairs assuming that the removal of extraneous detail contributes to the *efficient* delivery of an item that conforms to performance requirements.

However the manufacture of a physical product and the provision of a service have a fundamental difference in that, at the end of its manufacture, a *product* takes on an existence of its own, whereas a *service* is an emergent property of the process of its delivery.

The recent "Committee Draft 2" re-statement of ISO 9001 (BSI, 1999a) and its sister standard ISO CD2 9004:2000 (BSI 1999b), which place more emphasis on process control approaches, and Investors in People (IIP) type standards which emphasize organizational development, represent early attempts at the formal assurance of service quality but they have yet to be formally integrated within a coherent theoretical framework. Because of this, formal recognition of a skills based approach (and, consequently, manageable quality management systems in the service sector) have remained problematic.

The quality of a service cannot be assessed by how thick, how long, or how heavy it is. No matter how fast or intelligent our machines become it is unlikely that they will be able to assess an *intangible* characteristic in the same way that they can assess a *tangible* object. Service, and by extension *service quality*, is a *people* issue.

Developing the managerial capacity to deal with this insight requires a new insight into the management of quality, a robust and adaptive model of organization — i.e., one capable of responding to the demands of internal and external stimuli including those of established quality

management standards where appropriate (developed in chapters three and four) — and, for anything but the simplest (smallest?) organization, an effective information system to facilitate its administration.

The Problem §2

profession (noun)

a vocation or calling, especially one that involves some branch of advanced learning or science.

Concise Oxford Dictionary

Taking the dictionary definition of a "profession" (given above) it can readily be seen that the problem with the active implementation of service quality management resides in an unreflected attempt at the mechanization of the process. It is the attempt to reduce the *professional ability* (i.e. skill) of the provider in their interpretation of the body of professional knowledge in active consultation with their client to a pre-determined and linear process that contravenes the "law of requisite variety". *The professions are skilled* — any attempt at quality management must recognize this, and treat them as such.

The idea of using skills to assure quality is not new (consider the medieval craft guilds), even amongst the quality community. There is a section in the ISO 9000 family of standards which relates to what it calls "special processes" (see Hoyle, 1994, p. 293, BSI, 1994, p. 7), processes where the quality of the output is not susceptible to assurance through normal methods of inspection (see extract above). From Hoyle's statement that:

“Among such processes are welding, soldering, adhesive bonding, casting, forging, forming, heat treatment, protective treatments and inspection and test techniques such as X-ray examination, ultrasonics, environmental tests and mechanical stress tests.” (Hoyle, 1994, p. 293).

It can be deduced that the emphasis inferred by the commentators on the standard, if not the authors of the standard themselves remained firmly in the manufacture and physical provision sector. However in the following section, where Hoyle (1994, p. 294) discusses the “qualification of processes” and in the standard itself there is an explicit requirement that these special processes “... shall be carried out by qualified operators ...” (BSI 1994, p. 7) there is an explicit reference to the utilization of *skill* or

competence on the part of those people engaged in the operation of the process.

Medieval (and more recent) craftsmen were "skilled" — their skill lay in an understanding of the materials they were working with (rather than *on*), the techniques they used and an ability to recognize when things were *right*. This *rightness* was not defined in terms of conformance to a measurable standard but, rather, in terms of balance or fit or some aesthetic. Because of this it was inaccessible to those outside the guild and, therefore, beyond their control.

Similarly, the established professions, to the extent that they retain control of the body of knowledge and right of admission, continue in the craft tradition. It is only relatively recently, with the rise of corporate provision of professional services, that the need for a separate managerial function was felt. This rise in external managerial control, allied to increasing governmental intervention in the enforcement of professional standards can be expected to lead to a quality frenzy similar to that experienced in manufacturing.

Paradoxically, perhaps, this rush can be expected to drive down the perceived levels of quality delivered. This is because the move away from individual responsibility based on professional ability and towards managerial control of professional performance removes the capacity for process control from the quality loop (and this, ironically, at a time when manufacturing seems to be moving towards more active process control).

When viewed in the context of the progressive mechanization of the work process in the broad sense³ the development of quality management for the professions can be seen as a natural extension of the mechanization of the production process. The relocation of control of the point of professional contact will, in a manner similar to that experienced in craft production also remove an integral unit of *quality control* necessitating the imposition of an external unit of control on the process. One which can operate only *after the event*.

Whilst the effects of this displacement of control have been ameliorated by advances in technology in the field of mass production such approaches are not readily available to the professions. Therefore it is

not surprising that the development and implementation of quality management systems for professional services providers has a troubled history.

The Characteristics of a Solution

It should be apparent from the previous discussion that the key to the problem (and therefore the primary assumption of the research into a model for a solution) is that *quality in services provision is necessarily skill based*. And that the disregard of (or inability to conceptualize) this evident in the standards (and from previous consulting interventions) leads (of theoretical necessity) to the difficulties mentioned. What is more, experience gleaned during earlier interventions suggests that the more effective the mechanization of the process becomes the more likely and the more entrenched does a culture of minimal performance. This experience is repeated at the corporate level where companies seek accreditation to the various standards as a marketing device rather than through any 'real' commitment to the delivery or improvement of quality.

³ That is the reduction of complex 'craft' processes to minimal and highly specified tasks (see, e.g. the work of Taylor, 1911; Fayol, 1916 and, for the counter position,

This is not to say, however, that there is no element of service performance that is susceptible to formal measurement; only that the quality of service delivered (rather than the administration of its delivery) is *a function of the skill of the service deliverers*. Indeed, to operate effectively in the identification, delivery and improvement of quality, the skills based approach needs to be an integral part of a *system* of monitoring, control and improvement (defined in operational and normative modes) of the performance of the whole organization.

Figure one introduces, in outline, an integrated model for the management of quality and organizational effectiveness. This model is a simplification (designed by J. Beckford and given here for reasons of clarity) of a more detailed model (given as appendix three) that illustrates the elements and structure of a generic model for the implementation and ongoing maintenance of a quality management system. The model is explicitly based on the principles of the “ultrastable system” introduced by Ashby (1960, pp. 80 - 99) and Beer’s “3-4-5” homeostat (in his definition of the Viable System Model, e.g, 1979; 1981; 1985) of which it forms the basis, and as such is entirely consistent with the research

Braverman, 1974).

aims set out in the introduction. In later chapters the formal derivation of the model is developed in relation to theory, the results of the case study based research carried out and the formal requirements of the forthcoming revision to the ISO9000 family of quality management standards (expected to be published in late 2000).

One should note, in relation to the diagram, that its operation is circular, i.e. there is no explicit start point. The *entry point* to this particular element of the organization is through the business performance, appraisal and planning processes (i.e. those parts of the organization that Beer (1981) calls normative and that parallel Ashby's "essential variables" (1960, p. 42) and labelled "Business Performance"). Thus, the quality management system defined in this model is driven directly by business objectives which are, presumably, set in reference to past performance, current market conditions, regulatory and/or statutory constraints and organizational objectives/desires for future performance. As is implicit in both Ashby's and Beer's work the outcomes of this area of organizational activity are responsible for *both* the values applied within the organization to the assessment and evaluation of organizational performance *and* capable of change in relation to changes

in business needs in a manner that improves the potential of overall business performance.

The business performance appraisal and planning processes contain an implicit statement of the *identity of the organization* — and this identity will impact not only the value set applied but the shape and operation of the processes, people and skills used to produce or deliver the outputs the organization creates. In short it is the *what the organization is* that makes possible, and makes sense of, what the organization *does*.

By underpinning the appraisal and planning processes (located in the box labelled “Strategy Formulation” in the upper left hand corner of the diagram) the identity created by the business performance appraisal process provides the context for organizational activity and, by extension, defines what is and is not considered to be *quality*. It is also the location of the potential for organizational *change*.

The cluster of activities to the centre of the diagram illustrate the tight coupling of the quality management system to business goals (via “Corporate Review”) considered necessary if the quality management

system is to adapt and support *ongoing* quality provision. However where this model is thought to be superior, to for example, the “Business Excellence Model” used as a basis for the formulation implicit in the ISO standard, is in the explicit differentiation between mechanistic *quality control* and an *adaptive* ability or skill based *quality assurance* .

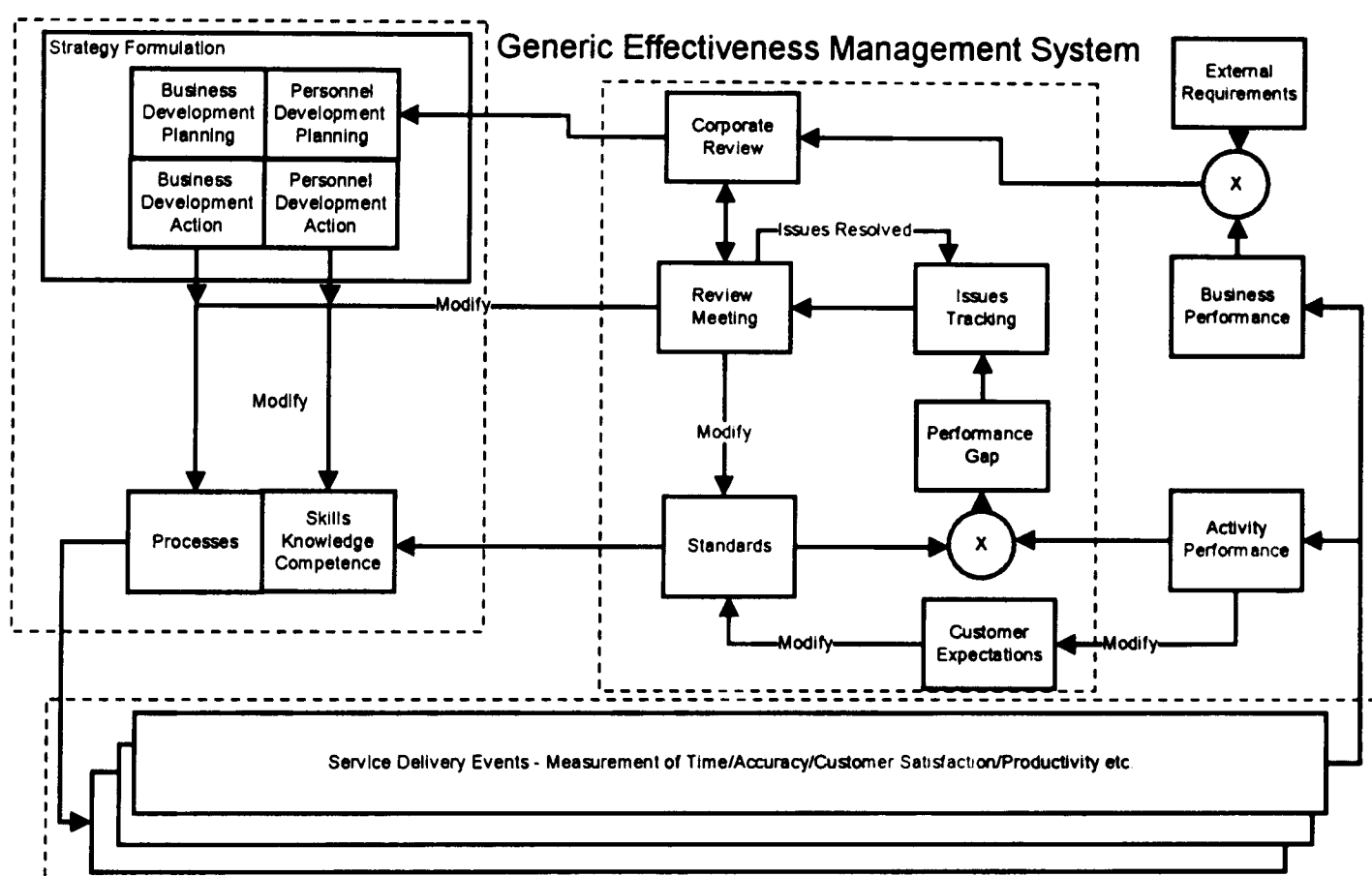


Figure 1: An Integrated Model

The lower section of the diagram is concerned with *historical* performance measurement — a method that is widely used in manufacture and *is* applicable to the routine elements of service provision. Here (in service provision and manufacture) the emphasis is on contracted performance e.g. meeting deadlines, operating within

turnaround times or numbers processed. It is, in short, the basis of the traditional quality management loop which, although it is crucial to good *operations management*, is insufficient to the task of ensuring the quality of service provision in the non-mechanistic, intuitive sense.

The upper left section of the diagram deals explicitly with the development and maintenance of what I, in common with the ISO 9000 standard (BSI, 1994), have called the "special processes" and the ability to carry them out.

Returning to the earlier extract, the special processes are those:

"Where the results ... cannot be fully verified by subsequent inspection and testing of the product and where, for example ... deficiencies may become apparent only after the product is in use..." (BSI, 1994, p. 7).

As an emergent property of the process of its delivery, a service is the *archetypal* special process. It is not, by definition, possible to place an inspection or test capacity between its production and the end user. In some cases such as, e.g. architecture, the outcomes may be technically

sound but *aesthetically* unsatisfactory, and so, even in use it may not be possible to define an objective performance standard.

Although it is impossible to protect totally against the subjective (e.g. the aesthetic, moral or ethical) measures of performance, it is reasonable to assume that exposure to technical and/or contractual risks in situations such as these can be minimized. Again the ISO 9000 standard provides a clue:

"... the processes shall be carried out by qualified operators ..." (BSI, 1994, p. 7).

In the established professions, quality of service has historically been assured by virtue of the same approach. "Operators" became "qualified" through gaining and demonstrating some minimal mastery over the body of knowledge necessary for admission. Following admission, the code of ethics of the professional body⁴, and the requirement that the admittee

⁴ Note that in, e.g., law and medicine membership of, and a certificate to practice from, the professional body is a legal requirement if one is to practice.

will continue to develop his/her mastery of the field⁵, was assumed to ensure both technical currency and social responsibility.

Any corporatist trend in the professions (i.e., any trend toward large practices with increasingly specialized sub-units or departments) can (and does, as the consideration of the ISO standard used in this research reveals) be expected therefore (if it parallels recent industrial history) to necessitate a formalization of quality control capability similar to the approaches of e.g., Taylor or Fayol, in order to bring about *managerial* control. As was pointed out earlier this can be expected to lead to similar problems as the move to factory based mass production in manufacture.

As I (with Beckford) have argued elsewhere (Dudley and Beckford, 1999), the mechanistic approach to service quality management is not tenable. Such methods violate the "Law of Requisite Variety" (Ashby, 1964, pp. 202 ff.n), provide no basis for the provision of "Ultrastability" (Ashby, 1960, pp. 80 ff.) and disregard the necessity of redundancy. The unreflected drive for *efficiency* inherent in current quality management approaches compromises any chance of sustainable *effectiveness* at the

⁵ This is often seen as "continuing professional development" (CPD) expressed as a need for a fixed

level of the organization. Hence the fact that service quality management systems are, generally, either *service administration* quality management systems, unsuccessful or both.

The model proposed in figure one overcomes the limitations of the mechanistic approaches by linking the quality management system directly to the business direction of the organization. New business directions necessitate new procedures and performance measures (the bottom half of the diagram) which create new information for inclusion in the next planning cycle. New business directions also create new *skills needs* or the necessity for different *skills mixes*.

By capturing the skills held by members of the organization (through, e.g., the appraisal process) and feeding this information into the "this year's skills needs" calculations it is possible to build a picture of organizational ability that identifies development needs in direct relation to business objectives. Thus the organization develops an adaptive *skills and knowledge management* capacity.

number of hours training per year dependent on the role and length of experience of the individual in

Taking the model a step further, i.e., identifying the "skills needed this period" in terms of those needed to carry out the tasks and roles stated as necessary to the business plan (i.e. by "qualifying" the tasks). It is now possible to build a quality assurance model based on the notion of the "special processes". By constructing a database of the tasks necessary to the organization, and the skills or knowledge necessary to the tasks, and a parallel database which records the skills and knowledge held by members of the organization it is possible to demonstrate that the processes *are* carried out by qualified operators.

Summary

This chapter has identified the core problem of designing and implementing quality management systems in the services sector as one centered around an inability to grasp the nature of the industry they intend to serve. That is, an inability to conceptualize, and, therefore to control the skills based characteristics of service provision. By implication this statement of the problem also forms a critique of the reductionist approaches to quality management in general — those which

question.

follow in the tradition of the “scientific management” movement and its tendency to alienating and deskilling task and role specifications.

The central assertion of the chapter is that there is an inherent combinative factor in the provision of services. This ensures that, for all intents and purposes, each service provision event is unique and, therefore, not susceptible to attempts at assurance or control that rely on the pre-definition of solutions to “non-conformity” in advance. That approaches that rely on this method of pre-definition are necessarily destined for failure is a logical outcome of the application of Gödelian incompleteness theory (i.e. that any self-consistent system is incomplete). In that, in that interpretation of quality, consistency (i.e., repeatability of output) is a fundamental element and therefore it is possible that there will be acceptable outputs that the quality management system is not capable of recognizing as such.

The definition of *standardization* that follows from this implies a *reduction in the potential variety of the behaviour of the system*. Therefore approaches to quality management that rely on variety reduction when, in services, the subjective element which exists in the

interaction between service provider and service client at least creates the condition where variety in the *desirable* outcome is likely to proliferate, create the conditions whereby a *variety inequality*, operating to the detriment of the service provider is likely to occur. Thus the misunderstanding of *variety management* (as per the “picturesque” statement of “Ashby’s Law”, 1964, p. 207)) as *variety reduction* creates the conditions where *managed* quality provision is not possible.

Finally, the chapter introduces an outline model for the creation of skills based quality management systems based on the principles of the “ultrastable homeostat” introduced by Ashby, and later developed by Beer into the “3-4-5” homeostat of the “Viable System Model”. This model, (developed as part of consulting and training interventions carried out in the UK and overseas in Hong Kong and the Peoples’ Republic of China) formed the basis of early (i.e., pre-project) consulting interventions and provided a basis for the implementation of the theoretical elements developed in later chapters.

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Chapter 3

The Standard¹

Introduction

This chapter addresses the requirements, and philosophy of the forthcoming “2000” version of the ISO 9000 family of standards. The new standards, ISO 9001:2000 and ISO 9004:2000 are (at the time of writing) at the “Committee Draft 2” (CD2) stage of the development and implementation process (see figure 1) and are due for full implementation in the fourth quarter of 2000.

¹ Chapters three and four form the intellectual basis of the delegates’ information pack for a series of training courses for quality managers and senior executives with responsibility for organizational quality presented in the UK, Hong Kong and the People’s Republic of China. The courses were attended and supported by, in the UK the BSI (UK), in Hong Kong by BSI Pacific and in the PRC by “Q China” the Chinese national standards body. At the time of delivery this support was seen as providing tacit validation of the approach suggested. Since then explicit validation (see also chapter twelve) has been forthcoming by way of contractual agreements and statements of intent to adopt the model as the basis of compliance audit and management system tools.

The design and implementation of “ISO” international standards is administered by the International Organization for Standardization (ISO) in collaboration with its member “national” bodies.

The International Organization for Standardization (ISO) is a worldwide federation of national standards bodies from some 130 countries, one from each country.

ISO is a non-governmental organization established in 1947. The mission of ISO is to promote the development of standardization and related activities in the world with a view to facilitating the international exchange of goods and services, and to developing co-operation in the spheres of intellectual, scientific, technological and economic activity.

ISO's work results in international agreements which are published as International Standards.

ISO is made up of its members which are divided into three categories:

Member Bodies:

Correspondent Members: usually an organization in a country which does not yet have a fully developed national standards activity. Correspondent members do not take an active part in the technical and policy development work, but are entitled to be kept fully informed about the work of interest to them;

Subscriber Members: for countries with very small economies. Subscriber members pay reduced membership fees that nevertheless allow them to maintain contact with international standardization.

A member body of ISO is the national body "most representative of standardization in its country". Thus, only one body in each country may be admitted to membership of ISO.

A member body takes the responsibility for:

Informing potentially interested parties in their country of relevant international standardization opportunities and initiatives;

Ensuring that a concerted view of the country's interests is presented during negotiations leading to standards agreements;

Providing their country's share of financial support for the central operations of ISO, through payment of membership dues.

Member bodies are entitled to participate and exercise full voting rights on any committee and policy committee of ISO.

(This section extracted and adapted from the ISO website *www.iso.ch*)

The British member body is the British Standards Institution (BSI) which:

“... works with manufacturing and service industries, businesses and governments facilitate the production of British, European and international standards. Today has a turnover approaching £170 million a year, employs around 3400 people has operations in over 90 countries including the US, Pacific Rim and China. In facilitating the writing of British standards, BSI is one of the world's leading authorities representing UK interests across the full scope of European international standards committees” (source: BSI website, *www.bsi.org.uk*).

The reasons for adopting the proposed 2000 version of the standards, rather than the established 1994 version are largely pragmatic. First there seemed little point in carrying out the detailed research and development necessary to be able to propose an appropriate solution to the problem of creating a model of a management that was capable of certification to a standard that was soon to be come obsolete. Second the rationalization (of language and structure), said to be included as part of the revision, promised to simplify the process. Finally there was an established collaborative relationship with members of various standards bodies (including a BSI member of the ISO international board, a Regional Officer of BSI (Pacific) and a Provincial Director of “Q China”). And these links provided a unique insight into the development of the new standard, and the issues surrounding its communication to accreditation and certification bodies and the potential users of standards, both at (i.e., in the UK) and overseas.

Having said this, there is a need to explore the content of the new standards in the context of the need for change, and, in relation to ISO

9001:2000, in relation to the changes in the *content* of the requirements it contains.

This chapter considers the structure and content of ISO 9001:2000 at a factual level, drawing comparisons to BS EN ISO 9001:1994 where appropriate. Chapter four explores the conceptual bases of the revision and examines the potential problems which, I believe, have been either left unresolved or will be created by the implementation of the new standard.

Why the Change?

International standards are subject to review every five years. The intention behind these periodic reviews is to ensure that the standards remain current, reflecting market and industry expectations and practices and encouraging best practice amongst their signatories.

The ISO 9000 family of standards was last revised in 1994 and, since then, management thinking (more particularly *quality* management thinking) has moved on. The model of organization implicit in the 1994

version of the standard, as was the notion of the quality it seeks to achieve, is largely static. That is, the quality of the outputs, and the methods used to both achieve and monitor it are, once established, regarded as fixed. This is, by and large, a consequence of the emphasis on quality as *standardization*, the “making the same” of the outputs implicit in the manufacturing bias of the standard². This led to the accusation that the standard allowed the accredited organization to produce very low quality — so long as it was properly documented and *consistently* low.

Because the emphasis of the 1994 standard was on the proper *documentation* of raw materials, work in hand and completed work, and its inspection for conformance to specification before acceptance or release, the function of compliance was separated from the quality of the output of the organization. The standard never was a *quality management* system it was only ever an *output documentation and administration* system.

² Note that this is accepted by ISO in the explicit requirements for “continual improvement” and, to a lesser extent, the need to manage the transition of the QMS during periods of organizational change, absent in the 1994 version but included in the proposed 2000 version.

Timeframe for Implementation		
Period	Year	
First Quarter	1998	Working Draft — for information
Second Quarter	1998	Working Draft — for information
Third Quarter	1998	Committee Draft (CD1) — for comment
First Quarter	1999	Committee Draft (CD2) — for vote
Fourth Quarter	1999	Draft International Standard (DIS) — for vote
Third Quarter	2000	Final Draft International Standard (FDIS) — for vote
Fourth Quarter	2000	Revised International Standard published.

*Figure 1: Timeframe for the introduction of the new/revised standard.
(source: ISO, 1999)*

The fixation of the standard on the operational level of the organization (necessitated by the focus on output documentation and control) also led to the perception (supported by interviews with quality managers during the workshops) that quality was an operational issue. That is that quality management was not relevant to the more senior levels of the

organization³. This also suggests that the reason that management gurus begin their books on quality management by underlining the need for senior management commitment is that it is the most difficult thing to achieve in practice. One should note in this context the reviews of such gurus as Crosby:

“... Establish management commitment ... a half-hearted attempt will fail” (Beckford, 1998, p. 56);

Deming:

“ [the] PDCA emphasised the need for management to become actively involved in their company’ quality initiatives” (Flood, 1993, p. 13);

and Juran:

“... responsibility for success or failure in getting quality right lies with management” (Flood, 1993, p. 18).

³ This criticism is also accepted by ISO and is addressed by way of explicit reference to the role of

Without such ‘high-level’ commitment, if quality is not shown to be relevant to the senior executive, the best that can be achieved is ‘lip service’, a grudging and half-hearted statement of support that is unlikely ever to be fulfilled.

Another significant weakness in the 1994 standard is that of the overt manufacturing bias (mentioned in the previous chapter) which it is the stated aim of the new standard to reduce. However, this seems (in relation to CD2) to be restricted to the use of the words “product and/or service” in place of the word “product” in the 1994 version.

Finally, for now, is the problem of the consistency of terminology and the integration of other standards. The period since the last version has seen many other standards which impact on the operation of business come into being (e.g. ISO 14000, environmental management; BS 7799, information security; BS 8800, health and safety, etc.). Because these standards were drafted to achieve specific objectives under specific environmental demands they were, largely, drafted in isolation. This led

“top management” in the 2000 version of the standard.

to the repetition of work (usually drafted in different terminology) and in some cases to contradictory demands in the different standards.

For all these reasons the standard was in need of review — indeed reasons such as these demonstrate the need for the structural inclusion of a review process. It can be seen as a measure of the complexity of the issues involved (in revising this standard in particular) that it will be more than six years, rather than the regulation five, before it is finally implemented.

What Does It Look Like?

In most cases the clauses of the 1994 standard have been expanded in the 2000 version, both numerically (i.e. there are more clauses) and in terms of the scope of the requirements (i.e. the new standard requires more of the organization in each of the areas).

ISO 9000:2000 is currently at **CD2** (BSI, 1999a; BSI, 1999b), this means that it is still subject to a number of rounds of (potential) revision. Current information (received in conversation from representatives of

ISO 9001:1994		ISO/CD2 9001:2000
1	Scope	1
2	Normative Reference	2
3	Definitions	3
4.1	Management Responsibility	
4.1.1	Quality Policy	5.1; 5.4; 5.5.1
4.1.2	Organization	4; 5.5.2
4.1.2.1	Responsibility and Authority	5.6.2
4.1.2.2	Resources	5.1; 6.1; 6.2; 6.3; 6.4; 6.5
4.1.2.3	Management Representative	5.6.3
4.1.3	Management Review	5.1; 5.7
4.2	Quality System	
4.2.1	General	4; 5.1; 5.6.1; 5.6.4
4.2.2	Quality System Procedures	4; 5.6.5
4.2.3	Quality Planning	5.5
4.3	Contract Review	5.1; 5.2; 5.3; 7.1; 7.2
4.4	Design Control	7.1; 7.3
4.5	Document and Data Control	5.6.6
4.6	Purchasing	7.1; 7.4
4.7	Control of Customer Supplied Product	7.1; 7.5.3
4.8	Product Identification and Traceability	7.1; 7.5.2
4.9	Process Control	6.5; 7.1; 7.5; 7.5.5; 8.2.2
4.10	Inspection and Testing	8.1; 8.2.3
4.11	Control of Inspection, Measuring and Test Equipment	7.1; 7.6
4.12	Inspection and Test Status	7.1; 7.5.2
4.13	Control of Nonconforming Product	8.1; 8.3
4.14	Corrective and Preventive Action	8.1; 8.5.1; 8.5.2; 8.5.3
4.15	Handling, Storage, Packaging, Preservation and Delivery	7.1; 7.5.4
4.16	Control of Quality Records	5.6.7
4.17	Internal Quality Audits	8.1; 8.2.1; 8.2.1.1; 8.2.1.2
4.18	Training	6.1; 6.2.2
4.19	Servicing	7.1; 7.5.1
4.20	Statistical Techniques	8.1

*Figure 2 Correspondence between ISO 9001:1994 and ISO CD2 9001:2000
(source: BSI, 1999a)*

both BSI and ISO) is that amendments to the language of the standard can be expected but that major changes to, for example, the intent, content or direction, are unlikely.

both BSI and ISO) is that amendments to the language of the standard can be expected but that major changes to, for example, the intent, content or direction, are unlikely.

Clauses one, two and three of the new standard cover the same areas as clauses one, two and three of the 1994 version that is, **scope, normative reference and definitions**. However the twenty nine (29) sub-clauses of clause four (which contain the *requirements* of the standard) in the 1994 version of the standard have been converted into seventy three (73) sub-clauses in the 2000 version.

These seventy three functional sub-clauses of the ISO 9001:2000 standard have been divided between four main areas (clauses) under the following headings:

Management Responsibility (clause 5);

Resource Management (clause 6);

Product and/or Service Realization (clause 7);

Measurement Analysis and Improvement (clause 8).

The most obvious difference between the two standards is in their structure, figure two (above) is abstracted from BS EN ISO/CD2 9001:2000 and shows the correspondence between the clauses of ISO 9001:1994 and BS EN ISO/CD2 9001:2000.

This table also makes apparent the fact that the standards body is attempting to ease transition from the old standard to the new. Whilst this is useful to those organizations who are already certified and wish to continue it is also creating an element of 'short-termism' in those organizations that are currently seeking 'first-time' certification in the interim period. This is caused by organizations needing certification in the short term (for commercial or contractual reasons) being forced to adopt the 1994 standard (as it is not yet possible to be certified to the new one) rather than undertaking the organizational review and change program necessary to achieve fulfilment of the requirements of an (as yet) incomplete new version.

There are also two more fundamental changes to the proposed content of the new standard:

the possibility of the “reduction of scope” of certification; and,

the formal requirement for the demonstrable achievement of “continual improvement”.

Until the implementation of the 2000 version of ISO 9001 it is possible for organizations to choose to be certified against the standard (i.e. set of requirements) that most closely fitted their business requirements and operations. ISO 9001 provided the requirements for a quality system for an organization that needed to demonstrate “quality assurance in design/development, production, installation and servicing” (Hoyle, 1994, p. 26). ISO 9002 provided the requirements for a quality system for an organization that needed to demonstrate “quality assurance in production, installation and servicing” (Hoyle, *ibid*). ISO 9003 provided the requirements for a quality system for an organization that needed to demonstrate “quality assurance in final inspection and test” (Hoyle, *ibid*). The introduction of the new standard will, however, remove this option by withdrawing ISO 9002 and ISO 9003 and replacing it with the ability

for organizations who previously had, or would now, be certified to them to register to ISO 9001 with a “reduced scope” of applicability.

The second item, this time a major addition to the *content* of the standard is the need to be able to demonstrate “continual improvement”. It has been apparent (through attendance at, and presenting of, various seminars/workshops etc. where standards bodies speakers have taken part) to detect a shift in the official attitude to this requirement. When first announced it seemed that the intention was to require demonstration of an improvement in the *output* of the organization. However the wording of the requirement in CD2 (clause 8.5.1) requires only an improvement in the *operation of the quality management system*. As will be argued in the next chapter, it is believed that this was necessary as a consequence of the lack of an appropriate model of organization, i.e. that the models applied to the formulation of the standard are *monotonic* and, therefore, nominally capable of achieving ‘perfection’ from where improvement (continual or otherwise) becomes meaningless.

The Clauses

What follows provides a review of the contents of the current Committee Draft (**CD2**), however, for the precise wording readers are referred to the actual document — BS EN ISO/CD2 9001:2000, and later revisions as they become public. These should be available from national certification bodies and/or the local office/representative of ISO. The **bold type** and the **numbers that follow** relate to the clauses in CD2 as they are **currently** headed and numbered.

Management Responsibility (Clause 5)

The new standard is more prescriptive of the role to be taken by the management of the host organization. Clause five is divided into some fourteen sub-clauses detailing actions to be taken in order to demonstrate adequate commitment on the part of executive personnel.

In general (5.1) management is required to “demonstrate its commitment to” the creation and maintenance of an awareness of the importance of fulfilling customer requirements, establishing quality

policy, objectives and planning, establishing a quality management system, performance of management reviews and ensuring the availability of resources.

In terms of **customer requirements (5.2)** management is required to “ensure that” customer needs and expectations are determined and converted into requirements and that these requirements are fully understood and met.

Management is expected to establish and maintain a procedure that ensures that the organization is able to identify, and has access to, information regarding the **legal requirements (5.3)** applicable to the quality of its products or services.

There is a responsibility to establish a **quality policy (5.4)**, ensuring that it is appropriate to the organization and its customers, makes a commitment to meeting the needs of customers and continual improvement, provides a structure for setting and reviewing quality objectives, communicated, understood and implemented throughout the organization and is reviewed for ongoing suitability.

The requirement for **quality planning (5.5)** includes a stated need for the setting of **objectives (5.5.1)** for each relevant function and level and for the documentation of the results of the **quality planning (5.5.2)** process, and should identify the activities and resources necessary to the achievement of quality.

In particular the standard requires that planning should cover the processes necessary in the quality management system (and a statement of any reduction in scope), the operational processes and resources needed and the identification of quality indicators appropriate at different stages of operations and the verification activities, criteria for acceptability and the quality records needed.

The stated intention of the planning process is that organizational change be brought about in a “controlled manner and that the quality management system is maintained “ during such change.

A **quality management system (5.6)** shall be established which, in **general (5.6.1)** shall serve to enable the meeting of quality policy

requirements, achieving quality objectives and ensuring the products or services conform to customer requirements. Within the structure of the quality management system roles and their interrelations and **responsibilities and authorities (5.6.2)** must be defined and must also be communicated throughout the organization, where it is necessary any form of “organizational freedom” or discretion “shall be defined”.

The organization shall appoint a **management representative (5.6.3)** “shall have defined responsibility that includes” ensuring the establishment and maintenance of the quality management system, reporting to senior management regarding the performance of the quality management system and ensuring awareness of customer requirements within the organization.

The standard has a requirement for the establishment and maintenance of procedures for **internal communication (5.6.4)** between the levels and functions of the organization with regard to the functioning and effectiveness of the quality management system.

The organization must prepare a **quality manual (5.6.5)** which contains descriptions of “the elements of the quality management system ... their interaction ... and any reduction in scope ...”. The quality manual must also contain reference to the operational procedures used. The standard includes the note that “The quality manual need not be a stand-alone document”.

It is required that procedures are in place to ensure the necessary **control of documents (5.6.6)**. This is to ensure that all documents are reviewed and approved for adequacy before dissemination, are subject to periodic review, amendment and re-approval, are available where they can support effective functioning of the quality management system. And that obsolete documentation is removed and/or prevented from unintentional use and that obsolete documentation retained for reference or to satisfy legal requirements is suitably and easily identifiable. A further requirement is that an index of current revisions is maintained to further protect against unintended or inappropriate use.

Documents relating to the quality management system should also be legible and accessible with external documentation included or referred to in the quality management system being identified and recorded.

Procedures are also required for the **control of records (5.6.7)** used to demonstrate the conformance to requirements and effectiveness in operation of the quality management system. These record must also be subject ot procedures for identification, storage, retrieval, etc., as the documentation referred to above.

The final requirement of the standard listed under the heading of management responsibility is **management review (5.7)**. Senior management must establish and implement a procedure for periodically reviewing the “suitability, adequacy and effectiveness” of the quality management system. The intention of this requirement is to ensure that needs for changes to the structure and operation of the quality management system are identified. The clause contains the statement that:

“Management review shall include periodic review of current performance and improvement opportunities related to:”

results of audits;

customer feedback;

process performance and product conformance analyses;

status of preventive and corrective actions;

follow-up actions from earlier management reviews;

changing circumstances.

And that “The outputs from management review shall include actions related to:”

improvement of the quality management system;

process, product and/or service audits;

resource needs.

Finally the clause states that the results of such reviews should be recorded.

Resource Management (Clause 6)

Although the stated intention of the standard is to make it reflect more accurately the terminology used in modern business this clause appears misleadingly titled. In interviews carried out with quality managers the preferred use of the term “resources” was, with the exception of personnel, to describe consumables or raw materials. As becomes clear in reading the clause the intention in CD2 is to use the term to describe structural resources — that is, for the most part, the organizational enablers that support the execution of the core business activities.

In general (6.1) there is a requirement on the host organization to ensure that the quality management system is properly resourced. This means that the resources necessary to the establishment and maintenance of the quality management system are identified and provided at times which are appropriate to its functioning.

The standard mentions in particular:

Human Resources (6.2);

Information (6.3);

Infrastructure (6.4);

Work Environment (6.5).

In relation to the **assignment of personnel (6.2.1)**⁴ emphasis is placed on ensuring that those persons employed in particular tasks have clearly defined responsibilities for action and are competent to carry out such tasks as they have been assigned “on the basis of applicable education, training, skills and experience”.

To support this, within the standard, the areas of **competence, training, qualification and awareness (6.2.2)** are singled out for particular attention. There is a stated requirement of the organization to set up and maintain “system level procedures” which:

Identify competence and, therefore training needs (note that little is said of the implication for skills audits)

Ensure the provision of appropriate training to satisfy training needs

Assess the efficacy of training (with a requirement for the definition of assessment intervals)

Maintain records of training etc. delivered in the context of the quality management system.

A further requirement within clause 6.2.2 is that of having operational procedures for making employees “at each relevant function and level aware of”:

The importance of conformance to the quality policy and requirements/demands of the quality management system;

The significance of their work to the achievement of quality in the organization;

The benefit (presumably to the organization) of consistently improving their personal effectiveness;

Their personal roles and responsibilities in the achievement of conformance to the quality policy, procedures and requirements;

The actual or potential consequences of deviation from the stated procedures.

⁴ This is the area of the proposed standard that relates to what I have called, in agreement with the 1994 standard the “special processes”. Although they are expanded in the 2000 version no attempt (as can be seen from the wording) has been made to exploit them to the benefit of the service sector.

Requirements for **information (6.3)** management are that information needs for the control of operations and the ensuring of “conformity of product/and or service” are defined and that the quality management system has defined procedures that provide “access to and protection of information”. The exemplars of “typical types of information” are those relating to “process, product and/or service... and data from suppliers and customers”.

The **infrastructure (6.4)** necessary to the achievement of conformity is stated to include:

An appropriate “workspace and associated facilities”;

The equipment necessary to the deliver of outputs, which can include computer hardware or software;

The maintenance protocols needed for such equipment;

“Supporting services.

Finally in this section, under the heading **work environment (6.5)** the standard identifies “those human and physical factors” necessary to the achievement of conformity. The standard singles out:

Health and safety;

Working methods;

Work ethics;

Ambient working conditions.

As examples of the areas it considers appropriate for mention.

Product and/or Service Realization (Clause 7)

In keeping with the intended rationalization of the structure of the 1994 standard those elements that relate to the creation of the outputs of the organization are collected under this heading. The result of this is that this one main clause contains the full or partial requirements of ten of the sub-clauses of the previous version.

This clause also contains the areas that are permitted to be subject to the application of a “reduction in scope”. The withdrawal of the ISO 9002 and ISO 9003 standards as ‘stand alone’ sets of requirements means that for organizations that, prior to the implementation of the 2000 version,

assured and/or controlled quality by way of production process control (and were, therefore, certified to ISO 9002) and those which controlled quality by way of post-production testing (and were, therefore, certified to ISO 9003) will be allowed to reduce the scope of their certification to ISO 9001 to reflect the fact that they have no need for, e.g., design control, etc..

In general (7.1) the standard requires that the organization identify and take appropriate action to control the processes it requires in order to deliver the products and/or services it provides. These processes should be based on the outputs from quality planning and steps should be taken to ensure that they operate in a controlled and consistent manner to satisfy customer needs. In particular attention should be paid to the “sequence and interaction” and the “ability to meet ... requirements”. This general statement is expanded by requiring that the organization shall:

“Establish methods and practices” to ensure consistency of operation;

Define and operate “criteria and methods” in order to control processes to “achieve ... conformity with customer requirements”;

Ensure that processes can be operated so as to achieve this conformity to requirements;

Define and operate “arrangements for measurement, monitoring and follow-up actions” which will allow continued operation within defined limits;

“Ensure the availability of the information and data necessary” to support this operation within defined limits;

Maintain records “of the results of control processes” in order “to provide evidence of effective operation and monitoring”.

In a section headed **customer-related processes (7.2)** the standard expands those areas of attention relating to the definition, operationalization and ongoing satisfaction of customer needs. In the first, **identification of customer requirements (7.2.1)**, it states the need for a defined process that will identify or verify:

The completeness of stated customer requirements;

Those unspecified requirements necessary to achieve “fitness for purpose”;

Legal or regulatory requirements relating to the product and/or service;

Requirements relating to “availability, delivery and support of product and/or service”.

Prior to entering into any commitment to supply the organization shall conduct a **review of customer requirements (7.2.2)**. This review should include consideration of changes requested by the customer and is intended to confirm that:

Requirements are clearly and unambiguously defined;

Requirements have been confirmed prior to acceptance (whether or not a written statement has been provided by the customer);

Issues relating to differing requirements (from e.g. previous expressions) are resolved;

The organization has the capacity and/or capability to meet requirements.

Any subsequent actions and the results of the review and required to be recorded and held as *quality records*.

There is an explicit requirement for the organization to define and implement procedures for **customer communication (7.2.3)**, with the stated “aim of meeting customer requirements”. Conformance to this sub-clause requires that the organization has procedures for acquiring information relating to:

The product and/or service;

Query and order handling (to include amendments to orders);

Complaints and rectification procedures;

Customer comment regarding performance.

The area of **design and development (7.3)** is one where the organization may choose to limit the scope of its registration. Where design is to be included the **general requirements (7.3.1)** are that it plan and control the elements of the process in the same manner as other areas of operation. This is detailed as the preparation of “design and/or development plans” including:

The stages of the design/development process;

The necessary review, verification and validation activity (and the periods between them or points they are appropriate);

The responsibilities and authorities of personnel involved in the design/development process.

A further requirement is for the management of the handover/interface points in the process in order to ensure “effective communication and clarity of responsibilities”.

The requirements the product and/or service must meet must be defined and held on record. These requirements are designated **design and development inputs (7.3.2)** and must include:

Customer or market originated performance requirements;

Regulatory or legal requirements;

Environmental requirements;

Derived requirements imputed from earlier similar designs;

Non-stated requirements necessary to the design/development process.

Design inputs must be subjected to a review process which ensures the resolution of issues of incompleteness, ambiguity or conflict.

The initial (and final, subject to completion of the process) results of the design/development activities are designated **design and development outputs (7.3.3)**. These outputs are to be recorded “in a format that enables verification against the input requirements”. Design and development outputs should be demonstrated to:

Meet the input requirements;

Refer to or contain acceptance criteria;

Identify those characteristics of the design that are essential to the “safe and proper use” of the product and/or service.

Documents relating to design and development outputs must be reviewed and approved by an authorized person prior to release.

The **design and development review (7.3.4)** is intended to ensure that the design/development process is making proper progress. The standard requires that the organization identify appropriate stages of the process and subject progress to date to scrutiny. These reviews should:

Assess the capacity of the design to achieve the quality requirements;

Identify problems (actual or potential) and propose possible solutions.

The review process must allow for the inclusion of representatives from the “functions of the design stage being reviewed”.

The outcomes of the reviews along with subsequent actions must be recorded as a *quality document*.

Design and development verification (7.3.5) is required by the standard. In the context of the standard this can be taken to mean *getting the design right*. The requirements of this activity are that the design

results are compared to the “design inputs” in order to assess the extent to which the finished (or interim) design meets initial criteria.

The outcomes of this activity are to be recorded and held as *quality records*.

Design and development validation (7.3.6) is concerned with ensuring that the organization has produced the *right design*. The emphasis is on the performance of the finished product or service rather than conformance to formal design specification. The standard requires that “Wherever applicable, validation shall be ... completed prior to delivery or implementation ... [where this is not possible] partial validation ... shall be undertaken to the maximum extent practical”.

The outcomes of this activity are to be recorded and held as *quality records*.

The organization must exercise **control of changes (7.3.7)** in the design and development process. All changes to or modifications of the process

require approval by an authorized person and must be recorded in quality records prior to implementation.

In addition the organization must assess the consequences of changes on:

The interactions between elements of the process;

The interactions between component parts of the resultant deliverable;

Pre-existing products and services and post-delivery operation;

The need for re-verification and/or re-validation of the design outputs.

The outcomes of this activity are to be recorded and held as *quality records*.

To the extent that materials and services that are sourced externally effect the quality of the products or services of the organization **purchasing (7.4)** is also subject to control. **In general (7.4.1)** it is necessary to have processes to control purchasing to ensure that organizational requirements are met. The standard allows that the "type

and extent” of the control methods be “dependent on the effect” of the purchased items on the finished product or service.

The organization is required to maintain documents containing **purchasing information (7.4.2)** that clearly describes the product or service required including if appropriate:

“requirements for approval or qualification” of products or services, procedures, processes, equipment and personnel”;

“any management system requirements”.

The documents must be adequate to the “specification of requirements prior to release”.

The standard requires that arrangements necessary for the **verification of purchased product and/or services (7.4.3)** are defined and in operation.

If such activities are to be performed on supplier premises the organization shall define these and the methods of release in purchasing documentation.

Organizations are required to plan and control **production and service operations (7.5)**. In **general** this must include those undertaken in-house and after delivery by:

The availability of specifications of characteristics or performance;

The availability of work “specifications or instructions” needed for conformity to specification;

Use and proper maintenance of appropriate equipment;

Provision of acceptable working conditions;

Use of appropriate measuring and monitoring equipment;

Operation of appropriate verification procedures and activities;

Use of appropriate methods release, delivery and/or installation.

The organization is required to ensure the **identification and traceability (7.5.2)** of products or services as appropriate in relation to any required measurement or verification. This should include that ability to identify items “throughout all processes” if applicable. This requirement extends to individual component parts should their interaction impact on conformity. If traceability is a requirement of

specifications it is necessary for the organization to “control and record the unique identification” of the product or service.

Customer property (7.5.3) should be treated with due care whilst in the care or possession of the organization. Such property if used for incorporation in products or services must be identified, verified stored and maintained in an appropriate manner prior to incorporation. If such property is found to be unsuitable for any reason this must be recorded and reported to the customer. The standard identifies intellectual property under this heading.

The organization must implement measures for **handling, packaging, storage, preservation and delivery (7.5.4)** which ensure that during processing and/or delivery that the ability of items to conform to specification is not compromised. This requirement is extended to component parts of products and elements of services.

This requirement must be proceduralized to ensure that product release or service delivery does not occur in the absence of completion and other related documentation is “available and authorized”.

The organization is required to undertake the **validation of processes (7.5.5)** where outputs “cannot be readily or economically verified by subsequent monitoring, inspection and/or testing. The aim of such validation is the demonstration of “effectiveness and acceptability”. The validation of processes must address:

Those processes to be qualified prior to use;

The qualification of equipment or personnel;

Specific procedures or records to be used;

Protocols for re-validation.

The outcomes of these activities are to be recorded and held as *quality records*.

The organization must design and implement protocols for the **control of measurement and monitoring devices (7.6)** — noting that this is an area which will not be appropriate to all organizations. Where such devices are appropriate to demonstrate the conformity of products or

services the devices themselves must be subject to control for e.g., accuracy, protection from damage, etc.

Computer software used in this manner must be validated prior to operation and special purpose software specifically for testing must meet the product development criteria included in the standard.

Where monitoring or measurement equipment is appropriate the organization must be able to demonstrate:

That measurement and monitoring devices have been calibrated or adjusted at appropriate intervals or times “against equipment traceable to international or national standards”. In the absence of such standards “the basis used for calibration shall be recorded”;

Clear identification of measuring and monitoring devices and their calibration status;

Definition of the methods of calibration;

Recording of the results of calibration;

That environmental conditions at the time of calibrations, tests, etc., were suitable for them to be carried out;

Adequate safeguards against adjustments that would invalidate calibration are implemented;

That the validity of previous test results is assessed if devices are found to be out of calibration and that appropriate action has been taken.

Measurement, Analysis and Improvement (Clause 8)

This final clause states the requirements for the control elements of quality management systems. It is an area that was problematic to service providers in the past — although this seems to have been overcome by stating that tools such as, e.g. statistical methods were inappropriate to the business (an approach taken by the financial services provider discussed later). In the new version, however, the requirement is ‘toughened up’ in that there is an obligation to “identify and use appropriate statistical tools” (BSI, 1999a, p. 21).

This clause also contains the major change to the content of the standard, i.e., the need for continual improvement which was not in the 1994 version. This, also, appears to be causing some confusion in its

interpretation. The wording of the requirement is that “The organization shall continually improve the *quality management system*” (BSI, 1999a, p.23, italics added) not that it continually improve its output — it seems that the accusation regarding the ability to produce rubbish is *still* valid.

In general (8.1) the standard requires that the organization identify, plan and operate measurement, monitoring, analysis and improvement measures with the aim of ensuring that the its quality management system and its processes and products or services conform to requirements. In practice this means that the organization must:

Determine and record the timing, frequency and locations of measurements and the types of records necessary to support this;

Assess the effectiveness of such measures as are taken and define the periods/timings of such evaluations;

Identify and use appropriate numerical methods (note that none may be appropriate);

Use the results of this analysis and the subsequent improvement activity as a source of information for management review processes.

The standard provides a number of examples **where measurement and monitoring (8.2)** is considered applicable.

Procedures for the **measurement and monitoring of system performance (8.2.1)** are required. Although the standard does not list appropriate indicators “customer satisfaction shall be used as one measure of system output and internal audit shall be used as a tool” for assessing consistency of performance and continued compliance.

Tools and methods for the **measurement and monitoring of customer satisfaction (8.2.1.1)** must be defined.

The organization is required to carry out ‘objective’ **internal audit (8.2.1.2)** to establish whether the quality management system is being effectively operated and that it continues to conform to the standard. Audits are also suggested as a means of identifying opportunities for improvement.

Audit procedures and the scheduling of audit activity must take account of the relative importance of operative processes and previous audit results in the areas covered.

There is a requirement to define a procedure for audit activity that includes scope, frequency, methods and responsibilities and requirements for conduct. Audit results are to be recorded and reported to management.

Audits must be performed by persons other than those who carry out work in the area being audited.

It is regarded as necessary within the standard to undertake the **measurement and monitoring of processes (8.2.2)**, this is in order to ensure that those processes that impact on the meeting of customer requirements are demonstrably under control and continue to be able to satisfy their original purposes. The results of these activities should be used to improve performance.

Suitable methods for the **measurement and monitoring of product and/or service (8.2.3)** should be identified and used, this is in order to ensure that the requirements for the product or service are met.

Records should be kept of measurement and monitoring activity required by the quality management system, these records should contain information relating to the (non)conformance to acceptance criteria and responsibilities for release or delivery of product or service.

The organization must be able to demonstrate the **control of nonconformity (8.3)**. In general (8.3.1) it must be possible to ensure (and demonstrate that this is done) that nonconforming product or service is prevented from unintended use or delivery. This is achieved by providing for the identification, recording and reviewing of the nature and extent of nonconformity identified. A procedure for doing this must be defined as part of the quality management system.

This leads to a need for **nonconformity review and disposition (8.3.2)**. Within the terms of the standard the organization is required to review

those nonconformities that arise and decide upon the action to be taken.

The standard allow for four courses of action:

Correction or adjustment so as to conform to requirement;

Release/acceptance under concession with or without correction/adjustment;

Re-assignment for valid, alternative, use;

Rejection.

Within the review and disposition process responsibilities and authorities for resolution of issues surround or arising from nonconformity must be defined. Where required by contract used of repaired or reworked nonconforming product must be reported to customers for approval.

All reworking, acceptance of nonconformity, repair, etc. must be recorded. Where rework is necessary verification requirements must be defined and applied.

It is necessary to define and implement a procedure for the **analysis of data for improvement (8.4)** within the quality management system.

This is to assess the effectiveness of the system and to aid in identifying where operational improvement can be made. This analysis should be based on data from measuring and monitoring activities and “any other relevant sources”.

The organization must identify and analyze data to provide information regarding:

Operational process trends;

Customer (dis)satisfaction;

Conformance to requirements;

The characteristics of processes products and/or services.

The organization must be able to identify and strive towards continual **improvement (8.5)**. **In general (8.5.1)** it is required of the organization that it operates a procedure within the quality management system that describes the use and interaction of quality policy, objectives audit results, data analysis corrective and preventive action and management review in order to continually improve the performance of the quality management system.

Corrective action (8.5.2) is aimed at the reduction or elimination of the causes of nonconformity and the prevention of recurrence. A procedure within the quality management system is required which must define the requirements for:

Identifying nonconformities (including complaints);

Identification of the causes of nonconformity;

Definition of the need for action to prevent recurrence of nonconformity;

The undertaking of actions to ensure the prevention of the recurrence of nonconformity;

The effectiveness of preventive action and ensuring that it is recorded.

Preventive action (8.5.3) is to be taken as part of a defined process for the elimination of the potential causes of nonconformity. Inputs to the preventive action process are taken from the quality management system records and the results from the analysis of data for improvements.

The organization must define a procedure within the quality management system that addresses:

The identification of *potential* nonconformities;

The definition of the causes of identified *potential* for nonconformity;

The identification of preventive actions necessary to remove the causes of *potential* nonconformity;

The undertaking of preventive action;

The review processes that assess the effectiveness of preventive action and that such action is recorded.

Summary

This chapter has presented a description of and (limited) commentary on the contents of ISO/CD2 9001:2000 and the timetable for its implementation as a full international standard for the design and implementation of quality management systems. Although it was not the intention, in this chapter to develop any form of detailed critique (that being the subject of the next chapter) references were made to areas

where problems or weaknesses have been apparent in either the content, conceptual bases or in the promotion or dissemination of information relating to the standard or its implementation.

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Chapter 4

Towards a Solution

Introduction

In the previous chapter the draft version (CD2) of the proposed new standard was introduced. In this chapter the principles and organizational model behind the standard will be discussed. This begins with a fuller discussion of the Viable System Model (VSM) and a reprise of the differences between CD2 and BS EN ISO 9001:1994. Following this the “eight principles” adopted to enlighten the formulation of the standard and the model of organization adopted by the standards body are discussed in the context of the VSM. Finally, the requirements of the standard are related to the functional elements of the VSM. The chapter concludes with a *de facto* definition of the characteristics required for a solution model that will:

satisfy the formal requirements of the standard;

satisfy the *implicit* organizational development issues raised

by the standard;

be accessible and useful to organizations intending to adopt

the standard;

be capable of *generalization* to both the manufacturing and

services provision sectors.

The VSM

In this discussion of the standard, its principles and organizational model it is accepted (following the discussion of method in chapter one) that *quality management*, due to the fact that it constitutes a unitary *control* activity, is susceptible to the principles of *cybernetics*. In particular the work of Ashby (1960; 1964) and Beer (various) were selected as appropriate analytical tools. This choice of approach, and the experience of the implementation of quality management systems gained as part of the case study (presented in later chapters), and other 'pre-project'

consulting interventions, informs the development of the model proposed later in this report.

The VSM (and its forerunner, Ashby's "ultrastable system") are introduced at this point to illustrate the intellectual basis used for the definition of the characteristics that must be possessed by a model that aims to fulfil the requirements of the standard. That is, a *rigorous* basis for providing the adaptive and control capacity to identify and ensure the ongoing *relevance* of the activities of the organization.

In the chapters that follow (i.e. those which derive the model formally and those that show how the model can be used to implement *management quality*) the individual elements will be expanded. However for now it is necessary is to demonstrate that such a solution is conceptually possible.

Figure one (below) gives a representation of Ashby's original version of the ultrastable system:

Ashby describes this mechanism in the following manner:

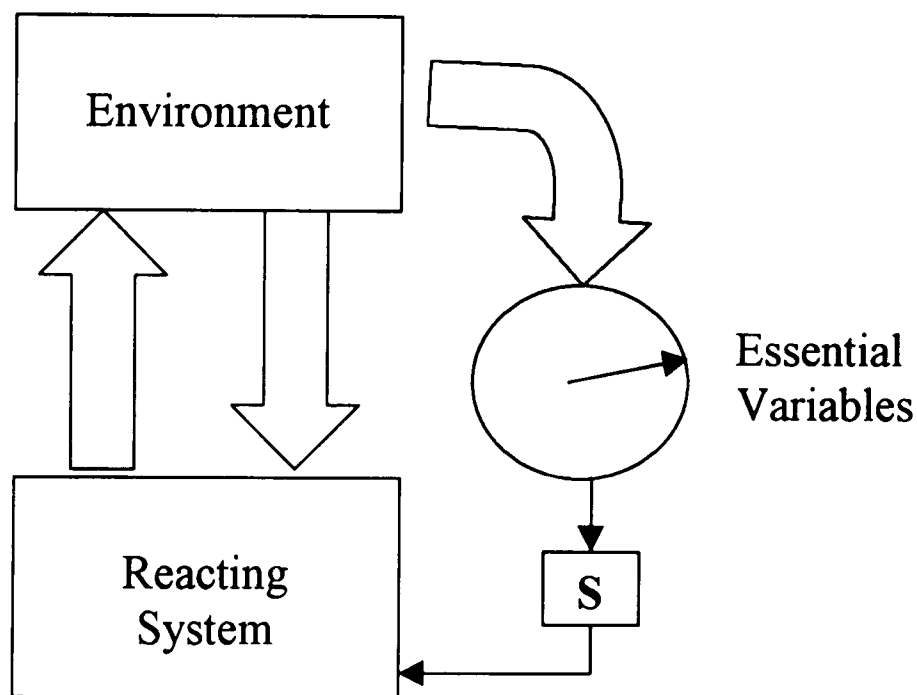
“The organism that can adapt thus has a motor output to the environment and *two* feedback loops. The first loop ... consists of the ordinary input from eye, ear, joints, etc., giving information about the world around it. The second feedback goes through the essential variables (including such correlated variables as the pain receptors); it carries information about whether the essential variables are or are not driven outside the normal limits.” (Ashby, 1960, p. 83).

While Beer describes the device capable of ultrastability thus:

“A device that seeks equilibrium in the face of expected perturbation, that is a perturbation already familiar from experience, is capable of stability. But a device that can adapt to unexpected perturbation, insofar as the new perturbation is outside the range of familiar experience, is capable of *ultrastability*.” (Beer, 1994, p. 236)

Here we find precisely the capacity necessary to the learning or adaptive organization. The capacity and authority to implement and sanction change has been internalized and recursive structures become possible.

The original ultrastable system (presented as figure one) was later modified (to the form given in figure two) for use in management seminars (by Dudley and Beckford, see, e.g, 1999a) which, it was felt, was more accessible to practicing managers.



*Figure 1: The ultrastable system
Adapted from Ashby, 1960, p. 83.*

This later interpretation of Ashby’s original model replaces his environment with ‘market’ terminology, the “essential variables” with Beer’s (1979, p. 351) “normative management” and the “reacting system” with “operations”. To some extent the recorded “parameters” (i.e. those environmental conditions that are remembered as being in effect when a particular stimulus occurred have been renamed “strategic

action” which, in organizational terms, instantiates this ‘memory’ in a new structure appropriate to current conditions.

In this modified version of Ashby’s model it is possible to locate the potential for change outside the operational area of the model, in the normative or strategic levels. This is consistent with both the standard (see later) and resource management at the strategic level (as the implementation of structural change implies the provision of non-operational resource). And customer focus has both a specific (i.e. specific provision to specific customer) and a general, or organization wide (i.e. whole organization to market) focus

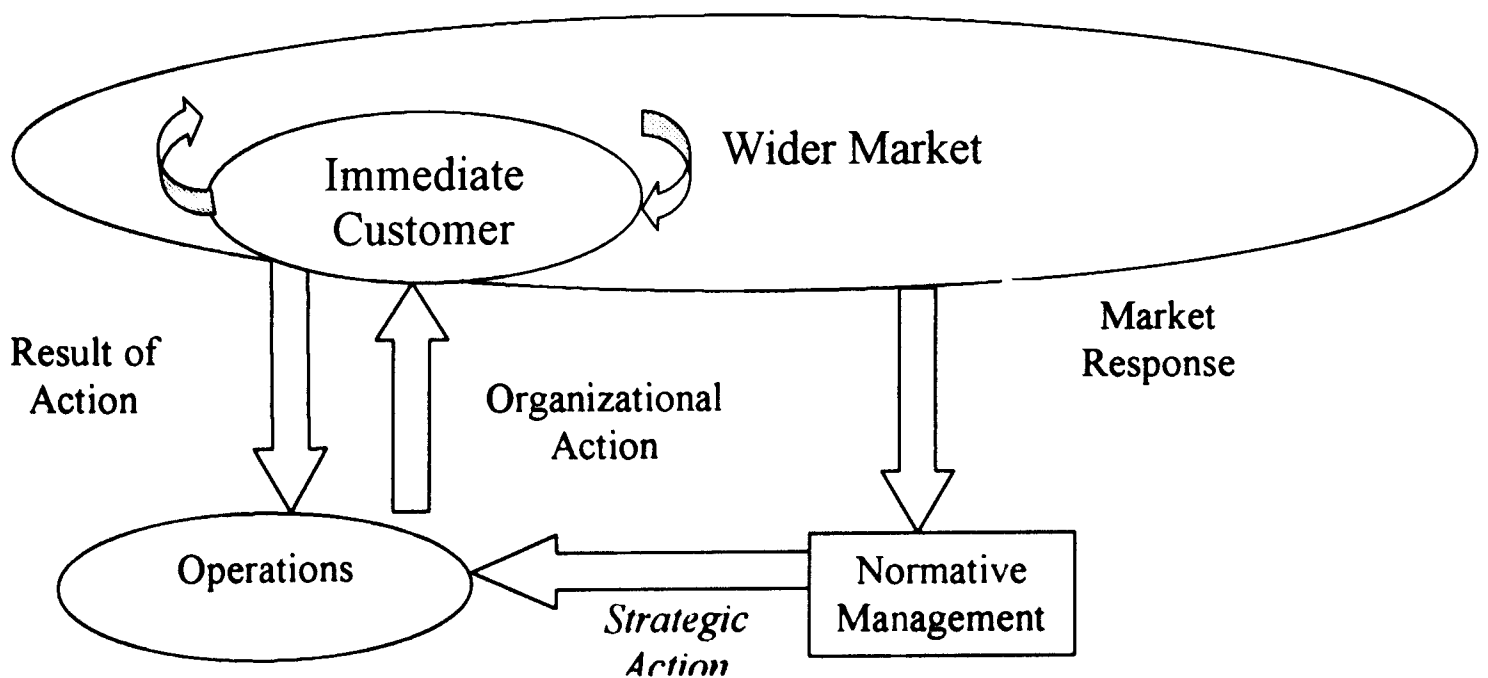


Figure 2: A 'business friendly' representation of the ultrastable system
Adapted from Dudley and Beckford, 1999b

The two problems with this representation when attempting a detailed mapping of the requirements of the standard (even at this level of generality) is that a) the more detailed requirements relating to performance are contained in the “operations” box (which has no detail to address) and that there is no facility to apply the continuous improvement activity *from* operations *to* the strategic or normative levels. Dudley and Beckford (1999b) overcome this by making the arrow representing strategic action bi-directional (i.e., the strategic action becomes a negotiated process between organizational *desire* (normative) and organizational *capacity* (operational), while Beer (1979) in the VSM achieves this by creating the “3-4-5” homeostat, effectively including operational management in the meta-system that Ashby creates outside his “reacting system”.

As a practical measure at this stage of the paper (i.e. before the formal derivation has been presented) the pure form of the VSM is used as, it is believed, it has the advantage of ease of completeness of coverage over the requirements of the standard.

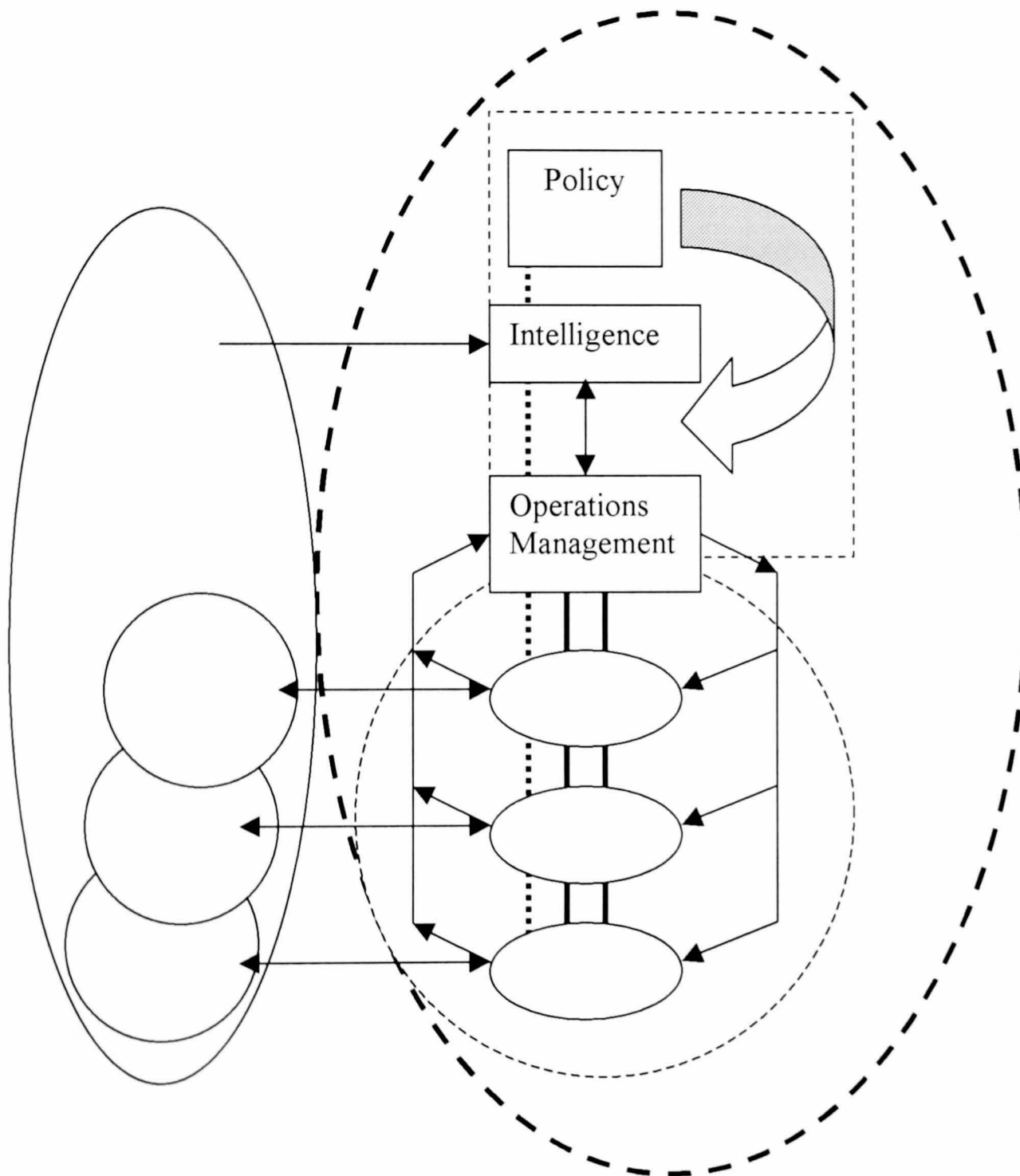


Figure 3: A representation of Beer's VSM (see, e.g. Beer, 1985)

Beer names the elements of the VSM (see figure three) as:

System Five

— That element that I have labelled “Policy”. This element represents/creates the *identity* of the organization – it is this identity that provides the basis for deciding between the recommendations for change (provided by system 4) and constraints on capacity (provided by system 3).

System Four

— That part that I have labeled “Intelligence” which ‘scans the environment’. System four is an effectiveness machine and is responsible for the identification of ‘opportunities or threats existing in the environment.

System Three

— That part of figure three that I have labelled “Operations Management” which sets operational performance targets and allocates resources to the operational units. System three is an efficiency machine, as

such it is responsible for the identification of 'strengths and weaknesses' existing internally.

System Two

— The line to the far right of the diagram. System two "co-ordinates the activities of the various systems one, thus ensuring that they make a coherent contribution to the performance targets set by system three.

System One

— The oval shapes in the lower part of the diagram. The various systems one carry out the activities that make up what the organization as a whole does. The strength of the concept of recursion is that each of the systems one forms a complete viable system (at a different level of complexity) in its own right.

Three Star (3*)

— The line to the far right of the diagram.

Three star is the “audit channel”, it carries information regarding the performance of the various systems one back to system three for analysis.

The Command Channel

— The two heavy lines to the centre of the diagram which connect all the systems one together. This is where performance targets and resource allocation/negotiations take place. It is through this channel that system three *controls* the activity of the systems one.

The Algedonic Channel

— The heavy dotted line to the left of the diagram which connects all the boxes together. The algedonic channel communicates ‘pain’, where immediate and/or critical threats to the survival of the organization are identified it allows its

immediate communication to all parts,
superceding normal channels of
communication.

The detailed workings of the viable system model will be addressed in later chapters (as will the modifications/reinterpretation of it proposed as part of this research).

An additional advantage gained from the choice of related models (i.e. the “ultrastable system” and the “viable system”) is that the area surrounded by the dotted rectangle (at the top of figure three) constitutes an ‘Ashbean’ ultrastable system in its own right¹. This is not surprising as Beer in his own work (e.g., 1994, p. 236) refers back to Ashby’s. Beer’s contribution, in his definition of the viable system model has been to add more organizational detail, both in the areas Ashby defined as the “essential variables” and “parameters” (i.e. the meta-level of the organization) and that he called the “reacting system” (i.e. the operational level of the organization).

¹ This has proved to be a significant advantage *in practice* (i.e. during actual consulting interventions) as it allows for the appropriate focus of the model to be used. That is to say that ‘strategic’ discussions can be focused using the ultrastable system model (thus removing the need for operational detail) and ‘operational’ discussions with the complete VSM at a particular level of recursion.

The Differences

In ISO 9001:1994 standard the aim is to demonstrate “*capability to design and supply conforming product*” and “*achieving customer satisfaction by preventing nonconformity at all stages*”. This version of the standard is said to be applicable when:

“Design is required and the product requirements are stated principally in performance terms, or they need to be established”;

“Confidence in product conformance can be attained by adequate demonstration of a suppliers capability in design, development, production installation and servicing”.

However in the CD2 version the standard aims mainly at:

“Achieving customer satisfaction by meeting customer requirements through the application of the system, the continual

improvement of the system and the prevention of nonconformity”
(1.1).

and further that

“The requirements specified in this Standard are generic and applicable to all organizations, regardless of type and size” **(1.1).**

It is apparent from this change in the emphasis in the wording that the intended focus of the standard is moved:

away from the operations of the organization to the operation of the standard;

apparently away from simply *production*, to include the more service oriented elements of organizations.

The effect of this change of emphasis will be to extend the applicability of the standard across more organizational functions. In particular it will tend to impact most on the planned provision of human resources and the

establishment of infrastructure as these areas were largely unspecified in the 1994 standard. This will mean that the management of an organization aspiring to the 2000 version of the standard will need to *think through* the structural aspects of their operations in order to comply with the specifications presented.

A second difference in the new version of the standard is the possibility of a reduction in scope of the requirements (1.2) where “customer requirements, or the nature of the product and/or service, do not require certain quality management system requirements for the processes specified ...”. In effect the standard is recognizing that not all requirements will be appropriate to all circumstances and allowing, under specified conditions, the host organization to exclude them from the scope of any proposed registration.

However such a reduction of the scope of the requirement of the standard explicitly does not “absolve the organization of the responsibility to provide product and/or service which meets customer requirements”. In addition a reduction in scope removes neither responsibility for compliance with any legal or regulatory requirements (NOTE 1, 1.2)

nor, should legal or regulatory requirements necessitate change to the quality management system which takes it outside the scope of the standard, will any revised quality management system necessarily be sufficient to the requirements of the standard (NOTE 2, 1.2).

In practice any reduction in the scope of the requirements is likely to be where the organization would not, under the 1994 standard, have been seeking ISO 9001 (e.g. where there was no design element) and therefore did not have particular processes under internal control, or where the nature of operations render particular elements of the model inappropriate (e.g. the use of statistical process control in a service industry).

In all cases “Exclusions are to be defined within the organization’s quality manual”.

Another overt intention (which has been repeatedly raised in formal BSI/ISO presentations relating to the introduction of the 2000 version) behind the introduction of the new standard, and the revisions to its structure, was the rationalization of the language (within and between

standards) and an explicit attempt to bring the management role more closely under the control of the quality management system. This should not cause any undue stress to organizations that used the ISO standards to genuinely improve the way they did business, but, for those who were seeking certification in isolation from the desire to improve the business it is likely to cause a certain ‘culture shock’.

This shock is most likely to be caused by the logical consequences of the eight principles (discussed below) and their impact if applied consistently in the area of “management responsibility”.

The idea of transparency of operation that seems to be implied here is intended to ensure that the workings of the organization and the structures for quality control are easily understood. If the organization functions in a “blame-centred” or a “knowledge is power” centred manner, there will be little incentive to admit and identify mistakes or share knowledge. It will be necessary to pay attention to the cultural issues (see, e.g., Huczynski and Buchanan, 1991, for a discussion) such a move in attitude will need in order to be accepted in the organization —

asking people to willingly engage in weakening their position in the organization is unlikely to succeed.

An extension of the notion of transparency is the principle of “fact (or “evidence”) based decision making”². This principle is intended to lead to greater objectivity in the decision making process, removing the potential for bias and/or the suspicion of the abuse of position (see, e.g., Huczynski and Buchanan, 1991; Jennings and Wattam, 1994). It is apparent that, to operate effectively, both these principles will need to be used together — transparency of operation will demonstrate the objectivity of decision making, and objectivity will encourage transparency.

Although the ability manage change³ (or the notion of “controlled change”) sounds desirable enough it implies that “change is normal” and, however much organizations may know this with their “minds”, that is, however much they can accept this intellectually, they generally do not “feel this in their hearts”. The requirement (in CD2) for continual improvement underlines this idea and, to some extent, also endorses the

² A term that has been widely used in formal BSI/ISO seminars.

TQM style of improvement, i.e., incremental or gradual gain (see, e.g., Flood, 1993, p. xvi). However sometimes what is needed is radical change⁴, which implies the structural ability to recognize and implement a complete redefinition of organizational values. An example of this is the change needed for a full implementation of the thinking behind CD2.

Because of the way that the new standard appears to be heading it is apparent that the “management responsibility” clause will impact all areas of the business. Organizations who, in the past, have been content to ‘badge hunt’ will find that redesigning their systems to conform to the new requirements will bring the need for a complete rethink of the way they run their businesses. Simply ‘going through the motions’ is unlikely to satisfy the certification bodies.

³See, e.g., Ackoff, (1981).

⁴ It should be noted that although this sounds similar to the notions propounded by the advocates of Business Process Re-Engineering (see, e.g., Hammer and Champy, 1993) this would be a trivialization of the nature of the change intended. Here the intention is to convey a notion of the ability to implement a complete redefinition of “self”. BPR redefines only the processes necessary to an ‘already existing’ organization and the values that define it — here it is the ability to recognize and implement a redefinition of these values.

The Eight Principles

The construction of the standard is said (by ISO/BSI in various presentations and in pre-launch literature, see “References” for this chapter) to have been founded on eight “quality management principles” gleaned from consultation with “quality experts” (none of whom were identified) around the world. These principles are:

Customer focused organization;

Leadership;

Involvement of People;

Process Approach;

System Approach to Management;

Continual Improvement;

Factual Approach to Decision Making;

Mutually Beneficial Supplier Relationship.

(source BSI presentation)

Whilst it can be seen that the principles above can provide organizational benefits there is also a danger that they will become little more than platitudes in the implementation of formal quality management systems.

Customer focus, for example, is an integral part of most of the literature relating to the quality movement (see, e.g. Beckford, 1998; Flood, 1993 for comprehensive reviews). A similar function can be found, if the term is read as “environmental awareness” as a necessity in the design of systems using cybernetic principles (see, e.g., Ashby, 1960, pp., 36, 80 – 99, 115; and Beer’s definition of the role of “system 4”⁵, e.g., 1985, pp. 110 ff.).

The notion of leadership, presumably derived from the “Business Excellence Model” which appears extensively in ISO/BSI literature (see,

⁵ Note that this does not preclude the connexion of individual “systems one” with the environment. However, a logical outcome of the concept of recursion, as applied to the VSM, necessitates that these individual “systems one” are connected to the environment by *the “system four” of their level of recursion.*

e.g., www.efqm.org/imodel/modelintro.htm) is also problematic. Leadership (in this context) in relation to the principle of the “factual approach to decision making⁶ (see later) and the “involvement of people” seems to create the conditions for a contradiction. It defines an ‘elite’ (i.e., the *leaders*) which therefore excludes outsiders (i.e. the *led*) from the decision making process⁷; the danger is that this apparent involvement becomes a marketing exercise, the encouragement of ‘buy-in’ rather than genuine inclusion.

Similarly there is a danger in the adoption of a “process approach” and a “systems approach to management”. Given the level of understanding demonstrated in CD2, these principles may oppose each other to the extent that the organizational *system* will merely be an aggregation of the processes identified — taking little or no formal account of qualities of emergence or wider implications⁸.

⁶ This is because *effective leadership* will create the value set that determines the relevance of the facts used in decision making. This can, in the manner of Beer’s “humpty dumpty” paying words extra (Beer, 1966, p.88) prejudice the effectiveness of the organization by ensuring that the *relevant facts* are not the *organizationally appropriate facts*.

⁷ This is an example of the situation Ulrich’s critical methodology (see, e.g., Flood and Jackson, 1990, pp. 197 ff; Ulrich, 1981; 1991) was intended to counter.

⁸ This lack of understanding of emergence possibly explaining the inability to conceptualize service as an emergent property of its delivery and, therefore, the missed opportunity in relation to the “special processes” mentioned in chapter two.

Similarly the principle of “continual improvement”. Whilst conveying the notion of *quality* improvement, seems to relate (see previous chapter) only to the operation of the quality management system. Although it has become part of the new 9004 document (“Guidance for Performance Improvement”), it is difficult to see how it could operate effectively in an organizational structure with a monotonic leadership function.

The notion of fact-based decision making⁹ is gaining acceptance in areas outside the traditional quality management area, there is, for example, a movement in dentistry (see case study later) to what has been called “evidence based diagnosis”. At this level of consideration it must be admitted that this notion will have a positive effect. However this must be considered in the context of the comments made earlier relating to the definition of relevance in so far as there is an enforced, rather than shared, value set underlying the ‘factuality’.

⁹ “Fact-based decision making” seems to be an extension of the “rational” model (see, e.g., Huczynski and Buchanan, 1991 or Jennings and Wattam, 1994). The extension coming from the ability to demonstrate the evidence or information upon which the decision was taken. The *legitimacy* of the inclusion of this evidence or information in the decision making process is, of course, a higher order question. As such it is susceptible to Ulrich’s (1980) critique, and demonstrates the point raised earlier relating to “leadership”.

The final principle, “mutually beneficial supplier relationship” also has much to commend it. The development of collaborative relationships with suppliers can bring benefits to both parties in terms of quality of provision, predictability of supply/demand and costing/pricing. However, when taken in the context of the requirement in the new version of 9001 that:

“The organization shall monitor information on customer satisfaction and/or dissatisfaction...” (BSI, 1999a, p. 21);

it appears that an opportunity to provide information relating to implementation of the requirements of the standard has been missed. This is because (again supported by interviews with quality managers) most managers understand the nature of a customer/supplier relationship from the side of the customer — however they have difficulty when they are placed on the other side. When it was pointed out to these managers that the relationship was reciprocal, i.e., that developing a supplier relationship required the same kinds of information wherever in the supply chain *their* organization stood, and that in soliciting customer satisfaction data the supplier/customer relationship still existed although

now *they* were the supplier not the customer, it became clear to them that the information they were soliciting from their customer was the same as the information they were *giving* to their suppliers the requirement seemed less daunting.

The Management Model

As mentioned earlier, one of the principles underpinning the construction of the new standard is the “process approach” and that it is considered central to the standard can be judged from the following extract from an ISO document relating to it:

“Any activity or operation which receives inputs and converts them to outputs can be considered as a process. Almost all product and/or service activities and operations are processes.

For organizations to function, they have to define and manage numerous interlinked processes. Often the output from one process will directly form the input into the next process. The *systematic* identification and management of the processes employed within an organization, and particularly the interactions between such processes, may be referred to as the ‘process approach’ to management.

This International Standard encourages the adoption of the process approach for the management of the organization and its processes, and as a means of readily identifying and managing opportunities for improvement.” (ISO, 1999, p. 6, italics added¹⁰).

Figure two is a representation of the current model being promoted by the ISO and its member national bodies. Previous versions of the model had included an explicit reference to Deming’s (1986) “plan-do-check-act” cycle although this was (reportedly) removed when it was realized that the model itself represented such a cycle.

The four areas of concern represented by the explicit clauses in the standard are present and are shown as connected to the customer by way of arrows in and out of the model. The solid arrows (at the bottom of the diagram) represent customer requirements being fed in to the realization process (left) and the outputs of these processes being sent to customers (right). The dotted lines (towards the top of the diagram) represent customer satisfaction measures being fed in to the quality performance measurement process (right) but little information regarding the dotted

¹⁰ The reason for the italicization of the word ‘systematic’ is to counter position it to the word ‘systemic’. Although the extract also mentions the “interactions between processes” it is apparent

line at the top left is forthcoming (either in the documentation or in discussion with members of the standards bodies) and it is presumed that this relates to some ‘higher level’ relationship between the host organization and its customers (possibly contract negotiations/review).

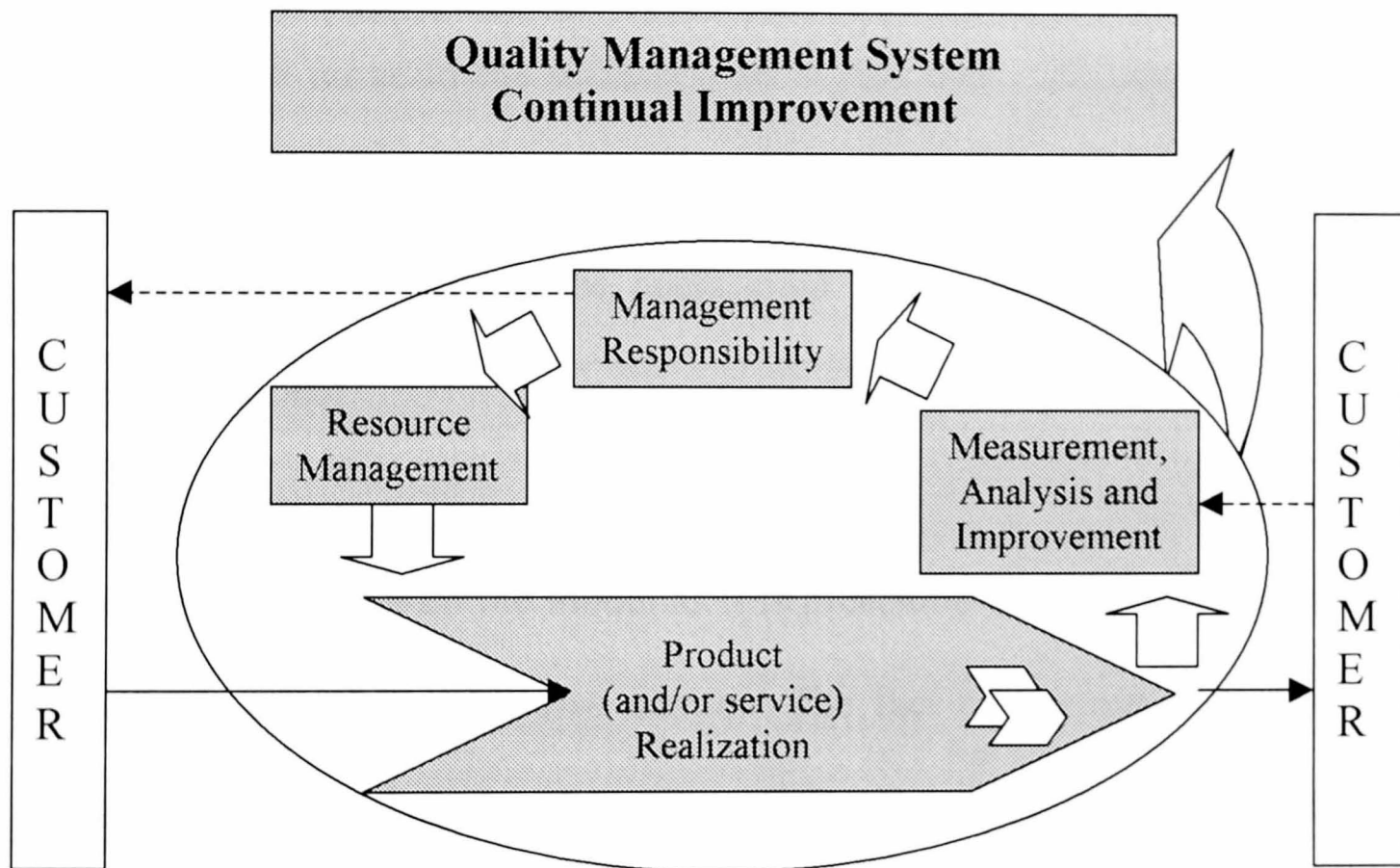


Figure 2, ISO Quality Management Process Model (adapted from ISO, 1999, p. 7)

The arrows defining the cycle within the boundary of the model allow it to be internally self-consistent and the final large arrow across the boundary (top right) correctly identifies the “continual improvement”

from the wider meaning of the extract that the overall interpretation is reductionist, regarding the

activity as meta-systemic as in the “essential variables” element of Ashby’s “ultrastable system” (Ashby, 1960, pp. 42, 81 –85) and Beer’s “3-4-5” homeostat in his “Viable System Model” (Beer, various). However, by not differentiating the “management responsibility” between operational (e.g. Beer’s system 3) and normative (e.g. Beer’s system 5) the move to the meta-system is one way. Although there is obviously an *assumed* connexion back from the improvements made (i.e. the re-definition of self) to the operational level it is not made explicit within the model.

A second problem with the model as it is presented is the absence of any attempt to model its *recursive* nature. The fact of the removal of the “plan-do-check-act” cycle when it was realized that the whole cycle also possessed these characteristics betrays a strictly hierarchical view of the organization, whereas it would have made more sense (certainly from the view of the cybernetics theories contained in Beer’s VSM) to have represented the whole model within itself. Although it may be argued that the chevrons contained inside the “realization” box hint at this notion, there is neither explicit reference nor implicit use of it anywhere

organization as the sum of its processes rather than an emergent entity.

in the documentation relating to the standard. And, it must be added, that the implication of the notion of leadership rather than identity, discussed above, leads to the ability to define and implement *improvement* being perpetually outside the range of possibilities to any element of the organization under scrutiny — thus the model cannot be truly recursive.

Critique

The purpose of this section was not to devalue the efforts or achievements thus far of the people responsible for creating the new standard. It is a far reaching and thoroughgoing revision of the earlier version. The problem lies not in the words, but in the apparent understanding of organization that lies behind them.

The first problem is a technical one, it relates to “standards in general” rather than to *the standard* in particular. By creating a system which represents part of the organization in isolation, and not embedding it in an overarching model which places it in context, the natural reaction, especially when that part is to be assessed, is to concentrate on the operation of the system rather than the organization it is there to support.

The process model adopted, even when it is embedded in the wider model is relatively shallow, for example it separates resources from management from inputs. Whilst this may facilitate a greater ease of understanding of the concepts contained in the model it does not solve the problems of re-integrating them into a coherent whole.

Going further, the model as it is presented also (as predicted) falls foul of the incompleteness theorems in that the attempt to render it internally consistent has brought about the need to *externalize* the process of change. Otherwise the organization, and its quality management system, is in a permanent state of flux rendering *rational* decision making problematic. This leaves the QMS as a monotonic system with change imposed from outside thus precluding the possibility of the “involvement of people” and the ability to plan for all but the most minor of operational change — i.e., it violates a number of the principles it establishes itself upon.

More importantly this externalization of the authority to identify and sanction change precludes access to benefits of recursive structures and thus condemns itself to being an increasingly complex *detailed* control

model. This means that the organization loses the benefits of managing individual units as “black boxes” (Ashby, 1964, pp. 86 ff.; Beer, 1979, p. 40) and, almost by definition will fall foul of the law of “requisite variety” (Ashby, 1964, pp. 202 – 215) where the variety of the manager or management team (control system) is less than the variety of the unit of the organization it is attempting to control.

By not addressing the continual improvement issue the model adopted precludes access to the advantages of implementing recursive structures. And thereby precludes variety in the organization (i.e. it must reduce the complexity of the organization to a level where the variety levels *do* match — which also reduces potential responses to environmental demands and reduces the possibilities for survival — or relinquish the ability to control the organization at all.

At a more general level, even the version of the requirements presented in ISO/CD 9004:2000 is internally monotonic, this means that once a fact is established it remains true or once a value is established it remains valid. This is all good science, especially if you are proposing a “fact-based” approach, it provides a degree of certainty in the process of

decision making. However it precludes the possibility of learning which, in a practical sense, means the changing of values or the discarding of “facts” to accept new, or revise old, ones that are more appropriate to current circumstances.

A final point, and one which I believe is as important to the uptake of management systems in general as theoretical rigour is that they must deliver demonstrable business benefits. I have said earlier that I consider the process of implementing the new standard to be a useful exercise (this parallels Patten’s remark that plans are nothing but *planning* is everything), but this process is discrete — it comes to an end. Unless, once this process is completed, it leaves behind a management system that reflects the nature and dynamism of the organization the client organization will not be capable of the ongoing adaptation necessary to its survival.

The new version of ISO 9001, and ISO 9004, in common with other standards, do not have this capacity and are thus at the mercy of ‘champions for change’ or visionary ‘leaders’. Change in the

organization is, because of this, almost always ‘crisis management’ and cannot, over the medium to long term, ever be planned.

The Standard and the VSM

Overlaying the functional capacity of the VSM with the general requirements of the standard (as figure six, below) makes it possible to locate the requirements of the standard within the functional areas of the VSM. Thus (at this level of recursion), it can be seen that:

Management Responsibility resides in the meta-level, but is embedded throughout the organization because of the recursive nature of the model;

Resources Management resides with operational management (at all levels of recursion);

Product/Service Realization resides in the “3-2-1” homeostat (at all levels of recursion);

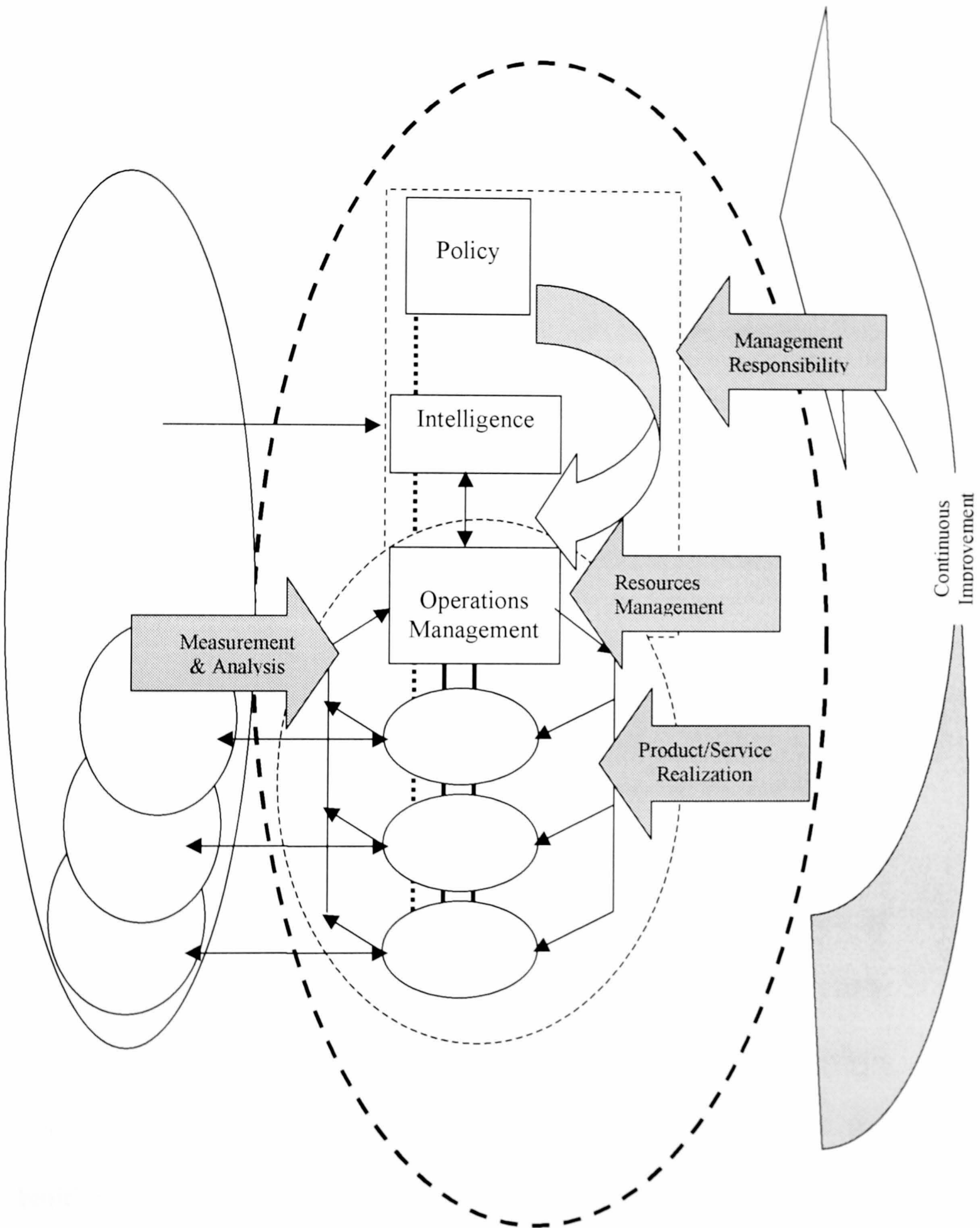


Figure 6: the elements of the Standard mapped onto the VSM

Measurement and Analysis are facilitated (internally) by the audit channel (3*) under the control of operational management (at all levels of recursion);

Continuous Improvement is a 'whole system' issue (based on information acquired by "system four") but is also the responsibility of individual operational units (i.e., systems one) at their level of legitimate responsibility because of the recursive nature of the model.

Summary

In this chapter a more critical review of the contents of the standard has been presented. This was then taken forward into a proposal for a model that is nominally capable of both satisfying the formal requirements of the standard, based on Ashby's "ultrastable system" and Beer's "viable system model". The mapping of the general elements of the standard onto the VSM demonstrate that it is feasible to attempt to design and build compliant quality management systems (i.e. which satisfy the

requirements of the standards) based on these systems approaches to organizations.

The discussion in this chapter also supports the assertion that, where the standard has weaknesses in relation to the functioning of organizations, for example in the externalization of the adaptive capacity without formal mechanism for its re-integration, the cybernetic model(s) proposed have the capacity to overcome them without prejudicing compliance.

In reference to the other aims of the chapter, it has been possible to rephrase the language of the cybernetic models to make it more accessible to 'lay-users' of the models. The re-wording in the interpreted version of the ultrastable system is a demonstration of this, as is the response that has been received from various audiences comprised of practicing managers around the world.

Finally, thus far in the exposition of the model none of the concepts used have been biased towards either manufacture or service provision and so the potential application of the model is general.

In the four chapters that follow, the derivation of the principles and the construction of the final model will be presented, beyond this the basic mapping presented in this chapter will be developed into an operational model for the development of quality management systems which, although targeted at the service provision sector will be generally applicable.

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Part

Two

Chapter 5

Mathematical Models Of Change

“Nietzsche was one of those who detected the echo of creations and destructions that go far beyond mere conservation or conversion. Indeed only difference, such as a difference of temperature or potential energy, can produce results that are also differences. Energy conversion is merely the destruction of a difference, together with the creation of another difference. The power of nature is thus concealed by the use of equivalences.” (Ilya Prigogine and Isabelle Stengers, Order out of Chaos).

Introduction

In this next set (of four) chapters I derive the model that informs the analysis of the case study presented in chapters ten and eleven.

In this chapter I will present a selection of mathematical models that informed some of the early thinking which led to the theoretical

necessities of the model proposed. In particular the chapter explores the notions of:

self-organization;

the organization as iterative system;

context.

Following this, Ashby's notion of ultrastability is revisited and a preliminary consideration of autopoiesis (Maturana and Varela, 1975; 1980) is undertaken.

The reasoning behind undertaking this review of essentially mathematical models that would appear more relevant to "chaos" or "complexity" theories (see, e.g., Gleick, 1987 and Kaufman, 1995 respectively) is twofold. First it can be demonstrated that such ideas are relevant to management and organizational change (see, e.g., the work of Allen, 1992; 1995; 1997b). And second, because of this, that the integral

ability to *control* systems that appear to obey such principles is likely to be of value to managers¹.

Thus the aim of the chapter is to *explore* these models and their potential to illuminate the formal development of the approach to be taken to the case study. Because of this, no formal comparison between more traditional approaches to organization theory (see, e.g., Silverman, 1970) or Pugh and Hickson, (1989) for a comprehensive review) is undertaken. However a ‘first cut’ attempt *is* made at the integration of the insights the mathematical models provide and the core models chosen for the investigation.

Self Organization

Perhaps the most fundamental contribution to a ‘physics of emergence’ has been the notion of “self-organization” introduced by Prigogine (1980), Jantsch (1980) and developed more recently by Prigogine and Stengers (1985).

¹ It must also be underlined again that it is not suggested that organizations *are* like this, simply that they may *appear to behave* in this way.

Self-organization provides a model of organizational change where systems “far from equilibrium” (Jantsch, 1980, p. 36; Prigogine, 1980, p. 104; Prigogine and Stengers, 1985, pp. 140-5) spontaneously restructure when pushed beyond a given (although generally unknown) structural limit. At some point in this far from equilibrium area, the usual attractor state (of minimum entropy production) ceases to apply and, the structural characteristics of the system become probabilistic. Thus it is possible for the system to take on a new stable form, i.e., to move to a state where a new attractor applies.

A characteristic of Prigogine and Stengers’ understanding of the behaviour of such systems is:

“The interaction of the system with the outside world, its embedding in nonequilibrium conditions [which] may become ... the starting point for the formation of new dynamic states of matter — dissipative structures.” (Prigogine and Stengers, 1985, p. 143).

The relevant points are the notions of the “outside world”, what has been called elsewhere environment and “dissipation” (in this case it is the dissipation of energy). And so it is necessary to consider the ideas of

embeddedness and entropy creation as part of the explication of self-organization.

A self organizing system cannot be understood in isolation from its environment as, if it is, the process of organization (i.e. its differentiation from its environment) seems to contradict the laws regarding entropy growth. However, as a dissipative system degrades the energy it receives from its environment (i.e. the source energy which pushes it into a far from equilibrium state) there is an entropy growth across the field of its environment as a whole which offsets the growth in organization at the local level. That is, self-organizing systems ‘pay’ for their organization (i.e. negentropy) at the local level by increasing the entropy (and/or its growth rate) at some global level.

A much earlier, and more succinct statement of this was given by Schrödinger in 1943, i.e.:

“It is in avoiding the rapid decay into the inert state of ‘equilibrium’ that an organism seems so enigmatic ... [n]ature means an increase of entropy in the part of the world where it is going on ... [organisms can only survive] by drawing from its environment negative entropy —

which is something very positive ... [t]hus the device by which an organism maintains itself stationary at a fairly high level of orderliness (= fairly low level of entropy) really consists in continually sucking orderliness from the environment ... [a]fter using it they return it in a very much degraded form ...” (Schrödinger, 1944, pp. 72 – 75).

Here we find Schrödinger describing life in the same way as Prigogine and Stengers describe dissipative structures (Prigogine and Stengers, 1985, p. 142). Life, it seems, is a self-organizing phenomenon, a far from equilibrium event. Living systems are not equilibrational systems they are, to coin a phrase introduced by Cannon (1929), *homeostatic*. Homeostasis is distinct from equilibrium in that although it is the state a system will return to following perturbation, it is not a state of minimum entropy production. Because of this homeostatic systems are, by definition a long way from equilibrium, the attractor is not the point of thermodynamic equilibrium but some other relatively stable state. Hence, where the ‘energy tension’ created *across* the whole system (see later) by its embeddedness in its environment is balanced by the energy degradation process(es) permitted within its structural constraints, relatively minor environmental changes may instigate radical change in systems’ form.

When taken in conjunction with Prigogine's self-organizing system it is possible to imagine a situation where the homeostatic system seeks some established homeostasis between bifurcation points (i.e. those points where it undergoes radical change) and appears stable. Only when it passes through such a point will such an apparently stable system collapse — and then only to a new (possibly pseudo) equilibrial structure. This is because the possibility is that the system may form a new homeostatic structure (i.e. stable but not equilibrial in the thermodynamic sense) or, if not, it may only be stable by moving to thermodynamic equilibrium (i.e. death in a biological sense).

It is possible to understand the operation of the process of self-organization using the language of Bogdanov's notion of progressive positive podbor (1996, pp. 190 ff.) in conjunction with the process of equilibration². That is, a system which is being pushed into a far from equilibrium state can equally well be regarded as a complex under circumstances of progressive positive assimilation; where the quantity

² The term "equilibration (referring to the work of Bogdanov) was introduced in the works of Gorelik (1987) and Zeleny (1988) to describe a system moving towards an equilibrium point, and extended in this interpretation by Sadovsky (1996). The interpretation used here is different in that here the system is not assumed to adapt toward *an* equilibrium point in any absolute sense. The system does not exist *at* equilibrium but as and in the process of *moving toward* a perpetually mobile equilibrium between itself and its environment.

which is being assimilated is energy. Thus at some point the structural capacity of the system to absorb the influx is overcome. At this point, the “crisis” in Bogdanov’s words (1996, pp. 157 ff.), the system breaks down and the collection of hyper-energetic particles seeks³ some stable structure within which to reform⁴.

The form this new structure takes, it appears to me, is critically dependent on the proximity of an “attractor” or point of locally maximal entropy generation. That is, that the collection of hyper-energetic particles will assume the form that maximizes entropy production *across* levels. Which is to say that any increase in organization at the level of the particles as a collection taken *in isolation* will be more than offset at the next higher level (i.e. the energy field that constitutes the environment).

Schrödinger (1944, p. 52) provides a structure which appears to support this assertion in his discussion of the stability of isomeric molecules. He suggests, in explicit similarity to Planck, that stability at the micro-level

³ There is an implication of *intent* in this phrasing which cannot, of course, exist. A more correct phrasing may be “are attracted toward some physically possible ...”.

(i.e. where the numbers of individual atoms are not large enough for statistical laws to apply) is brought about by threshold energy levels needing to be achieved before extant molecular structures are able to transform into isomers⁵. That is, that isomeric molecules are differentiated stable states of a particular collection of atoms which are *not* simply separate points on a linear continuum but which can be imagined as “valleys” separated by a higher energy level boundary which must be crossed in order for them to fall back into a different valley in order for a ‘different energy’ isomere to form.

To relate Schrödinger’s model to the original assertion a system must be pushed a long way out of its original, stable, form in order to reform in a new state. The energy differential between state one and state two being absorbed as the ‘organization cost’ and the differential between state two and the threshold value being released into the environment. In this way the amount of available energy in the ‘wider system’ (i.e. the {source/energetic particles/environment} system) is reduced, thus

⁴ This is not too dissimilar to Simon’s (1988, p. 209) “stable intermediate forms” which, although used in reference to the move towards increasingly complex systems conveys, in the same manner that I intend, the notion of a range of stable points given a particular set of constituent parts.

⁵ Note that Schrödinger was one of the ‘founding fathers’ of quantum theory and therefore it is not surprising that this “threshold” level has similarities to the notion of quanta (i.e. discrete packets) of energy being needed to cause change.

increasing entropy (calculated as homogeneity) and differentiation simultaneously.

In order to clarify this it is necessary to move a little in front of ourselves. If the natural progression of things is toward maximal entropy, but the generation of organization is representative of the reduction of entropy and if my interpretation of equilibration is correct. Then the only way organization can arise spontaneously is if the generation of organization in some way also increases the generation of entropy. Therefore the {collection of particles/energy/environment} system must be solving a pair of simultaneous equations which lead to the creation of a structure which maximizes the *net production* of entropy. In other words the increase in entropy across the environment minus the increase in negentropy, as represented by the net increase in differentiation brought about by the formation of the new structure, is maximal.

We know that, at the quantum level, there is a limit to the amount of energy that a particle can be subjected to before it changes structure, this is represented in Planck's constant. We know also, via the second law of

thermodynamics, that the natural tendency of systems is toward increasing entropy and, also, that this is universal. Lastly, if we accept the notion of equilibration across fields, we can assume that a relatively stable system will attempt to maintain its identity in the face of excess energy input through the process of homeostasis.

So, if a given system in a given environment is subject to energy input (or, 'positive' differentiation) there is of necessity a 'hot spot' of some sort which acts as a source. Therefore we have a hot source, an increasingly hot system and a relatively cold environment which taken together at any time t_0 (= the present) are in their minimal entropy state. Whilst the system retains structural integrity, entropy in the {source/system/environment} system (i.e. one level of recursion up from the system in focus) approaches its maximum as the energy content of the system approaches that of the source. However if the system is pressed beyond the capability of its structure to re-assert homeostasis we are presented with a {source/hyper-energetic particles/environment} system. Under these circumstances (assuming that the particles themselves retain their nuclear integrity) this wider system is faced with solving the simultaneous equations referred to earlier.

Assume that the entropy growth of the source is constant. Assume further that the entropy of the (ex) system is maximal; as indeed it must be. In this case the only relevant entropy measure is that of the wider system as a whole (see above), and this must of course include that of the (ex) system. Therefore the {source/hyper-energetic particles/environment} system will attempt to maximize the $\Delta H_s + \Delta H_e$ equation. Which is to say that $(\Delta H_s + \Delta H_e)_{t_0} < (\Delta H_s + \Delta H_e)_{t_1} < (\Delta H_s + \Delta H_e)_{t_2}$. This is *not* to say that ΔH_s and ΔH_e are *both* necessarily increasing over time; only that the *net effect* is.

Thus by explicitly including a meta-system (the energy field) into our analysis we can arrive at a situation where, conceivably, the growth of organization and the growth of entropy can progress in tandem, each co-determinate of the other.

Therefore:

“It seems reasonable to assume that some of the first stages moving toward life were associated with the formation of mechanisms capable of absorbing and transforming chemical energy, so as to push the

system into “far from equilibrium” conditions” (Prigogine and Stengers, 1985, p. 191).

Life, it seems, arises by absorbing energy but not getting hot. The dissipative structures suggested by Prigogine (Prigogine, 1980 and Prigogine and Stengers, 1985) allow for the throughput and degradation of energy — thus entropy growth across a field is consistent with organization growth within it. The growth of organization within the field leads to the removal of energy differentials across it.

Organizations as Iterative Systems

Following on from the previous section is what mathematicians (e.g., Feigenbaum, 1981; Barnsley, 1985) call iterative systems — systems that take the output of their operation from time t to use as the input for their operation in time $t+1$. I can say this because many of the self-organizing systems, dissipative systems described by Prigogine (1980) are what Kauffman (1995, p. 49 ff.) describes as “autocatalytic sets” (see fig.1), i.e. a system, the output of which, creates its inputs, the conditions necessary to their creation or the conditions necessary to the continued creation it its outputs.

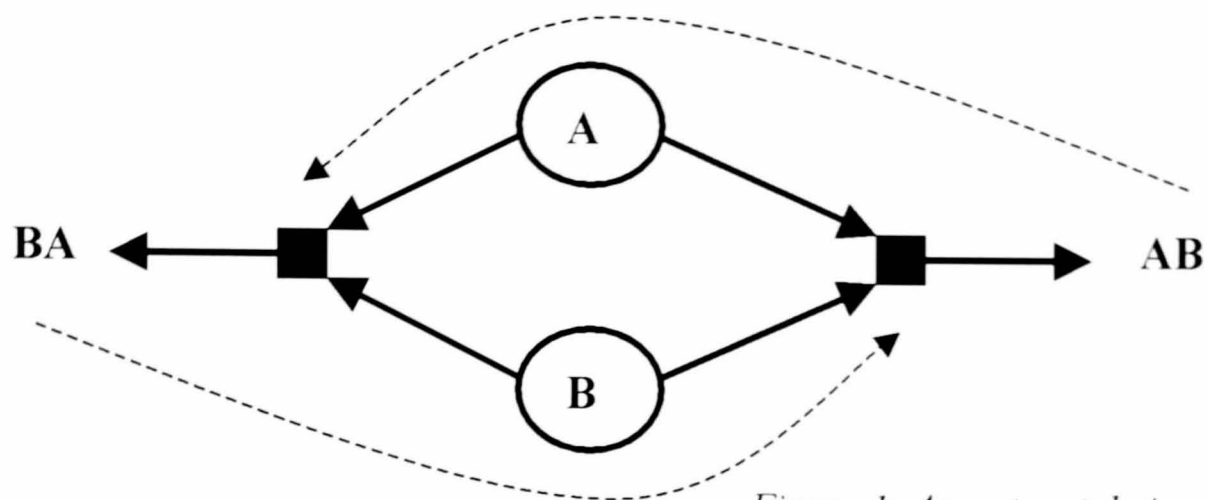


Figure 1: An autocatalytic set
(source Kauffman, 1995, p. 49)

In the model of an autocatalytic set given in figure one:

“Two dimer molecules, AB and BA, are formed from two simple monomers A and B. Since AB and BA catalyze the very reactions that join As and Bs to make the dimers, the network is autocatalytic: given a supply of “food molecules (As and Bs), it will sustain itself.”

Kauffman, 1995, p. 49, italics in original).

Autocatalytic sets, as can be seen from figure 1, are similar to iterative systems insofar as their operation creates the conditions necessary to their further operation

Two simple examples of iterative functions, drawn from the fields of population dynamics and fractal geometry respectively, provide an insight into the operation of such functions and, hopefully, their relevance to organizational modelling.

The logistic difference equation is used to model population figures for a species in an environment with a specific carrying capacity and is written thus:

$$P_{t+1} = P_t r (E - P_t)$$

Where P_t is the initial population, r is the reproduction rate, E is the environmental carrying capacity and P_{t+1} is the population in the following period. The interesting feature of this equation is that it is sensitive to the reproduction rate and the initial population level (see Gleick, 1987, pp. 63/4; Prigogine and Stengers, 1985, p.193/4) such that below certain levels the population falls off to zero, whereas above a certain level of reproduction rate (typically 3) population levels fluctuate wildly in successive years. This effect is usually represented as a 'bifurcation graph' with successive bifurcations occurring periodically as

a function of the increase in reproduction rate (Feigenbaum, 1981 has calculated a universal constant for predicting successive bifurcations as 4.669, i.e. $R_{t+1} = R_t + (R_t/4.669)$).

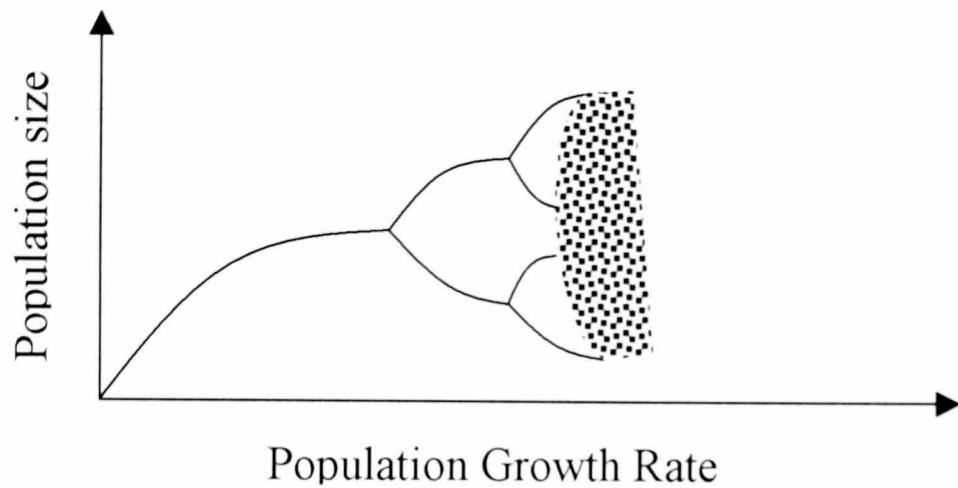


Figure 2: A representation of a simple bifurcation graph

The progressive “period doubling” shown in the graph occasionally (but not always⁶) descends into “chaos” (represented by the dotted area), i.e. an area where the plots become densely packed and apparently random. As the rate continues to climb (i.e. beyond the chaotic region) the graph will usually settle again into a stable period doubling sequence, although this will not necessarily follow directly from where it ‘left off’ before descending into chaos. It is suggested that this “chaotic region” parallels the point of spontaneous restructuring that Prigogine describes as characteristic of the self-organizing system.

⁶ This is supported by Yorke’s (1975) paper where he states that whether or not such a system has a “chaotic region” can be predicted by whether or not the bifurcation graph contains an area of “period three”.

The second example, which is probably more well known, is the graph of the Mandelbrot set⁷. The formula for this is even simpler than the logistic difference equation, thus:

$$X \Rightarrow X^2 + X < \alpha$$

Where α is some numerical value less than infinity, and X is a complex number, i.e. it is comprised of a real and imaginary component (e.g. $X = 3+4i$).

The formula is iterated and the number of iterations taken for the value to exceed α is used as the basis on which to assign colours to different areas of the graph. Those initial values of X where α is not exceeded within a sufficiently large number of iterations are usually coloured black.

As can be clearly seen both these formulae contain a 'negative gain' element. In the logistic difference equation population is limited by the carrying capacity of the environment such that the higher the population

⁷ Described by Gleick (1987), pp. 222-223.

at time t the smaller the number by which the population at time $t+1$ is multiplied. And in the Mandelbrot equation the negative element is supplied by the fact that $i^2 = -1$ and therefore that $X^2 = (x + i)^2 = x^2 + 2xi - 1 = (x^2 - 1) + 2xi$.

However, one should note that in the Mandelbrot formula, as in business, the constraint is not absolute, it holds only for certain, critical, initial values (i.e. those where repeated iterations do not lead to instability, in this case running off towards infinity).

A second point which must be made clear is that there is no adaptive element in these formulae, that is, not only does output from t form the input for $t+1$ but the formula remains constant. Whilst this is not problematic in the abstract world of mathematics, in the realm of individual living, or social, systems a fixed formula must be right (i.e. it must accurately reflect *both* the internal and external dynamics of the system), otherwise they will not survive. Later in this chapter I present an example where not only is the formula fixed, but also does not appropriately reflect the dynamics of the situation, leading to problems

which, whilst the effects are obvious enough, the causes are difficult for the organization to cognize.

Context and Adaptation

“The early appearance of life is certainly an argument in favor of the idea that life is the result of spontaneous self-organization that occurs whenever conditions for it permit.” (Prigogine and Stengers, 1985, p. 176).

That complexity in the adaptive system is a combinative phenomenon is made clear by Allen’s (undated) statement that:

“For systems made up of microcomponents with fixed internal structure, their interactions can lead to *self-organization*. However, if the microcomponents have diverse internal structures, then *evolution* can take place as the emergent macrostructure affects local circumstances ... this affects the relative performance of different kinds of individual which in turn changes the macrostructure...”

(Allen, undated)

In this section of the chapter I will propose a model of an adaptive system which, by its recursive application, allows for Allen's statement and provides a basis for its conceptualization within the wider milieu of which it is an integral part.

This approach, i.e. to the 'system in context', renders the problem both meta-systemic and recursive in that the environment of the system must also be viewed as an adaptive system at some higher level of recursion. And, as environmental constraints are what the adaptive system is presumed to adapt within/to, the environment must form *one* of its meta-systems.

The problem of identity arises because of the impossibility of the recognition of a system as adaptive in the absence of its environment and, thus, the apparently arbitrary nature of the definition of any particular entity as 'system' in isolation. At this point the model *assumes* the validity of "autopoiesis" (Maturana and Varela, 1975; 1980) which is initially integrated at the end of the chapter and introduces the notion of the 'eigenfunction' as the basis of systemic identity (both of which are dealt with in detail in chapter seven).

The model proposed suggests that the system in focus can be represented dynamically as a flow in $n+1$ -space (where n is the number of dimensions of its inputs and outputs and the extra dimension as a transformation) and therefore, initially, that its input and output surfaces can be represented by Poincaré sections across this flow (see Stewart, 1989, pp. 61 ff.). Because the Poincaré section is represented as a disc in 2-space representing all possible combinations of input/output values (including zero probability values) the flow is assumed (for simplicity) to be circular in section.

Realistic systems, of course, will operate in more than two dimensions and, therefore, the flows modelled represented in a 3-d *hyper-space*. That is, a flow in 4+1 (representing a system with four input/output dimensions would cut the surface of a Poincaré section represented by a hyper-disc in 4 dimensions.

The identity of the system is represented as an attractor around which the flow orbits but never achieves, thus the flow representing the system in focus can be visualized as a torus in n -space.

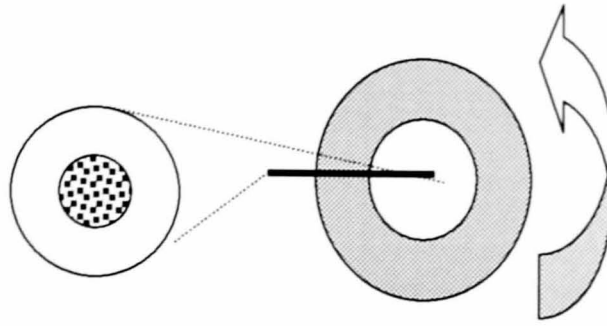
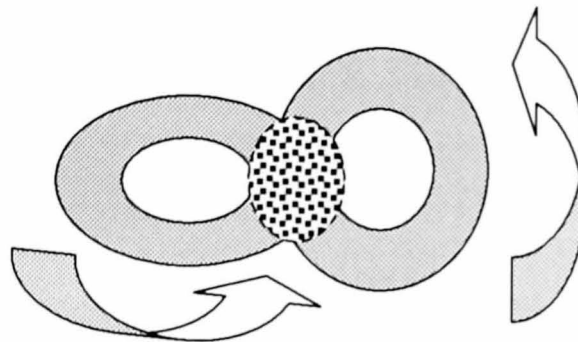


Figure 3: The system as a flow in 3 (i.e. $2=1$) space can be mapped as a series of points in 2 space.



*Figure 4: The interface of system and environment
Because of the volume relationship, unit increases in flow variables
increase environmental interactions exponentially.*

The ‘system in its environment’ can thus be represented as two intersecting flows each orbiting their own attractor and providing, to each other, the centripetal ‘kick’ which prevents the orbiting flow from collapsing into its attractor. In this way a dynamic system with a tendency to some terminal equilibrium state is held at a distance from it.

The interface of these processes is the equivalent of a (hyper)sphere in $n+1$ space and, because of the volume relationship, unit increases in

input/output potential cause a disproportionate increase in the number of possible input/output states⁸.

Hence the model provides for the combinatorial complexity of the system, the notion of the identity of a 'system in focus' in the wider milieu in which it must be understood, explicitly includes notions of meta-system and develops a basis for the complexification of input to input critical systems.

In addition, the hypersphere model provides a basis for the perceived robustness of complex systems in nature where the reverse tends to be the case in artificial systems (see, e.g. Beer, 1981, pp. 202 ff.) which obeys the "law of requisite variety" (Ashby, 1966, pp. 202 ff.) and therefore supports Beer's "variety management/engineering" (Beer, 1981, pp. 279 ff.; 1979, pp.39,69,89, 522). The "variety management" is made possible because (when modelled in this way) the input/output points of the system in focus (i.e. the values they can take on when passing to or from the environment) multiply *exponentially* because (as a

⁸ This is because of the volume relationship (in this case of a sphere) creating an exponential increase effect for arithmetical increases in input/output variety, i.e. (taking Π as $\frac{22}{7}$):

where $\Delta r = 1$: $\frac{4}{3}\Pi r^3 = \frac{4}{3} \times \frac{22}{7} \times 1 (1^3) = \frac{88}{21} = 4.19$ (approx.); and

where $\Delta r = 2$: $\frac{4}{3}\Pi r^3 = \frac{4}{3} \times \frac{22}{7} \times 8 (2^3) = \frac{704}{21} = 35.52$ (approx.).

flow through an interface *volume*) they are exposed to a greater number of environmental values ($\varepsilon_i - \varepsilon_j$) for any given system input/output value (α) (see figure 5).

This exponential effect, in short, adds substantially to the *information carrying* capacity of the interface (Beer, e.g., 1979, p. 124; 1981, pp. 367 ff.; 1985, p. 47 ff. calls this *transduction*) . And, it does not matter whether this information is understood in the humanistic sense (as I shall use it later in the development of skills based quality management systems or in the sense used by Shannon and Weaver (1963) in their development of ‘information theory’.

In fact whichever way it is understood small internal increases in variety generation produce larger effects on the ability of the system to transfer information to and from their environments. This is also supported in the work of Ashby in his calculation of the entropy⁹ of a Markov chain (Ashby 1966, p.179) where it (i.e. the entropy or information conveyable) is a function of the length of the chain. That is, if the

⁹ The word “entropy” here is the term introduced by Shannon and Weaver to measure information conveyed in a message. It was coined because the formula used to calculate it was the same as that used in thermodynamics. i.e.

$\sum p_i \log p_i$.

information conveyable at each step of the chain is 1 bit, the information conveyable over x steps of the chain is $x \times 1$. In the hypersphere representation this (two dimensional model) is simply extended to $n+1$ dimensions, i.e. the information conveyable is that of the plot on the Poincare section (in n dimensions) multiplied by the length of the trajectory the flow traces through the interface volume.

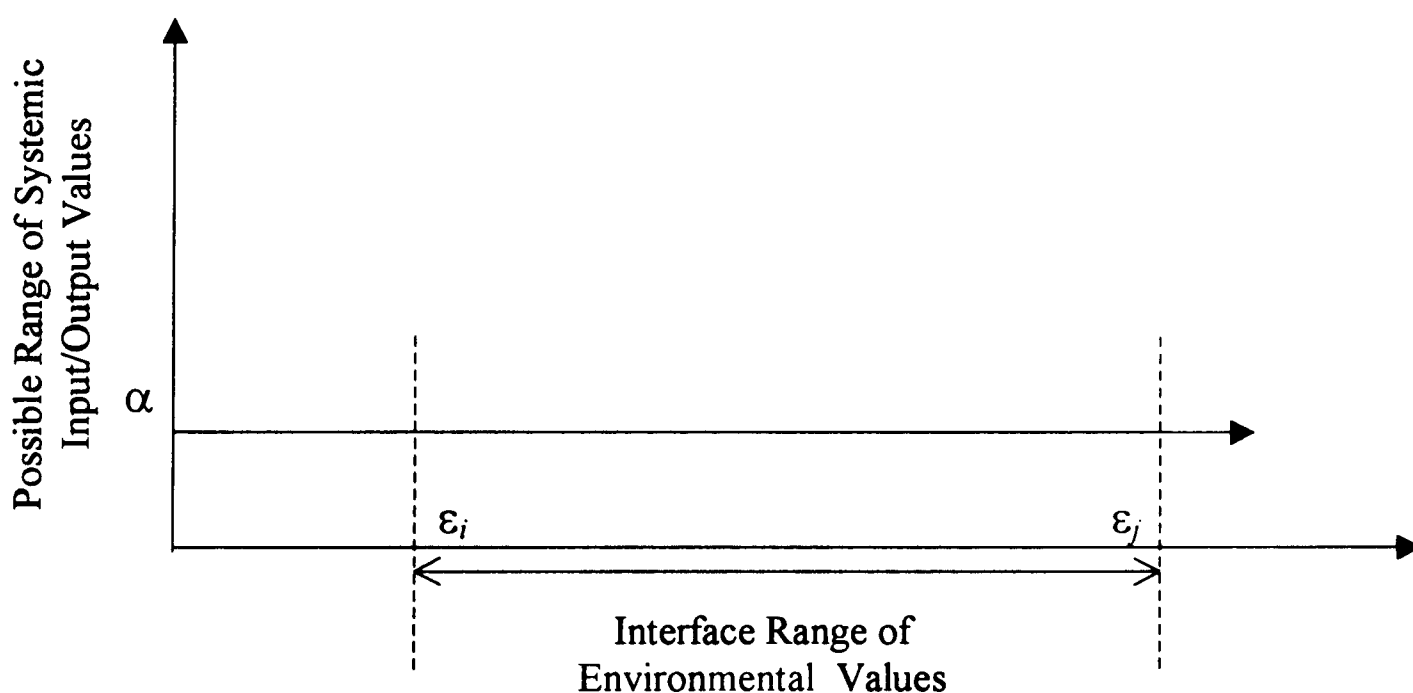


Figure 5: The interface

In this way complex systems can become more robust not only because of their *absolute* variety but also for the fact that this provides an *additional* transductive capacity at the system/environment interface.

Ultrastability and Autopoiesis

Ultrastability, the ability to “adapt to unexpected perturbation” is posited on a notion of ‘selfness’, represented in Ashby’s model by the essential variables. The organization that aspires to it, therefore, must develop a model of self which it can use to evaluate the environmental information available to it and its knowledge of what it is trying to achieve. In this way each of the activities of the organization can be assessed in relation to the question “How does this affect ‘me’?”.

It is important to note in this context that it is not the relationship between the *intention* in carrying out the original action and the consequent response of the environment that is important. It is the *effect* that the environmental response has on the *identity* of the organization, however this is measured. Which is to say that the conformance to prediction of the outcomes of action is not the issue. It is whether or not the outcomes of actions, as mediated through the environmental response, facilitate the maintenance of the identity of the organization within acceptable limits.

Thus the role of the manager, in the attempt to control an ultrastable organization (or indeed the researcher in attempting to understand it), reaches beyond simply understanding management models of environmental manipulation into the realm of understanding the organization as an entity with *needs*. In order to do this one needs not only an understanding of the cybernetics of homeostasis and ultrastability but also a working knowledge of the organization as a *physiological* entity. This leads to the need to construct a mechanism which facilitates *autopoiesis*. An autopoietic system has been defined by Maturana and Varela as:

“... a network of processes of production (transformation and destruction) of components that produces the components which: (I) through their interactions and transformations continuously regenerate and realize the network of processes (relations) that produced them; and (ii) constitute it ... as a concrete unity in the space that they (the components) exist ...” (Maturana and Varela, 1980, p. 79).

The essential variables of a system thus provide the organizational measure of *selfness* against which the appropriateness of organizational

action is evaluated. And it is this capacity to recognize itself, the notion of self-awareness, applied in the operation of the organization that will identify potentially pathological tendencies of methods of operation in a dynamic environment.

A second point is that the autopoietic system cannot be entirely *informational*, there is a physical element implied in the *constitution as a concrete entity*. Maturana and Varela implicitly recognize that whilst the ‘media may not be the message’ it certainly produces it — this is a theme I shall return to in chapter seven.

If we now apply the notion of autopoiesis within Beer’s version of Ashby’s ultrastable system, i.e. the “3-4-5” homeostat (see figure six) it is possible to locate the functions necessary to achieve it¹⁰.

That the ‘autopoietic relationship’ runs between “system 5” and “system 3” is not surprising, as this is the link between identity and action (see Beer, 1985, pp. 128 ff.). “System three” as (in this case) representative

¹⁰ It should be noted that this system would remain autopoietic in the absence of the “system four” function, however the system would be merely ‘stable’ rather than ‘ultrastable’, and would, in effect, be equivalent to a “3-2-1” homeostat.

of the “systems one” is the equivalent of Ashby’s “reacting system” and “system five” the essential variables whilst knowledge (memory?) of the environmental conditions (Ashby’s “parameters”) is the domain of “system four”.

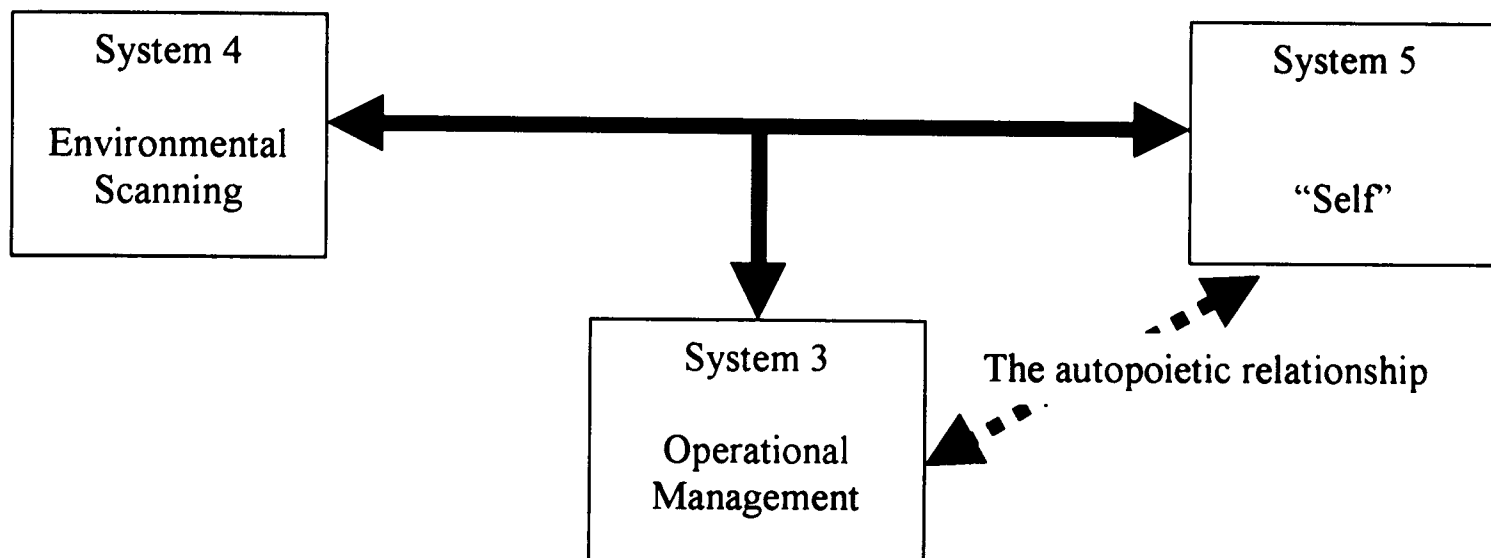


Figure 6: The “3-4-5” homeostat with the autopoietic relationship

In effect “system five” contains a ‘blueprint of self’ whilst “system three” contains and controls the activities by which the ‘blueprint’ is realized. In the absence of the “system four” function it is possible to see the “3-5” system in its autopoiesis as an autocatalytic system, i.e. given the ‘blueprint’ (or the physical laws governing the reaction) and an adequate supply of ‘food’ the system is able to maintain its existence.

The inclusion of the “system four” function explicitly recognizes the existence of an environment (and implicitly the fact that it is capable of

change). The inclusion of the environment brings a need to acquire information, for example regarding food sources or threats to survival, which necessitates the consideration of interface devices capable of recognizing first the conditions existing there, and second any changes. This is because, as both Ashby and Beer state, the *ultrastable system* is capable of responding to stimuli it has not experienced before. That is, it is capable of an adaptive response which can only be brought about by a *restructuring* of the elements that control its actions (or a resetting of the equilibrium values of the essential variables, which amounts to the same thing¹¹). This form of adaptation can be described (within a completed VSM, i.e. one that includes systems “one” and “two” and the audit channel three *) as a modification of the performance criteria of the systems “one”. That is, as a modification of action or behaviour that maintains the current integrity of the ‘self’ within new environmental constraints.

A second possibility for change however, is the radical re-definition of this ‘self’, the move from the current region of stability (or “attractor

¹¹ Ashby’s statement(s) that:

“... stability belongs only to the combination ... [t]wo systems, both unstable, may join to form a whole which is stable ... and may form an unstable whole if joined in another ...” (1960, pp. 56/7).

basin”, see e.g. Gleick, 1987, pp. 233 /6) to a new one. Such a shift would bring a change, not in the values of the variables needed for stability, but in the variables themselves. This is similar to what Ashby (1960, p. 93) describes as a “step-function”, the ability to make a discontinuous shift between regions of potential stability.

These possibilities for change have the effect of moving the interpretation of the autopoietic system from the *self*-maintaining to the *self*-creating to the *self*-recreating. The emphasis on ‘self’ being core to the interpretation whether this is “informational” (e.g. Beer, 1994, pp. 210 ff.) or physical (as is implied in Maturana and Varela’s definition, *op cit*), as the “what the system does” (Beer, 1985, p. 128) in order to be either “viable” or “autopoietic” is to make itself.

The role of the “systems one”, in Beer’s words, is not to create what would normally be regarded as the output of the system (i.e., in commercial or industrial terms, the *product* or *service* it delivers to market), it is to create the system itself. And, given this interpretation, allows a basis for biological analogy whereby, e.g.:

suggest that the essential variables possess a vector like quality such that stability is a characteristic of

differentiation *within* a market may be regarded as *genus* level specialization;

and

shifts between markets as *speciation*.

The first being a *refinement* of the current interpretation of ‘self’, i.e., current behaviours are modified to allow continuation of identity in changed or competitive conditions, and the second a complete redefinition of the self to be maintained.

Summary

In this chapter a number of mathematical models were discussed with the aim of “*exploring* these models and their potential to illuminate” the construction of the prototype of the model eventually proposed. As always, the chapter assumes the basic validity of the principles of cybernetics, and that they have a general applicability — whether formal or simply illustrative or heuristic.

the whole, hence the actual values of the variables has importance only *in combination*.

That most systems which exist in dynamic equilibrium with their environments are iterative can, I think be adequately demonstrated in fields as diverse as planetary biology (e.g. Lovelock's "Gaia" hypothesis, Lovelock, 1995a; 1995b), population dynamics (as demonstrated in the logistic difference equation, see, e.g. Gleick, 1987, pp. 63/4 or Stewart, 1989, pp. 145 ff.) and commerce (in the fact that the resource inputs for future periods (i.e. revenues) is a function of the outputs of previous periods (i.e. the price and sales levels of products/services¹²)).

And iteration, taken together with Prigogine's model of the self-organizing system and Kauffman's autocatalytic set provide a basis for proposing that autopoiesis can be viewed as a dynamic process of:

self-maintenance whilst environmental conditions allow an established system to approach stable states within current structural constraints and;

self-recreation in environmental conditions where the interaction of structural constraints and constituent parts are taken beyond this.

¹² Note that this is returning to the traditional definition of organizational output

By thus synthesizing notion of autopoiesis with a representation of Ashby's ultrastable system (i.e. Beer's "3-4-5" homeostat) it was possible also to arrive at the conclusion that the function of the operational level of an autopoietic system (i.e. Ashby's "reacting system" or Beer's "3-2-1" homeostat) was not to create an output which was passed *across* systemic boundaries but to create the system itself¹³, and to maintain this existence over time in a dynamic balance with its environment.

Finally, there are two outcomes from the model introduced to demonstrate the necessity of the embedment of the system in an environment. The first is its ability to demonstrate an efficient manner of increasing sensitivity to environmental stimuli (i.e. the exponential rise in the variety of the interface in relation to arithmetical rises in internal variety¹⁴). And the second in that, by modeling both the system in focus

¹³ An interesting conclusion to this line of reasoning is that the "products" of commercial companies are waste products of the maintenance of the organization, rather than the organization being necessary to the provision of the product.

¹⁴ It should be noted that this strongly supports the critique of quality management through variety reduction (in chapter four) and, by implication, the "skills based" approach to the quality assurance of service provision.

and its environment as *flows*, the re-iteration of the dynamic system as iterative¹⁵.

It is suggested that when the insights from these models are integrated with the ‘active’ cybernetic models selected (i.e., with the ultrastable system or the “3-4-5” homeostat of the VSM) they provide some formal basis for the consideration of autopoiesis, stability and change. These considerations, along with those from the next chapter, are developed further in chapter seven and formalized into a coherent model in chapter eight.

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¹⁵ Note that a recursive application of this principle provides an *a priori* basis for the “Gaia hypothesis”, assuming only that the environmental system is ‘pumped’ by the sun.

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Chapter 6

Biological Models of Change

Introduction

This chapter concludes the discussion of models and mechanisms of change *in isolation*. The reason for such a detailed consideration is the belief (argued for in chapter seven) that the key to survival lies not in self *identity* but in self *similarity*. That is that the “viable” system maintains its viability by changing (however slightly) in each new recreation of itself.

Where the previous chapter considered models of systemic change ‘in the abstract’ this chapter considers *applied change*. This consideration of biological change arises from an interest *survival* or “viability”. That

is, the question of why such relatively fragile entities as living things should be able to display so tenacious grasp on existence. In other words "How can something so obviously fragile be so apparently robust?". The chapter concludes by proposing a structural model of change based on a synthesis of the biological models discussed and which is consistent with the rubric of the VSM and the ultrastable system.

The idea that a living entity is a function of its environment (a conclusion I share) has been accepted at least since the time of Lamarck . The fact that Lamarck's model was eventually rejected in favour of Darwin's is not really the point. The point *is* the statement and acceptance of the fact that an organism or population of organisms *changes as a result of the pressures placed on it by its environment*.

Living entities are not unconditionally or absolutely robust, their robustness is an emergent property of their adaptedness to their environment. Thus, in biological terms, robustness is relative (ask a hedgehog on the M6).

The most widely accepted model of evolution is that of “natural selection” presented in Darwin’s ‘Origin of Species’ (first published in 1859). However, today’s orthodoxy was not universally accepted at the time, indeed when

“[T]he Origin of Species by Means of Natural Selection appeared ... [I]t was greeted with violent and malicious criticism” (preamble, Darwin, 1985).

Lamarck’s “inheritance of acquired characteristics” (Lamarck, 1914), for example, presented an equally convincing argument and one, as we shall discuss later, which may be more appropriate to management science. In this discussion I shall also consider Kimura’s “neutral theory” (Kimura, 1968 and 1983), which suggests that the vast majority of genetic mutation is selection neutral; therefore overcoming the problems of Darwinian selection by providing a mechanism for offsetting its reductive tendency. And Bogdanov’s “podbor” (Bogdanov, 1996, pp. 175 ff¹.) which provides a much more ‘modern’ model of systemic adaptation.

Natural Selection

The Origin of Species by Means of Natural Selection (Darwin, 1859), is now regarded as being the seminal scientific (i.e. non-creationist) account of the existence of the many, diverse life forms we now observe. Paradoxically however, Darwinian *evolution* does not rely on *adaptation*. Individuals do not adapt to their environment in Darwin's model; populations evolve through the selective reproductive advantage gained by individuals that have characteristics more suited to their environment than their counterparts. These characteristics are not developed over the lifetime of the individual as:

“Natural selection can act only by the *preservation* and accumulation of infinitesimally small *inherited* modifications...” (Darwin, 1985, p. 142; italics added).

From the language Darwin used it is obvious that he considered natural selection to be a *positive* force for the *improvement* of “organic beings”. In this way each population, being comprised of innumerable individuals in their turn possessing minor variations, would gradually come to

¹ One should note that in this translation “podbor” has been rendered as “selection”, although, more

possess characteristics which uniquely suited them to their place in the world. Thus the environment, in all its pre-existing diversity is the driving force of the origin of species.

“It may be said that natural selection is daily and hourly scrutinising ...every variation, even the slightest; rejecting that which is bad, preserving and adding up all that is good; silently and insensibly working ... at the improvement of each organic being in relation to its organic and inorganic conditions of life.” (Darwin, 1985, p. 133).

The problem is that selection is not positive. Natural selection does not choose those characteristics that are suited to a particular environment it eliminates those which are not; natural selection is negative. And the negative selection of unsuited form leads to the *reduction* of variety both within a given environment and a given population.

Darwin's model was also far from immune to the influence of the social and political orthodoxy of the day, as is demonstrated in his proposal of the “struggle for existence” (Darwin, 1985, pp. 114 ff.). Based on his acceptance of Malthus' doctrine concerning the arithmetic growth of

recently, this has been challenged by Pustyl'nik (1995) and Dudley and Pustyl'nik (1995).

resource and the geometric growth of population (Malthus, 1803) Darwin comes to the conclusion that:

“... as more individuals are produced than can possibly survive, there must in every case be a struggle for existence ... [I]t is the doctrine of Malthus applied with manifold force to the whole animal and vegetable kingdoms ...” (Darwin, 1985, p. 117)

And, as Darwin states later;

“... the struggle almost invariably will be most severe between the individuals of the same species, for they frequent the same districts, require the same food, and are exposed to the same dangers.” (Darwin, 1985, p. 126).

Thus arises an intra-specific war where those which are most alike compete most fiercely against each other for increasingly scarce resources in, quite literally, a fight to the death. This war is won by those (individuals or groups) in the population that possess even the slightest advantage, and so go on to breed. This increases the percentage of the population that possesses the desirable characteristic. The losers are

doomed to extinction through premature death and the inability to reproduce; there is no reprieve, no opportunity for its later acquisition.

Taken together, negative selection and the struggle for existence should lead to the irrevocable loss of particular biological patterns and, with a fixed environment, imply the evolution of a single, *super-species* which is perfectly adapted to it. This, of course, is the complete opposite of what Darwin wished to prove.

Darwin was not unaware of the advantages for survival to be gained from differentiation, although, in relation to the “struggle for existence” it is presented in the negative:

“... the struggle will generally be more severe between species of the same genus ... than between species of distinct genera ...” (Darwin, 1985, p. 127).

To present this in reverse, *the struggle will generally be less severe between species of different genera than between species of the same genus*. Hence the more different two populations are the less intense is their competition likely to be.

It is apparent that Darwin was aware of variety generation in the evolutionary process but was limited by the absence of an understanding of genetics. As we can see from Darwin's conclusion that:

“... we may conclude that in many organic beings, a cross between two individuals is an obvious necessity for each birth ...” (Darwin, 1985, p. 147)

thus variety in the *Origin* is combinative (see Darwin, 1985, pp.142-147), based mainly on sexual reproduction. This however does not overcome the essentially negative nature of selection.

A more powerful force for the generation of variety is Darwin's tacit acceptance of a co-evolutionary process demonstrated in the statement that:

“... I can understand how a flower or a bee might slowly become, either simultaneously or one after the other, modified and adapted in the most perfect manner to each other, by the continued preservation

of individuals presenting mutual and slightly favourable deviations of structure.” (Darwin, 1985, p. 142).

Taken together, combinative variety generation as a result of sexual reproduction and the possibility of a moving environment go some way toward assuaging the reductive tendency of the overall model. Unfortunately Darwin seems to have disregarded the wider implications of the co-evolutionary paradigm and, due to the fixed nature of individuals during their lifetime, an infinitely varied environment is necessary for natural selection to continue to generate variety indefinitely. This is, of course, quite consistent with the Victorian attitude and it is not surprising to find it reflected in Darwin’s thought; however some further force or mechanism is needed to complete the model of natural selection.

Neutral Theory

Kimura’s “neutral mutation-random drift hypothesis” suggests that the fixation of change at the molecular level and, therefore, genetic diversity is the result of largely random mutation in the nucleotide sequences that provide the code for amino acids. If applied in the strong sense this

means that, far from being caused by positive pressure for change (as predicted by the Darwinian model), evolution is driven by fixation of randomly occurring mutations according to the probabilistic mathematical models of population genetics. Therefore that the major influence on genetic diversity within populations is the “random drift” into and out of existence of selectively neutral or nearly neutral molecular level mutations; their eventual loss from or fixation in the general population being more dependent on initial frequencies than any other factor.

In his paper (Kimura, 1968) Kimura states that the rate of molecular level mutation is

“... approximately one substitution in 28×10^6 yr for a polypeptide chain consisting of 100 amino acids ...” (Kimura, 1968, p. 625).

And that:

“Because roughly 20 per cent of nucleotide replacement caused by mutation is estimated to be synonymous, that is, it codes for the same amino acid, one amino acid replacement may correspond to about 1.2

base pair replacements in the genome. The average time taken for one base pair replacement within a genome is therefore

$$28 \times 10^6 \text{yr} / (4 \times 10^9 / 300) / 1.2 = [\text{approx.}] 1.8 \text{yr}$$

... the calculation of the cost [of this high rate of substitution] based on Haldane's formula shows that ... the substitutional load becomes so large that no mammalian species could tolerate it" (Kimura, 1968, p. 625,).

His conclusion is that the vast majority of nucleotide mutation must be "selection neutral"; i.e. that the changes that occur either code for the same amino acid or the new amino acid is "synonymous" (i.e. it is functionally identical).

In his later work he presents "The neutral mutation-random drift hypothesis as an evolutionary paradigm" (Kimura, 1983, pp. 34 ff.).

Here he asserts that:

"... at the molecular level most evolutionary change and most of the variability within species are not caused by Darwinian selection but by random drift of mutant alleles that are selectively neutral or nearly neutral" (Kimura, 1983, p. 34).

This assertion and the construction of Kimura's "evolutionary paradigm" is based:

"... on the well known fact in population genetics that mutants do not need a selective advantage for some of them to spread through the population. If mutants are selectively equivalent ... their fate is left to chance ..." (Kimura, 1983, p. 35).

Thus the drive for evolutionary change is the random mutation of selectively nearly equivalent (i.e. they do not have a selective advantage of more than the reciprocal of twice the effective population size (Kimura, 1983, p. 35)) nucleotides rather than the positive selection predicted by Darwinian natural selection. Because of this selectively advantageous and deleterious mutations (as long as their co-efficient of selective advantage falls within the limits stated) drift into and out of the population dependent more on initial frequency than selection as to their eventual fate.

Gould takes up this issue in an essay entitled *Betting on Chance—and No Fair Peeking* (Gould, 1993, pp. 396 –406). In this essay he raises a

point that is related to the critique of natural selection in the previous section, i.e.:

“If selection controls evolutionary rate [i.e., if selection is positive], one might think that the fastest tempos of alteration would be associated with the strongest selective pressures for change ... Neutral theory predicts completely the opposite ...” (Gould, 1993, p. 401; brackets added).

This neatly defines the criteria by which to test whether or not the neutral theory has any value. If, for example:

“For Darwin, the predominant source of evolutionary change resides in the deterministic force of natural selection. Selection works for cause and adapts organisms to changing local environments. Random variation supplies the indispensable “fuel” for natural selection but does not set the rate, timing or pattern of change.” (Gould, 1993, pp. 397/8).

And if in neutral theory:

“The most rapid change should be associated with unconstrained randomness — following the old thermodynamic imperative that things will invariably go to hell unless you struggle actively to maintain them as they are.” (Gould, 1993, p. 401).

Then in deciding which of the two models is correct it is necessary initially only to consider the rates of molecular change in genes which are selection neutral. This Gould does and states that:

“The most impressive evidence for neutralism as a maximal rate has been provided by forms of DNA that make nothing of potential selective value (or detriment) to an organism. In all these cases, measured tempos of molecular change are maximal, thus affirming the major prediction of neutralism.” (Gould, 1993, p. 402).

This notion of *maximal* rate is central to the argument because of the prediction inherent in the positive aspect of natural selection that the rate of change will tend to be highest in those areas where the potential for selective advantage is highest.

This, however, is not the complete rout one may expect. It appears that the rate of molecular change is not constant at all levels. Selection does also play a part; molecular level change is not entirely random, the mutation of *selection active* genes is *damped*. This effect is brought about by what Gould calls “watchdog selection” a process whereby individual molecular level changes are screened not for positive advantage, but for damaging effects. Because of this changes that have no effect on the characteristics of the organism, and are thus “invisible” to the selection process, are allowed to continue unchecked. This model of selection has the advantage of being relatively cheap in terms of the effort involved in generating change at the molecular level whilst retaining systemic integrity. It also has the advantage of explaining the possibility of the retention of genetic diversity within a reducing model:

“... we should not overlook the possibility that some of the ‘neutral alleles may become advantageous under an appropriate environmental condition ... neutral mutants have a latent potential for selection ... polymorphic molecular mutants, even if selectively neutral in prevailing conditions of a species, can be the raw material for future adaptive evolution. To regard random fixation of neutral mutants as

‘evolutionary noise’ is inappropriate and misleading” (Kimura, 1983, p. xiii).

Once genetic mutation is freed from the constraint of “positive selection” it becomes possible for the gene pool to vary consistently within the reducing tendency of Darwinian evolution. And also makes it possible for latent selective advantage to be built into the genetic system.

The Inheritance of Acquired Characteristics

The “inheritance of acquired characteristics” model of evolutionary change ascribed to Lamarck is now discredited as a method of explaining biological transformation. The notion that:

“... it is not the form of the body or its parts which determines the habits, the manner of life of animals; but that on the contrary it is their habits, their manner of life, and all the effective circumstances which have, in time established the form of the body and of its parts.”

(Lamarck, 1984, p. 415).

i.e. that the habitual use or disuse of particular elements of form in the daily process of maintaining existence will, over time, come to bring

about changes in the form of the individual which has these habits; and that, once acquired, these characteristics can be passed to subsequent generations through the reproductive process, were superseded by the work of Darwin, published some fifty years after the original publication of *Philosophie Zoologique* (Lamarck, 1809).

Lamarck distilled this doctrine into two laws:

“First Law

In every animal which has not passed the limit of its development, a more frequent and continuous use of any organ gradually strengthens, develops and enlarges that that organ, and gives it a power proportional to the length of time it has been so used; while the permanent disuse of any organ imperceptibly weakens and deteriorates it, and progressively diminishes its functional capacity, until it finally disappears.

Second Law

All the acquisitions wrought by nature on individuals, through the influence of the environment in which their race has long been placed, and hence through the predominant use or permanent disuse of any organ; all these are preserved by reproduction to the new individuals which arise, provided that the acquired modifications are common to

both sexes, or at least to the individuals which produce the young.”

(Lamarck, 1984, p. 113, italics in original).

As can be quite clearly seen, the first of Lamarck’s “laws” is, according to the definition presented earlier, *adaptive*, that is it allows change in the organism during the course of its own lifetime; practice is the determinant of form. In isolation this statement is uncontentious as it squares with human experience such as the development of muscle in the athlete or the progressive loss of muscle tone following illness or injury.

The first law can also be viewed as a model of learning, continued practice in the acquisition of skills or knowledge during schooling, apprenticeship or instruction in the professions can be relatively easily perceived in the same light. And loss of skill due to prolonged non-practice is also coming to be recognized.

It is in relation to the hypothesis of the second law, asserting the heritability of these acquired changes, that Lamarck’s doctrine was successfully challenged by the Darwinists. Current orthodoxy states that the concretization of *structural* change across generations is not possible

on the basis of the behavioural patterns of breeding individuals; the blacksmith's son will not necessarily be musclebound.

Even when set

“... in the context of a uniformitarian geology that provided the vast expanses of time necessary for imperceptibly small changes to produce over countless generations all the different forms of life on earth.” (Burkhardt, 1984, p. xxiii);

it seems that nature did not adopt such a mechanism as Lamarck proposed. Thus as a model of the natural change of biological forms we must abandon the “inheritance of acquired characteristics”.

However, all is not lost for the Lamarckian model. As Gould states:

“Human culture has introduced a new style of change to our planet, a form that Lamarck mistakenly advocated for biological evolution, but that truly does regulate cultural change — inheritance of acquired characters. Whatever we devise or improve in our lives, we pass directly to our offspring as machines and written instructions.”
(Gould, 1993, pp.215/6).

Learning, which Gould (above) calls cultural change, is an adaptive process; indeed the notion of learning is meaningless if it cannot be recognized as change within the lifetime of an individual. The beauty of Gould's statement is the succinct way in which it demonstrates the passing of the change across generations.

Perhaps here, in the areas of individual and organizational learning, the inheritance of acquired characteristics can make a contribution to knowledge. If we take Gould's proposal, i.e. that enculturation is a process of acquiring characteristics and that to be regarded *as cultural* these acquisitions must persist, as a starting point, then it is possible to consider the extent to which cultures reproduce and/or change.

Podbor

The final model of systemic change to be considered is Bogdanov's "podbor". However, unlike the previous writers, Bogdanov, working on this concept in 1912, explicitly includes a mechanism for the role of the environment — coining the phrase "bi-regulator" to describe a mechanism by which two functionally connected systems each influence

the other's behaviour. In the extended extract below Bogdanov describes this mechanism.

“This is a combination in which two complexes mutually regulate each other. For instance, in a steam engine it can be arranged such that the speed of rotation and steam pressure mutually regulate each other: if the pressure rises over the correct level then the speed [of rotation] increases as well and a mechanism depending on it then lowers the pressure and vice versa. In nature biregulators are also not infrequent: an example — the equilibrium system of water and ice at 0 degrees C. If the water warms above zero the ice in contact with it takes away the excessive heat, absorbing it in the process of thawing; if it is cooled then some portion of the water freezes releasing heat which prevents the temperature of the ice from falling below zero. In social organization the biregulator occurs very often in the form of systems of "mutual control" of persons or institutions, etc.

The biregulator is a system which does not need a regulation from outside because it regulates itself. And it is obvious that if living protoplasm turned out to be a chemical biregulator it would be possible to explain why materials coming into it do not change its composition but rather are arranged into its frame.” (Bogdanov, 1989 vol. 2, p. 97),

Bogdanov in his major work, *Tektology* (first published 1913), attempted an explanation of the existence, development and demise of objects in the physical world. Although Bogdanov held Darwin's work in great respect, calling him the "great father", the intention of the *Tektology* was to go beyond the biological model proposed in *The Origin of Species* and account for universal processes of change. Bogdanov also, in common with many Russian thinkers of his time, rejected the influence of Malthus on Darwin's work considering it "... an apology for capitalism ..." (Bogdanov, 1996, p. 185) which led him to a rejection of intra-specific struggle, "red in tooth and claw" as the basis for universal organization and change.

The mechanism Bogdanov proposed for universal organizational development were the two forms of "podbor" or "selection", conservative, the "[L]aw obedient retention or destruction" (Bogdanov, 1996, p. 175) of forms and progressive, "the dynamic element of conservation" (Bogdanov, 1996, p.193). Bogdanov did not use the Darwinian adjective natural

“... for in tektology the difference between “natural” and “artificial” processes is not important ... The notion of selection, which has made its way in the world, first of all in biology, is nevertheless, as we admit, a universal one: organizational science must apply it to any and whichever complexes ...” (Bogdanov, 1996, p. 175).

In extending the applicability of podbor from biological to universal relevance Bogdanov makes use, in place of intra-specific struggle, of the notion of equilibration, or the process of equilibrium seeking. This term was introduced by Gorelik (1987) and mistakenly defined as movement toward *the* equilibrium. Later work by Dudley and Pustyl'nik (1996) restates the case for equilibration within the wider context of the tektological model and posits it as a perpetual process in an open system maintained “far from equilibrium” (see, e.g., Jantsch, 1980; Prigogine, 1980; Prigogine and Stengers, 1985).

The complex is the fundamental object of Tektology, and is what we would now recognize as an open system; its separate existence explained as the result of *disingression* or, the balancing of equal and opposite *activenesses* (Bogdanov, 1996, p.136ff.). Thus, for Bogdanov, the complex exists in some form of balance or equilibrium between its own

internal dynamics and those of its environment. Changes in either will cause changes in the point of balance and, therefore, in the complex in its relationship with the environment. Thus a complex, immersed in a constantly changing milieu, is constantly having to cope with differing points of balance.

It is against this background that *conservative* podbor operates in a manner similar to Darwinian selection. In conservative podbor the “fundament” (Bogdanov, 1996, p.183) of selection is the ability of the complex in its extant structural form to attain a balance against environmental pressure. If this is possible, and the structure is retained, the complex survives; if not, and the structure collapses, the complex in its original form, ceases to exist. An interesting extension to this in Bogdanov’s reasoning is that, even given the collapse of the extant structure, in Bogdanov’s model the constituent parts continue to exist but in a structural form, or relationship, where balance can be attained.

Progressive podbor is rather more interesting and Bogdanov was explicit in its definition. First, as Bogdanov makes plain in a footnote:

“... “Progressive” here originates not from the word “progress”, but “progression”, i.e. a continuous sequence of events, going on in this or that direction.” (Bogdanov, 1996, p. 203).

Thus the notion of progressiveness does not imply a particular direction or *improvement* but a continuity of process.

Second, Bogdanov’s conviction that:

“...precise conservation is impossible, and approximate conservation implies only practically small changes towards the prevalence of assimilation over de-assimilation, or the other way round. This alone makes the scheme of conservative selection scientifically insufficient ... generally, it can be easily proved that the real conservation of forms in nature is possible only by means of their progressive development; without it, “conservation” imminently reduces to destruction ...” (Bogdanov, 1996, p. 190/1);

suggests that complexes in Tektology are constantly changing; they are understandable only as *process*, as opposed to *state* oriented objects.

This short passage finally disproves the definition of equilibration applied by Gorelik (or Zeleny, 1988) as, if a complex is constantly changing in response to differing points of equilibrium, it can never rest at *the* equilibrium. Therefore the process of equilibration in Tektology maintains the complex in a continual process of adaptation within the context of an equilibrium-seeking but non-equilibrium, ingressive² world

Progressive podbor functions through the accumulated effects of assimilation/de-assimilation (Bogdanov, 1996, p. 190), that is the acquisition or loss of the activities/resistances (Bogdanov, 1996, p. 72 ff.) that constitute the complex. It is necessary to the complex not only because of the impossibility of retention through simple conservation (see earlier) but also to allow for the development or maturation of forms. In Bogdanov's words, its absence:

“... makes problematic the explanation of those cases when a form changes by progressive development; to call them “conservation” would be inaccurate and, of course, they are not cases of destruction ... we know that a baby is not just conserved but is developing ... [I]f

² Ingression is the mechanism by which “complexes” are joined together. Bogdanov extends this concept to “world ingression”, the complete interconnexion of all complexes on the planet (see Bogdanov, 1996, pp. 127 ff. and 169 ff.).

the baby ceases to grow, we see nothing good in that he remains as he is ... we assume that his viability has decreased, that he is threatened by degeneration.” (Bogdanov, 1996, pp. 190/1).

Somewhat counter to Bogdanov’s assertion, the necessity and contribution of progressive podbor lies not in the ability to explain change within a particular structural form (whether positive or negative) as this can be adequately accounted for by the simpler notions of conservative podbor or, equally, in Darwin’s natural selection. I believe that the contribution lies in the notion of crises. Crises are the events he introduces as the limit cases of progression in any given direction.

Other things being equal, the structural integrity (or identity) of a complex will remain intact whilst individual variables hold one of a range of possible values. This range is not infinite, nor will it generally extend to the full range of physical values available to the variables in isolation. It will be constrained within the limits set by the structural relationships of the complex as a whole. Thus a sustained acquisition or loss of activities/resistances will, eventually, force the complex beyond its structural capacity to re-equilibrate itself; that is it will be unable to

maintain itself in its previous form. At this point an inevitable, and radical restructuring will occur.

The process of progressive podbor, through the mechanisms of assimilation or de-assimilation, can be seen to be the process of pushing an equilibrating complex “far from equilibrium” toward a structural “crisis”. Some seventy years later, using different examples, Prigogine (Jantsch, 1980; Prigogine, 1980; Prigogine and Stengers, 1985) restates Bogdanov’s notions of organization and crisis; naming them, respectively, “dissipation” and “self-organization” (see also Dudley and Pustylnik, 1996).

In Summary

This chapter introduced four models of change that have, at different times and with differing degrees of (scientific) success, been applied to explain evolutionary change in biological systems. All, however, have potential utility in the design and investigation of organizations and on machines to simulate them.

Natural selection, in conjunction with the neutral theory, is accepted as the mechanism of the evolution of living beings. A negative bias on selection, such as that put forward by Darwin, seems to be a necessary corollary to the expansive tendencies of a reproducing population, and a reproducing population seems to be a necessary corollary to a population where the individual members have a limited lifespan.

Darwin's natural selection appears as a normalizing model; operating in a conservative manner it 'damps down' selectively non-neutral mutations. And Kimura's random drift hypothesis generates the possibility of the perpetual change needed to stop the reductive nature of this leading to genetic homogeneity. It therefore seems sensible to consider them as two halves of the same model; a model which leads to 'punctuated diversity', a state of affairs where all things are different but are also clustered into stereotypical groupings such as species, genera, etc..

The inheritance of acquired characteristics, although recognized as false in relation to biological evolution, does give indications of promise for the areas of cultural or knowledge development. This area extends quite

naturally to include management science, providing a basis for motivated or *directed* development. There is little practical difference³ between the inheritance of *acquired* (or accidental) characteristics and the *motivated* (purposeful) development of characteristics for inheritance. A second avenue for exploration suggested by this model is the development of adaptive genetic algorithms, these can then be used to specify the wider system, leading to the possibility of ‘structural learning’ which may be applicable to research into artificial intelligence or artificial life.

Finally podbor; Bogdanov’s notion provides a conceptual framework for positioning these other models, suggesting the mechanisms that may trigger or instigate change processes. The wider context of the Tektology also provides a connexion between the models of the physical and biological sciences.

As with so many things in the human study of nature the combined Darwin-Kimura model is not the only conceivable solution, simply a solution which nature seems to have adopted. Perhaps this is a

³ Although there may be a profound *ethical* difference.

consequence of living in a quantum universe. Both Lamarckianism, as demonstrated in Gould's statement that although:

“... [M]istakenly advocated for biological evolution ... does truly regulate cultural change ... Whatever we devise or improve in our lives, we pass directly to our offspring as machines and written instructions. Each generation can add, ameliorate, and pass on, thus imparting a progressive character to our technological artifacts.”

(Gould, 1993, pp. 215/6.).

and podbor, as demonstrated above, are also valid in different areas of study.

By developing a synthesis of the four models it is possible to suggest a structural solution to the problem of a mechanism for change within the VSM/ultrastable system rubric⁴. This synthesis, because of the bias towards *positive* adaptation (and the mode of heritability), is, following the argument made by Gould and the discussion in this chapter (see earlier) *Lamarckian*. However it makes use of the control mechanisms

⁴ See also chapter eight.

of the Darwin/Kimura model and the notion of “crisis” from Bogdanov’s “podbor”.

Thus for any given level of recursion:

As an operative sub-system (i.e. a “system one”) meets a circumstance it is unable to deal with it is forced to restructure according to its internal capacity for change and the constraints implicit in its environment. That is, there is a “crisis” which causes change, the outcome of which is either continued survival in a new (but recognizable) form (i.e., adaptation) or the cessation of existence (i.e., a radical change to some other form, which includes decay or dispersal of the constituent parts). This is the Bogdanovian “crisis” operating as a ‘trigger’.

To the extent that this sub-system continues to exist *and* the effects of the change are either *beneficial* to the operation of the wider system or, as a minimum, *do not compromise* the integrity of its operation *in its current environment* the changes are disregarded.

This is the Kimuran⁵ tendency to “maximal rate” and can be seen to reflect Beer’s (1979, pp. 214/5) assertion regarding the necessity of “autonomy” at the level of system one.

However, to the extent that the sub-system continues to survive such change and *negatively* affects the integrity (or operation in the *current* environment) of the wider system changes are prohibited. This is the element of the Darwinian model that Gould (see discussion earlier) calls “watchdog selection”. This *measured* prohibition of change parallels Beer’s (1979, p. 215) “... minimum metasystemic intervention” — ensuring that the system as a whole continues to fulfil current environmental demands.

The final level of the synthesis is Lamarckian in that as the system meets elements in the environment which cause it discomfort, or it is unable to deal with, it will attempt to change its behaviour (or capability to behave) in a manner that removes the discomfort.

This is the *positive* adaptation evident in both the VSM (Beer,

⁵ However one should note that it is, potentially, a *motivated* change due to the recursive nature of the VSM

1979, p. 231) and the ultrastable system (Ashby, 1960, p. 83/4). It is also a Bogdanovian “crisis” at the next higher level of recursion.

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Chapter 7

The Model

Adaptation and Eigen-ness.

Introduction

In this chapter I shall, using the insights gained from the previous two, present the last of the theoretical arguments used in the construction of the model proposed in chapter eight.

The core of the argument presented in this chapter was originally presented as a response to Beer's "Concept of Recursive Consciousness" (Beer, 1994, pp. 227-255)¹. In his paper Beer lays forth a theory of consciousness that includes notions of recursion, homeostasis, ultrastability and viability, integrating them into a coherent whole.

The aim in writing the response was to integrate "Recursive Consciousness" with the evolutionary and adaptive capacity of physical

consciousness that includes notions of recursion, homeostasis, ultrastability and viability, integrating them into a coherent whole.

The aim in writing the response was to integrate “Recursive Consciousness” with the evolutionary and adaptive capacity of physical rather than cognitive systems. The synergy between the two has led toward what I believe to be a more generally applicable model that I shall develop in what follows.

The approach taken was to use the ideas introduced by Beer, and attempt to use them to construct a model that demonstrated that life and (some minimal) consciousness are, to all intents and purposes, synonymous. Such monistic approaches are, of course not new², however the now dominant ‘enlightenment’ view which strictly separates the verifiable, empirical (and therefore scientific) world from the ‘unverifiable’ (and therefore unscientific) world of the mind and spirit represents them as quaint and old fashioned. It was not intended, nor should it be inferred, to show that all is spirit (or all is matter, for that matter), simply to demonstrate that the models proposed for the adaptation and evolution of

(living) physical systems and those Beer proposes for consciousness systems could be shown to obey similar rules.

I eventually came to the conclusion that non-living physical and living physical and consciousness systems are qualitatively irreducibly different, separated by a boundary of *absolute complexity*, that is, that living physical systems and consciousness systems are *absolutely* complex whilst non-living systems are not³. And that living and consciousness systems are effectively one and the same thing at any given level of recursion.

The one caveat to the above statement being brought about because living and consciousness systems are constructed of the same atomic and/or molecular base materials as non-living systems. And that because of this, systems that exist at the level of absolute complexity will be, to some greater or lesser extent, dependent upon the physics of their constituent *absolutely simple* sub-systems. This leads to the necessity for

² See, for example, *Empiriomonizm*, (Bogdanov, 1906) and *Tektology*, (Vol. 1, Bogdanov, 1996 and Vol. 2/3 Bogdanov, 1989) for a systemic and systematic development of a monistic approach.

³ Note that it is an explicit basis of the cybernetic model that the principles gleaned from the operation of "living" systems are generalizable (see, e.g., Ashby, 1960; Beer, 1981; Wiener, 1961). And that it is possible to extend their applicability to the machine (Ashby and Wiener) and the human or social organization (Beer). Thus the *organization* is regarded as a living (and, by the extension of this

a *commonality of mechanics* across the dividing line between absolute simplicity and absolute complexity. And this commonality must, whilst retaining their essential difference of character and capability, provide the possibility of modelling, for example, the structural collapse of the absolutely complex system following a radical disruption of its absolutely simple constituent parts.

The homeostatic systems introduced in earlier chapters maintain identity, that is to say that when perturbed they actively attempt to return to their original state⁴. The models based on this ability have, in the past⁵, been criticized as leading to stagnation and, by extension, death due to the inability to adapt. The following discussion will attempt to overcome this criticism by specific inclusion of the tension, in adaptive systems, between the need for continued identity and the need for change in order to survive.

Viability (the capacity to persist) requires the walking of a very specific tightrope. As I have said before the ultrastable device is by definition

argument in some way *conscious*, in that it has the potential for an awareness of its identity or *selfness*) system. See also the discussion relating to *absolute* complexity later in this chapter.

⁴ The ability to achieve this is, of course, constrained. Not least by the ability to maintain structural integrity as referred to in relating the relativity of the "robustness of the hedgehog" at the beginning of chapter six.

⁵ See Beer, 1994, pp. 242/3 for his review of the 'anti-homoestatic' literature.

homeostatic — it maintains itself. But this self-maintenance is a *process*, a continuous negotiation between absolute identity and absolute change, rather than a move between *states*; where homeostasis is dynamic *equilibrium* ultrastability implies dynamic *homeostasis*.

Earlier (chapters four and five) I introduced a (simplified) mechanism that supports the extrema of this idea (i.e. where the ultrastable system (or “3-4-5” homeostat) is represented as a simple autopoietic machine). In that model, as in the VSM and the ultrastable system there are two dynamics, one for producing the *current* model of self and one for *(re)defining* it.

Change and Viability

Beginning from the ultrastable homeostat it is possible to address the notion of viability, which Beer (quoting the Oxford English Dictionary) defines as the “ability to maintain a separate existence” (see e.g. Beer, 1985, p. 1). This separate existence again connotes some form of identity; that is it must be possible to identify just what it is that is

maintaining this separate existence. The system under observation must, therefore, have some mechanism for determining its 'selfness', that is it must have a way of determining what constitutes a normal state of affairs for its mode of existence.

For living systems this is, quite literally, vital. To be unaware of danger, damage or malignancy could mean death. Therefore a notion of self, which is necessary in the maintenance of the normal, is also fundamental to determining the abnormal. Likewise in consciousness systems the awareness of self is fundamental to one's learning, enculturation and functioning in society. The inability to sustain a viable identity will almost certainly lead to psychosis or sociopathy. And in both cases it is the *normal*, defined as *conformity to the currently held model of self*, which provides the basis for systemic stability⁶.

But what constitutes this 'selfness'? Selfness (systemic *identity*) it seems is an emergent result of some or other form of "closure" (see, Beer 1994, p. 13 for a discussion of "logical closure"). This may be physical in the usual sense of the word but, in terms of perception it will always be

‘informational’, that is, that in the case of a self awareness there will be a circularity of reference. The informational closure will create the ‘self’ and the ‘self’ will maintain the informational closure.

In adaptive systems this closure can never be complete. In order to be adaptive a system must be aware of its environment but, because of the relative closure, any stimulus received from the environment will be assessed in terms of its impact on the ‘self’.

Here the models of change presented in the previous chapter separate into the two forms suggested.

In the Darwin/Kimura model (presented in chapter six) change *is not adaptive*. Change in this model is largely random, generated by an ongoing flux at the level of genetic identity (with the “watchdog” function damping down selectively “non-neutral” mutation). Whilst such mutation remains neutral, change across *populations* is determined, not by adaptive or selective pressure, but by the frequency of

⁶ Note that there is an implicit recursion from the individual to the societal level contained in this statement. Sociopathy is, by definition, socially determined, it contains within it a notion of what is considered to be ‘socially normal’ and, therefore a notion of societal *selfness*.

occurrence⁷. However, in a dynamic environment (i.e. an environment that *is capable of adaptive change*) neutral changes may very well become *selection active* (whether positive or negative) and thus impact on the adaptedness of the individual or population⁸. The point here is, that the organism *does not change in relation to environmental pressure, it lives or dies according to whether or not its current form is appropriate to current environmental conditions.*

The question “How does this affect me?”, in relation to the evolving biological system can be answered only in one of two ways, i.e., “It allows me to live” or “It causes me to die”. This is because the *identity* is fixed at the individual physical level. Self-similarity, at this level of detail, is a function of *populations* rather than individuals, thus there is a statistical element in the evolutionary process that permits random change in individuals to appear as adaptive change in groups.

The Lamarckian and Bogdanovian models (see also chapter six), on the other hand, by (conceptually) allowing change to the definition of self

⁷ This is because the greater the initial number of occurrences the greater the chance of any single mutation being ‘bred in’ to the wider population.

⁸ Note also that remaining constant in a changing environment can also have the same effect (see the section on “Podbor” in the previous chapter).

can be seen as adaptive. When these systems ask the question “How does this affect me?” they are capable of adding to their evaluation “... and this is what I will do about it”. The access to structural change *during the lifetime of the individual* provides it with an ability to change a) only available to the Darwin/Kimura model at the level of the population (and even then only negatively); and b) capable of application in a positive sense (i.e. the system can *choose* its response)⁹

Both models allow for ultrastability as defined earlier, but it is the range over which they can be considered ultrastable that is different. In one the hedgehog takes its chances if it ventures onto the M6, in the other it is (nominally) capable of metamorphosing into something more apposite.

The *Eigen*-System

It seems to me that any and all adaptive systems need to be able to both change and remain the same. That is they must *approximate* self-identity in the process of change. Identity is, therefore maintained not in exact

⁹ Although this mechanism is not necessarily teleological (as in the case of the Lamarckian model it may be mechanical response to an external stimulus) it can be seen to reflect what Shoderbek, Shoderbek and Kefalas call “third order cybernetics” (1990), i.e. able to “... reflect upon its past decision making ... [it] examines its memory and formulates new courses of action” (ibid. p. 89).

sameness but in *self-similarity*. There *are* changes in state or process variables but they are retained within certain bounds.

And so we must ask “How is it possible to both maintain the self and facilitate change?”. An answer to this question can be modelled using the idea of eigenfunctions and, initially at least, in a manner analogous to their use in quantum mechanics¹⁰, thus retaining our goal of the commonality of mechanism across boundaries of complexity.

Adaptation as a process, as I have already said, allows for the modification of the system whilst retaining its identity, thus we are looking for a model or function where the core structure remains intact, subject to some modifier. In addition we are looking for some mode of representation whereby we can identify the changes in a system as the result of its experience. Prigogine and Stengers provide a key:

¹⁰ In quantum mechanics an eigenfunction is a mathematical representation of a particular systemic state where the associated eigenvalue corresponds to an “observable” value possible under that representation. Thus, where the values observed under experimentation are discrete, for example, one can infer that the system’s variables under investigation correspond to specific eigenstates of the system which themselves are discrete. This is the basis of the discovery, in quantum theory, of the discrete energy states of the electron orbits of the atom. See Dirac (1958) pp. 34 – 48 and pp. 53 – 58 for a detailed description.

“... certain functions behave in a peculiar way with respect to derivation ... the derivative of “ e^{3x} ” is “ $3e^{3x}$ ”: here we return to the original function simply multiplied by some number ...” (Prigogine and Stengers, 1985, p. 221).

From this short extract comes a way forward on both fronts. First, derivation gives a formula for calculating the change in the derived (or output) variable as a function of the change in the independent (or input) variable. And second, the “certain functions [which] behave in a peculiar way”, in particular returning themselves, with the inclusion of a specific modifier¹¹, as the derivative of their application, demonstrate a parallel with the notion of *self-similarity* introduced earlier.

To make this point explicit it is necessary to state that, because we are interested in the approximation of identity following stimulation and/or perturbation, the view we must take is not the traditional one of the application of the transformative powers of the system to its inputs, thus creating outputs. Indeed it is quite the reverse. We must view the

¹¹ We must note one of the characteristics of the choice of example used by Prigogine and Stengers. The constant “ e ” is the base of the natural logarithms and is also its own derivative, that is $d/dx e^x = e^x$. A valid generalization of this is that as $e^x = e^{1x}$, its derivative equals $1e^{1x}$. Therefore the derivative of $e^{ax} = ae^{ax}$, thus obeying the rules stated and giving a general formula for calculating this kind of eigenfunction.

know that adaptive systems *persist*, the result of this application of input to the system must return the system itself altered only by some or other *identifiable* modification. In this model, the derivative of the application of the input to the system is the system (plus some nominal waste product), thus our *eigen*-system appears appropriate.

With this in mind we can use the characteristics of eigenfunctions to overcome the dichotomy between reductionist (i.e., a local and/or linear action orientation *within* a particular value set) and systemic, or holistic (i.e., which would explicitly consider the nature of effects and interactions *between* elements or activities and thus be able to actively manage them), thinking. Reductionist approaches would represent the system as aggregations of processes, whereas systemic approaches represent them as irreducible wholes. However the two approaches can be combined if we accept that, first, a system constitutes, and is

The capacity to maintain this eigen-state will of course be enhanced by the ability, on the part of the system, to differentiate a larger rather than smaller number of states of the environment, thus providing a more finely grained view of environmental conditions. An ateleological basis for this capacity was presented in the *hypersphere* model of chapter five, demonstrating that the system with greater internal variety was capable of generating an exponential gain in interface sensitivity. This extended sensitivity also provides advantage where the system has a motile capacity (i.e. it can move within a spatially differentiated environment, see below) or it does not utilize all the available elements within its environment. Under these (amongst other) conditions is allowed some degree of *choice* in the inputs it will accept in the maintenance of its existence. The completion of this line of reasoning is that progressive adaptation leads to a progressive narrowing of the range of inputs the system is *able* to accept in order to maintain its existence and, therefore, its adaptedness is relativized.

(i.e., which would explicitly consider the nature of effects and interactions *between* elements or activities and thus be able to actively manage them), thinking. Reductionist approaches would represent the system as aggregations of processes, whereas systemic approaches represent them as irreducible wholes. However the two approaches can be combined if we accept that, first, a system constitutes, and is constituted by, a sub-set of the possible permissible combinations of the possible permissible outcomes of all its individual constituent processes taken in isolation. For example a possible and permissible outcome of the combination of water and heat (which does occur in living systems) is boiling water (which doesn't). And second that it is possible for the eigenvalues¹³ of a given function to take on either discrete values or continuous values within a range. Thus it is nominally possible to define an eigenfunction of the form $d/dx e^{ax} = ae^{ax}$ that models the transformation of the system brought about by the operation of the individual processes in combination. But which, for the sets $\{Op P_1 \dots Op P_n\}$ and $\{ae^{ax}\}$, produces a non-empty intersection set only for specific values of a . The eigenfunction or, more correctly, the eigenvalues of the function determine those possible permissible

¹³ An eigenvalue is the number that an eigenfunction is multiplied by to give its derivative see note 5

combinations of the possible permissible outcomes of the constituent processes of the system which allow the system to remain itself, a coherent and recognizable whole. *The eigenvalues provide the indicator of systemic selfness.*

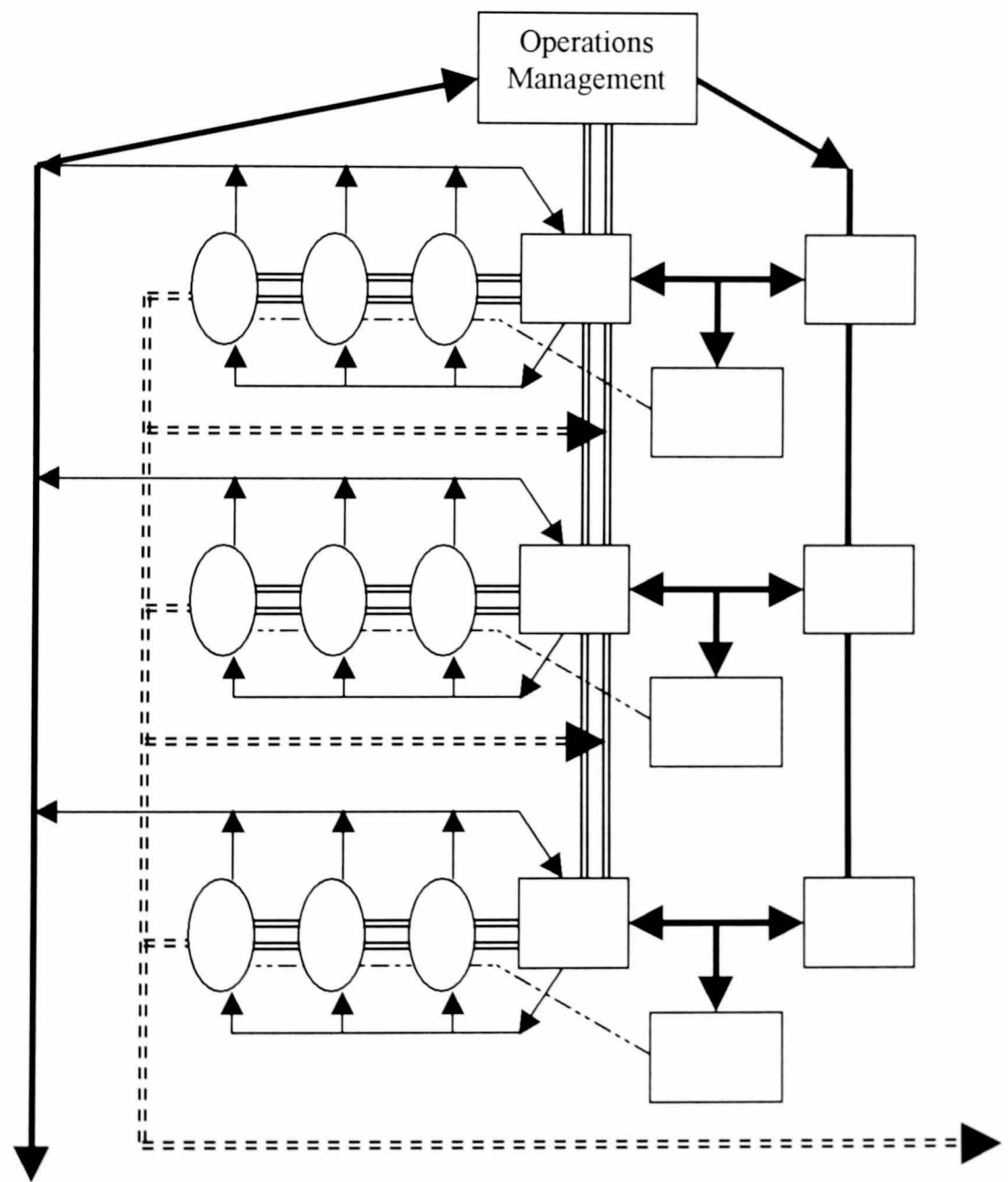


Figure 1: This level of the model can only be considered stable when it balances the capacity of the systems one and the demands of its environment and the demands of the "3-4-5" homeostat.

regarding the rubric.

Now it is possible to begin to construct the model by returning to the ultrastable homeostat. Ashby's *two* feedback loops correspond to two *different aspects* of the existence of the system. The first giving a means for *assessing* the outcomes of action or behaviour in quantitative (or goal oriented) terms, and the second a means for *evaluating* the outcomes of action or behaviour in relation to self. And both loops can be thought of as 'eigenfunctional'.

A detailed development of the first loop is presented in the next chapter. However, at this level of consideration the first loop of Ashby's ultrastable system can be viewed (assuming a complexity of structure made explicit in the VSM) as a *vector*¹⁴, with the output values of the "systems one" representing the elements. Thus the values contained in the vector can be seen to be resultant upon the interactions of the constituent subsystems with their environment(s), of which the second loop can clearly be seen to be part.

The operational level of the system (i.e. Ashby's "reacting system" or Beer's "3-2-1" homeostat) can be seen to be in a stable state when the

values represented by the vector are such that this homeostat as a whole is capable of retaining its current structure (i.e. it is in an eigenstate), both within the physical constraints which exist as a function of the physical capacity of the systems one and the demands made on it by its environment (external in terms of resource availability, etc. and *internal* (for want of a better word) in terms of the demands made upon it by the “second loop” or “3-4-5” homeostat). That is, the achievement of the eigenstate allows this level of homeostasis to persist over time whilst functioning as an iterative system.

The implication (in Dirac’s (1958, p. 37) work on quantum mechanics) that for a vector of this kind to be an *eigenvector* its constituent vectors must also be in their eigenstates does not contradict Ashby’s assertion that:

“... stability belongs only to the combination ...[two] systems, both unstable, may join to form a whole which is stable ...” (Ashby, 1960, p. 56).

¹⁴ Note that this approach also allows for the concepts of recursion and variety filtering. see the summary to this chapter.

This is because, in a dynamic system, the “combination” by moving the environment will also move the local point of stability; thus a subsystem taken in isolation may not be stable but achieves stability when taken in the context of the wider system.

The advantage that the notion of the (self) dynamic system adds to the *purely* mathematical or biological representations is in providing the basis of the ability to *manage* (by defining a value set or *self*) the relationships between its constituent parts, and between itself and its environment, to *actively* achieve stability as opposed to *reactively* be (or not) thrust into it.

If this is viewed in the context of the iterative system embedded in its environment, it is possible to say that (in reference to the model of system as *flow* presented in chapter five) that the eigenvalues of the “3-2-1” homeostat (and/or its constituent processes) are the observed values of the output variables when the homeostat as a whole is in its eigenstate.

And that these values are the points that show on the Poincare section across the flow¹⁵.

Moving to the second of Ashby's loops it can be seen that it provides not only the basis for the integration of the first loop, but also the ability for the definition of systemic identity.

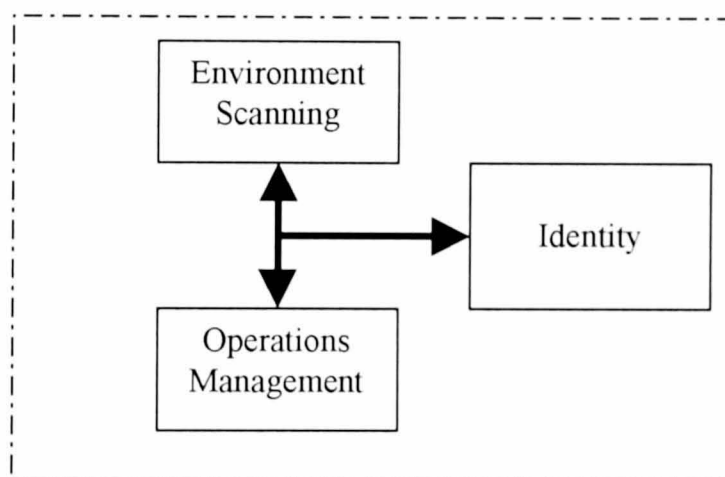


Figure 2: This element of the model is stable when environmental demands and internal capacity return identity as the derivative value

By combining Ashby's second loop and the eigenfunction it becomes possible to replace the "essential variables within acceptable limits" with an eigenfunction such that the comparator in the feedback loop is

¹⁵ Note, as an extension to this, that it is therefore an increase in the variety (response complexity?) in the "3-2-1" homeostat that increases the area of the Poincare section and, therefore the *volume* of the interface. This is entirely consistent with the assertion that "systems that exist at the level of absolute complexity will be, to some greater or lesser extent, dependent upon the physics of their constituent *absolutely simple* sub-systems", i.e. the structural integrity of the system is, although an emergent

If the second loop is (as for the operational level) also envisaged as an vector entity, with the values received from the environment and the eigenvalue of the operational level as the elements of the vector representing one of the exponential values, and the vector representing identity as the other. The system can be seen to be in a stable state when the eigenvalue of this representation is the vector representing identity. This is because environmental demands, internal capacity and identity are ‘harmonised’. If however, this is not the case there are three options if the system is to regain stability:

- a) adjust the values received from the environment (i.e. move),
- b) adjust the stable state of the operational level, (i.e. learn and/or adapt) or
- c) change the values recognized as identity (i.e., become something else — evolve or die).

The first of the possibilities can be seen as either reflex reaction, i.e. action in response to what Beer (e.g., 1979, p.408; 1981, pp. 336/7; 1985, p. 113; 1994, pp. 236 ff.) calls the “algedonic” mechanism or as a ‘hunting’ strategy. In the first sense it causes a convulsive reaction in ~~the~~

“motor” elements of the system causing it to move away from a stimulus that causes “pain”¹⁶, whereas in the second it can be seen, negatively, as a move away from an environment that is unfavourable, because e.g., for lack of food, or positively, towards an environment where it is more plentiful.

The second possibility is more *managerial*¹⁷, in that it relies on an active setting of a *goal state*. Recalculation of the vector representing the “3-4-5” homeostat such that it achieves an eigenstate by resetting the value of the “3-2-1” vector changes the conditions under which the “3-2-1” homeostat is stable, therefore instigating an adaptive response¹⁸. It is also in this type of response that the *physical* and the *informational* are explicitly brought into contact. This is because there is a capacity, in “system three” for “resource allocation” and, via “system two”, for “coordination”. Therefore there is an ability to actively maintain the (physical) outputs of the “3-2-1” homeostat within the (informational)

¹⁶ Note here that “pain” is a “hard-wired”, and internally unpleasant, reaction to a stimulus which compromises the “self-ness” of the system.

¹⁷ Note that this usage is *very* broad.

¹⁸ It should be noted here that this adaptive response is possible because of the recursive nature of the model, i.e., each of the “systems one” in a viable system model is considered to be a viable system in its own right.

the “3-2-1” vector changes the conditions under which the “3-2-1” homeostat is stable, therefore instigating an adaptive response¹⁸. It is also in this type of response that the *physical* and the *informational* are explicitly brought into contact. This is because there is a capacity, in “system three” for “resource allocation” and, via “system two”, for “coordination”. Therefore there is an ability to actively maintain the (physical) outputs of the “3-2-1” homeostat within the (informational) constraints set by the “3-4-5” homeostat as represented by the eigenvalue assigned to the “3-2-1” vector.

The third possibility, metamorphosis, is rarely seen in the biological realm (with the notable exception of the insects) as a adaptive response¹⁹. This kind of change requires *geological time* and the ability to develop “selection neutral mutations” which acquire selection positive status due to environmental change to bring about alteration of forms. However it is a form of organizational change that is suited to, and possible within, social structures as asserted by Gould (1993, pp. 215/6) in his statement that culturation has Lamarckian characteristics.

¹⁸ It should be noted here that this adaptive response is possible because of the recursive nature of the model, i.e., each of the “systems one” in a viable system model is considered to be a viable system in its own right.

¹⁹ See the argument regarding the Darwin/Kimura model of evolution.

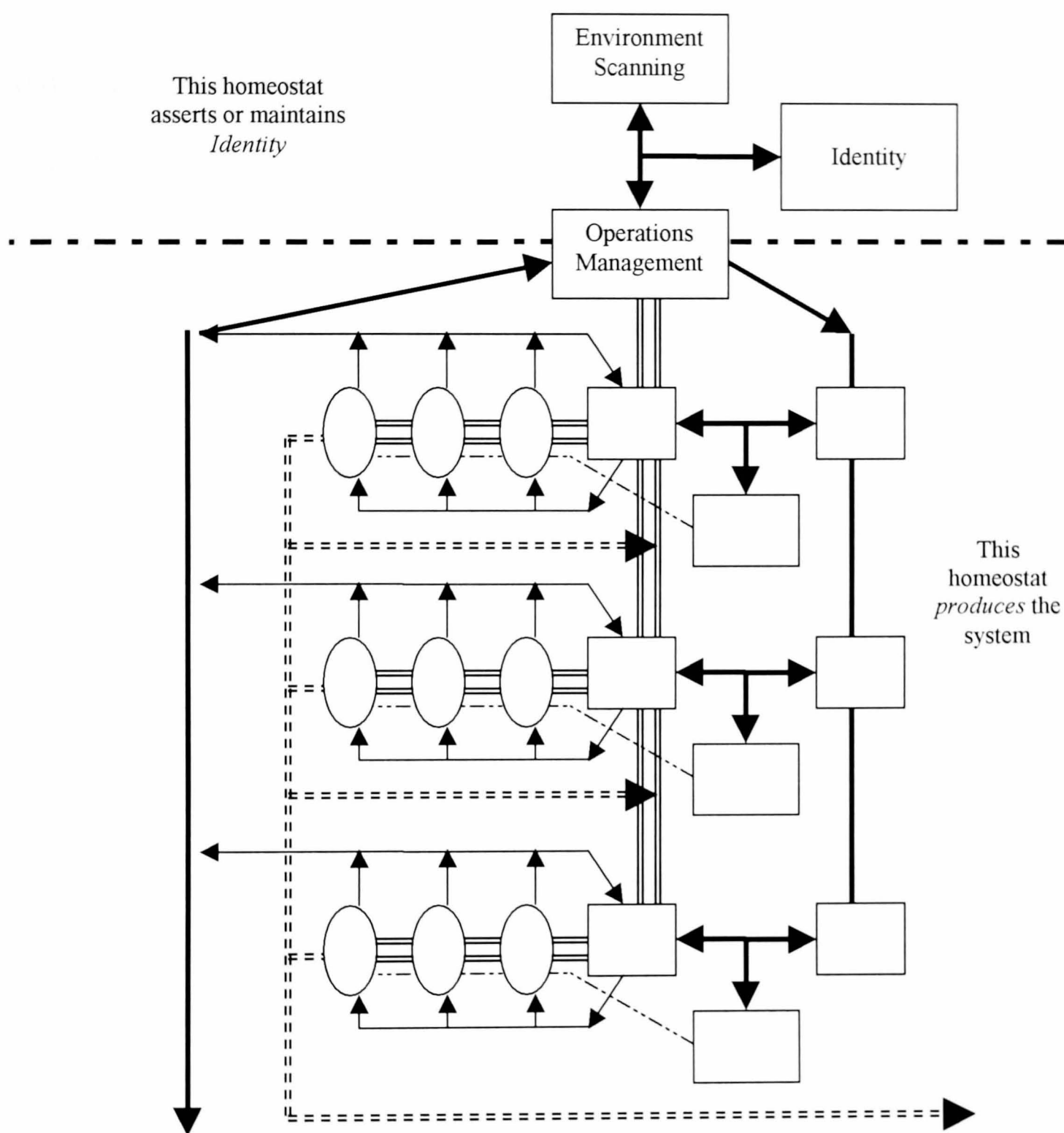


Fig 3: The two homeostatic sections of the VSM satisfy eigenfunctional arguments joined through the activity of "system three".

Thus can the "ultrastable" system or the "viable" system be represented as eigen-systems, but eigen-systems that satisfy two eigen-functional arguments at any given level of recursion.

And that adaptation and/or evolution in these systems can be modelled as a simultaneous satisfaction of the structural conditions (as determined by the values contained in the ‘identity vector’) of these functions within the mechanical constraints of capacity (internally) and resource availability (externally).

In addition to this it must be said that this ‘adaptive capacity’ is only possible

- a) because of the recursive application of the eigen model;
- b) because, at the lowest level of recursion, there are physical constraints on the possible physical changes that can occur.

That is to say that first, in agreement with Allen (undated)

“... if the microcomponents have diverse internal structures, then *evolution* can take place ...”, and second that although the characteristics of the system are an *emergent property of the combination* of its “microcomponents” (Allen undated).

it is still, to some greater or lesser extent, *dependent on their physics for its existence.*

The recalculation implicit in the above model will, of course, take time (however short), and the existence of delays in natural systems would support the verity of the argument. Beer has noted that, in fact, such delays do exist and has given them various names “Relaxation Time” (1974, p. 14; 1979, p. 390) “Reverberation” (1994, p. 14) and “Refractory Period” (1994, p. 233) are a few that are apposite. Although these terms are all used in different contexts they all relate the same concept ‘systemic recovery time’ or, the re-establishment of homeostasis.

Relaxation is the re-approximation of stability following perturbation, reverberation is the approximation of “group consciousness” following the input of information to an “infoset” and the refractory period is the time taken for a neuron to recover after firing. And it seems to me that they can all usefully be conceptualized as the recalculation of self, i.e. the re-assertion of the eigen-ness of the system.

Hence the adaptive system, in cognizing an event seeks a representation of it such that, when it is applied, the outcome is the system itself, modified (probably) by some additional value. Thus, and again in a circular manner, an adaptive system cognizes its reality as a function of itself. In particular those events that are admitted to a given level of consciousness are the eigenvalues that result from the operation of experience on the perceiving system. And learning and/or adaptation are behavioural or structural changes in the “motor output” brought about so as to manipulate the derivative (outcome) of the operation to a state where it is a member of some possible intersection set. The system thus can only allow into cognition those representations of its experience of which its identity is capable of being an eigenfunction and only at the level at which the new eigenvalue ascribed (experience cognized) does not cause a re-calculation at the next higher level (see next section).

An interesting extension of this line of reasoning is that the states available to the system as a result of its experience, within a particular structural set, will correspond to the spectrum of the function. And so, it is possible that there are limits not only to *what* we can experience, but also *how* we can experience it, and that, in calculating the spectrum of

the function used, we can also calculate the quantitative and qualitative limits of cognition.

In common with quantum mechanics the process is not commutable; that is the order of learning is irreversible, learning A before B will not yield the same result as learning B before A. This is consistent with the apparently Markovian orientation of learning, all future 'learning' is at least flavoured, if not determined, by past experience.

An Aside on Variety Filtering

It is now possible to make explicit the role of recursion in the model. Because the statements that a stimulus of which the system cannot make itself an eigenfunction of cannot be cognized and, that a system will attempt to make itself an eigenfunction of a received stimulus are apparently contradictory some further explanation is needed. I say that the problem is apparent because it is a result of activity at different levels of recursion rather than phenomena at the same level. In this model a stimulus is received into the system at the lowest possible level of recursion, i.e., imbibing poison will cause disruption at the *chemical*

level of the cell whereas being struck by an arrow (not poisoned) or a club will cause a disruption at the *physical*.

Both may cause *pain* at the conscious level. The poison because the chemical disruption it causes cannot be contained and therefore it may also cause *physical* damage (here the poison and the club coincide).

The stimulus is passed up a level *because* the state adopted by the receiving level in attempting to maintain its eigen-ness is such that it causes a re-calculation of the eigen-ness of the next higher level of recursion. This 'upward' transmission will continue to a point where the re-calculation of eigen-ness at the receiving level does not cause re-calculation at the next higher level. And, it is my contention, that it is only at this last re-calculated level that it will be admitted into cognition, and therefore be able to drive some or other form of change.

In this manner the upward transmission of stimuli from the lower to the higher levels operates as a variety filter. Perturbations/stimuli are passed into the levels of consciousness which are, from the position of adaptive,

operational or behavioural advantage, most appropriate (this being limited by the informational boundaries of the system in focus).

It is in this way that the atomic or molecular level impacts of the gases of the atmosphere against our skin are not felt. They are (assumedly) absorbed at the cellular level and, thus, do not cause the need for the re-calculation of the eigen-ness of the organ. Thus however much we may be aware of the existence of the individual atoms which constitute the atmosphere, and the fact that they are striking our skin, at the theoretical level, we cannot directly perceive it — it is not taken into consciousness at the *human* level²⁰.

Absolute Complexity

I believe that the argument in the previous sections make it possible to identify an absolute level of complexity analogous to the concept of absolute smallness in quantum mechanics. And to argue that only when an entity crosses into this level does it have the complexity requisite to truly adaptive behaviour.

²⁰ As an aside, it is conceivable that such variety filtration eventually comes to be 'hard-wired', i.e., that the physical distribution of receptors is modified in response to the perception of stimuli over time.

Such a statement requires a definition. Thus, as a first attempt, and paraphrasing Dirac²¹:

If an object is such that it can be reduced to the level of absolute smallness before encountering a fundamental change in its nature, that object can be said to be *absolutely simple*. Its apparent complexity arising only as a result of the *number* of its constituent parts rather than as an *emergent* characteristic of their interaction at some level of minimal complexity.

If, however, an object is such that it cannot be reduced to a level of “absolute smallness” (i.e. where the rules of quantum mechanics apply to observation) before encountering a fundamental change in its nature, that object can be said to be *absolutely complex*.

The use of the phrase “absolute smallness” (used in the same sense as Dirac) is important here because, when the transformation to the quantum level occurs, we are by definition moving away from the macro-level at which life exists. Life is a macro-level phenomenon, it is

²¹ See Dirac, 1958, p. 4.

also a self-organizing or dissipative phenomenon²². This does not mean, however, that dissipative systems are necessarily living systems.

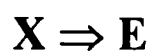
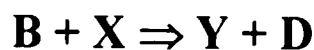
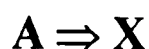
Although it may be tempting to follow that line, I believe it would be difficult to accept chemical self-organizing systems such as the “Brusselator” (see Prigogine, 1980, Prigogine and Stengers, 1985) as conscious²³.

The dissipative system is, no doubt, a step on the path to the living system; by demonstrating the possibility of an entropy trade off such as the one I described in *Food for Trees* (Dudley, 1998) it provides the physics. And it should be possible to model such systems using the eigenfunction notion I have introduced here.

However, and although these systems are absolutely large, they are still absolutely simple, based on the interactions of large quantities of a small number of variables and therefore, allowing for the potential for the statistical variation in composition, are capable of only a small number of combinative states.

²² See Prigogine, 1980 and Prigogine and Stengers, 1985.

The Brusselator, for example (see below), has two constituents capable of generating five self-catalyzed outputs and therefore has, as a maximum $factorial(2+5) = 5040$ possible states; (even a very simple nervous system consisting of only thirteen cells capable of two states each = $2^{13} = 8192$ possible states).



The Brusselator transformation (*taken from Allen, P., LSE lecture*)

In this model atoms cannot be adaptive. This is because the identity of the entity is directly related to its constituent parts, i.e. given one proton and one electron you will get hydrogen, and likewise for all the elements of the periodic table. As in quantum mechanics, where the operation of observation necessarily affects the state of the system being observed, at this level any (quantitative or qualitative) alteration of the constituent

²³ See Allen's assertion regarding the necessity of layers of self-organizing "microsystems", chapter 5.

parts alters the system being observed. And not in an adaptive sense, the change is not an adaptive response, nor is the result a different version of the same thing, it is complete alterity at the level under observation. The system is so simple in some *absolute sense* that its identity is a function of its constituent parts.

Neither are molecules adaptive. They are capable of isomeric forms or, possibly *largely isomeric forms*, (Schrödinger, 1944, p. 56 footnote) which could account for DNA mutation under both natural and radiation induced conditions. But they too are paragons of sameness. And, in addition, the same argument that applies to atoms is relevant here, the isomeric form is entirely different (see Schrödinger, 1944, pp. 52/3), here *identity* is a quantitative function of the structural relation of the constituent parts, and the relatively small numbers involved make this a *direct* relation.

Cells, however, are a different matter altogether. The genetic variation possible through the *mutation* of the DNA molecule added to the buffer provided by the number of atoms/molecules needed to form a cell begins to render the importance of the individual elements (i.e. the

atoms/molecules) absolutely low. Thus, at this level it becomes possible to maintain the macroscopic identity of the higher level self independently of the lower level elements. We come to a threshold of absolute complexity.

And, because the system is recursive, once the threshold has been crossed the quality is retained in the succeeding levels until some qualitative boundary is reached²⁴. Thus both the organ and the organism retain the quality of adaptation²⁵.

Autopoiesis

Thus far the notion of autopoiesis defined by Maturana and Varela (1980, p. 79) has been used in a relatively weak sense, that is, it has been assumed that the organization that continued to survive *was* autopoietic by virtue of its dynamic achievement of viability. Here, because of the conceptualization used during consultancy interventions and the nature of the eigen-system model, this assumption must be subjected to closer scrutiny. Mingers, (1995) presents a “six point key for identifying an autopoietic system” thus:

²⁴ See again Allen’s assertion regarding the necessity of layers of self-organizing “microsystems”

- i) Determine, through interactions, if the unity has identifiable boundaries. If the boundaries can be determined, proceed to 2. If not, the entity is indescribable and we can say nothing.
- ii) Determine if there are constitutive elements of the unity, that is, components of the unity. If these components can be described, proceed to 3. If not, the unity is an unanalyzable whole and therefore not an autopoietic system.
- iii) Determine if the unity is a mechanistic system, that is, the component properties are capable of satisfying certain relations that determine in the unity the interactions and transformations of these components. If this is the case, proceed to 4. If not the unity is not an autopoietic system.
- iv) Determine if the components that constitute the boundaries of the unity constitute these boundaries through preferential neighborhood interactions and relations between themselves, as determined by their properties in the space of their interactions. If this is not the case, you do not have an autopoietic unity because you are determining its boundaries, not the unity itself. If 4 is the case, however, proceed to 5.
- v) Determine if the components of the boundaries of the unity are produced by the interactions of the components of the unity, either by

²⁵ Resulting in abnormalities, e.g., arterio-sclerosis, and/or malignancies such as lung cancer as a

transformation of previously produced components, or by transformations and/or coupling of non-component elements that enter the unity through its boundaries. If not you do not have an autopoietic unity; if yes proceed to 6.

vi) If all the other components of the unity are also produced by the interactions of its components as in 5, and if those which are not produced by the interactions of other components participate as necessary permanent constitutive components in the production of other components, you have an autopoietic unity in the space in which its components exist. If this is not the case, and there are components in the unity not produced by components of the unity as in 5, or if there are components of the unity which do not participate in the production of other components, you do not have an autopoietic unity.

(Mingers, 1995, p. 17)

Mingers explains this “key” thus:

“The first three are general, specifying that there is an identifiable entity with a clear boundary, that it can be analyzed into components, and that it operates mechanistically, i.e., its operation is determined by the properties and relations of its components. The core autopoietic ideas are specified in the last three points. These describe a dynamic

response to tobacco smoke.

network of interacting processes of production (vi), contained within and producing a boundary (v), that is maintained by the preferential interactions of its components (iv). The key notions ... are the idea of production of components, and the necessity for a boundary constituted by produced components” (Mingers, 1995, p.17).

From the key, and Mingers’ further explanation, it is obvious that there is also a ‘strong’ interpretation of autopoiesis; one that it would be difficult, if not impossible, to envisage a non-living system being able to fulfil²⁶. However I think that it is reasonable, given what has been said earlier (both in this chapter and in the models presented in chapters five and six), to suggest that the eigen-system model, insofar as it is applied to biological systems, provides a basis for autopoietic operation.

I also think that it is possible, within the model, to regard social or commercial organizations as autopoietic in a much stronger sense than Mingers’ discussion suggests. This is because:

- a) Social and/or commercial organizations are usually presumed to have an *outcome* or *product*, whereas the biological equivalent of this

outcome or product is regarded as *waste* (see e.g., Mingers, 1995, p. 11). Systems theories in general (and autopoiesis in particular) *begin from a generalization of biological principles*. However this generalization has not been carried to its conclusion, probably due to the fact that it is difficult to accept that we (i.e. humans in general) spend a great deal of time and energy producing the organizational equivalent of excrement. The eigen-system argument suggests that the organization is only stable when its output allows it to persist as an *iterative* system, therefore, that unless it *produces itself* in the process of creating its output it will run out of control²⁷, i.e. it will become non-viable. This reconceptualization of the outputs of a (social/commercial) organization suggests that the primary output of the system is the system itself, the outputs being whatever is left over after the inputs have been so transformed. It also suggests that to question the autopoietic nature of such an organization is to question an analytical truth.

²⁶ Mingers explicitly recognizes this in the discussion contained in chapter eight of his book (Mingers 1995, pp. 119 – 152).

²⁷ The “structural coupling” suggested (Maturana and Varela, 1980, pp. 107 ff.; Mingers, 1995, pp 34 ff.) as representing the feedback mechanisms which allow for adaptation or control can be seen to be posited (implicitly) on the notion of the retention of identity.

b) The torturous language of the sixth element of the “key” which, partly because of its impenetrability, creates a self fulfilling prophesy. The language used in the phrase which allows for components

“... which are not produced by the interactions of other components [but which] participate as necessary permanent constitutive components in the production of other components ...” (Mingers, 1995, p. 17),

seems to preclude those things(?) which are central to the constitution of human/social/commercial systems, e.g., money and/or happiness and/or security, etc.. Society, social or special interest clubs and businesses provide these things in much the same way as biological entities provide advantageous environments to, e.g., useful bacteria, to ensure that *non internally produced* components become²⁸ “permanent constitutive components in the production of other components”.

c) One of the produced components of a social or commercial organization is that of member or employee or, perhaps, shareholder.

²⁸ The inclusion *in the system* of people is, of course statistical, people join, leave (and die) thus varying the direct relationship between individuals and the system in question, but this is no different to comparable relationships in the biological realm.

Being or not being eligible to join one or other of these categories creates the boundary to the system. And, as these conditions are set by committees, departments or roles authorized by the organization (i.e., by components of the organization) it is possible to regard the boundary as being constituted by produced components.

By addressing these issues in this manner the eigen-model can be considered autopoietic in a (relatively) strong sense.

Summary

This chapter introduced the last element of the model, the idea of the *eigen*-system, which was proposed as a structure for integrating the tools and models of change introduced in chapters five and six and the requirements necessary for systems to be regarded as *adaptive*.

The first of the requirements discussed were those of *homeostasis* and *ultrastability* and, following Ashby (1960) and Beer (various), it was asserted that the eigen-system is capable of supporting these notions by way of its structural capacity for asserting its *identity*. That is to say that the derivative of an eigen-function is a multiple of the function itself. In

this way the “essential variables” of Ashby’s ultrastable system could be replaced with an eigen-functional argument that allowed the system to evaluate environmental conditions such that the system was stable (i.e. “... whether or not the value [of the essential variables] is within physiological limits”, Ashby, 1960, p. 81) when the calculation returned the function in an eigen-state.

The notion of identity was then extended to the question of viability where it was suggested that viability in a dynamic environment was dependent on the ability to change in response to environmental conditions (i.e. ultrastability). Here the notion of self-similarity was contrasted to that of absolute identity and the traditional conceptualization of the transformative power of the system was questioned. That is, it was suggested that rather than the system transforming its inputs (from the environment) into outputs (sent back into the environment) the transformation which occurred was the effect the environment had on the system. Therefore that the outputs (traditionally interpreted) were the waste products of the creation of the

system. Such a system, therefore, is continually creating an *approximation* of self in response to environmental conditions²⁹.

In addition to this the eigen-system (when modeled within the ultrastable system) has the potential to change due to the fact that eigen-functions have potentially many eigen-states represented by different eigen-values. Where this occurs in the second of Ashby's feedback loops (i.e. the one that passes through the "essential variables" the system is presented with three options to regain a lost stability: move away from the troubling stimulus, redefine internal structures to cope with the troubling stimulus, become something else. In terms of the eigen-function model this was claimed to be the same as redefining the values in a vector representing the system³⁰.

Using the vector model allowed consideration of the notion of *absolute complexity*, an approach supported by Allen (undated), i.e. that the kind

²⁹ Note that in extending this interpretation in the context of the 'system as flow' model presented in chapter five a basis for an interactive, or co-evolutionary, model is possible. This is because, in that model the "structural coupling" (Maturana and Varela, 1980, pp. 107 ff.; Mingers, 1996, pp. 34 ff.) allows both to be represented as *adaptive*. Therefore the process of equilibration (see chapter six) is bi-directional, *the system is the environment of its environment*. See also Lovelock's "Gaia Hypothesis" (Lovelock, 1995a; 1995b).

³⁰ And, it should be noted that the third option, i.e., *become something else*, is an evolutionary change that is independent of the actual method of change. It is therefore possible for this to allow for the biological model of Darwin/Kimura (assuming that the system has the requisite capacity to generate

of change required by systems such as these also required some minimal level of complexity be available (e.g., Allen's "microsystems with diverse structures"). And that this complexity was qualitatively different from simple numerical complexity (i.e., it was dependent on a recursive structural differentiation rather than simply large numbers of homogenous (and fixed) elements). A recursive application of the eigen-model, in the manner of Beer's VSM (i.e. adaptive, viable systems containing adaptive viable systems) allowed for this but also created the potential for a pathological growth in internal variety (as suggested (negatively) by Beer, see, e.g., 1981, p. 308).

By being comprised of vectors, the elements of which were also vectors, the eigen-model was able to model the recursion and, by making the *eigen-values* of the managed vector the performance criteria it was possible to suggest a method of variety management. That is, by being interested only maintaining or acquiring the eigen-state of the level in focus (based on the eigen-values of the next level of recursion down as the *observable* outputs thereof) the level in focus could treat the next

the non-directed or random change) and the potentially motivated approach allowed in the models of Bogdanov or Lamarck.

level of recursion down as a black box whilst retaining its ability to contextualize behaviour.

The last issue to be addressed was that of autopoiesis in the strong sense. I believe that to say that the eigen-system (when in an eigen-state) is autopoietic is tautologous, any system that must create itself (or a modification thereof) to be stable must create itself (or a modification thereof) to be stable.

However the autopoiesis of the eigen-system is dynamic, it does not simply (re)create an extant self but actively re-calculates the self that is to be created. In this way it is able to close the loop of its “structural coupling” to an environment that is also dynamic whilst still retaining an (internal and self defined) identity which is to some extent independent of it.

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Chapter 8

What Does It Look Like?

Introduction

In the first three chapters of this section I have introduced a range of ideas that relate mostly to change in physical and/or mathematical systems. In this (last) chapter dealing with the model in isolation I shall construct an integrated version, based on Beer's Viable System Model for use in the case study of the next section. Beginning by discussing each of the elements in turn, integrating the characteristics suggested by the previous chapters as appropriate and introducing the alterations necessary to this conceptualization of the VSM. I will then complete the chapter by proposing a rigorous model to apply (in chapter nine) to the problem of satisfying the constraints of ISO CD2 9001:2000 and fulfilling the aspirations of ISO CD2 9004:2000 and (in chapters ten and eleven) to the construction of a quality management system for the Zubnich dental practice.

Chapter five in considered various mathematical constructs which displayed characteristics that appeared to mimic the characteristics of ‘natural’ adaptive or evolutionary systems; whilst chapter six discussed models that have been proposed for these natural systems themselves.

The “self-organizing” systems of Prigogine (1980; 1985) provided a basis for a combination of the ability for *spontaneous* changes in structure under specific circumstances with an apparent equilibrium seeking capacity under others. And the extension in his (and Jantsch’s) reasoning to the notion of “dissipative systems” (Jantsch, 1980, pp. 35 ff.; Prigogine , 1980, pp. 84 ff.; Prigogine and Stengers, 1985, pp. 12 ff.) that provides the conceptual basis for the simultaneous growth of entropy (as the degradation of useable energy) *and* of organization (conceptualized as *negentropy*) which seems to allow for the existence of *living* systems.

The “autocatalytic sets” introduced by Kauffman (1995, pp. 47 ff.) and reflected in the work of Allen (1994; 1997a; 1997b) provide a rigorous, if preliminary, basis for a mechanical model of autopoiesis. And which, when taken together with the “self-organizing” or “dissipative” systems

mentioned above allow for the existence of self-generating persistent systems capable of (spontaneously) adopting diverse structures, given only a supply of an appropriate ‘fuel’.

The principle of autocatalysis is, of course, an extended form of iteration, whereby the output of one element of the system forms the input (or constitutive conditions) for another, the output of which forms the input (or constitutive conditions) for the first. In this way the constitutive elements of the autocatalytic system are interconnected in what Bogdanov (1996, pp. 117 ff.) called a “chain connection”. Thus the autocatalytic system (as per Kauffman’s definition) is a particular case of a weak form of the “iterative system”. The particularization being brought about by the control mechanisms rendered possible by the notion of “identity”. And the “weakness” from the fact that the autocatalytic system as first defined has a break between the “input” and its “output” and thus the implication of a “disjointed” environment.

However, when this environment is envisaged as a flow, in the manner suggested in the “hypersphere” model (in chapter five), it is possible to

see that the ‘relatively closed system¹’ this representation makes it possible to see the autocatalytic system (embedded in a wider system) as (potentially) iterative in the strong sense, that is, its outputs form the basis of its inputs².

The problem this causes is that iterative systems, as was discussed in chapter five, have the potential (dependent on their initial conditions) to exhibit “chaotic” behaviour — the Mandelbrot set, for example, demonstrates the capacity of relatively simple equations to produce extraordinarily complex results. And, although it is possible to see this as an advantage at a superficial level (and over the short term) it cannot provide the basis for long term stability. An iterative system that is to be stable over the long term must have the capacity to control any inherent tendency to run out of control.

This capacity brings a number of requirements:

a) a sense of, or basis for, the definition/recognition of, *identity*;

¹ Note that, even when this system is recurred out to a planetary level, the closure cannot be complete as the planetary system is “pumped” by the energy received from the sun. This does however create the conditions necessary for the existence of a “self-organizing” or “dissipative” system.

- b) some method or mechanism for acquiring necessary environmental information;
- c) a fluid structure, comprised of “micro-systems” which also have fluid structures;
- d) some method or mechanism for acquiring information regarding internal processes/activities and their operation;
- e) some method or mechanism for acquiring/providing the resource(s) necessary to support the operation of the system as a whole.

All five of which are impacted upon by the need for *control* which, because a control system can “... be effective only insofar as its model of what is regulated is adequate ...” (Beer, 1981, p.308) and the “... variety proliferation in pursuit of adaptation and evolution ...” (Beer, *ibid*), requires that the *control system* explicitly take account of “...the law of Requisite Variety” (Ashby, 1966, p. 207) ³.

² And this provides the basis of the Gaia Hypothesis (Lovelock, 1995a; 1995b, and of co-evolutionary models (e.g. Jantsch, 1980, pp. 75 ff.)

³ Ashby’s formal statement of the law, i.e., “only variety can destroy variety” (*ibid*), is much stronger than Beer’s “Only variety can absorb variety” (1981, p. 308) and may give the impression that variety *reduction* is advantageous. This would contradict Beer’s “Ashby’s Law can be met **either** by expanding regulatory variety ... or by curbing evolutionary variety ...” (*ibid*), and the argument I shall present regarding the *necessity* of variety in the adaptive process and the criticism of the the ISO standard in relation to service quality management. However, Ashby’s definition is *contextual* as is made clear by his statement that “... a set’s variety is not an intrinsic property of the set: the observer and his powers of discrimination may have to be specified if the variety is to be well defined.”, (Ashby, *ibid*). This contextualization clearly makes “variety” a function of the *perceived* relationship, thus clearly providing the basis for the simplification of a decision making (broadly used) scenario

Chapter six introduced and discussed five models that have been proposed to explain the way *nature* solved the problem of adaptation and/or evolution. And although the hybrid that I have called the “Darwin/Kimura” model is now widely accepted as correct in biological evolution (see, e.g. Gould, p. 216), the Lamarckian model has characteristics to recommend it to the study of the socio-cultural sphere (e.g. Gould, 1993, pp. 215/6).

Then there are the Bogdanovian notions of *equilibration* (developed following LeChatelier’s model (Bogdanov, 1996, pp. 101/2) and “crises” resulting from the action of “progressive podbor” (Bogdanov, 1996, pp. 190 ff.) within the wider structure of “world ingression” (Bogdanov, 1996, pp. 169 ff.). These were intended to explain the phenomena of natural/biological change within a more general (indeed *universal* if the title of the Tektology is to be taken literally) framework *without* reference to the overt Malthusian overtones of Darwin’s *Origin*⁴.

whilst retaining the complexity of the relationship at some further, but imperceptible, level. This is what allows Beer (1985, p. 25) to say that “The lethal variety attenuator is SHEER IGNORANCE”, and is also implicit in the hypersphere model (chapter five).

⁴ As a committed socialist Bogdanov, along with many of his Russian contemporaries, found the Malthusian idea of intraspecific competition repugnant, (see, e.g. Todes, 1989) and Kropotkin, 1914).

From a contemporary perspective, a more radical model of biological evolution is suggested by Margulis' (1999) in her serial endosymbiosis theory (SET). This is because she suggests that *all* eukaryotic⁵ lifeforms are (originally at least) symbionts, the results of collaborative interactions (in the sense of the early Russian anti-Malthusian theorists) or failed predatory (possibly cannibalistic) attempts.

The aim in chapter seven was to integrate these insights into a coherent notion of the "eigen-system". However to show that this could be done is, in itself insufficient to demonstrate that the model is applicable outside the area of its origin (i.e. the biological, physical or mathematical). Ashby's ultrastable system, especially as presented as part of Beer's viable system model *has* been accepted as applicable to many (social and managerial) fields, from a beehive (Foss, 1989), to the development of "organizational competence" (Holmberg, 1989), to a country (Beer, 1981, pp. various from 245 – 347), and therefore suffers from no such problem.

If the eigen-system can be shown to operate as a *viable* system⁶, and if the various models of change can be shown to be capable of inclusion in this structure (without transgressing the rules of viability) the biological, physical or mathematical elements of the eigen-system can *a fortiori* be considered to be applicable to the (social or managerial) organizational realm of the viable system. To this end most of the references to the viable system are taken from *Heart of Enterprise* (Beer, 1979) and *Diagnosing the System for Organizations* (Beer, 1985) which relate to the application of the VSM in the organizational context.

The model representing this is presented in its entirety as figure one (below); loosely following Beer, the area bounded by the dotted circle is the *operational* eigen-vector and that by the dotted rectangle the *ultrastable* eigen-vector.

⁵ Eukaryotic cells are those which contain a differentiated nucleus, as opposed to prokaryotic cells (such as bacteria) which do not. see also chapter six.

⁶ Thus in demonstrating that the eigen-system is a viable system it becomes acceptable to extend the use of the elements of the eigen-system beyond the areas of their origin into areas where the viable system model has previously been demonstrated to be valid. In this way it is hoped that the "cognitive variety" available to organizational researchers will be increased. One area where such an approach may be seen to be of interest is in the extension of notions of autopoiesis to social organizations, especially in the light of Margulis' serial endosymbiosis theory. Here the cultural (re)production of novel organizational forms could be viewed as being seeded by an endosymbiotic relationship resulting from the importation of new personnel, which, because of access to the biological model, could be viewed as retro-viral (i.e. an external agent *infects* the host with new structural form thus

The “3-2-1” Homeostat

System One

“We shall start here because it is this part of the system in focus that produces it.” (Beer, 1985, p. 19).

Beer has often said, and probably more often been quoted as saying:

“The purpose of a system is what it does. There is, after all no point in claiming that the purpose of a system is to do what it consistently fails to do.” (1985, p. 99).

What a *viable* system does is survive, if it did not it could not be considered to be viable. “And what the viable system *does* is *done* by System One” (Beer, 1985, p. 128).

There are *two* points of emphasis in the consideration of the individual instantiations of systems one at any given level of recursion.

redefining the notion of self) or mutagenic (i.e. a change of board membership causes a profound *and direct* change in the definition of self.

The first is that the individual systems one form the points of recursion in Beer's model, that is that it is here that the structure of the model repeats itself at the next lower (or embedded) level of organizational complexity. Therefore all that follows in this chapter (in relation to the viable system model as a whole) also relates to each of the individual systems one in isolation – that is to say that the viable system is an *adaptive model recursively comprised of adaptive models*.

The second, and more obvious, is that it is in some way a productive *process*. That is to say that both individually and taken together the system(s) one transform the *inputs* of the system into *outputs* – this is the emphasis that will be used in the remainder of this part of the discussion.

The quotation from Beer given at the beginning of this section is one of the crucial points of the research, i.e., that *system one produces the system*. This assertion sits comfortably alongside Maturana and Varela's model of autopoiesis, i.e., that the system produces itself, indeed as Beer argues elsewhere:

“(i) a viable system is autopoietic;

- (ii) the autopoietic faculty for this viable system is embodied in the totality and in its Systems One, and nowhere else ...”
(Beer, 1981, p. 338).

Where Beer argues for autopoiesis to be “embodied in the totality” he also adds credence to the notion of the eigen-system presented in chapter seven in that it is in *the whole vector, its operation and the eigen-value* that it is autopoietic.

However it also raises the question of what is left over after the system has “done what it does”, if what it does it create itself. In the biological model this question is relatively easily answered, what is *left over* is waste and is excreted into the environment. But in the commercial model this *what is left over* is the *product*, the way by which the company adds value in the marketplace, it is, therefore, difficult to conceptualize this valuable output as *excrement*. Controversial as this may be it is a direct logical consequence of Beer’s assertion and the model of autopoiesis when applied to the commercial arena.

However both nature and the VSM allow for more than one type of system one (this is what allows Jackson and Keys (1984), and the later

Flood and Jackson (1990, p. 42) for example, to place the VSM approach on the “complex” axis of their “system of systems methodologies”), all of which carry an adaptive and/or evolutionary capacity. Thus is it possible for the formation of *symbiotic* relationships where the excretions of one system form the inputs to another.⁷

The first overt modification to Beer’s original diagram (see figure one) is a re-drawing of the relationship between the individual systems one⁸. I do this to make clear that the model I present is *both* physical *and* informational; without the physical there is no basis for the informational and without the informational there is no basis for the control of the physical.

This simple modification also brings the advantage of being able to use the VSM to model processes – that is, by following Beer’s advice to “...

⁷ One should note here that the notion of symbiosis can be recurred out such that it includes individual entities *or* markets/environments/ecosystems.

⁸ It should be noted here that this *is a modification of the drawing* and not a *modification of the model*. Note that Beer allows for this in describing operational connexions thus:

“... about the connecting squiggly lines –

- the basic convention on the operational axis is the same as that on the command axis. That is, the simple arrangement ... does not mean that the operations flow into each other: only that there are connexions ...
- for instance, operations may be so loosely coupled (e.g., in a conglomerate) that the connexion is no more than a competition for capital ...
- Sometimes operations are very strongly connected, and indeed do flow into each other...” (1985, p. 58)

arrange the operations in the appropriate order ...” (1985, p. 58) the diagram representing system one can be made to look like a process map. However this form of process map will have the significant advantage of explicitly including not only the procedural elements of the process but also its resource, informational and control requirements and, should it be considered to be appropriate, an adaptive and/or evolutionary capacity⁹.

System Two

“ ... the lot of System Two is not a happy one ... insofar as those that play the Two role are often accused of destroying horizontal variety – whereas their proper function is merely anti-oscillatory ...” Beer, 1979, p. 178).

As can be seen from Beer’s remark, he sees the role of system two as “anti-oscillatory, that is, in damping down “uncontrolled oscillation” (ibid, p. 175).

⁹ A further *practical* advantage is that it also identifies a natural *lowest* level of recursion, i.e., that where the process is strictly *linear*, e.g., $X = x_1 + x_2 + x_3$.

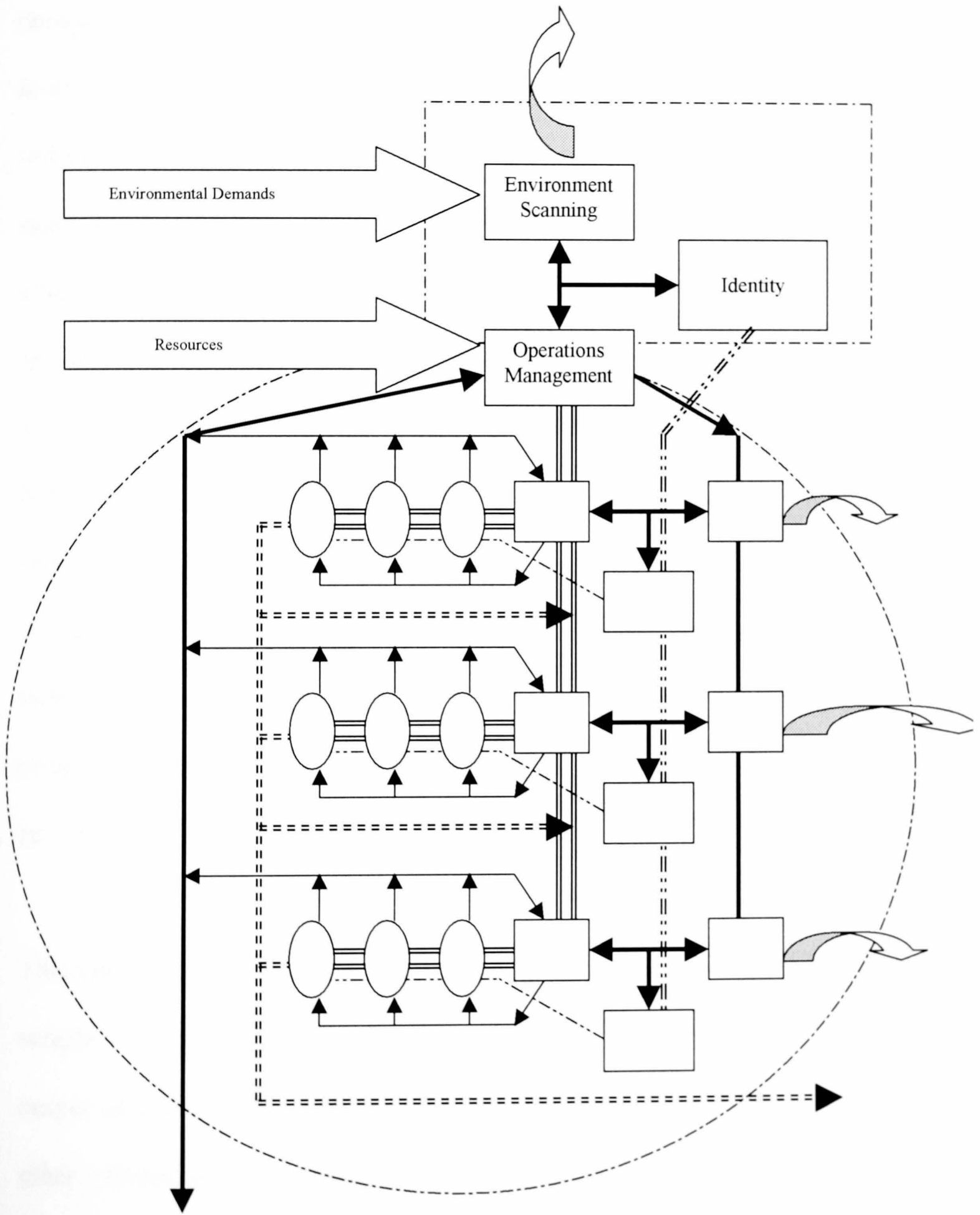


Figure 1: An interpretation of the VSM

Whilst agreeing with this, and his extension of the remark in demonstrating the necessity of not inhibiting “horizontal variety” (see the section relating to “variety filtering” in chapter seven), I find the term coordinative more useful. “Co-ordination” conveys more effectively the understanding of the function as applied to the model I present in this chapter. This is because there is an implication in the reference to *uncontrolled* oscillation that requires an understanding of purpose that is a function of the “3-2-1” homeostat in its relation to the “3-4-5” homeostat which is, therefore, not accessible to system two¹⁰. Active co-ordination of systems one can be achieved without a higher level of goal orientation as a result of the characteristics of the systems one themselves when operating in a *constrained resource* environment (a point which is implicit in the “Later in the Bar” discussions; Beer, 1979, pp. 191 ff.).

This can be demonstrated from the case of the simple homeostat, or the simple autocatalytic system, whereby any increase or decrease in the output of either of the participants (positively) affects the output of the other. Given an unconstrained primary input, such a system will grow

¹⁰ This is a necessary outcome of the nature of control languages and their relative complexities (see

exponentially (the exponent being defined by the reproductive rate of the system, i.e., a reproductive rate of 2 will lead to a growth by powers of 2).

However where the autocatalysis is not completely closed, i.e. where both elements require an input from the environment (which is constrained) *and* the input they receive from the other, and where there is an expansionist tendency (i.e., where it is in some way *in the nature* of the participants to attempt to exploit all available environmental resource for systemic growth) such unconstrained growth is not possible. Here the growth of the *individual* participant can only be *maximized* and this is possible only by ensuring the *optimal* sustainable mix of environmental input and input from its autocatalytic partner(s)¹¹. Thus this *maximization* and *optimization* are holistic functions, that is, emergent values dependent upon the interactions of the autocatalytic partners.

In this way it becomes possible to conceptualize the role of system two as *adding value* to the function of an autocatalytic system by providing the basis for managing the interactions of the participants in the

Shoderbek, Shoderbek and Kefalas. 1990, p. 91-3)

relationship. And in a way that simplifies the operation of the “3-2-1” homeostat.

For a Viable System this can be relatively simply modelled given five assumptions:

That the structural resources for and raw materials transformed by the operational units are differentiated, i.e., at the level of operation systemic *food* and systemic *input* are not the same – thus providing for the logical necessity of the transformation –this differentiation need not be *physical*, the necessity is only that, internally, these inputs are treated and/or utilized differently¹²;

That structural operational resource is generic, i.e., that the resources necessary to the construction and operation of all operational units at the same level of recursion is largely the same in all cases – this simplifies the role of system three as

¹¹ Note that there are elements of the system three role inherent in this discussion which will be dealt with in the appropriate section.

¹² However that they are *connected* in some way is a necessity for Beer’s “accountability” one of the elements of the “command and control” channel (Beer, 1985, p.40).

resource allocator because, by and large, it is only allocating one resource;

That, as was suggested earlier, the *output* of the operational unit is considered to be *waste product*, i.e. that which is left over *after the system has created itself* – the logic behind this, in a co-ordinative sense, is that as Margulis says “No organism feeds on its own waste” (1999, p. 119), therefore the “product” as *waste product* can be assumed to carry a degree of *toxicity* to the producing unit;

That raw materials are *sucked in* by the receiving unit on an ‘on demand’ basis rather than *pushed out* by the producing unit on a ‘product completed’ basis – this ‘closes the loop’ on the co-ordinative capability by utilizing the *toxicity* of ‘excess production’ to inhibit productive capacity.

That either, the operational unit has an expansionist capacity (similar to, e.g., mitotic division in cell population and which is strong enough to outrun the capacity of the

environment to carry it), and/or, that for each operational unit one or more of its autocatalytic partners has an output capable of stimulating its expansion (for example a *growth hormonal* function);

The first four of these assumptions allow for the existence of a coordinative capacity in a system containing differentiated productive elements with fixed capacity (i.e. where capacity in the individual units cannot be gained, by e.g., growth or evolutionary change, or lost, by, e.g., attrition). Such a function operates negatively, i.e., by *reducing* production when there is too much of a given substance, by utilizing the toxicity of the product on the producer to reduce the *rate* at which it is produced.

It is not, however capable of the active management of the entity comprised of the productive units. It is only with the addition of the fifth assumption, i.e., the ability for *expansion*, that the system both becomes *manageable* and *requires management*.

The system *becomes* manageable because it is now possible to adjust the physical capacity of the operational units to provide whatever it is they provide rather than merely the rate at which they provide it. This is an *efficiency* control. Where in the first case it was possible to affect output by affecting the *rate* of provision which, without affecting the internal capacity to provide, left extant any structural overheads (and, therefore, costs), the ability to alter this structural capacity is also the ability to alter *costs of provision*.

The system *requires* management because the inclusion of the expansion of the operational units (based on internal criteria), whether stimulated by food supply or 'hormonal' intervention, may render the system unstable due to unconstrained growth beyond the limits of the carrying capacity of the shared environment.

The co-ordinative function provided by system two is able to achieve this because, in the absence of an *evolutionary or technological shift* the

throughput capacity/capability of the individual systems one can now be viewed as a population function¹³.

The interpretation of the productive capacity of the individual units as a population function also helps to identify the various roles of the elements of the viable system model, and the intimate interaction of “coordination and control”. The model presented above can now be written as a modified version of the logistic equation, with an additional term which allows for the activity of the throughput inhibiting activity allowed by the toxicity of the output of the systems one thus:

$$P_{t+1} = P_t \times R (C - P_t)$$

Where P = population level, R = reproduction rate and C = carrying capacity of environment. Productive capacity thus equals

¹³ That is to say that the *quantitative* ability to turn inputs into outputs is dependent upon the *number of processing units* that constitute the particular system one. Individual systems one can then be seen to operate under an expansionist imperative which can be governed by the logistic equation (see chapter five) whereby the reproductive rate of the units is inherent in the entity or population (note that in the *cellular form* this is two, which is below the figure where bifurcations appear in the graph of the equation), but that the population sustainable is a function of the carrying capacity of the environment. Hence it is possible to assert that the role of system two, at recursion level R , must determine growth enhancement or retardation stimuli *in the environment* of systems at recursion level $R+1$. Therefore these stimuli are, by the rubric of the VSM, necessarily scanned for and received by system four at any appropriate level of recursion.

$$P \times I$$

Where I = throughput capacity, and is a function of the residual toxicity of the output of the unit.

The system two elements of the restated equation are thus:

I , which reduces the possible rate of production within a given population by, effectively, poisoning the unit with its own waste;

R , which increases output capacity by stimulating population growth (or the increase of internal productive elements) by allowing the uptake of structural resource beyond the need for extra throughput.

The carrying capacity of the environment (i.e., C in the equation), and, therefore the *actual* population, is a system three role and will be addressed later.

Thus are the systems one co-ordinated using criteria which are defined by the systems one themselves (which is consistent with Beer, op cit) but which affect these systems one through their environments (which means that they will be detected by their systems four), hence, in figure one, the system two element of the system in focus is shown connected to the system four of the next lower level of recursion.

Three Star (3*)

“There is in fact plenty of evidence for the existence of this high variety channel – which does not exist to command, but to inform system three...” (Beer, 1979, p. 211).

The “three star” (3*) function presented in my interpretation of the VSM is assumed to play essentially the same role as the one described by Beer (op cit), i.e., reporting to system three on the *performance*¹⁴ of the individual systems one. However the protocol adopted in figure one is rather more complex than that usually applied to representations of the VSM (see, e.g., Beer, 1985) in that the channel is seen connecting systems one to system three at *both* levels of recursion. Because of this

it is potentially capable of representing two (*ideal type*) interpretations of the function, both of which can be operated according to two (*ideal type*) methods of variety reduction.

Beer (1979, pp. 211 ff.) describes a method of variety reduction along 3* based on the application of *professional judgement*, that is to say that *everything* is observed the observers then compiling a report for system three containing the salient points. The variety fed into system three is thus reduced by exclusion of *extraneous* detail (this extraneousness being decided on the basis of some or other accepted level of competence and trust, hence the reference to professionalism).

A second method is to apply the exclusion *in advance*. That is, to make the decision as to which indicators are important and measure only those. This has the advantage of *simplifying* the channel, i.e., reducing the bandwidth and the activity necessary, but complexifying system three by necessitating an extra variety filtration function.

¹⁴ "Performance" in this statement can be taken to mean either 'inputs used and outputs produced' or extended to include other relevant information such as time elapsed etc. or as far as the detailed auditing information required by Beer in his explication of the 3* role (1979, p. 211).

In terms of the two interpretations mentioned above, Beer (1979, pp. 211 ff.) exemplifies the role as that of “audit”, which (because it necessitates “... direct access ... to the operations themselves ...” (op cit, p. 211)) is consistent with his “metasystemic intervention” (op cit, p. 212), i.e., the ability of system three to intervene in the internal affairs of the individual systems one¹⁵. The diagrammatic representation in figure one could be considered to be supporting this interpretation insofar as the individual systems one are connected to 3* which, in turn, is connected to *both* system three at the same level of recursion *and* system three at the next higher level. Thus it allows for a ‘successful audit’ given Beer’s assertion that audit “... can be successful only if *every* transaction in a sample of activity is inspected” (op cit, p. 211), by allowing *internal* access, i.e., access at a level of recursion below the level of recursion being inspected.

The second view is, perhaps, more naturalistic in that it effectively invalidates the notion of accountability and its associated capacities of audit and intervention. Here the 3* channel can be envisaged as split insofar as the individual systems one report (as is the usual rubric) to

¹⁵ Note that both notions are meaningful only in conjunction with his *other* notion of “accountability”

system three at the same level of recursion and *that it is system three that generates the information passed up to the system three of the next higher level*. Accountability, in the sense that is implicit in the legalistic model, is not possible here because the next higher level of recursion has access only to the *outputs* of the system in focus, thus can exercise direct *control* over this system one only as a “black box” (see, e.g., Ashby, 1964, pp. 86 ff.). Once again the advantage is one of the simplification of the relationship at the expense of the complexification of system three (this time at the next higher level of recursion).

System Three (1)

“The autonomic system, number Three, sits in the middle of the procedure monitoring the effects” (Beer, 1981, p. 132).

Autonomic is defined in the OED as “functioning involuntarily ... control of ... functions not consciously directed...”. Because it “sits in the middle” this involuntarism may be expected to function in relation to either, or both, of two consciousnesses.

(see note 12 earlier in this chapter).

Because of its “metasystemic nature” (Beer, 1979, p. 202) and the fact that it adopts a “SYNOPTIC SYSTEMIC viewpoint” (ibid) system three is *beyond* the consciousness of system one and its own subsidiary units (i.e. system two and 3*). But if, as Beer (1985, p. 128) points out “... what the viable system *does* is *done* by System One”, the regulatory and co-ordinative functions carried out by system three are carried out *in the service* of system one (i.e., it carries out those functions which create the conditions under which system one can operate adequately) the apparent relationship of dominance is reversed and, in the absence of the ultrastable elements provided by the “3-4-5” homeostat, *system three becomes part of system one.*

When taken as part of the ‘other consciousness’, i.e., when system three is addressed as part of the “3-4-5” homeostat, its autonomic nature is more intuitively defined. That is, system three operates *below* the ‘consciousness’ of the ultrastable elements of the model in providing the ‘whole system’ resources necessary to the functioning of the system in focus.

My view is that *both* interpretations apply and that system three operates as both a variety amplifier (from “3-4-5” to “3-2-1”) and a variety attenuator (from “3-2-1” to “3-4-5”) of huge capacity. Because of this, the discussion of system three is in two parts, each treating one of the directions in which system three faces. This section concerns those elements of system three that relate to the management of operations.

Following Beer (1985, p. 39), the ‘control axis’ (i.e., the direct connexion between system three and the individual systems one) is assumed initially to be comprised of:

Some method of informing the systems one of the “legal and corporate requirements” which pertain to them;

The “resource bargain”;

Some channel for ensuring “accountability” for the resources provided.

In their strong sense “legal and corporate requirements” and “accountability” are intricately interwoven, providing the validation for and assurance of each other. And it is their existence that necessitates

the first interpretation of the function of 3* given above¹⁶. Both notions, as is the interpretation of audit they require, are *legalistic*, i.e., they are necessitated by the form of the organization rather than any fundamental organizational necessity¹⁷.

Beer (1985, p. 38/9) defines the resource bargain as:

“... the ‘deal’ by which some degree of autonomy is agreed ... [T]he bargain declares: out of all the activities that System One elements might undertake, THESE will be tackled (and not those), and the resources negotiated to these ends will be provided”.

Thus it can be seen that system three operates as “... a major resource allocation centre” (Beer 1979, p. 133) and that, outside this role, the functions undertaken are there to ensure some form of conformance. Which is to say that, within the direct constraints on system one variety imposed by the “legal and corporate requirements” (Beer, 1985, p. 38),

¹⁶ I.e., that is allowed access to the *internal* workings of the individual systems one under its control.

¹⁷ Although it may be argued that “corporate requirements” form part of the “resource bargain” element on the basis that system three must extract a surplus of resource provided over resource expended in the operations of system one in order to be able to support the overhead costs of its own and system two and 3* operation.

they exist to ensure that the autonomy passed to them by result of the resource bargain is exercised appropriately.

When these considerations are taken together with the formal interpretation of the audit function (see above) and the implied legitimacy, transferred to system three, to *intervene* in the internal workings (and, therefore, the *identity*) of the systems one¹⁸.

However it is possible to envisage an equally metasystemic identity for system three, based on the descriptions of the roles of system two and the 3* channel that does not rely on what I have called the *legalistic* elements of the interpretations given by Beer. That is, that system three is envisaged as an *emergent property of the interactions of the systems one* within the constraints of their own nature.

When system three is viewed as an emergent entity the “3-2-1” homeostat appears as an ‘eco-system’¹⁹ where the individual systems one

¹⁸ This is an extension of the definition of audit used by Beer, on the basis that there is no point in being able to dis/un cover what the systems one are doing if you are then unable to enforce changes if it is not what was agreed as part of the resource bargain.

¹⁹ Margulis defines an “ecosystem” as the “... smallest unit that recycles the biologically important elements” (1998, p. 105), therefore it seems appropriate here especially if the term “biologically” is allowed to drift towards the term “organizationally”.

represent the constituent populations. And here it is possible to return to the logistic equation mentioned earlier in relation to system two, i.e.:

$$P_{t+1} = P_t \times R \left(\frac{C - P_t}{C} \right)$$

Where P = population level, R = reproduction rate and C = carrying capacity of environment. Productive capacity thus equals

$$P \times I$$

Where I = throughput capacity, and is a function of the residual toxicity of the output of the unit.

Thus system three is able to *control* the overall levels of production of system one simply by controlling the amount of *structural* resource available. This is because C in the above equation is the amount of structural resource, that is, it is the amount of *food* or *fuel*, available to resource the creation and running costs necessary to sustain the populations that provide the outputs of the system.

Therefore, the role of system three is that of *resource provision* and, because in this eco-system model the individual systems one are potentially *entirely independent of any purpose brought to bear by the metasytem of which system three is a part*, and under no obligation to pass on any *excess* resource they may acquire for *re-allocation* by it, system three must also be the *primary source* of such resources²⁰. This is the reason that system three is shown, in figure one, as connected to the environment – receiving resource.

The Operational Eigen-vector

The “eco-system” interpretation of the “3-2-1” homeostat simplifies systems two and three by making their existence emergent properties of the inherent nature of the constituent systems one, and ensures the requisite ‘bandwidth’ of 3* by making it a general medium comprised of their outputs. The *managerial function* of system three is the satisfaction of that set of ‘physical laws’ which constrain the operations of the systems one. These ‘physical laws’ being contingent upon the structures of the systems one themselves. Hence, the systems one comprise their

²⁰ This primacy may be emergent, e.g., the sunlight falling on an eco-system and therefore driving the photo-synthesis at the base of the food chain, or physical, e.g., the alimentary tract of some higher animal.

own system two by the inherent toxicity of their output, and system three exercises control on the basis of resource provision (which is an *absolute* control because the criterion is ‘perform or die’).

There is no loss of dynamism in this simplification because the systems one are now accepted as providing the “micro-diversity” (Allen, 1997) which allows for:

“... the diversity of behaviours among individuals in any part of the system ... [to be regarded as] the result of local dynamics occurring in the system ... [b]ecause of this, it is possible to make the local microdiversity of individuals an endogenous function of the model, and in this way move towards a genuine, evolutionary framework ...”

(Allen, *ibid*).

All of which supports the assertion that systems two and three, and the 3* channel can legitimately be viewed as emergent from the interactions of the systems one. And that it is the (internal) micro-diversity of the systems one, within the constraints applied by the necessity of access to a restricted supply of resource, that drives the adaptive or evolutionary change that occurs at this level of the model.

Taken as a whole the “3-2-1” homeostat can be seen to be operating as a dynamic version of the logistic equation within which, as Allen states:

“Stability, or at least quasi-stability will occur when the microstructures of a given level are compatible with the macrostructures they both create and inhabit” (Allen, ibid).

That is, the “3-2-1” homeostat is in an “eigen-state” when the interactions between the individual systems one are in such a balance that, given a particular level of external resourcing, the populations represented by them are able to maintain themselves at such a level that the balance between them is also maintained.

Which is to say that the role of system three (as emergent entity or management function) is to resource the processes which create the outputs represented in the vector P where:

$[P] = [p_1 \dots p_n]$ = outputs from systems one

such that $[P_{t+1}] = a[P_t]$

for all p_i

under the input $C_t + I$

within the equation $P_{t+1} = P_t \times r(C_t - I_t)$ ²¹.

The role of system two is to *co-ordinate* the outputs of the members of the vector $[P]$ such that the autocatalysis made possible by their symbiotic relationship is maintained. Which is to say that, within the *absolute constraint* of the available resource on the overall population (i.e. system one as a whole) it functions to balance the outputs of the *specialized* populations (i.e. the individual systems one). This function is, mathematically, non-trivial, being an example of what is called the “knapsack’ problem” (Lauriere, 1990, p. 180), to which there is no certain algorithmic solution other than a complete search of the solution space²². System two *addresses* this problem by adopting a heuristic strategy based on the idea of residual toxicity, introduced above leading to the discovery of *adequate* rather than *optimal* solutions to the co-ordination problem in a manner similar to Simon’s (see e.g., 1981, pp. 36/7 for a definition) “satisficing”. And because, in a dynamic system,

²¹ The stable solution to this problem is relatively trivial where P is a single (i.e., non-differentiated) number, i.e., the population P is stable when $(C_t + I - P)/C_t$ is equal to $1/r$, is contracting when it is less than this and growing when it is more. Note also that the range available to P_t is limited to being $0 < P_t < 1$.

²² See Lauriere (1990, pp. 177/8) for an exposition of the use of a “Non-Deterministic Turing Machine” for the solution of “non-deterministic polynomial problems”, a class of problems that he calls “a mystery”.

this heuristic must be applied ‘on the fly’ over a population of internally dynamic systems one (as a result of the recursive nature of the model), it is foreseeable that there will be a tendency to a periodic stressing and relaxation of individual systems one; which may be interpreted (in a teleological system) as oscillation, as each individual population *recalculates* itself in response to current conditions. However, it is my suggestion that where this activity is both *strictly periodic* and *within the internal capacity of the systems one to survive*, it is not pathological, but an inherent part of the functioning of dynamic systems (in a manner similar to the existence of alpha rhythms in the brain), hence the choice of the word “co-ordination” rather than “damping”.

The role of 3* is thus a communication/transmission milieu which carries the outputs of the individual systems one and the resources from the (nominal) system three, it therefore provides the informational basis of system two (which is an emergent property of the tolerance to the toxicity of their own outputs) and system three which is an emergent property of their resource needs under any given mix.

Within this representation it is possible to generate a model which utilizes the roles of systems two and three as defined above, and which provides a single number resource utilization measure – thus providing the variety reducing benefits of the eigen-system model referred to in chapter seven.

Assuming that the system two function identifies a tolerable operating mix and the adaptive nature of the systems one is able to move into it (which are effectively the same thing), the outputs of the systems one will define a vector $[O] = [o_1 \dots o_n]$ which parallels the vector $[P] = [p_1 \dots p_n]$ that represents the populations represented by the systems one. Over and above utilization/neutralization of the internally generated outputs of other systems one (which contribute to their inputs these systems one will have need of what I have termed above “structural resource” which is derived from gross input, thus generating another related vector $[I] = [i_1 \dots i_n]$ representing the structural resource needs of the systems one under the operating demands of the mix defined by the system two function. Thus defined this vector can be represented as a characteristic line in n -space (n being the number of dimensions of the vector). And this vector can be compared to the vector $[C] = [c_1 \dots c_n]$ in

a similar space representing the gross input (or externally provided resource as above) as per figure two.

Because the absolute constraint on activity is the resource available, $[C]$ has been taken as the “base” vector and, because there is an element of co-usage of the generic structural resource by the individual systems one (i.e., none of them will use all of it), and there is an *organization cost* (or entropy) the vector resultant upon the mix defined by the system two function is assumed to run at an angle to the base. In addition, because it is not possible for the systems one, either in concert or in isolation, to make something out of nothing the *maximum* length of $[I]$ can be no more than the length of $[C]$.

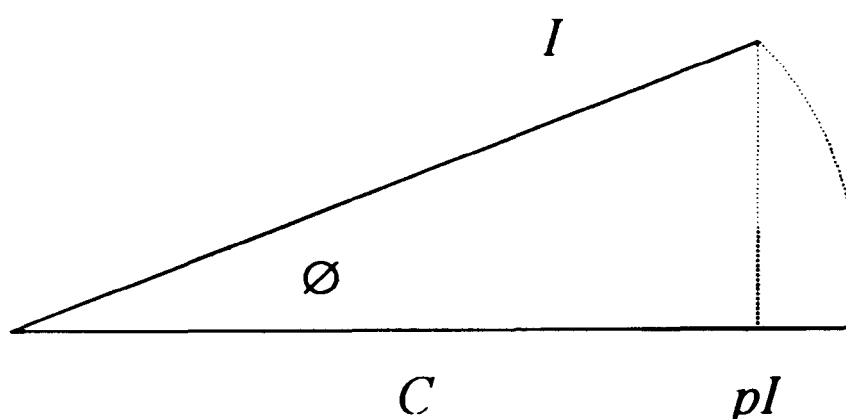


Figure 2: Comparison of the vectors $[C]$ and $[I]$

Thus because the angle of $[I]$ will be characteristic of the mix adopted (irrespective of the absolute numerical values) it is possible to assert that

the *process efficiency* (resource utilization measure) of the mix is a function of the angle of deviation from the base, which is, in effect, the projection (see Macbeath, 1964, pp. 37/8) of $[C]$ onto itself after rotation through θ (the characteristic angle of the mix). Thus if $[C]$ is of unit length the measure of the 'mix efficiency' is $\cos\theta$ ²³.

Within the limit case it is foreseeable that the possible *sustainable* mixes (i.e. those stable states possible *within* the available resource) may not necessitate (or be capable of) utilization of *all* available resources. Here the measure of resource utilization is the projection of $[Ia]$ (= actual uptake of resources) on the base vector as shown in figure three, calculated as $[Ia]\cos\theta$.

The interval $pla - pl$ is, thus, the *potential* resource available for growth. This potential can either be lost to the system (i.e., pumped out as *waste* or *product*) or taken up by newly evolved populations able to exploit it (which would re-define the stable mix and, therefore, the characteristic angle θ). Alternatively, given a fixed resource and a (nominally) fixed technology (or evolutionary state), it is possible that the expansionist

²³ This is because the cosine of an angle is zero at 90 degrees (i.e., no utilization and therefore total

tendencies of some *individual* system one is able to overcome the inhibition exercised by the system two function (by, e.g., dilution of the residual toxicity of its output over the additional availability of resource), and, in so doing, set up a cycle of peaks and troughs *around the sustainable mix*.

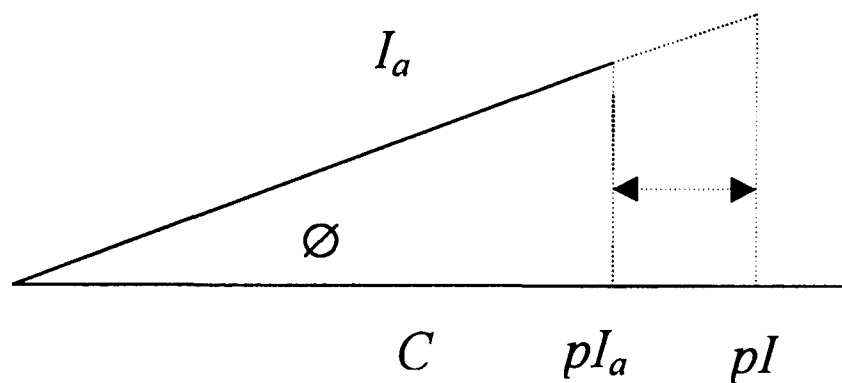


Figure 3: The projection of $[I_a]$ on $[C]$

In this way the system would appear to demonstrate a *stable periodicity* which, by regularly stressing the individual populations, would provide the stimuli to drive the adaptive and/or evolutionary capacities of the lower levels of recursion.

The “3-4-5” *Ultrastable* Homeostat

System Three(2)

Once system three becomes part of a *formal* metasystem, in the manner that Beer (1979, pp. 199 ff.) describes it, it ceases to be a notional entity

waste) and one at zero degrees (i.e., maximum utilization and therefore no waste).

for the *passive provision of resources* as is implied in the discussion above and becomes a *controller*. This control can still be exercised within the logic of the vector projection model presented above, albeit in an extended form.

In this case we must assume (primarily for simplicity) the availability of a stable level of some gross resource, represented by the vector $[R]$, and that some of this gross resource cannot be utilized/processed by the system in focus, leaving a residual amount, represented by the vector $[I]$ which can. Therefore the interval $I - R$ can be taken to represent “waste”, or, that part of the gross resource that is left over after the system has taken what it needs.

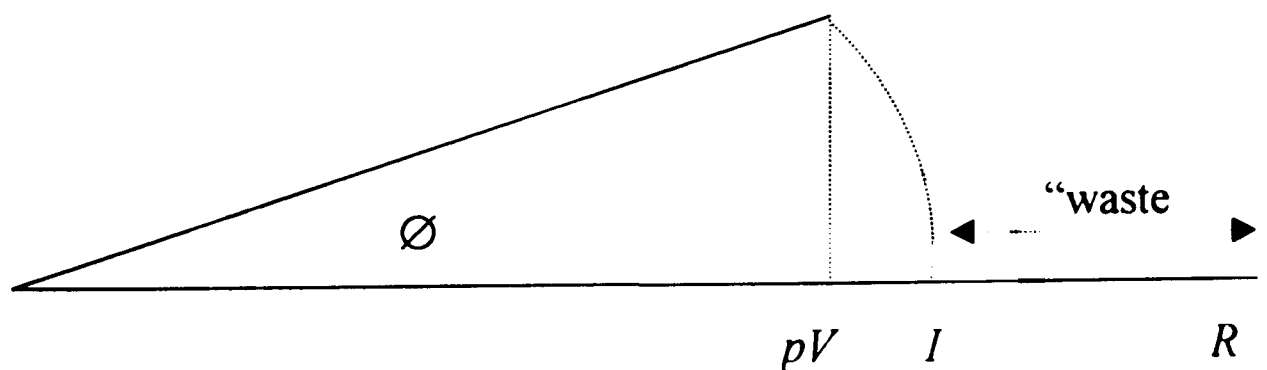


Figure 4: The inclusion of a “waste” product

Assuming also (and again for simplicity) that this time the lower level populations are able to utilize *all* available resource, and that there is an

inherent processing or organizational cost incurred in turning the gross resource into utilizable resource and waste we create a vector projection similar to those above (see figure 4).

Where θ , as before, is the characteristic angle of the mix defined by system two and, thus, pV/I (i.e., the projection of V divided by I , or, $\cos\theta$) defining the *efficiency* of the conversion process. Now, if $I - pV$ represents the ‘direct’ or ‘variable’ costs of processing²⁴, there is also a structural, or ‘fixed’ cost in maintaining the physical integrity of the processing units which will be met by consuming a portion of the utilizable resources made available by the operation of the mix. This cost can be shown (as its absolute value) as the interval $pV-v$ along the base vector $[I]$ thus figure five.

However because these fixed costs must be met from the available utilizable resources, i.e. from the vector $[V]$, the calculation of fixed costs as a proportion of *total available* resource is:

$$pV - (I/\cos\theta)f \text{ (where } f \text{ is the net amount of fixed cost)}$$

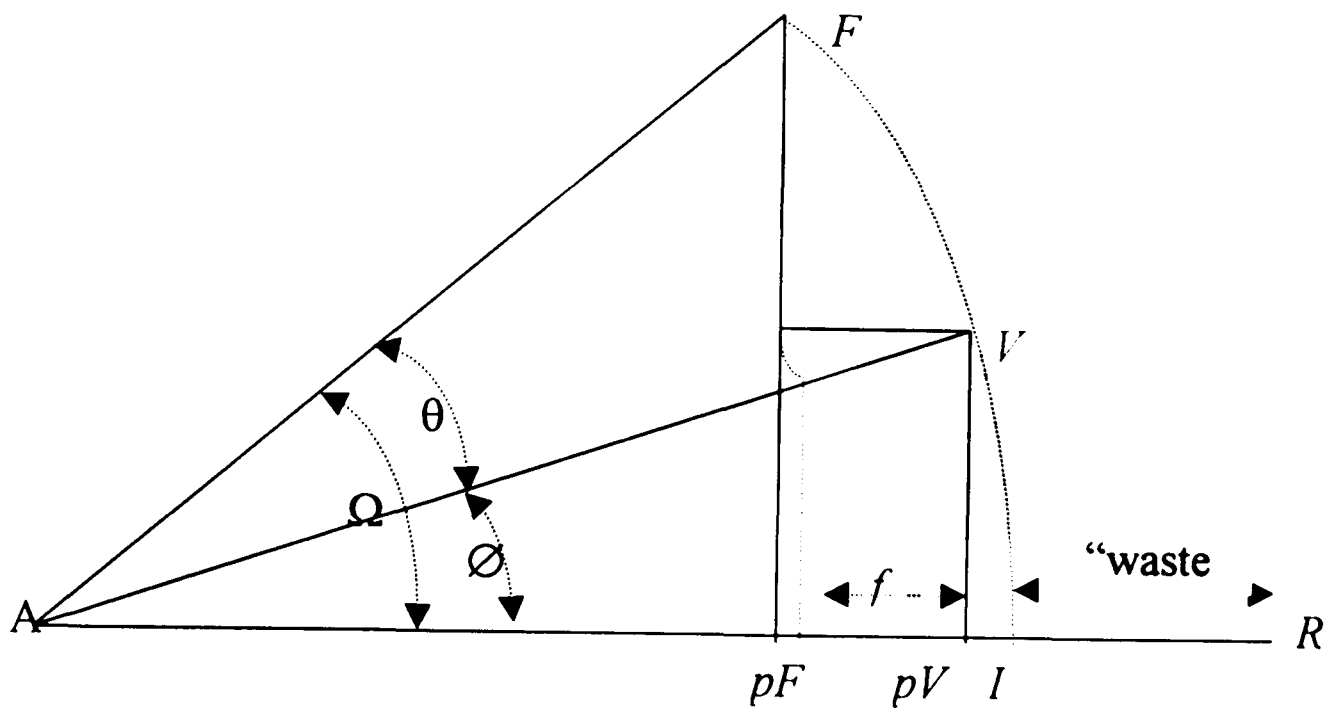


Figure 5: The inclusion of fixed costs
(note that $[F] = [V] = [I]$).

Which, by rotating the vector V , as before, gives the vector F . Thus the projection of F on R , gives a measure of the overall efficiency of the 'production' process in relation to available input (i.e. $[I]$) as pF/I or $\cos\Omega$ (where $\Omega = \emptyset + \theta$) F , which reduces to simply $\cos\Omega$ where $[I]$ is the unit vector²⁵.

²⁴ Note that, because it is defined by a *ratio*, as the volume of I shrinks or grows the *absolute value* of I - pI varies proportionately, which seems intuitively correct.

²⁵ Note here that because the interval v is defined as a number it remains constant in relation to the variations in 'direct costs', thus its *proportion* of the whole varies, which again is intuitively correct

The final element of this part of the model is the inclusion of *management* costs which are calculated in the same manner as the fixed costs, i.e., the subtraction of the ratio $1/\cos\alpha$ of the net management cost, but where the angle α is Ω rather than \emptyset (see figure six). This because, in a dynamic model, it is necessary to visualize costs as a *proportion* of inputs rather than as an absolute value. Thus the “3-4-5” homeostat has an indicator of the performance of the operational (or “3-2-1”) homeostat which gives a ratio of utilizable resource produced per unit utilizable input provided, i.e., pM/I . And it is from the resources produced through this ratio that management costs must be met.

Thus the available resource for distribution to facilitate internal development is the projection of an interval on M equal to the interval A,pM on the baseline, or, $\cos\Omega$ divided by $1/\cos\Omega$ which, by cross multiplication, is equal to $\cos\Omega^2$.

At any level of recursion, and because system three is concerned with *internal* function, the ‘waste’ product (represented by the interval I,R) is of no interest, being simply that element of the gross input that is of no

experimenting with responses which will tend back to an internal equilibrium. Then there is no *need* to know in advance what might cause a disturbance; there is no *need* to know what has caused a disturbance.” (Beer, 1981, p. 27, italics added).

The reason for the italicization of the word “need” in the quotation from Beer is that although there is no “need”, in a relatively simple system (such as the computer example he gives on the following page), the ability to ‘remember’ regularities, enhances the ability to survive.

In a ‘real-time’ system, such as the one described in the previous sections, it is the ability to recognize (and, where there is some form of memory, avoid) the *abnormal* that stimulates adaptive change and provides the basis for “viability”. And as:

“To be adapted, the organism, guided by information from the environment, must control its essential variables, forcing them to go within proper limits, by so manipulating the environment (through its motor control of it) that the environment acts on them appropriately.” (Ashby, 1960, p. 82).

It is the role of system four to provide this information at the whole system level at any given level of recursion.

This raises two issues:

What does it need to do to provide this information, and;

How it remains appropriate to the system it serves.

As Beer points out (1981, p. 28) the ability to recognize “something wrong” provides the basis of ultrastability and, in a ‘real-time’ system such as the one described above, this “something wrong” will be recognized in a collapse of the values of the indicators of performance (i.e., the measures of self-ness) provided by system three (i.e., $\cos\Omega$ will tend towards, or become less than, zero). In a static (i.e., non-adaptive) system such an occurrence would lead to its demise, the system would *starve to death*, however in an adaptive system one would expect an attempt at systemic change in order to counter the detrimental effects of the environment. Thus system four, in order to justify its existence, must

provide more (or more detailed) information about the environment than simply the gross level of resource available to system three.

It seems apparent, if a more general reading of Ashby's statement (above) is allowed, that the adaptive system *manages its relationship with its environment*. That is, it attempts to position itself, either by altering its internal state (i.e. by changing its internal processes in order that it may continue to exist in a given environment) or by altering its external state (i.e., by moving within its environment until those conditions pertain under which it can continue to exist given its existing internal conditions), such that the system as a whole is relatively unstressed. In short, if an adaptive system is stressed, it will tend toward an eigen-state, either by changing itself (evolving/adapting) or changing its environment (moving/working).

Thus it can be seen that system four provides *evaluational* information, this can be seen as *qualitative* as opposed to the *quantitative* information available to and provided by system three, and provides the justification for Beer's statement that:

“... the environment of the viable system is by no means the sum of the environments of its own viable systems. But the viable system that we are modelling must respond to this larger environment. System Three cannot do this ... [but System Four] deals with the wider environment; that is, it takes account of a perceived cosmos that is much larger than the sum of its organic environments” (Beer, 1979, pp. 227 and 229, brackets added).

And it should also be clear, by extension of the argument in the earlier section regarding system two, that I think that the environment regarded by system four is not only *bigger* than the sum of the environments of the systems one, but *different*. The *information* provided by system four provides the basis for the evaluation of the *resources, processes* and *performance* of systems one, two and three.

Thus, taking the example of the “toxicity” argument; whatever the *level of performance* and whatever the *level of available resource* it is ‘bad’—rather than too high or too low — because of the toxic element. It does not matter, initially, whether the system is aware of the toxic element in isolation or that it is carried in its ‘waste’ product. What matters is that it has the capacity to recognize it in some way, and is able to adapt its

behaviour such that it ‘knows’ that the way to alleviate the stress that the toxin causes is to reduce its productive activity. Thus system four ‘reads’ the environment in order to provide the information for this ‘learning’ or structural change.

The inclusion of ‘memory’ in the repertoire of system four obviously expands its utility to the system as a whole because it allows for a mechanism of *avoidance* rather than merely *escape*. If the system is able to recognize an indicator of *future* stress rather than simply *current* stress, for by example, detecting low (i.e. pre-dangerous) concentrations of toxins, it has the potential to change its behaviour in order to avoid them rising to a level where they become dangerous.

This capacity is present explicitly in Ashby’s “ultrastable system” (i.e. in “changing the way of behaving”, (1960, pp. 84) by re-setting the “step-mechanisms” which “... affect the reacting part; by acting as parameters to it they determine how it shall react to the environment” (ibid, p. 98), and in Shoderbek, Shoderbek and Kefalas in what they define as “second order feedback” (1980, pp. 87/9). And is implicit in Beer’s consideration (see, e.g., 1979, pp. 227/9).

Thus ‘memory’, in the broad sense used here, allows for the existence of an *apparent* ‘foresight’. It is apparent because it can occur without any recognizable consciousness, i.e., the ‘memory’ of a prior ‘bad’ experience and the appropriate response (e.g. change or flight) is hard-wired into the structure of the system. This is why, in figure one and elsewhere, for example, the “toxicity of the output” is described as ‘informational’ and why system four is shown as connected to system two of the next higher level of recursion — a) it is *logically* possible to view the inhibiting effect of abnormally high concentrations of the output of any given system one on its ‘productive capacity’ as a learned response to environmental stimuli; and b) that this learned response is the emergence of system two, i.e., the level of concentration tolerable before the productive capacity is inhibited is for just that amount necessary to maintain the internal balance of the system as a whole.

To address the second issue raised at the beginning of this section, i.e., that of continued relevance, it is necessary to commit (apparently at least) what may be considered to be heresy — to treat system four as a

viable system in its own right²⁷. I can do this because, whilst agreeing that as an *informational* entity system four cannot be viable in isolation, as a *physical* entity it *certainly must* display the characteristics of a viable system in order to continue to be a part of the informational viable system Beer describes. That is, in order for Beer to be able to describe the viable system model as having a system four there must be, and have been, systems four that have persisted over time. And for a living system this means that there is some *selective* advantage to be gained (by the wider system in focus) in providing the resource necessary to maintain it.

I think, therefore that it can be asserted, without too much intellectual sleight of hand, that system four maintains its physical viability by existing as a non-viable element of an *informational* relationship. And that, because of this, the (informational) system as a whole gains the selective advantage of an *adaptive* system four.

Thus the information provided by system four can be seen as its 'product', which it trades for structural resource in much the same way as the 'products' of the systems one which contribute to the physical

²⁷ *Shock! Horror!* But the Viable System Model is, after all, a *model*.

existence of the system are. And, whether they are brought into existence by positive adaptation or by random mutation, will continue as *physically* viable units for so long as the information they provide allows a selective advantage which outweighs the resource cost of their maintenance. One need only look to the example of *Spalax erhenbergi* of which Gould says:

“Subterranean mammals usually evolve reduced or weakened eyes, but *Spalax* has reached an extreme state of true blindness. Rudimentary eyes are still generated in embryology, but they are covered by thick skins and hair. When exposed to powerful flashes of light, *Spalax* shows no neurological response at all ...” (1993, p.403).

Here we can see that, when the informational necessity is removed, evolution, as we would normally understand it, runs backwards, thus demonstrating a degree of independence between the viability of the elements of system four and the viability of the system as a whole. This apparent contradiction provides the basis for an evolutionary drive on the functionality of these elements.

The ‘evolving out’ of (previously ‘evolved in’) characteristics when their “selective advantage” is removed by external conditions is only possible if the system as a whole is able to *evaluate* the contribution of its parts in terms of the survival worthiness of the whole. This suggests that they must be conceptualized as existing at a *different level* of recursion to the system as a whole²⁸. This is where the heresy mentioned earlier becomes *apparent* rather than *real*. It is the *physical* rather than the *informational* system four that exists at this lower level — the eye as an organ of sight has no meaning or viability outside the organism which sees through it; but the eye as physical object does. And, as can be seen from the example of the *spalax* the mole rat, given above, the eye is capable of evolving (quasi) independently of the wider system once it ceases to provide any selective advantage.

Viewed in this way, i.e., as a *physical-informational* system, it is possible to subject the physical system four to the same *kind* of evolutionary pressure as the systems one. That is, as an element of the wider system it will be judged on the quality of its output (i.e. the information it

²⁸ I.e., in order to be evaluated and controlled against the standards of the whole system the “control language” of the whole system must be of a degree of complexity that is higher (and, therefore beyond the understanding of) the controlled systems.

provides), but now, as it can be treated as a system in its own right, it will also endeavour to manage its internal structure so as to maximize its survival worthiness. And, as an environment scanner, this contribution will be judged (and resourced) against the ability to comment on (or predict) the effect of the environment on the internal stability of the wider system of which it forms the system four.

The mechanism for this, given the earlier discussion, is relatively simple. The recognition of stable relationships between environmental stimuli and internal conditions. In a simple ultrastable system (e.g. Beer's computer mentioned earlier) the "transduction" capacity need only be sufficient for "something not quite right" to be recognized, stimulating the response *move*. In an adaptive system the possible response repertoire can also include *change internal structure to regain stability*. However both these cases assume appropriate²⁹ transduction capacity and give little insight as to how system four should arise in the first place. My suggestion here is that it is the utility of the information provided³⁰ by *any* element of a system in focus that moves it into a system four role, and that progressive refinement of this information

source leads to its preferential resourcing due to the selective advantage it allows.

The extension of this into more complex models allows for a simple ‘learning’ process whereby it is possible for system four to ‘hunt’ regularities, i.e., where there are internal crises which correlate to no apparent external stimulus externally facing elements can be set into *search* mode in an attempt to discover the regularities necessary to avoid similar problems in the future. And when this is the case it seems reasonable to suggest that any element that identifies such a regularity will receive preferential resourcing³¹.

Operational and Aspirational Environments³²

One of the issues that arise at this level of the model is that the system, in tracking these regularities can be seen to adopt two foci (and, therefore, in effect create two environments) — that I have termed “operational” and the “aspirational”. These environments, as the names suggest, deal

²⁹ “Appropriate” here is taken to mean capable of recognizing those environmental stimuli that lead to internal perturbation.

³⁰ Initially by chance in the biological model, as is allowed for in Kimura’s model (see chapter six).

³¹ And, in the opposite case, i.e., where recognition of such regularities cease to have any advantage (as in the case of the mole-rat and light) will receive a progressively reducing resource.

³² This block is shaded because it is the result of an iteration from the “application” back into this “theoretical” section.

with two *different* futures for the system in focus and are driven by two differently focused discourses undertaken by system four.

The first, the operational, can be viewed as being predominantly between system four and system three, *within* the “logical closure” (Beer, 1985, p. 129) provided by system five. Here the system operates as Beer would suggest, that is what I have termed the *evaluation* of the activities of the system is based on the extent to which they enhance the existence of the system *as it is* in some way. That is to say, that system five can be regarded as *static*, and “... will monitor the operation of the balancing operation between Three and Four.” (Beer, 1979, p. 259) against that set of values determined to represent *identity*. This identity, however, can be seen to exist in a *relationship with the environment*. And it is at the level of this (ideally) *constant* relationship with the environment that any and all *adaptive* changes are made. In practical terms, as was demonstrated by the experience with the dentist (see chapter ten), the activity undertaken by the system in response to this level of interaction with the environment is “How do we become better at what we are doing?”. This is not the same as asking “How do we do it more efficiently?”, as this is a resource allocation issue, but is more akin to “What must we do to

more *effectively* satisfy environmental demands?”, i.e., it is a resource *acquisition* issue. Viewed in this way this *operational environment* can be seen to be the focus of Beer’s area of “strategic” (1981, p. 164) activity and, in the wider context of this project the locus of quality management.

The “aspirational” element, on the other hand, is the locus of a *dynamic* relationship between the system and its environment. And the choice of the term betrays the difficulty in relating it to the predominantly biologicistic model employed in the rest of this chapter. In human or social terms it is a straightforward task to accept the teleological overtones of the word “aspirational” whereas once one moves away from this arena it becomes problematic. I believe, however, that it can be argued that the random mutation implicit in Kimura’s model (see chapter six) creates a dynamic relationship between a biological system in focus and its environment in the same manner as human desire in a managerial system. The effect of both is to redefine the value set of the system and, therefore, redefine its identity. Because of this, the discourse undertaken by system four is pre-dominantly with system five, this time constrained by the capacity/capability of system three to allocate the necessary

resources to the system as a whole to allow the changes to be made. This assertion is implicit in the argument relating to the “approximation of self” presented in chapter seven and parallels Beer’s “normative planning” (ibid).

This discussion serves to underline the basis for the “selective resourcing” of the *informational product* of system four in that, in the operational environment, it allows for the *efficient* allocation of resource to the achievement of the *effective* operation of the system as a whole. And it also locates quite neatly the mechanism for the *breeding in* of new informational capacities. It is in the “aspirational” aspect of the system four discourse that the potential for new abilities of perception occurs. As stated in Gould’s consideration of Kimura’s theory (see chapter seven) the mutation of “selection active” characteristics is damped which, in this context, leads to the formation and retention of a stable “operational level” system four discourse; whereas the rapid mutational effect in “non-active” characteristics may cause a redefinition of the relationship between system and environment. And this, in its turn, may cause the redefinition of the identity of the system and therefore change the selection status of individual characteristics. Thus can a parallel

between the teleology of human organizations and the largely random genetic drift of biological systems be demonstrated in the way that they generate a dynamic tension between the current and the immediately past constitution of the system in focus.

System Five

“To use personal pronouns in this way may jar, since we are talking about institutions; and yet there very definitely is such a phenomenon as corporate identity in every enterprise ... the enterprise as if it were a self-conscious entity ...” (Beer, 1979, p. 114).

Beer (above) talks of the *identity* of the enterprise and, in this chapter and others, I have spoken of the *value set* of the organization or system. It appears that this awareness of self is necessary in order to define the value of actions or changes that are to be made, and the value of these changes is:

“How does it affect me?”

That is to say (again):

“The viable system is directed towards its own production” (Beer, 1979, p. 405).

The role of system five as “variety sponge” (Beer, 1985, p. 125) that allows it to create the informational closure of the system is based on the answer to the question (italicized) above. And, because of the tension between the management of internal coherence and external management (and (e)valuation) of the material output of any given system in focus:

“... each level of recursion is likely to answer the identity question differently” Beer, 1979, p. 405).

In its baldest presentation the role of system five is to decide whether to *stay the same or change*, either structure, direction or position — but in any and all cases (except the demise of the system) the outcome must be *me*.

To achieve this the system must choose, where it receives contradictory advice, between or in some way integrate the recommendations of system three and four (see Beer, 1979, p. 258, ff.). Here the calculus introduced by Beer (1981, p. 201 ff) and its implicit redundancy adds value to the discussion — but does not change the decision to be made.

Beer also provides the basis of a dynamic model (1981, pp. 162-166) capable of representing this process (presented as figure seven).

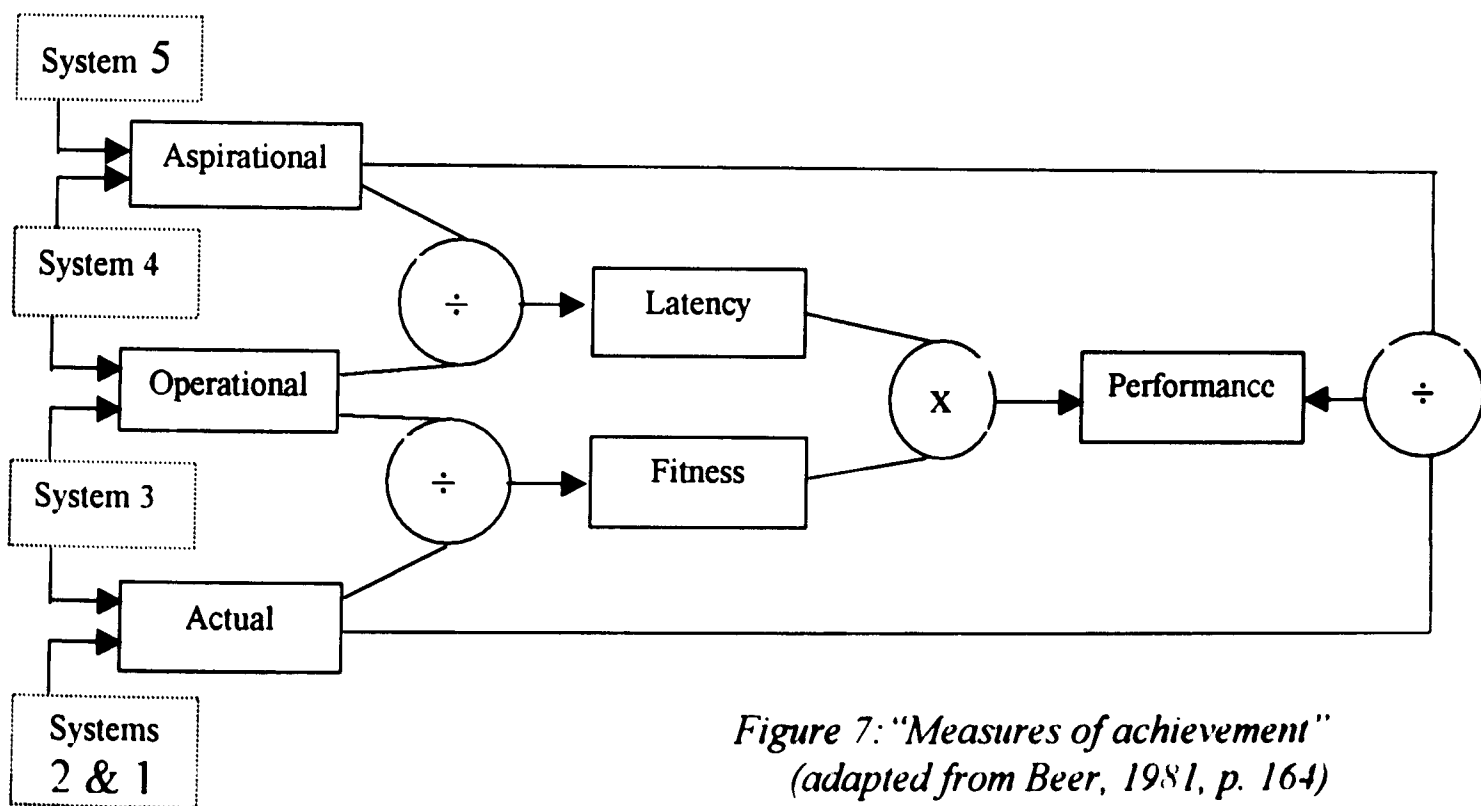


Figure 7: "Measures of achievement"
(adapted from Beer, 1981, p. 164)

With the terminology of Beer's model amended to reflect that of the previous section (although the operational calculations remain the same)

it is possible to flesh out this representation to expose the role of system five.

By inserting the figures from the previous sections “Actual” is seen to be $\cos\Omega$ (or possibly $1 - \cos\Omega$ if the system is exploitation rather than ‘profit’ oriented), i.e., the ratio of input to output (i.e. the extent to which the “self” is produced given current resource levels).

“Operational” represents the perceived carrying capacity of the current environment, that is, the level of resource available to the system if it were to fully exploit its current ‘habitat’. Therefore “Fitness” is the measure of internal capacity (i.e. “Actual”) to exploit an identified or nominated niche. Thus strategy or strategic change (given a relatively stable aspirational environment³³) would be constituted by progressive adaptive change in the internal capability of the system towards a state where its is able to more effectively exploit its environment. The role of system five within this activity is to provide the constraints or imperatives that render the environment system four is searching “meaningful” or relevant. Thus “*I am an X*” determines that the environment “*I*” operate in will be one that is relevant to *X*’s and,

therefore, that the informational equipment with which “I” scan this environment will be capable of identifying the elements of it that are relevant to “Me” as an *X* (see the section on the adaptation of system four, earlier) — this, of course, is part of the informational closure Beer (1979, p. 260) speaks of. This “closure”, and by definition the access to environmental information, effectively determines the constitution of the “operational environment”, thus what *is* perceived is, by definition, relevant³⁴.

Because of this the effective role of system five in such circumstances is as ‘arbiter’ when the outcomes of system three activity and system four information lead to conflict or contradiction, in effect “What, or how much of both, to do?”.

This, as referred to (in the iterative discussion earlier) can be viewed as a “learning” activity exactly similar to the modification of behaviour driven by the feedback through Ashby’s “essential variables” (1960, pp.

³³ As can be predicted from the “watchdog” effect on the mutation of selection active characteristics discussed by Gould (1993, p. 401 ff.).

³⁴ Within the constraints of the earlier discussion relating to the informational and physical viability of system four elements.

80 ff.) with the addition of a gradation allowing for measurement of the extent to which the constraints of these variables are satisfied.

Where the “Operational” environment is the functional habitat of the system in focus, the “Aspirational” is the environment it is *moving into*³⁵. There are two, general, possible reasons for this, *i*) it is the result of a volitional (therefore human) desire for change such as, for example, a change in market; or *ii*) it is the result of a structural change (and therefore *not* dependent on human consciousness) such as, for example, genetic mutation or environmental collapse.

In both these circumstances the relationship between the environment and the system changes and, as a result of this, so does the ‘optimal’ balance between them. This results in a ‘new’ operational environment being created necessitating the re-calculation of the informational equipment of the system for function³⁶ in order to support the creation of the ‘new self’.

³⁵ Note that the term “aspirational” is used because of the iterative nature of its introduction and is not intended to imply that non-human systems actively aspire to change. Indeed the majority of this section of the discussion is based on the premise that this *is not* the case.

³⁶ In either the case where the focussed on environment or where the system itself changes this re-definition of relationship can be expected to occur, rendering the effect of both, on the adaptive structures of the system, the same.

However this re-definition of self is not unconstrained. In much the same way that the “ethos” of system five constrains the decisions taken regarding the advice and activities of the “three – four” discourse the viability of the identity determined by system five (whether by change of aspiration or by genetic mutation) is constrained by the physical ability of the “3-2-1” homeostat to extract the resource necessary to its survival. Darwin’s assertion that “... any variation in the least degree injurious would be rigidly destroyed” cannot be ignored.

Thus system five can be seen to be the repository of the identity of the system, acting as both datum point and final arbiter — and in this way acting as the “variety sponge”, creating the “informational closure” necessary to the evaluation of any and all systemic change and/or activity any given level of recursion.

This is also why system five is shown (in figure one) is shown as having a direct connexion to the systems one. As repository of identity it must ‘know’ what this identity is comprised of, and if, when and/or how it changes.

The Algedonic Signal

“The cry is ‘wake up — danger!’” (Beer, 1985, p. 133)

In common with Beer (1985, p. 133), I have little to say regarding the “algedonic signal” in the abstract. However, it must be accepted that, if the parallel with the VSM is to be complete it must be present in some way. The model presented in figure one shows a direct connexion between system five and the individual systems one which, as stated above, I believe to be necessary for the maintenance and monitoring of the current state of *physical* (for want of a better word) identity. As the role of the algedonic signal is to “... decide whether or not TO ALERT SYSTEM FIVE” (ibid) with a warning of danger, it is reasonable to assume that algedonia is crucial to the maintenance of identity and that it is served equally by this direct link. And further (note that the link is shown between systems five at different levels of recursion) that it will be triggered when any given system one feels that its continued survival (i.e., the maintenance of *its* identity) is under threat.

The Adaptive Eigen-vector

The “adaptive eigen-vector” provides the closure of the model by taking a holistic view of systemic operation based on the notion of self, which is to say that all calculations are relativized against a subjective “Me”. In the section of this chapter where the cosine model was developed beyond the operational to the managerial function of system three, I made the point that the calculation of total system performance could be represented as a single, fractional figure ($\cos\Omega$). This figure was constituted by the projection of a rotated vector onto the baseline of inputs from the environment, thus giving an overall efficiency measure of the system in any given environment.

At the level of adaptive eigen-ness the goal is assumed not to be the *efficient* conversion of resource, but the *effective* maintenance of self. Thus the adaptive level of the model *subsumes* the operation of the operational and employs the *efficiency* measure in its calculation of effectiveness using a similar eigen-function model.

At the operational level the system could be said to be stable when $\cos\Omega \geq 0$. However here the model is related to the *identity* of the system

(which is set equal to one) rather than the *input* value (as was the case in the cosine model). This adaptive eigen-function can be stated as follows:

$$\cos\Omega E/I$$

where:

E is environmental input;

$\cos\Omega$ is the whole system efficiency measure from the cosine model;

I is the numerical calculation of identity.

This allows for a dynamic calculation of the operation of the system as a whole directed towards the maintenance of self which has as its result a single number equal to one when $E\cos\Omega = I$. Thus it can be seen that the system is in an eigen-state (i.e. it is stable in its constitution) when it is converting its environmental inputs into sufficient 'energy' to support its continued existence.

The elements of this aggregate representation can be teased out in order to demonstrate the functioning of the elements of the "3-4-5" homeostat to achieve the eigen-state of the system in the following manner:

$\cos\Omega$ is the information from system three regarding the efficiency of the system in operation;

E is the information regarding the operational environment from system four;

I is the actual numerical cost of operation and can be represented in disaggregated form as $\cos\emptyset$ (the direct or variable costs of operation) plus the fixed costs of operation plus the managerial costs of the system as a whole.

Thus when $\cos\Omega E/I \geq 1$ the system is in a stable (or growth) state, however when it is equal to less than one it can be presumed to be in a stressed (or reducing) state. As the 'goal' of the system is to survive it will need to take action to prevent its demise, and the actions it can take are:

reduce the variable cost of operation;

reduce the fixed costs necessary to the functioning of the system;

move to an environment where its resource needs are met³⁷.

The role of system five in ‘choosing³⁸’ between these courses of action is facilitated by ‘running the equation backwards’, that is, calculating the necessary changes (to achieve the stable state) in individual variables if the others are held constant. This has an interesting effect when the results are fed into Beer’s “measures of achievement model” (figure eight). It can be seen that the ‘cost reductions’ impact on the “fitness” calculation (i.e., the extent to which *current* operations meets *current* environmental conditions). And that the “environmental capacity” can be represented by the “aspirational” element.

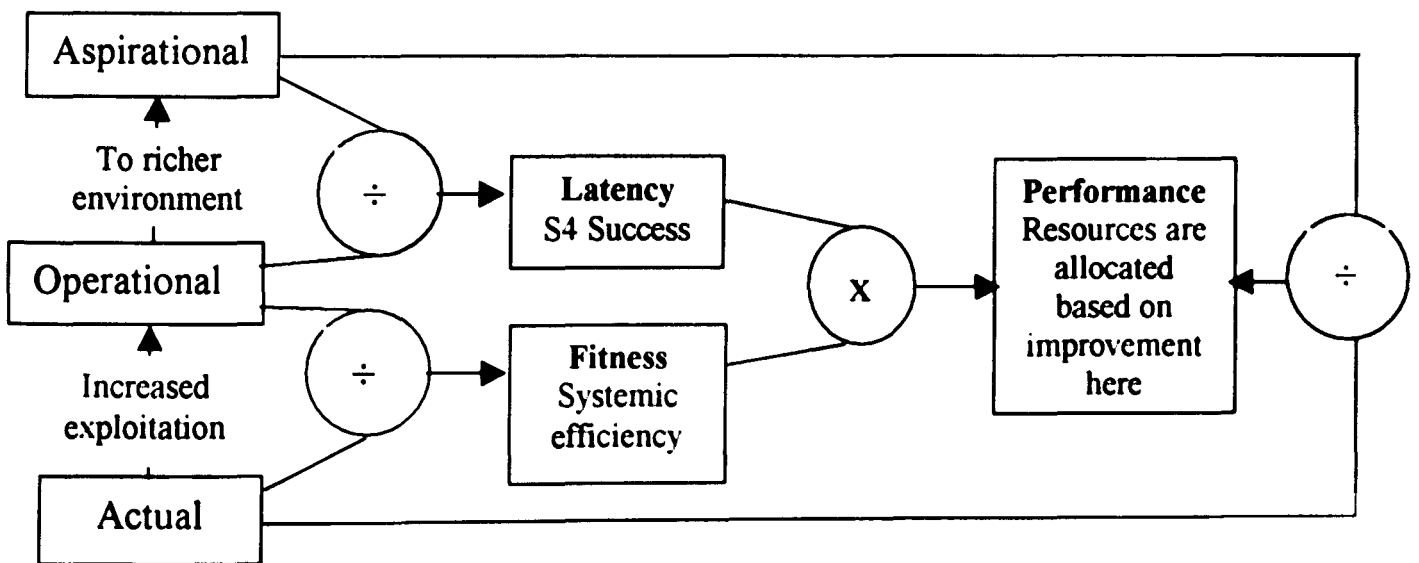


Figure 8: Locating adaptive behaviour.

³⁷ It should be noted that only the first two are ‘adaptive’ in the physical sense.

³⁸ The anthropocentrism is unfortunate. However I would suggest that biological systems attempt all three simultaneously, within their physical constraints, until some stable state is reached. This has the advantage of removing the need (within this representation) for conscious volition or foresight, being driven only by avoidance of ‘pain’, and is, therefore, consistent with the notion of self-awareness introduced in chapter seven.

And thus that:

adaptation is an internal response requiring no foresight or teleology beyond a basic survival instinct;

it is however possible, given only the basic capacity for self-awareness inherent in the equation, to derive a basis for a nascent teleology.

Both of which are driven (as suggested in Beer's (1981, p. 163) introduction of the model) by *current* conditions³⁹.

This is because the physical structures, and the emergent properties of their combination, that constitute the system determine the baseline tolerance of the system to environmental pressures⁴⁰. And, because the primary activity of the system operates in response to what I have called

³⁹ This being because, given the discussion earlier, the existence of 'stress' or 'pain' implies, in the context used here, the necessity of a richer environment or a more appropriate structural capacity to exploit current conditions.

⁴⁰ Which is entirely consistent with the notion that all higher levels of the system are "... dependent upon the physics of their ... constituent sub-systems" presented in chapter seven.

the “operational environment”, therefore, in the ‘outside and now’⁴¹ rather than Beer’s “outside and then” (1979, pp. 225 ff.), it does not require any foresight or notion of future that may imply the need for one⁴².

Which is to say that, when the system is *adapting*, it is in *improvement* mode — more closely approximating its existing eigen-state by *refining* a structurally determined (and therefore historical) repertoire in response to a defined range of immediate environmental stimuli⁴³. Whereas when it is ‘hunting’ it is attempting to approximate its eigen-state entirely *within its current repertoire*⁴⁴.

It can also be seen from figure eight that a ‘higher level’ resource allocation model is present — one which ‘decides’ between physical

⁴¹ This is a necessary consequence of a ‘real-time’ system. The existence of particular physical or informational structures can be taken to represent a form of ‘learning’ in a pragmatic Ashbean sense (see, 1960, pp. 82/3) in that their *retention* implies their validity, however this retention can imply either the extrapolation of their *continued* validity (which in turn implies consciousness) or the mechanistic solution to an immediate problem presented by an immediate environment (which does not).

⁴² This, of course, does not preclude the existence of consciousness, but merely removes the *need* for it whilst retaining the functional ability of the system to operate effectively in a (perceived or experienced as being) relatively stable environment or structural form.

⁴³ Note that this activity will, to be consistent with the remarks made in relation to variety filtration in chapter seven, be made at a lower level of recursion. In addition, in its pure form (i.e., when the activity is entirely adaptive) it assumes that the environment is fixed, i.e. the operational and aspirational environments are identical.

value (and therefore the basis of Beer's system three/one "resource bargain") and informational value (consistent with the discussion of physical and informational viability earlier in this chapter). Here again, because the basis of allocation is "performance" (i.e. resources are preferentially supplied to those elements that produce an improvement overall), successful behaviours are reinforced irrespective of their location. Thus physical 'reward' reinforces informational output (see discussion of system four as a physically viable system)⁴⁵.

A Population Function

Earlier in this chapter I described the co-ordination of individual systems one into a coherent System One by system two as capable of conceptualization as a "population function" (see especially note 14). And also made a case for the 'product' of a system to be treated as its waste product — but a waste product that was of value to the next higher level of recursion (see note 27). Making, in that context, the suggestion that a possible mechanism for co-ordination was the control of systemic

⁴⁴ This and the previous sentences have obvious implications for quality management. This being because, once a "specification" is established the environment (i.e. the demands placed on the system) is also fixed. Therefore the focus becomes internal (see discussion in chapter eleven).

⁴⁵ Note also that this notion of a physical 'cost' of information creates the basis for the "fixed" and "managerial" costs incurred in the operation of the system. In human organizational terms this may lead to the possibility of measuring the value added effect of management insofar as there is a measurable benefit achieved for a measurable incurred cost.

output via the control of population levels. That is that, for any given level of technology⁴⁶, the level of (system one) waste product produced could be seen as a function of the productive capacity of the individual system one, which could be seen as a function of the 'population size' of that system one.

I introduced there also the notion (following Margulis 1998) of the toxicity of the output of an individual to itself, and therefore the capacity of *overproduction* to reduce itself. Here I shall suggest a formal model to facilitate this.

If the figures used in the calculation of the eigen-state equation at the beginning of this section are used in the logistic equation (used to model populations, see, e.g., Gleick, 1987, pp. 63/4; Prigogine and Stengers, 1985, pp. 192/3) the equation below is achieved.

$$\text{Productive capacity} = P = \mathfrak{I} \{ I_{T+1} = (I_T \times r) \times (1 - I_{T+1} / \cos \Omega E) \}$$

⁴⁶ Mechanical *or* biological.

Which means that the productive capacity P is a function of the ability of the environment to support the population I , and the reproductive rate of that population. Thus the maximum productive capacity at any given time is the carrying capacity of the resources available, and the ability to move from one level to another is a function of the rate of growth.

The population and, therefore the productive capacity, can be seen to be stable when:

$$(1 - I/\cos\Omega E) = 1/r$$

because;

$$I \times r \times 1/r = I$$

In the stable state (i.e., where the equation above holds) the reproductive rate r will always be greater than one as long as the system itself is less than perfectly efficient in transforming resources into self. This is because any inefficiency in transformation will render the $(1 - I/\cos\Omega E)$ element of the logistic equation less than one and, therefore, necessitate r

being greater than one to compensate and maintain a constant population level over time.

This, of course, provides the “expansionist tendency” referred to earlier. Thus, when the environment expands (i.e. becomes richer) the population (and therefore the productive capacity) of the system will grow; likewise when it contracts so will the population of the system (by starvation).

However in a rich environment where the system is over producing, an inversely proportional link between the concentration of its output and the reproductive rate will satisfy the toxicity criterion. Rendering the reproductive rate fractional (i.e. less than one) will reduce output irrespective of available resource and, thus, reduce the overproduction.

In this way it is possible, again using only the model of self, to suggest an approach to managing across different sets of values. At this point the system in focus (following Beer’s rubric) becomes the system one of the next higher level of recursion and, therefore, subject to the protocols suggested for systems two and three earlier in this chapter.

Summary

This chapter has introduced a re-interpretation of the Viable System Model based on the explicit inclusion of a physical element alongside the informational elements defined by Beer. This re-interpretation was informed by the mathematical models discussed in chapter five and the notion of the “eigen-system”, a self creating entity based in the mathematics of quantum physics. And although it cannot be *proven* that either of these bodies of knowledge are formally applicable to either individual biological systems or the social arena (note however that Allen (e.g., 1994; 1997a; 1997b) *has* used similar ideas in social planning) they have had great *illustrative* value in this context.

The model has a number of differences to Beer’s ‘pure’ form of the VSM, most significantly:

the connexion of system three to the environment which *looks* very different but really only constitutes a logical convenience, but is consistent with the notion that the model is *digestive*, taking in gross inputs which it converts/refines

into itself and a waste product which is then released into the environment;

the formal connexion of system two at any given level of recursion to system four of the next lower level, thus reinforcing the belief that the co-ordinative function of system two is an informational role and that the response of the lower level system to co-ordinative pressure is essentially adaptive, both at the level in focus and the next level down;

the explicit connexion of the 3* channel from the systems one at any given level of recursion both to their own system three *and* that of the next higher level;

the treatment of the managerial/informational elements (i.e. those that Beer has as incapable of independent viability) as physically viable, whilst accepting the assertion that they are *informationally* non-viable, thus providing a basis for an adaptive function in these elements; and,

the division of the environments which form the focus of system four into “operational” and “aspirational”, thus identifying an additional “outside and now” locus for acquiring feedback regarding current activities.

In addition to this the looser connexions between the levels of recursion (permitted by the eco-system interpretation of the operational level) allows Systems three at the next higher level to “see” *R-I* (see figures four to six) as the output of its contained systems one and is, therefore able to “value” the very thing that the system one sees as toxic. The value set applied is an emergent property of the level of recursion and, thus, operates according to a non-monotonic logic, i.e., what is “good” at one level is “bad” at another.

The viewing of each of the levels of the system as variable at the next higher level (as assumed in the cosine model) will tend to cause either a curved performance plot or discontinuities in perceived performance because of the fixed elements of internal operational costs. The discontinuities can, however, be seen to correspond to the “step changes”

in systems performance identified by Ashby which he considers to “... occur abundantly in nature...” (1960, p. 88). One form of which has the characteristic that “...the use of two parameter-values ... [causes] the appearance of two fields...” (ibid, p. 94, brackets added, see also pp. 72/3). Thus Ashby is stating that changes to the parameters of a system can cause discontinuous changes in its output performance; changes that would, for example, be expected if the operational elements of a system were to undergo *evolutionary* change. This being because evolutionary changes in systems one would redefine the characteristic angle $\cos\emptyset$ (see fig. 2) thus establishing the system on a new output performance “field”. Each of these “fields” representing a stable or eigen-state of the system.

A final point, due to the eigen-system element of the model, is that this interpretation holds the promise of advances in the use of the VSM as the basis of the computer simulation of adaptive entities and the design of information systems along similar lines. This should also enhance the ability to integrate and focus human decision making in the managerial environment.

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Part Three

Chapter 9

Supporting the Standard

Introduction

“This approach enables an organization to reduce the risk of failing to satisfy its customers. It provides confidence to the organization and its customers of its ability to provide products that consistently fulfil requirements” (BSI 1999d)

The abstract above makes it clear that the intention of the provision of a standard for the design and implementation of a quality management system is to engender *confidence* that an organization is capable of supplying the product (or service) that it is contracted or retained to provide. Thus the standard itself is intended to supply criteria by which an assessment can be made as to whether the management system an

organization has in place is sufficient to the task of controlling its operations to that end.

In this chapter I will discuss the model developed in the previous chapter in relation to ISO 9001:2000 (CD2) and ISO 9004:2000 (CD2) with a view to establishing:

- a) that the model is capable of supporting the application of the standards, i.e. that it is capable of satisfying the criteria (requirements in 9001 and recommendations in 9004) they state as necessary; and,
- b) how informing their application in this way adds value to the organization and its operation by clarifying the business decisions to be made at any given point in the quality management process as defined in the standards.

The model developed in chapter eight provides a theoretical basis for viewing organizations as adaptive, autopoietic entities based on the Viable System Model of Beer (various). In it the emphasis was on the ability of the system to exploit the environment to recreate *itself*, with the

residual output (i.e. that portion of the total input that is left over after the recreation of self has been achieved) being treated as waste. However:

“ISO 9001 states quality management system requirements for use as a means of ensuring conforming product and/or service ...” (BSI, 1999c).

Taken together with the extract at the beginning of this chapter, the move of focus inherent in this is away from the creation and/or maintenance of self to the control of *output quality*. Thus the emphasis moves from *value to the system* to *value to the environment* — in effect the system is expected to concentrate its efforts on the characteristics of its waste product.

The obvious tension between the two interpretations is, I believe, responsible for the discrepancy between the common usage of the word *quality* and the more scientific definition used in the “quality community” (e.g., the “conformance to requirements” style of definition). Because of this the exhortations of the quality movement (evident in the extract above) can appear to devalue or disregard wider

(and more tangible) business necessities. And appear to regard 'quality' as some form of ideal (but external) characteristic to be achieved rather than as an integral, dynamic characteristic of the organization, its capabilities and the (possibly changing) demands of its environment.

I believe that the model presented in the previous chapter explicitly overcomes this problem by providing a rigorous grounding for the assertion that the successful organization must satisfy two apparently oppositely directed constraints:

continued survival by way of self-recreation, i.e., the business constraint; and,

adaptedness, by way of providing for, or fulfilling, some environmental demand, i.e., the quality constraint.

In the suggested model, quality management, in the sense implicit in the statements above, must be directed towards the "operational environment" loop. That is to say that "quality" (defined as

conformance to requirements) assumes the “relatively stable” environment alluded to in the previous chapter and is concerned with the continuous refinement of the operational behaviour of the organization in order to ensure that these “requirements” are more closely approximated¹.

As would be expected from this focus, the result of such emphasis is the creation of a stable identity for the system and, therefore, increasing effort being expended on the achievement of *efficient* provision or *minimal* conformity. Thus the aim of quality management system is to ensure, as a minimum, that *minimal conformity* is achieved at all times — and the value of certification to a standard is to demonstrate that it is capable of this².

To a great extent, the contents of the 9001 standard, rightly, focus on this area of organizational performance. However the 9004 standard attempts to go further, into the realm of “performance improvement”. And here, as will become apparent, as the sections of the standards are considered

¹ This is because, once established, the requirements take the form of an environmental constraint or demand, i.e., “Provide this”. And, once established, the requirements tend to be stable, taking the form of a contractual or legislative obligation and therefore having little or no scope for change.

² Note that this is not a pejorative remark, but a prediction based on the cybernetics of the model.

in turn, a degree of confusion (caused, I believe, by a lack of theoretical grounding) arises.

This confusion is understandably most apparent in what (both) the standards call *continuous improvement* — where one can be sure of neither *what* is to be improved nor what an improvement would *be*. This I believe to be a direct consequence of the presumed (on the part of the standards writers) equivalence of immediate, “operational”, quality and longer term, “aspirational”, quality. Because of this, quality management and performance improvement *as defined in the standards* are assumed to constitute the armoury of survival of the organization. However, following the model in chapter eight, such an armoury can be fully effective only if it is applied as a integrated element of a wider *effectiveness management* strategy — one that also explicitly treats internal (i.e. efficiency) needs, alongside the (operational and aspirational) environmental, to deliver tangible business benefits.

In the following the sections of ISO 9000:2000 CD2 are presented out of their original sequence (i.e., not in the order they are presented in the

standard), as it is felt that this will be more akin to the construction of the adaptive model.

Product and/or Service Realization (7)

The definition of the elements necessary to this “realization” are:

“Processes that are necessary to realize the product and/or service and their sequence and interaction ...” (BSI, 1999a, p.15).

Thus it is apparent that the elements of the organization the standard is referring to are those that Beer (and I, following his terminology) would call system one and system two (system two being necessary to enable management of their “interaction”). And what Ashby, in his definition of the ultrastable system calls “... the *system* that acts ... the part responsible for overt behaviour” (Ashby, 1960, p. 80).

To satisfy the requirements of the standard the constituent elements must be operated “... under controlled conditions and produce outputs which meet customer requirements” (BSI, 1999a, p. 15). The guidance the

standard provides as to how the organization may fulfil this requirement is that the organization shall:

- a) establish methods and practices relevant to these processes ...;
- b) determine and implement the criteria and methods to control processes ...;
- c) verify that processes can be operated to achieve product and/or service conformity ..;
- d) determine and implement arrangements for measurement, monitoring and follow-up ...;
- e) ensure the availability of the information and data necessary to support the effective operation and monitoring of the processes;
- f) maintain as quality records the results of process control measures...” (BSI, 1999a, p. 15).

While the related clause from ISO 9004:2000 CD2 that:

“The definition of quality requirements normally relates to how an activity is to be performed, while quality objectives are measures of process output or achievement. This lends itself to the recognition of any organization as a collection of processes and activities.

The principles of process management should be applied to any activity where work takes place. A process consists of inputs, activities or work and outputs or results. To ensure all processes operate as an efficient system, the organization should undertake an analysis of how processes interrelate, while recognising that the output of one process is often the input to another.

Key processes of the organization are related to the achievement of product and/or service outputs. In addition, processes for health and safety, environment and risk management should be considered.” (BSI, 1999b, p. 34).

It should be apparent from the description of the model presented in chapter eight that the “process” to be managed is system one taken as a whole and that the “key elements” of this overall process are represented by the *individual* systems one. The wider aspects of the model (i.e. the inclusion of system two and the “3-4-5” homeostat) and the ability to represent the process as a combination of linear and parallel interactions provide the structural ability to manage system outputs.

By necessity some of the activities necessary to this control are “meta-systemic” (see Beer, 1979, pp. 199 ff.) in that they rely on the “3-4-5” functions, rather than being wholly contained in the “3-2-1” homeostat.

This control is achieved in the following manner:

- a) overall output specification is defined at system three, i.e., specification of the output characteristics is included as a survival criteria and the costs of meeting these criteria are calculated as an integral part of the cosine calculations suggested in chapter eight. Therefore three star, at any given level of recursion, must carry as an integral part of the reporting procedure data confirming that output conformity has been achieved for that level.

- b) process design is defined at system three as a result of the operation of the “3-4-5” homeostat. That is to say that the positioning in relation to the environment made possible by the operation of the “3-4-5” homeostat defines ‘what the system must be’ in order to survive by defining what the system must provide to the environment in order to secure the necessary resources to support its existence. This is the

location of the interdependence between the model of survival and the traditional quality management model as it is the locus of *both* viability and autopoiesis. System three *enforces* the process design by selective *structural* resourcing based on continued contribution by individual elements to *overall* goals or performance criteria³. A further consideration here (because the “organization” has become socio-economic rather than biological) is that Beer’s “audit” capacity, providing “... direct access ... to the operations themselves ...” (1979, p. 211) *is* necessary to allow the informational closure of the process design loop⁴.

c) system two retains its co-ordinating role based on the “toxicity” model as before, but now the figures for input/output requirements explicitly include the formal specification in addition to simple quantitative measures. This inclusion is consistent with the biological model, suggesting that something that is not *recognizable* as an input *is not* an input⁵.

³ Note here that the individual systems one are the elements of the vector model introduced in chapter eight.

⁴ Note that the *contractual* (i.e., social) ability to intervene in the internal affairs of a system at a lower level of recursion is necessitated because the system in focus is itself operating under a contractual (i.e., social) rigidification of allowable outputs to its environment not faced by the biological system

⁵ Note again the *contractual* implication.

d) the individual systems one represent the separate tasks necessary to the creation of the overall output at the level of recursion in focus. The explicit recursiveness of the model, however, allows for the decomposition of these ‘individual tasks’ into levels of increasing detail. This is a significant advance on the ‘central command’ approach (implicit in the standard in its current form) as it allows for each separate level of recursion to be equipped with its own management function. In this way the responsibility for quality can be embedded into the fabric of the organization, and, because of this, the entirety of this chapter is applicable to each of these elements individually.

Thus, in terms of the stated requirements of the standard (i.e., 9001, see above);

a) the establishment of relevant methods and practices is met by the process design activity which is part of the role of the “3-4-5”

homeostat and which is enforced by selective resourcing⁶ on the part of system three

b) determination of control criteria is, necessarily, the responsibility of system three at any given level of recursion as is the implementation of 'post-process' control measures (this relates to the 'selective resourcing' mentioned earlier. However implementation of 'mid-process control' and the methods applied thereto are, in this model, the responsibility of the system three of the next level of recursion down. In both cases the information necessary to the exercise of this control is carried around the three star (performance reporting) an (what Beer, 1979, p. 252) calls the "command axis" and must be regarded as a function of the stated characteristics required in the output and the capacity of the system one⁷.

c) verification of the internal capacity of individual processes (i.e., systems one) is a process design activity at the next lower level of recursion and should include, as in "a" above the "3-4-5" homeostat

⁶ Note that this could include, in a social system, sanctions for inappropriate behaviour that would not be available to a biological system.

⁷ That is to say that it is of no use to monitor or control for an output that the system one is not capable of producing.

at that level of recursion operating within the performance constraints established at the level in focus. At any given level of recursion all other criteria must apply.

- d) arrangements for measurement and monitoring are the design of the three star channel and must, therefore, be a function of desired outputs/performance criteria and the capacity of system three to enforce control measures through selective resourcing. Follow-up actions can then be seen as adaptive responses on the part of system three to bring performance back into line with requirements.
- e) Given the existence of an effective three star channel the availability of information and data *to management* is ensured providing that appropriate data capture is designed in to the individual systems one. Effective *operation* of these processes falls to the design of system two which, if the suggested model is implemented, is a largely automatic function and the capability of the command channel.
- f) In a biological system the “quality records” would exist as learning or evolutionary change, retained because the action taken was effective

at producing the desired output. Therefore there can be no 'in principle' exclusion of the retention and/or recording of such information in this model. Assuming that the majority of information is captured and/or recorded using current information technology the generation of such records is not problematic⁸.

Thus it can be seen that the model proposed can not only support the stated (general) requirements of ISO 9001 and ISO 9004 but, by locating the points and necessities of certain types of control operations, can aid in the design of the organization. This extension of utility should enhance decision making quality by targeting the allocation of resource and managerial effort to the organization as a whole rather than merely on its output.

Resource Management (6)

The standard (as at CD2) appears to be ill defined on precisely what is intended by the word "resources". However the general requirement is that:

⁸ Even where such technology is not used this requirement is simply, if somewhat laboriously fulfilled

“The organization shall determine and provide in a timely manner, the resources needed to establish and maintain the quality management system.” (BSI 1999a).

The implication here is that there is a requirement to fund the quality management system. However, the remainder of the clause makes it clear that this responsibility extends (sensibly in my view) to the provision of resources to enable the proper functioning of the organization⁹ as a whole.

A second area of potential confusion is that nowhere in the clause is there any reference to the provision of raw materials¹⁰. Given this lack of clarity in the extant text, and the items that are specifically included (i.e., “human resources”, “information”, “infrastructure” and “work environment”) a reasonable interpretation is that “resources” are the equivalent of what I have called ‘structural resources’¹¹. And thus is it

⁹ It is assumed that, because of its terms of reference (i.e., quality management) the standard would require the provision of such resources as relate to the provision of “conforming product and/or service”. However I would argue that the model presented in these chapters requires a more exhaustive view of “resources” and would create a more robust process as a result.

¹⁰ Given that, in both ISO 9001 and ISO 9004 the organization is seen as a ‘transformation machine’, converting inputs to outputs this is indeed of concern. And, although it may be claimed that this is addressed under “purchasing” (clause 7.4) no reference there is made to ensuring continuity of supply to allow uninterrupted operation.

¹¹ That is to say, those items that facilitate or allow the operations to continue but are neither transformed nor consumed in the process.

possible to treat “resource management” as defined in the standard as the planned provision of the structural capacity to supply “product and/or service” to the required standard.

In a static system such provision would be the result of a simple interpretation of the received output specification in terms of structural needs, in short, an operational matter — a basic system three task. However, because in ISO 9004:

“... Resources necessary to permit and promote changes should be considered ... [and] Planning for future resources should be a part of the management review.” (BSI, 1999b, p. 27);

it is apparent that, even where it is not a “requirement” for certification¹², resource management is seen to be a dynamic rather than static function.

¹² ISO 9004:2000 constitutes “Guidance for performance improvement” and is, therefore, *advisory*, rather than containing a set of “requirements” which can be assessed as a basis for certification

This implicit inclusion of a dynamic element to the provision of resources in the organization creates a problem for the operational manager in that:

“Requirements for all resources should be defined in tangible terms ...” (BSI, 1999b, p. 27).

Because, as I have argued elsewhere in this document, output quality is part of the external loop (i.e., defined by the environment rather than the system itself) any tangible definition of resource needs will need to be responsive not only to non-conformity to existing specification but also to moves in the specification itself. Here the Janus-like character of system three arises again.

As the central resource allocation function for the whole system, system three ‘knows’ at any point in time the level of resource available for distribution (as, for example, an integral result of the cosine calculations suggested in chapter eight)¹³.

¹³ It should be noted here that system three resources *both* the “3-2-1” homeostat *and* the “3-4-5” homeostat. This is important because there is an assumption, implicit in the standards, that ‘management’ does not constitute a cost. However, the discussion of *spalax* in chapter eight makes it clear that there *is* a basis for the evaluation of the management role in terms of a *value added* criterion.

As an operations management unit, that is as an element of the “3-2-1” homeostat, system three is concerned with “doing things right” (Dudley and Beckford, 1999a) according (because of the inclusion in the cosine model of throughput as well as structural resource) to two sets of criteria.

The first of these criteria relate to the autopoiesis of the organization which, although not strictly necessary to the operational quality argument, is necessary to the continued ability to provide. The measure applied here is “ $\cos\Omega$ ” and is possible because system three has access to ‘total resource received’ information and ‘total resource used’ information. Where “ $\cos\Omega$ ” is greater than zero the resource available is greater than the resource necessary for the system to recreate itself and is, therefore able to continue to exist in its current form, under current environmental constraints and demands.

Within the absolute resource constraint implied by “ $\cos\Omega$ ”, system three is able to allocate residual resources to ensure continued provision of

and, therefore, it is possible to explicitly include management quality in the remit of a quality management system given suitable models of organization.

‘within specification’ output¹⁴. As can be seen from the extract above the basic requirement of the standard for resource provision is entirely consistent with the “inside and now” (Beer, 1979, p. 199), emphasis of this face of system three. As such *quality* performance measures (as an integral part of the three star function) such as, e.g., percentage throughput within specification, are only meaningful within a pre-established or pre-stated goal figure, such as, e.g., “not less than ninety five”. This is because, as an operational resource allocator, system three is an ‘efficiency machine’, therefore operating within an implicit value set, over which, in this role, it has no control.

Because of the fact that, in this role, system three is concerned with the internal functioning of the organization — and that therefore any direct perception of *quality*, defined as a function of the environment, is unavailable to it — it must rely on *indicators* of quality. And these indicators are represented by performance criteria which have been established *in advance* and therefore are necessarily external to its day-to-day operation. Therefore the resource provision undertaken at this level can be expected to comprise the selective application of resources

¹⁴ The amount of resource available for this was defined in chapter eight as “ $\cos\Omega^2$ ”.

and/or sanctions directed at the minimization of deviations from, or the maximization of moves toward, the achievement of *this* (i.e., the extant) standard of performance. Unsurprisingly, and in a manner that is entirely consistent with the operation of the “3-2-1” homeostat as described in the previous chapter, this can be expected to lead towards *a* stable or equilibrial point, or *simple homeostasis*. Unfortunately, for the organization, this state of affairs has, at least since the time of Bogdanov (see, 1996, pp. 188 ff) been regarded as pathological in a dynamic environment.

In order for the system to overcome this pathology, and to fulfill the aims of the “guidance” contained in ISO 9004:2000 in relation to the management of change, the ‘second face’ of system three is necessary. As an element of the “3-4-5” homeostat it is party to the discussions relating to the *strategic*¹⁵ allocation of resources. In fulfilling its role as a member of the “3-4-5” homeostat system three takes with it information relating to gross resource availability and current performance, which comprises the “*cosΩ*” as a basis for the quantification of performance relating to continued survival and (in this context) achievement of

current quality objectives. The role of the “3-4-5” homeostat is, using the mechanisms described by Ashby (1960, pp. 80 ff.) to ensure that the system as a whole is fulfilling environmental demands, a role that can only be carried out at this level because it is only here that the system is able to monitor whole system environmental demands.

The decision made at this level, in relation to resource allocation is, effectively, “What do we need to be in order to satisfy this demand?”, and, therefore, “What do the performance objectives need to be to facilitate this?”. The answer to the second question resets the objectives that system three attempts to achieve in its operational role and, assuming that the resources necessary as part of any changes identified are available, system one begins to function under the revised set of operational constraints. Where sufficient resources are not available some level of prioritization will be necessary (defined by the “3-4-5” homeostat) before operational objectives and budgets can be finalized.

In either case it can be seen that resource provision (within current availability and performance objectives, and, therefore, within the

¹⁵ Strictly speaking this element constitutes “management responsibility”, the subject of the next

constraints of the *requirements* of ISO 9001:2000) is a strictly operational matter, but that there is no facility for adaptation or change — and therefore will lead to a static formulation of resource management. However where the *guidance* of ISO9004:2000 is taken into account it is also necessary to include the wider capability of the entire “3-4-5” homeostat in order to be able to ensure that whole organizational objectives are met.

Management Responsibility (5)

The general requirements for the fulfilment of management responsibility state that:

“Top management shall demonstrate its commitment to:

- a) creating and maintaining awareness of the importance to fulfil customer requirements;
- b) establishing the quality policy and the quality objectives and planning;
- c) establishing a quality management system;
- d) performing management reviews;
- e) ensuring the availability of resources.” (BSI, 1999a, p. 11).

section.

In the absence of objective measures for measuring this “demonstration of commitment” it is necessary, in this section, to move away from dealing with ‘general requirements’, as is the case in the rest of this chapter, to the individual sub-clauses which contain the term (or variations on term) “the organization shall ...”. This being on the assumption that management commitment is adequately demonstrated on the basis that *the organization has...*

Beyond the “general requirements” (5.1) there are six sub-clauses (i.e., 5.2 – 5.7), treated in order below.

Customer requirements (5.2) must be determined, fully understood and met. A consistent application of the model presented in chapter eight indicates that this is primarily a system four role at any given level of recursion, particularly in relation to the “determination” and information received relating to the “meeting” of requirements. However, their being fully understood is more complex. Understanding customer requirements at the level of value to the customer remains a system four role, but understanding the requirements in relation to their impact on the

organization must include both system three and system five. This is because the “viable system” must ensure that the satisfaction of such requirements will not compromise its viability (a system five function) and beyond this, that it has, or can obtain, the capacity and or capability to fulfil them (an adaptive element of the system three role).

As customer requirements can be assumed to define the ‘primary environment’ in which the organization must exist they must also be seen as the primary driver for organizational adaptation. That is, that changing customer requirements (or attempts to better achieve existing customer requirements) pose an adaptive challenge to the organization. Because of this, although they are captured or identified as part of the environment scanning function of system four, they can only be evaluated and internalized (and, therefore stimulate internal change) as a result of the operation of the “3-4-5” ultrastable mechanism as a whole. Only when this process has been completed is it possible for the “3-2-1” element of the organization to settle into a stable (or planned transitional) mode of operation that allows it to attempt to fulfil the designed output.

Legal requirements (5.3) relating to the “quality aspects” of output can be seen to operate as an environmental constraint. This constraint can be operational (e.g., there may be requirements as to the processes that can be undertaken in terms of hygiene measures, as for example in the food industry) or relate to performance of output in end use (e.g., stress parameters in the aircraft industry). This section overlaps (to some extent) with the requirement in 7.3.2, (e) for the consideration of “any other requirements essential for design and development” (BSI 1999a, p. 16) and implies a level of *professionalism* which, for the most part, the standard itself seems reluctant (or unable) to tackle. As an integral part of the negotiation of contract (i.e. the determination of requirements) at the level in focus or as part of the design process (where this is applicable) at the next level down, such requirements are, I think, and as such part of the system four role.

Policy (5.4) at the level the wording of the standard implies is the definition of the *identity* of the organization and, as such, is clearly a system five function. The wording of this clause, in relation to the appropriateness of the policy “to the needs of the organization” and the provision of a “framework for establishing and reviewing quality

objectives” mirrors the essential aspects of Beer’s (1985, p. 125) definition of system five as a “variety sponge”, in that it provides the baseline values for organizational decision making. However, I find it difficult to understand how the organization can determine the appropriateness of its policy to the needs of its customers (5.4, (a)), beyond an historical relevance to the market. Other problems with the remainder of this clause (both highlighted and dealt with by the suggested model) are the basis for communication, understanding and implementation “throughout the organization” (5.4 (d)) (because the bureaucratic structure implied in the standard is more like to erect barriers to effective communication and acceptance of responsibility and which is overcome by the recursive nature of the model suggested). And an apparent ignorance of the fact that changing the policy will effectively change the identity of the organization — which has the potential consequence of changing the structure of the organization and, thus invalidating existing quality control procedures.

Planning (5.5) can now be seen comprise two aspects; the higher level “What should we do about the whole organizational impact of what system four is telling us?” which will integrate policy changes (as

mentioned above), and the more directly operational “What addition to, or subtraction from, resources shall we allow to the operational element of system three to allow us to achieve this?”. The (9001) standard (5.5.2) emphasizes only the latter interpretation, thus it has a great deal to say in relation to *operational quality* (i.e., quality as if it stood apart from the value sets of the organization involved in its provision), but very little in terms of the *effects* this provision may have, or the business benefits or disbenefits, that may accrue to it. This strengthens the assertion that (as it stands) the standard does not fully appreciate, and therefore cannot provide, the mechanisms necessary to support adaptive processes in the organization nor fully realize the advantages to be gained from their self-critical application.

Given that the (9001) standard relates to the implementation of quality management systems it is not surprising that one of its requirements (5.6) is that one is established. The advantage derived from the application of cybernetic modelling in general, whether Ashby’s ultrastable system in its pure form, Beer’s viable system model, or my interpretation of them, as particular instances thereof, is the location of the various elements of the management of quality in and around the host

organization and its environment. This location is based on the types of information necessary to and the organizational impacts of, the decisions to be taken and, because of this, it is possible to *integrate* the quality management system into a wider *management system* that supports the creation and management of an *effective* and *efficient* organization.

The final explicit element of “management responsibility” is “management review” (5.7). Here again it can be seen that the activities to be undertaken fall into the two distinct categories of ‘management’ (i.e. relating to “3-4-5” activities) and ‘operations’ (i.e., relating to “3-2-1” activities). Where, for example, “...changes to the organization’s quality management system, including policy and objectives” (5.7) are necessary as a result of a review, it can be seen that the impact of such changes will be structural or relate to the established values applied in the organization and, as such can only be undertaken in the domain of the “3-4-5” homeostat. However, where activities relate to, for example, “process performance and product conformance analyses” (5.7 (c)) or “process, product and/or service audits” (5.7 (h)) they fall within the remit of the “3-2-1” homeostat. This being because the former will tend to the creation or alteration of the *bases* of evaluation of organizational

activity, whereas the latter are based on the results of evaluation *within* these bases.

The ISO 9004:2000 guidance relating to “management responsibility” begins with the statement that:

“Management responsibility should include the following actions needed to achieve the continual improvement of the organization.

Planning

Deployment

Checking

Improvement” (BSI 1999b)

Which is an obvious adaptation of Deming’s (1986) “Plan-Do-Check-Act” cycle. The standard (9004) also goes on to state:

“Top management should define the objectives within the organization, and the responsibility of all management to operate in a manner to achieve these objectives.

Top management should also define a mechanism for the evaluation of performance in the strategic decision making process, which is their direct responsibility. Striving for quality improvement should be an integral part of the organizational strategy.

Top management should also periodically evaluate the culture and review the structure of the organization to ensure that continual improvement is the driver for organizational development” (BSI, 1999b, p. 13)

Here again we find the wording of ISO 9004:2000 attempting to extend the range of ISO 9001:2000 beyond its strictly quality management range into the realm of organizational effectiveness. Indeed the clauses quoted above reflect some of the imperatives given in chapter eight regarding the role of the “3-4-5” homeostat. However, and in common with ISO 9001:2000, there is no evidence in it, beyond lists of “issues to be considered” of any fundamental attempt to effect a thoroughgoing integration of its extended principles.

Thus I believe that it has been demonstrated that the cybernetic model as presented previously is not only capable of providing for the structural

needs of the standards (both 9001 and 9004), but also of providing a more rigorous foundation for *whole organizational* management (which necessarily includes a structure for quality management). And, because of the inherently recursive structure, gives the significant advantage of being able to precisely target management responsibility at any level of the organization — thus reducing the degree of complexity faced by any given level.

Measurement, Analysis and Improvement (8)

The general requirements of this clause are that:

“The organization shall define, plan and implement measurement, monitoring, analysis and improvement processes to ensure that the quality management system, processes and products and/or services conform to requirements.” (BSI, 1999a, p. 20).

I think that it has been sufficiently demonstrated within this chapter, and previous discussions, that the model suggested in chapter eight is capable of satisfying this requirement *in principle*. Not least because the elements this clause refers to are the very elements which form the basis

of the model, and that a “Viable System Diagnosis” approach, for example, as suggested by Flood and Jackson (see Flood and Jackson, 1990, p. 87 ff.) would be expected to concentrate on the investigation of their structures and interactions.

Indeed, when one moves away from the strictly operational elements of a quality management system, that is to say from the “processes and products and or services” as a point of focus and towards more managerial considerations, i.e., “the quality management system” itself, the *only* way to evaluate (and/or improve) performance is by applying the ‘second-order’ (see Shoderbek, Shoderbek and Kefalas, 1980, p. 87 ff.) cybernetic view implicit in the discussion of the potential for evolutionary shift in information processing sub-systems given in chapter eight.

Here again the model suggested adds value by suggesting both locations and mechanisms for change within the organizational structure which are not supplied in the current version of the standard.

In the ISO 9004:2000 standard a great deal of emphasis is placed on the potential *sources* of information that may be used to feed into the “measurement, analysis and improvement” process, and on the exhortation that the organization be “committed to continual improvement [and] ... provide for the measurement and evaluation of product and/or service ...” (BSI, 1999b, p. 52, brackets added). And, as before, there is nothing that cannot, in principle, be supported by the model as it stands.

Summary

In this chapter I have attempted to demonstrate how the adaptive model, completed in chapter eight, is able to fulfil the general requirements of ISO 9001:2000 and the principles of the guidance contained in ISO 9004:2000 as both stood as at CD2. This was achieved by taking the major clauses of ISO 9001:2000 and the associated guidance from ISO 9004:2000 as the base structure and considering the extent to which the elements of the model I have suggested were able to support them.

As far as was possible the consideration of the standards was kept at the level of their “general requirements”. This was because the model I have

presented is structural, identifying typologies of decision, action and information rather than the actual forms they should take. Operating at this general level has the advantage of allowing largely “unrestricted generalization”¹⁶ between diverse fields of study and, therefore the potential for the proposal of novel models (or novel interpretations of existing models, e.g., the notion of ‘output toxicity’ as a mechanism for system two operation). However, and although the principle of the general nature of organizational models has been explicitly included as the basis of work in the area of ‘systems research’ (see, e.g., Ashby, 1964, p. v; Beer, 1979, p. 67 [implicitly]; Bogdanov, 1996, p. 43; Wiener, 1965, p. vii), such generalizations, however rich they may appear, can only be held to be valid on a case by case basis.

This chapter, I believe, has successfully demonstrated this validity *at the general level* in relation to the ISO 9000:2000 quality management standard. As to whether this validity continues to hold when the more detailed requirements of individual organizations or ‘industries’ must be met is an empirical question. Although the experience of the seminal thinkers (above) and personal management consulting experience

¹⁶ A term used by Wang (1996, p. 9) to describe a principle utilized by Gödel in his work in formal

suggests that, within the social constraints inherent in organizations, this will be the case.

Taking this structural model *into an organization* in the attempt to construct a detailed working model that supports the management of it in both general commercial and quality terms. This test is undertaken chapters ten and eleven.

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Chapter 10

Managing Zubnich

Zubnich is an independent dental practice operating on a single site in the south of England towards the western end of the M4 corridor. At the time of writing the practice comprises:

Two Dentists

Two Dental Nurses

One Oral Health Educator

A Practice Manager

One Receptionist.

However there are plans to expand the practice to include a Dental Hygienist and another surgery in the near future.

The practice is associated with a private dental health plan company and offers treatment (for adults) to private patients only, with patients

divided between those who are members of this plan and independent payers (i.e. those who are not). The practice does, however, offer NHS treatment to minors (usually relatives of existing private patients).

It is anticipated that the second surgery will be located in an NHS health centre and *will* provide treatment to patients on the NHS.

Table 1: The Zubnich Dental Practice

Introduction

In this chapter I will develop a model of the Zubnich practice as a viable system; and begin to test the assertions made in the description of the interpretation of the VSM I introduced in chapter eight. This will form the basis of the data flow and control models to be introduced later. As a *specific* application of the approach suggested by the model it is to be expected that modifications to the *ideal type* will need to be made and, where this is necessary, comparisons with other, partial, applications will be made — in an attempt to discover whether they themselves are application specific or identify a need for modifications to the core model.

Building the Model

1 What the System Does

Zubnich provides dental treatment. At the most general level this service can be divided into two categories:

Corrective — fixing problems that have already arisen, work which will, because of its nature, be undertaken by a dentist; and,

Preventive — planned dental health care to minimize future problems, work such as this may be undertaken by a dentist (as in the case of routine check-ups) or by an oral health educator or dental hygienist (for example advice relating to dental hygiene or descaling)¹.

Thus, “what the system does” is provide dental services, either corrective or preventive, to its identified environment — the *patients*. Therefore, taking the practice as a whole as the “system in focus”, the “systems

¹ Note that these examples are far from exhaustive and, in the case of prevention may not be limited to *dental* prevention, a case in point being the recognition of lesions indicative of oral cancers.

one” are those elements of the practice that *directly* provide dental treatment and thereby generate revenues for the practice. That is to say, the dentists, oral health educator and (when one is appointed) the dental hygienist are the systems one of the Zubnich practice².

Described simply the overt role of the dental practice is to convert *patients* (i.e., those members of the identified environment recognized as a “gross resource”, see chapter eight) with current dental health concerns (whether corrective or preventive) into people without current dental health concerns (or with a planned program of treatment to remove them), i.e.:

In this simple process (figure 1) the “Treatment Required?” element can represent either an evaluation and identification of subsequent treatment or a routine check up. And, where further treatment is necessary (i.e., the “Treatment Program” element), it can either be undertaken immediately (i.e. as part of the same visit) or scheduled for some later date (and could be provided by either the same or some other dental professional).

² Hereafter these roles will be termed “clinical”.

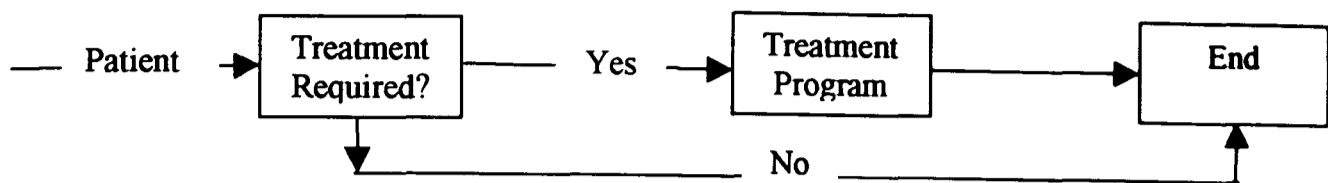


Figure 1: a simple process map.

In all cases, i.e., whether an evaluation with no subsequent treatment or where the evaluation leads to further treatment, the *effected transformation* of patient with dental health concern to patient with alleviated concern is brought about primarily by the exercise of the clinical judgement and/or ability of the dental professional³. It is this location and the consequent generation of income, and the fact that, theoretically if not actually, it is possible for the individuals to ‘rent a chair’⁴ within the practice that leads to their definition as systems one⁵.

The patients have been identified as a “gross resource”, as defined in chapter eight, because they constitute both a ‘raw material’ and a ‘resource. They are a raw material because the transformation effected

³ Hence the stress on the “skills based” element of the quality of provision of services in general, and of professional services in particular.

⁴ That is to operate as a functional part of the practice whilst being, e.g., self-employed and paying a portion of received income to the wider business owner, a practice that is also prevalent in other service industries, e.g. hairdressing.

⁵ Note also that in this case individual service providers in the same role (e.g. the two dentists) are treated as separate systems one. This is partly to take account of the possibility of individual professional specialisms and partly a pragmatic approach given the number of employees. In a larger

by the practice is either an informational or physical transformation *of the patient*. And they are a resource and because it is the fees that they pay for this transformation that constitute the structural resource available to the practice to ensure its future survival. They are a “gross” resource because they are complex, as outlined above, thus requiring ‘refinement’ into their constituent elements (i.e., raw materials are the bodies for treatment, and payment arrangements lay the basis for receipt of structural resource) and because they form part of the “that which is left over after the organization has created itself”. The treated patient that walks out of the practice takes with them their treated body and the consumable materials (e.g. mouth rinse, amalgam, anaesthetic, etc.) used in their “transformation”.

Thus we see that constructing a model of this level of the practice requires that the individual professionals be provided with two forms of raw materials, the patient (from the nominal environment) and consumable materials (which, prior to the discussion of operations management, can be seen as internally produced and, because of the recursive structure, access to some form of structural resource (to allow

concern it may have been desirable to add an extra level of recursion to accommodate differing types

for internal self-recreation at the individual level). This gives a diagrammatic representation of Zubnich as figure two.

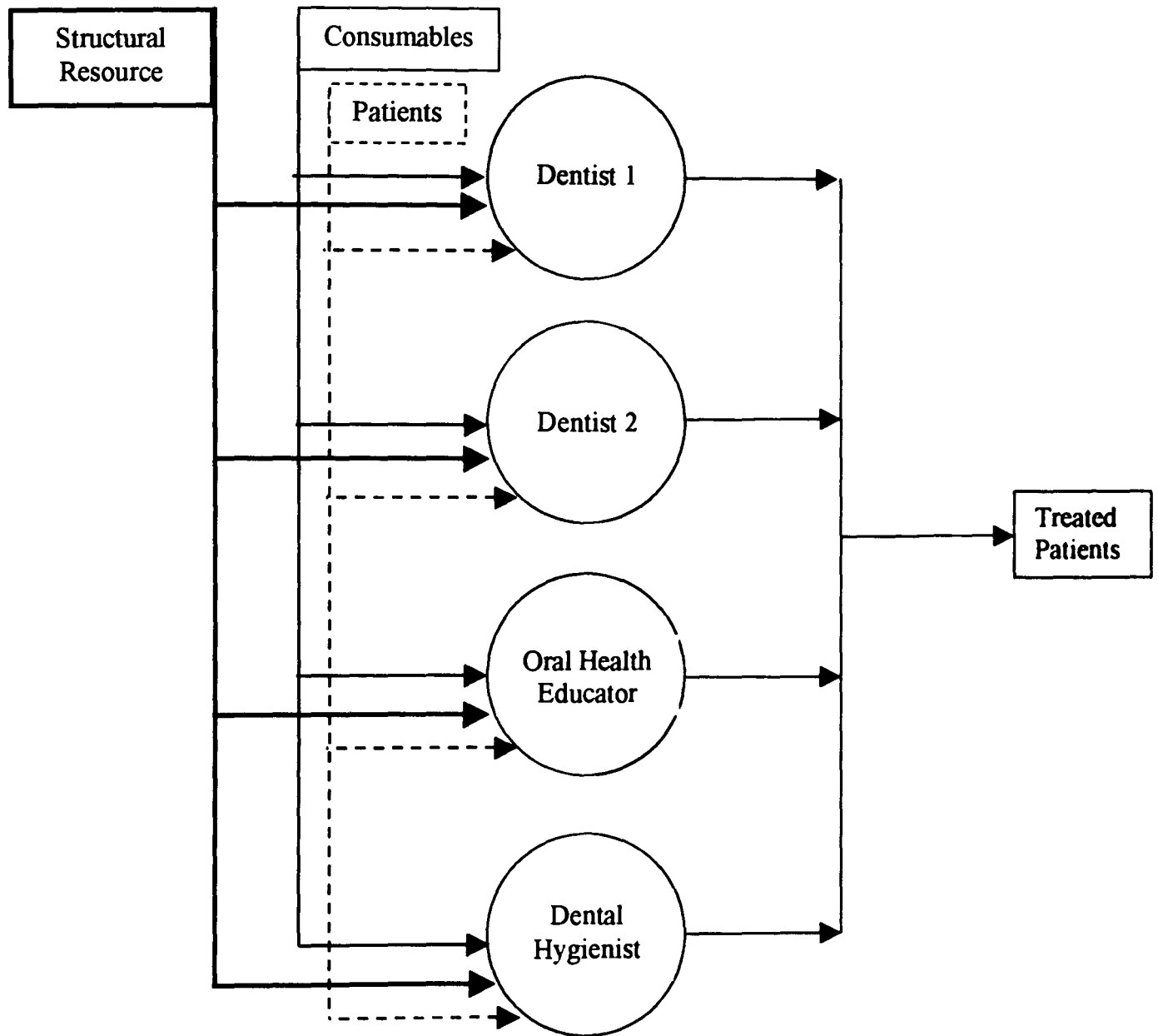


Figure 2: The basic resource/transformation model

It should be noted that, at the level of decomposition represented in figure two, the patient as gross resource has been refined (as suggested above) into three elements: a) the person to be treated; b) the

of treatment, e.g., dentistry proper and hygiene and education.

consumables purchased from fees received; and c) other monies (also extracted from fees received) for (or represented by) capital equipment, indirect labour costs, direct labour costs, etc.

As the final element of provision Zubnich also uses the support of the Dental Nurses. Their role is, inter alia:

To support the dentist during the provision of treatment;

To prepare surgical equipment for use, clean/sterilize equipment after use;

To prepare and maintain the surgery room in a fit state for use;

To ensure the maintenance of clinical stocks;

To provide interim assessment of patient needs.

These “clinical related” functions have been termed “technical” for the sake of clarity, in that they are clearly necessary to the provision of dental treatment but are not *directly* part of the transformation process undertaken. In the Zubnich practice the dental nurses ‘belong’ to the practice as a whole, i.e., although they may primarily work with a single nominated dentist they are a *shared resource* provided out of the practice

budget managed at system three. As such they would be treated as a “fixed cost” in the *cosΩ* calculations described in chapter eight.

However, it is equally possible that such support be considered part of the financial responsibility of individual providers (i.e., systems one) and, therefore part of the “direct cost” element of the *cosΩ* calculations. Such considerations are strictly empirical, dependent upon the actual arrangements in place and by no means invalidate the interpretation.

2 Co-ordination

Operational co-ordination at Zubnich is, perhaps unsurprisingly mainly carried out through the appointments procedure. That is, that ensuring that the appropriate skills and equipment are available to treat patients is made possible by reserving or booking them in the appointments diary. Thus we can see that the (majority of) the raw material (i.e. patients), and the structural resources necessary to their transformation (i.e., the capital equipment, the intellectual capital of the clinical professionals and the support capacity of the dental nurses) are brought together ‘at the right place, at the right time’ (i.e. in the surgery for the designated

appointment) by way of an informational transaction implicit in the making and keeping of appointments⁶.

The “output toxicity” model for co-ordination introduced in chapter eight was generalized from the notion of the management of a linear process (i.e., one where the outputs from a sub-system l_a formed the input to sub-system l_b etc.) and developed in a study of a firm in the agricultural sector (see table 2).

Igra'et Oak are a commercial mushroom producer undertaking all aspects of the mushroom production process from compost creation to packing and shipping produce to clients.

This comprises:

buying in baby pigs to fatten for slaughter in a deep litter barn;
collecting the straw (now saturated in urine and faeces) at the end of the fattening cycle;
composting the straw/excrement mix;
pasteurizing the compost;

⁶ The availability of the remainder of the “raw materials”, i.e. the clinical consumables used during treatments, is, strictly speaking a “resource allocation” issue. However, as one of the tasks of the dental nurse is to prepare the surgery for use, this “informational transaction” also provides the stimulus to the nurse to ensure their availability *at the point of delivery*, i.e. for the designated appointment.

adding paramecium spore to the compost and laying in trays;
allowing the spore to populate the compost;
setting the trays in growing sheds;
stimulating final growth by chilling the trays;
picking/packing/shipping.

The goal was to be able to manage this process such that market demand was adequately met at all times — complicated by the vagueries of the natural processes involved and the relatively small amount of manageable variability in the individual processes themselves.

Table 2: Igra'et Oak

In this simpler co-ordination model it is relatively easy to set the level of output tolerance to the level of input required by the subsequent stage in the process, that is that:

Goal state I_a = Input need I_b ... Goal state I_n = market demand.

And that the actual output is constrained by the level of resource available at all stages of the process, i.e.:

$$\text{Output } I_i = f(\text{Input } I_i)$$

Such that the output of the process can never be more than the input needed to create it.

With the exception of a small number of treatments (5 from 62 standard treatments offered) the services offered by Zubnich do not rely on a linear process relationship *between* clinical professionals. In fact, the relative independence of the individual systems one can be seen to move toward the opposite extreme — they are operating almost entirely in parallel.

This parallelism does not, however, invalidate either the linear model (which will be seen to be appropriate at the next lower level of recursion) or the notion of output toxicity as a basis for co-ordination. Under current conditions, the Zubnich practice has a structural capacity to support clinical professionals which exceeds the capacity to exploit it — the practice has five treatment rooms available and only three practicing clinical professionals (and even with the introduction of the proposed extra dentist and the dental hygienist will not be a constraint) — and

operates in a market where demand consistently outstrips supply⁷. Therefore there is little pressure on the co-ordination function beyond establishing some *acceptable* temporal delivery mix⁸. Thus, here the final constraint on operational performance is the time commitment of the clinical professionals and there is no need of a “toxicity” model to co-ordinate operations⁹.

However, and assuming similar market conditions, if the situation were to be reversed (i.e., the available slack were in the clinical time and the constraint being the capital resource) a “toxicity model” of sorts can be seen to apply. Where there are more clinical hours available than there are treatment room hours (or where they are exactly equal) — and after the primary co-ordination has been established via the appointment procedure, and therefore a coarse mix has been achieved — final

⁷ Information provided by Zubnich suggests a chronic under-supply of dentists in the UK, which, and although possibly less keenly felt in the private sector, means that there is little inherent environmental restraint on operation.

⁸ “Acceptable” here means sufficient to ensure the continued existence of the practice (which is not considered difficult due to market conditions). The inclusion of the word “temporal” is important because, with a range of individual treatment durations of 15 to 90 minutes, intelligent scheduling could significantly affect the earning potential of clinical professionals. However, personal experience in a comparable ‘appointment constrained’ service environment suggest that there is often a more subtle *informal* function whereby individual providers refine (subvert?) the appointment system based on professional judgement and/or the personal capacity/flexibility to allow appointment schedules to ‘slip’ in order to maximize throughput.

⁹ Note here that there may be a pressure to expand the clinical availability to fully exploit the capital resource available by either extending the time commitment of the clinical professionals (i.e. longer working hours) or expanding the clinical staff (i.e. recruit — the solution decided upon at Zubnich).

completion times will assume a prime importance. This is because to over-run a scheduled completion time will affect the start time of the incoming provider, thus compromising their professional reputation and/or their ability to provide the service expected by their patients.

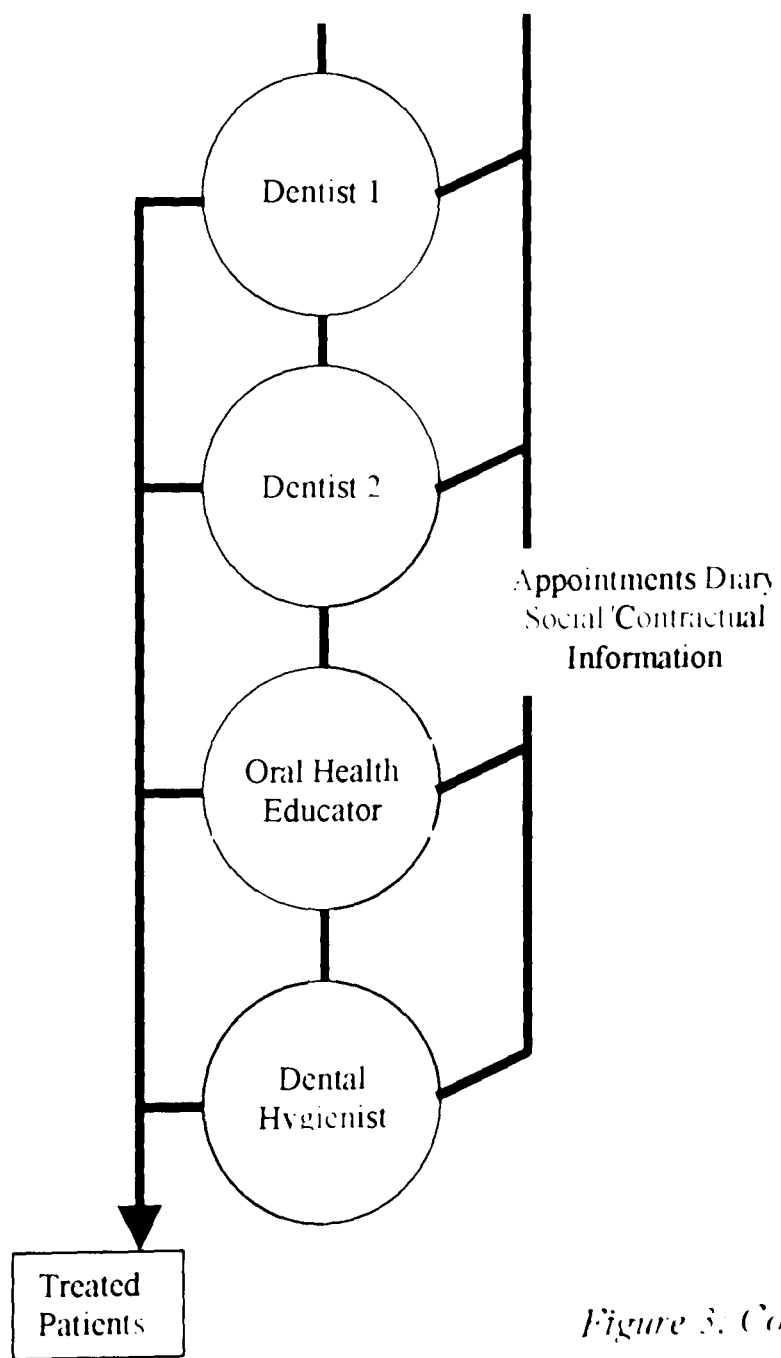


Figure 3: Co-ordination

both of which suggest a *population growth* approach consistent with the suggestion made in chapter

And although professional etiquette may prevent a forced vacation of the room, continued occurrences may well lead to social, or even contractual, sanctions being applied¹⁰. In this way also is the 'fine-tuning' of resource matching achieved, thus allowing relatively efficient, and stable, fulfilment of wider (higher level) operational goals.

Thus at this level the model of Zubnich can be seen as figure three (note that the resource input channels have been aggregated as the heavy central line).

3 Operational Control

The interpretation of the VSM that I introduced in chapter eight suggests that operational control is equivalent to the control of resources, which is to say that, if an individual system one contributes to the functioning of the wider "system in focus" it will continue to be resourced, and if it does not it will be starved out of existence. And it is that leads to the difference (in my interpretation) with Beer's *ideal form* of the VSM (see,

eight.

¹⁰ Because the activities in Zubnich run in parallel, and because it is a *service* rather than a manufacturer it is not volume *output* but volume *resource consumption* that stimulates the toxic response. This example makes clear the *analogical* nature of the toxicity model. The intention behind

e.g., 1985, p. 136). The *physical* element of my interpretation leads to the necessity of a connexion between system three and the environment that does not exist in Beer's purely *informational* model. The justification (here in concrete terms rather than the abstract, as in chapter eight) is that the ownership of the resource is at a *whole system level* — the patients as “gross resource” belong to the practice, not to the individual clinical professionals. Therefore although there may be a *logical* case to be made for linking the systems one directly to the environment, the physical (and the legal) interpretation suggests otherwise¹¹.

The first task to be undertaken at this level is the registration of a patient — on receipt of the “gross resource” (i.e. the patient) is the separation into *raw material* and *utilizable resource*, i.e. the differentiation into

it is to convey the idea that the limiting factor of the operation of a sub-unit within a more complex whole is an *integral part* of its own operation.

¹¹ This is because, in my interpretation, the system is *digestive* rather than *affective*. Therefore although the individual systems one interact (largely) autonomously this interaction is with *their* environment which is the milieu created by the “3-2-3*” functions rather than a link to the environment of the system in focus (which is one recursion higher).

One should note that the advantages of the recursive model are not lost by this — merely that they are re-located. This form of connectivity also provides the basis of an answer to the question of why a viable system should ‘choose’ to allow its resources to be ‘taxed’ by some other entity. It is because, a) it doesn't get them first; and b) because the depleted environment that it must exist in is simpler (i.e. it has to respond to fewer stimuli) and more predictable (i.e. it will be susceptible to fewer, and less dramatic, changes). Thus the lower level systems ‘trade-off’ the need for a higher operational efficiency for the ability to carry a lower informational overhead.

physical bodies to be treated and payment arrangements (to allow fees to be received). The physical bodies are entered into the appointment diary which performs the system two role by managing the *ability* to access the resources available from system three (i.e., if it isn't booked to a particular professional they cannot receive the associated fee — currently calculated as 50% of income generated subject to a contractual minimum)¹². And, once passed to a clinical professional for assessment/treatment subject to clinical judgement/ability to effect the transformation from patient with dental concern to patient with alleviated dental concern. This initial part of the process is generally carried out by the receptionist and can be represented as per figure four:

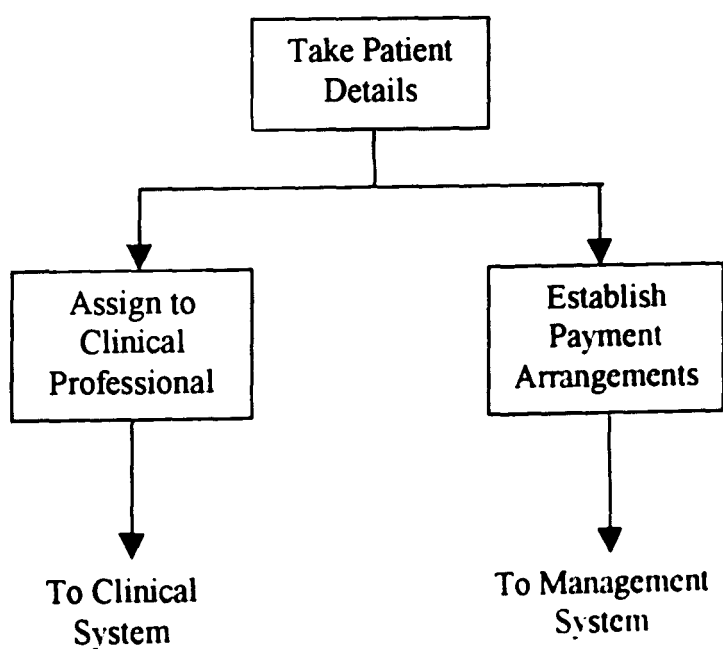


Figure 4: Initial separation of resource.

¹² This separation is one of the 'variety' advantages gained by the system one - book-keeping becomes the responsibility of the higher level.

The coarse filter applied in the “Assign to Clinical Professional” can be shown to be in the nature of *assign surgical problems to dentists and educational/hygiene problems to oral health educators dental hygienists*, and mirrors Beer’s system three “model of the system¹³” (Beer, 1970, p. 37). Here also it can be seen that the reception function provides both system three and system two activity in that it is “allocating resource” at some coarse level (this is because *any* appointment is the making available of resource) and *co-ordinating* systems one by way of managing bookings in the appointments diary (because *a particular* appointment at a *particular* time is a co-ordination) thus managing the *uptake* of raw materials).

The second element of resource allocation is what may more traditionally be regarded as ‘raw materials’ or ‘stock’. In common with other service providers, this element forms a relatively small percentage of the total

¹³ It should be noted that the *detail* of the transformation can vary as a result of the initial contact between ‘patient as raw material’ and the clinical professional, an interaction that determines the ‘problems’ presented in later appointments, and therefore also determines the allocation on the basis of the model of the system. An internal rule that initial consultations (i.e. a patient’s first clinical contact with the practice) are *always* undertaken by a dentist ensures the clinical decisions are never taken by unqualified personnel — yet another manifestation of the model of the system.

cost of provision (currently 6 % as opposed to 61% for salaries/fees¹⁴). Replenishment and maintenance of clinical stock is the responsibility of the senior Dental Nurse and is carried out on the basis of maintaining a relatively full stock of all appropriate clinical supplies *for each treatment room*¹⁵ from a central store that is replenished as necessary.

The final element of resource to be allocated is the “fixed” element, that is the capital expenditure on building and equipment improvement and maintenance, fuel and property costs and the salaries for the dental nurses. The denomination “fixed” has been applied here because such costs (largely) parallel the “overheads” category used in business and would normally be charged to ‘productive’ units as per an “apportioning procedure” (Drury, 1985, pp. 62 ff)¹⁶.

¹⁴ This is based on figures for six months trading to 31 Dec 1999. These figures also reflect personal experience of hairdressing where, and although varying between companies, ‘stock’ expenditure rarely exceeds 10% of post-tax turnover whereas salaries are generally 55%, giving a ‘cost of sales’ figure of 65% which is comparable to Zubnich’ 67%.

¹⁵ Because the Zubnich practice has more rooms than people at present it is possible for a direct link between clinical professionals and stock utilization to be established. However, because stocks are replenished into the central store, individual usage is not captured. Although it is not considered necessary in Zubnich at present, a simple refinement (i.e. logging out stocks taken) to identify individual usage could be implemented and would extend direct calculation of costs to individual units (see also note 16, below).

¹⁶ A similar consideration to the above (note 15) applies here — in that it is possible to allocate fixed costs directly because of the circumstances at Zubnich. However, the model introduced in chapter eight suggests that, as they are a shared resource at the level of system one “apportioning” on any other basis than actual expenditure (and, therefore allowing ‘real’ assessments of relative efficiency) is

The operational level also carries its own costs (which would, in the traditional model, also be apportioned to the 'productive units (i.e. system one) as "overheads"). In general these costs include the salaries of the Practice Manager, the Receptionist and the premium paid to the senior Dental Nurse for "stock control and maintenance" duties, and the general administrative consumables necessary for operation. Thus the operational management of the Zubnich practice can be represented within the *cosine* model (as figure five).

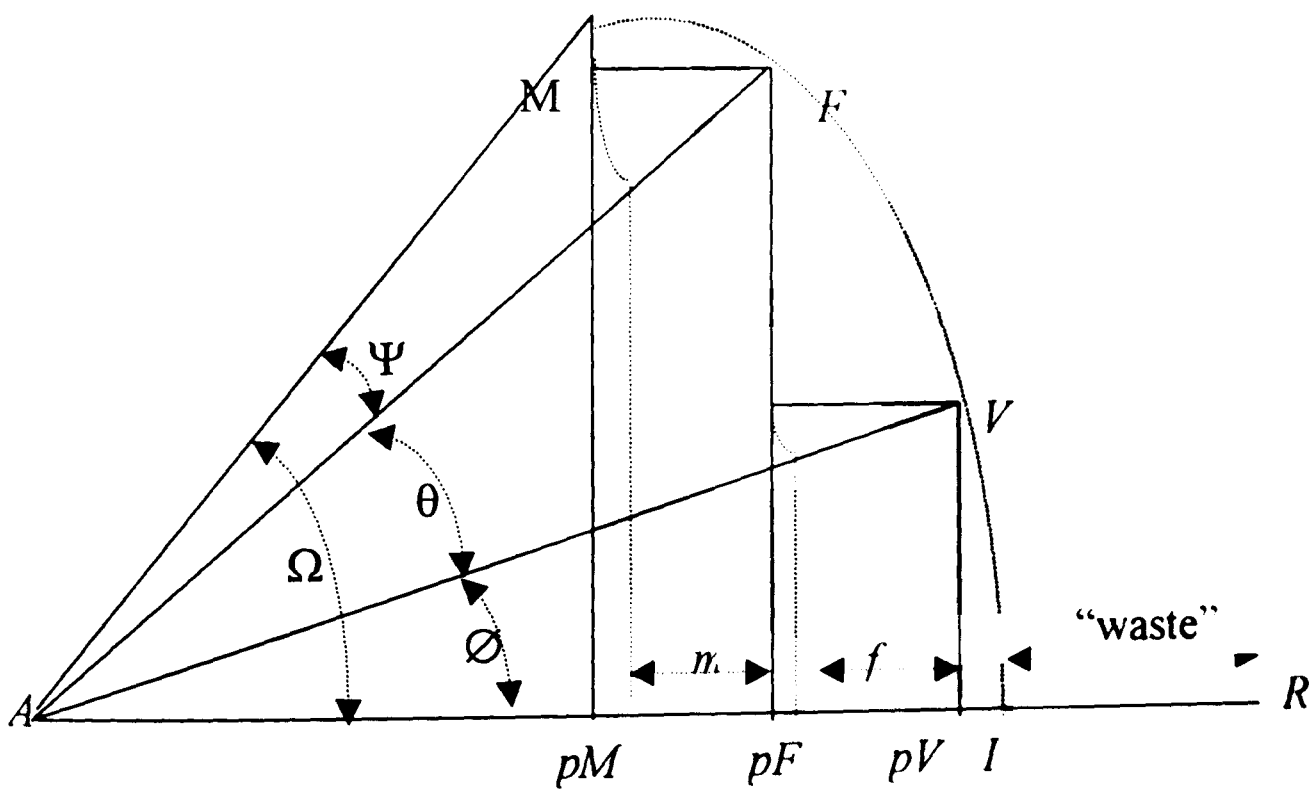


Figure 5: The cosine model.

a meaningless complexification of the information system. This is not to say, however, that costs incurred that necessitate single payments cannot be charged over time.

Here it can be seen that:

stock costs are represented by the interval $I-R$;

fees paid to the clinical professionals are represented by the projection of V on R , thus forming the angle \emptyset , which is determined by the available mix of patients and the ratio between the revenues this generates and costs of provision;

fixed costs, i.e., dental nurses salaries (excluding the management premium paid top the senior nurse), capital costs, etc.) are represented by the projection of F on R and generate the additional angle θ ;

management costs, i.e. the salaries of the practice manager, the receptionist, etc., are represented by the projection of M on R .

Thus the operational management of the practice has access to a 'real-time' (subject to the granularity of data capture) model of the

performance of the practice as a whole¹⁷. This model has the advantage (see note 17) of being largely independent of the cost (particularly the stock and indirect cost) allocation methods used — whilst still giving an accurate picture of the *efficiency* of the organization (efficiency here being defined as the ratio of the ability to convert external resource into self)¹⁸.

At this level the practice is managed on the basis of a “model of self” (see Beer, 1970, p. 37) represented by the role definitions (e.g., Dentists remove teeth, Dental Nurses support Dentists, Receptionists operate the appointments procedure, etc.), a standard list of charges for services and a list of standard services, and their providers, and expected durations. This “model of self” provides the basis for the allocation of raw materials (i.e., patients to clinical professionals), the co-ordination of productive units (i.e., it determines the time to be allowed in the appointments diary(ies) and it sets the level of the ‘refined resource’ (i.e. money) available to the practice to support the operational level and

¹⁷ It should be noted here that the model as presented here assumes the centralization of stock control, and therefore it is shown as a single deduction from revenue. However, were it to be decided to allocate stock to individual operational units, the absolute values (i.e. the value of pl , for example) would not change. Stock costs would be represented as part of the variable costs (and, therefore, pushed down one level of recursion, where they *would* be treated in this way). A similar argument applies to the “fixed” element.

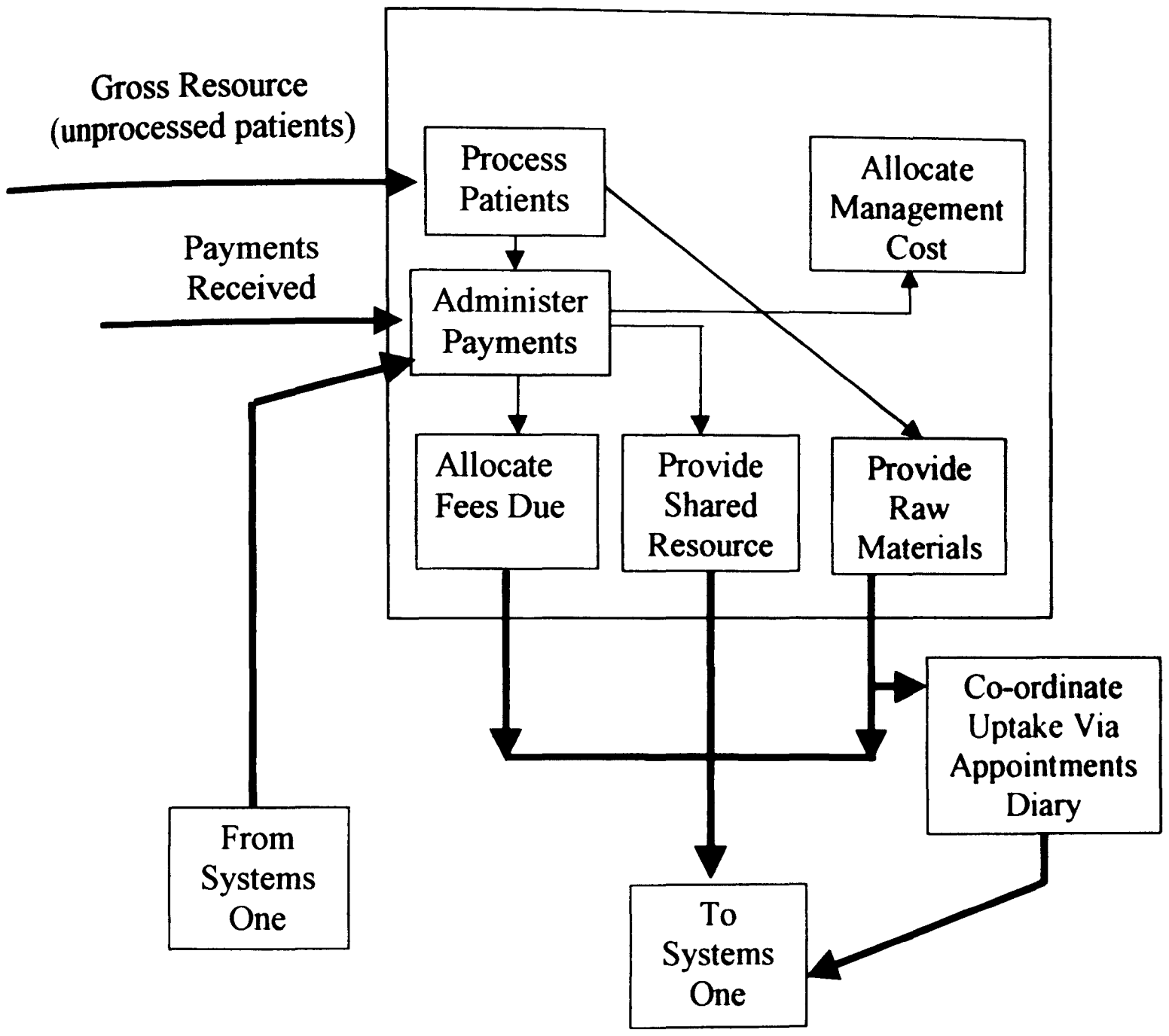


Figure 6: Operations Management.

provide the shared resources necessary to their adequate functioning. The final closure of this level of the model is provided by what Beer has termed “3*”, the line that leads back to the management function from

¹⁸ And, when laid out as a graph (as here) it has the added advantage of visibly representing the relationships between elements of cost.

the operational units. In this interpretation this channel need only carry confirmation of 'work carried out', by whom and its actual duration¹⁹.

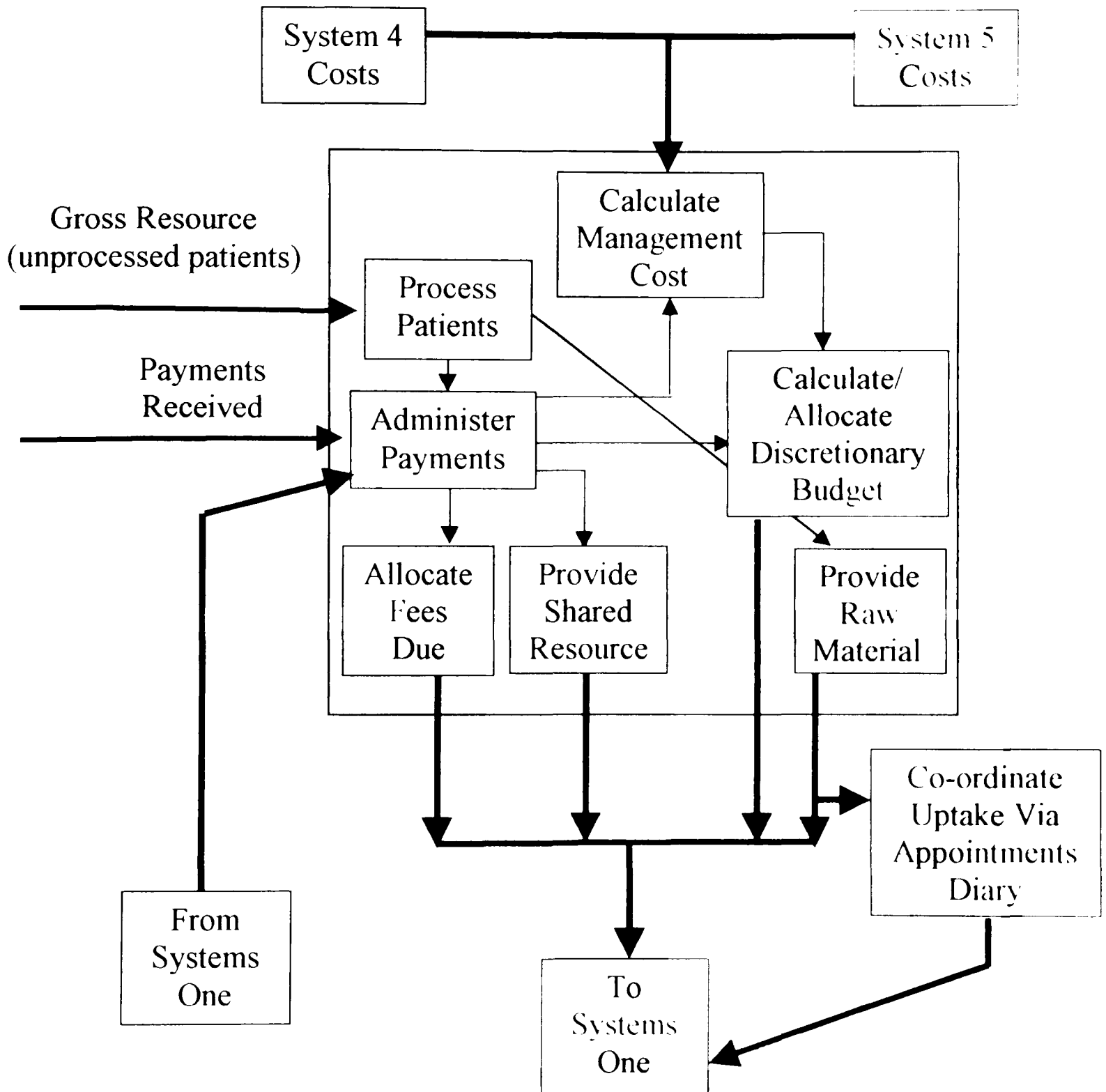


Figure 7: A Completed System Three.

¹⁹ Note that the "algedonic" signal, which may, or may not, be formalized, will provide information relating to the *immediate* inability to carry out current tasks, brought about, for example by the failure of capital equipment or the absence of clinical support.

This, because the simplifications achieved by the relocation of shared costs to the higher level removes the need for more complex information, suffices to confirm the *actual* level of refined resource to be extracted from the gross resource (i.e. the amount the patient is to be charged). In the dentist this 3* role is performed by the action of returning the (appropriately amended) patient records to the Receptionist following treatment²⁰.

This closure allows the administration of fees collection and onward allocation, the allocation of shared resource, materials and local management costs.

The additional information regarding “actual duration” of treatments provided allows for the assessment of the “model of self”, in that sustained deviations from the “standard list” can be identified and used for redefinition of the times allowed in the appointments diary(ies)²¹, or for the instigation of ‘development’ events such as routine and/or additional training. Such events being funded from the residual resource

²⁰ With the addition of the “actual duration” information which is not currently captured at Zubnich.

identified in the model in chapter eight as being equivalent to $\cos\Omega^2$. In this way the operational element of the practice is able to demonstrate adaptive behaviour both within its operational competence and a pre-determined, though dynamic, budget. However, the calculation of this “budget” requires that system three (as represented by the practice manager) must also be aware of the operating costs of systems four and five. And so, the “management costs” in figure six must also be fed this information, thus a completed system three must contain the elements and information flows shown in figure seven.

4 Higher Management

The “higher management” at Zubnich is not as clearly differentiated as may be suggested by the abstract model in chapter eight, however it is possible to identify two foci of activity:

Operational — defined (largely) as the “patients” that present themselves for treatment²². Thus the system four role here is the analysis of regularities based on trends in, or

²¹ Note that, at system three level, it is only the *durations* that are modified. Any alteration in the *price charged* for the treatment is an environmental consideration and must therefore be undertaken in collaboration with the other elements of the “3-4-5” homeostat.

patterns of, attendance mixes and patient satisfaction (i.e. some measure of the subjective experience of individuals or groups of patients) — a decline in the number of extractions, for example, could indicate the efficacy of preventive treatment or dissatisfaction with the treatment as it is offered.

Aspirational — defined as the wider environment into which the practice could enter, whether this is (inter alia) commercial (e.g., the move to NHS provision), technological (e.g., the adoption of new methods of treatment) or geographical. The system four role here is the identification of opportunities for (or threats to) the greater success of the practice as a whole²³.

This separation of the foci of activity also differentiates the location of the dominant partner in the discourse with system four. The operational discourse is primarily with system three (which is to say that response to

²² Although also eligible for inclusion in this are variations of currently used clinical materials, changes in regulations relating to building maintenance, upgrades for clinical, administrative and/or IT equipment, etc.

²³ One should note here the difference between the biological and the social in that the dental practice is able to reflect on the environment it *wants to be in* and therefore rationalize the changes it needs to make whereas the biological system (assuming Kimura) changes randomly and is therefore thrust into

pressures from *current raw materials* is the realm of operations management) within the *identity* constraint imposed by system five; whilst the aspirational discourse is primarily with system five (which is to say that *re-defining the relationship between self and environment* is the realm of the definition of organizational identity) within the constraint of available resources implicit in the whole system resource allocating role of system three.

As a simple example of the relationship of the two foci one can consider the case of “continuing professional development” (CPD)²⁴. Because of the requirement for CPD its provision can be seen to be a routine event in the operation of the practice (that is to say that it is included in the ethos established by the *identity* of the practice). Therefore, in the absence of other pressures, the information obtained as a result of the operational focus of system four would provide the basis of the selection of the CPD course to be attended — this because it will allow the practice to ensure that it has the ability/skills necessary to meet current trends.

a redefined relationship with the environment. Both cases, however, posit a *new* relationship between the “self” of the system and the environment.

²⁴ CPD is a membership requirement of many professional bodies where, to qualify for continuing eligibility, members must undertake prescribed periods of study relating to their field on a regular basis (usually defined in terms of hours per year), the intention being to ensure currency of knowledge.

However, the decision to introduce a new technology (e.g., ultrasonic tooth reduction, which would also require training that would also qualify as part of the CPD requirement) would constitute an *aspirational* focus, that is it would redefine the relationship of the practice to its environment by changing the services it offered. But, it must be noted, this technology can only be introduced if the resource necessary (i.e. the money to pay for it) is available, which is a system three constraint.

Thus the relationships between systems three, four and five are represented in figure eight.

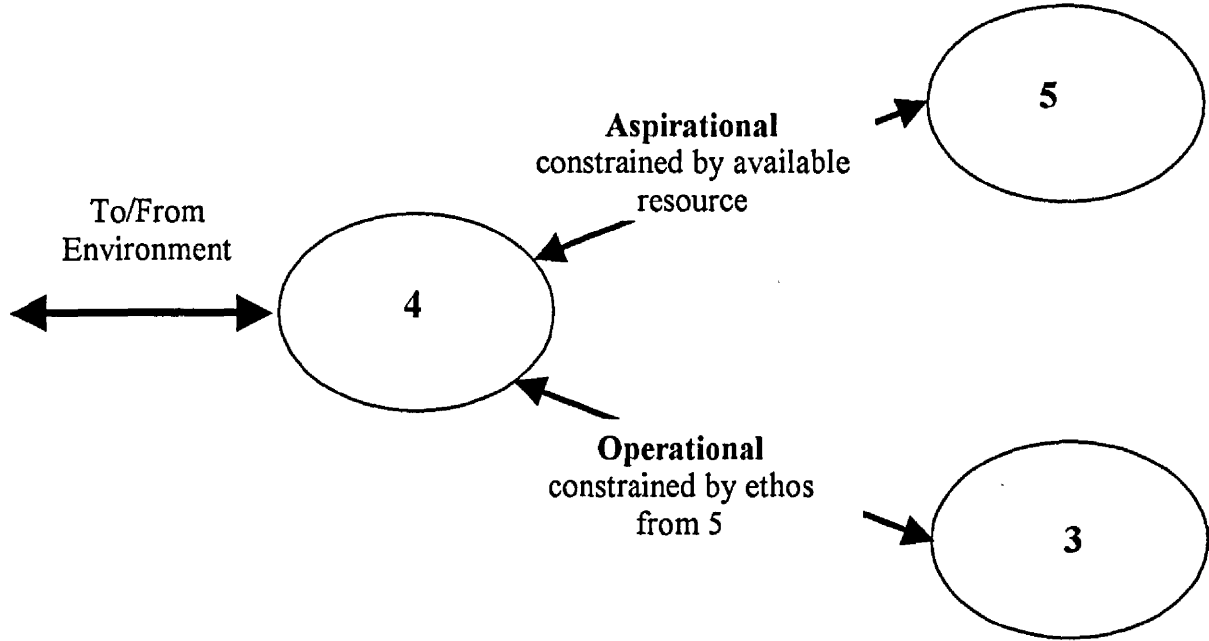


Figure 8: System Four in context.

5 Identity

The ethos for the practice or, its “identity” is provided by the practice owner, Zubnich. His decision to position the practice in the high middle market, i.e. “significantly above the standards available from NHS providers but below those of Harley Street”²⁵ effectively determines all other operational matters in the practice.

In addition to the operational matters contained in the model of self represented by the list of standard times and treatments this has a significant effect on the functioning of system four. In its aspirational role, significant amounts of time and money are expended in the identification and acquisition of the latest equipment and thinking relating to dental treatment, thus driving an extensive *developmental* CPD expenditure. Whilst in its operational, role the explicit positioning of the practice creates the need to ensure that the ‘client expectation’ this creates is satisfied. This drives in its turn the need to ensure that both

²⁵ Note here that the “standards” relate to the time allowed for treatments/consultations and the quantities and quality of materials and technology available rather than necessarily the abilities of the clinicians employed.

routine CPD (for the maintenance of current service standards) and wider practice maintenance are available and *effective*²⁶.

These considerations, I think, make it clear that the ability to determine identity adds an element to the management of human organizations — that of choice — therefore justifying the use of the term “aspirational”. Although this element is not present in biological systems, the effect it has in general is that the “variety sponge” (see Beer, 1985, p. 125) function of system five is brought into play in order to evaluate the actions of the system as a whole against the effect they have on the relationship of the system with its environment. And that this evaluation is necessary in all systems where the relationship is *dynamic*, whether caused by an (apparently) independently moving environment, human choice, or the random mutation of genetic materials.

Summary

This chapter explored the extent to which a ‘real’ organization could be represented using the model introduced in chapter eight. The Zubnich

²⁶ Which, I would argue, is the basic justification of the need for, and potential value of, some form of quality management.

Dental Practice was chosen as the case-study for this for two main reasons:

- 1 It was a professional service provider, and therefore allowed for exploration of the practical issues surrounding quality assurance in service industries (the subject of the next chapter);

- 2 Its size made investigation of the organization simpler, allowing direct access to both senior and junior members more easily than would be possible in a larger business.

This exploration can be said to have been successful to the extent that it has been possible, within the constraints of the abstract model, to define a physical/informational model capable of supporting the operation of the practice both in terms of identifying performance efficiency issues and in terms of environmental fit. However it became apparent that, in practice, the functional definition or assessment of ‘environmental fit’ had two sub-elements, i.e. “operational” and “aspirational” which were not immediately apparent in the biologically oriented abstract model.

This led to an iterative consideration of environmental scanning in the theoretical development of the model (in chapter eight), where it was concluded that it was in the “operational environment that the final closure of quality management existed.

This, in turn, allows for a more focussed consideration of a particularly troublesome element of the ISO 9000 standards — insofar as it identifies the difficulties therein as being the result of a lack of recognition or discrimination between these two environments and the implications of this for quality management and ongoing performance *relevance* management. A fact that would account for the confusion surrounding the references to “continuous improvement” made in chapter nine.

There is one significant simplification available to this chapter but not in the abstract representation in chapter eight — that of human intelligence and decision making ability. Here it has been possible to assume the value set to be used as the basis of the evaluation of organizational performance as a given, supplied by Zubnich or the members of his staff. Whereas in the abstract model it was necessary to demonstrate the potential for the existence of mechanisms for their generation. This, of

course, leads headlong into the criticisms of the cybernetic approach considered in the introduction and conclusion to this thesis and, as there, I can only state that I believe that the existence of human teleology in no way invalidates the application of cybernetic insights or theories.

In the next chapter I will describe the approach taken in designing and implementing a *quality* management support system based on the principles of this, and previous, chapters.

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Chapter 11

Quality Managing

Zubnich

Introduction

In this chapter I will develop the proposed design for a quality management system (QMS) at the Zubnich dental practice based on the outcomes of the previous chapters. This system, which is now in use at Zubnich, **has been implemented** in “Microsoft Access” and **the original¹ elements comprise proprietary and/or copyright materials for which all rights are reserved.**

The development of the QMS proceeds in five parts:

- a) issues surrounding professional service quality;
- b) the reduction of the complexity of managing professional service events;
- c) *assuring* professional service quality;
- d) measures of service support quality; and,
- e) data structures for controlling the above.

Of necessity this will mean re-visiting the principles introduced in earlier chapters. However this time the emphasis will be on the construction of a coherent, operationalizable management tool. And that the role of this tool will be the provision of information to the practice manager and owner that enhances their decision making in relation to the ongoing satisfaction of patient needs and the better clinical “fit” of the practice and its (technical and human) resources to current market demand.

¹ All other copyrights and/or intellectual property rights including, but not limited to, those of the

Professional Service Quality

The discussion of professional service quality presented in chapter two laid most of the ground for this part of the project. However in this section the intention is to revisit the argument from the standpoint of the cybernetics proposed in chapter eight. There it was suggested that “quality” was a function of “operational” activity, and that this activity took place in the (perceived by the system as being) relatively stable “operational environment”.

For the systems one of the dental practice (i.e. the clinical professionals) this operational environment is constituted by the resources provided by the practice as a whole (i.e. capital equipment, clinical raw materials, clinical, support and fees) and the patients (i.e. the non-clinical raw material). And, in a production oriented environment the model in chapter eight would predict that this relatively stable operational environment would be reflected in the existence of a similarly stable functional identity of the system as a whole. That is, one that would only be subject to a (radical) change of identity were the aspirational

environment of the system move away from its current focus². Thus “quality”, and the improvement thereof, is achieved by stability of input and stability of process operation.

Whilst this stability of environment can be assumed to exist for the practice provided elements, the inclusion of the patient can be seen as destabilizing to the extent that a patient’s subjective reaction cannot be wholly predictable. This leads to the conclusion that, in terms of *direct*³ clinical interaction, the definition of the operational environment is a *negotiation* between the clinical professional and the patient. Leading to the further conclusion that, because this negotiation of identity must occur in the aspirational environment of the systems one, their functional identity must be *re-negotiated* for each and every service event. And that procedure charting (i.e., the exhaustive definition of the procedural aspects of service events prior to their delivery) beyond the most general statements is a meaningless exercise for the control of service quality.

² This, of course, is because of the attractor effect of the operational environment. Note that this assumed stability is also reflected in the ‘procedure chart’ approach to quality management inherent in the wording of the standards.

³ I.e., that part of the interaction that satisfies the aim of the treatment, and therefore the criteria for judging the *quality*.

The implication of this for data capture at Zubnich is that there must be a facility for the acquisition of patient feedback regarding their perceptions of the service received.

A second (non-clinical) element of perceived service quality experienced at Zubnich (and presumably common to all providers operating an appointments based service) is that of time-keeping. This is a more complex issue than it at first appears (as will be discussed later), however within the Zubnich practice collection of data relating to the late commencement of appointments is simply captured internally and can be used to generate statistical reports.

Managing Professional Services

The practical effect of this “on-the-fly” re-definition of the identity of the process is to render any exhaustive or definitive description of the activities necessary to its proper operation extremely complicated. As can be seen from the example of the description of the “pre-treatment” assessment undertaken as part the replacement of a simple tooth filling provided by Zubnich and given as appendix two.

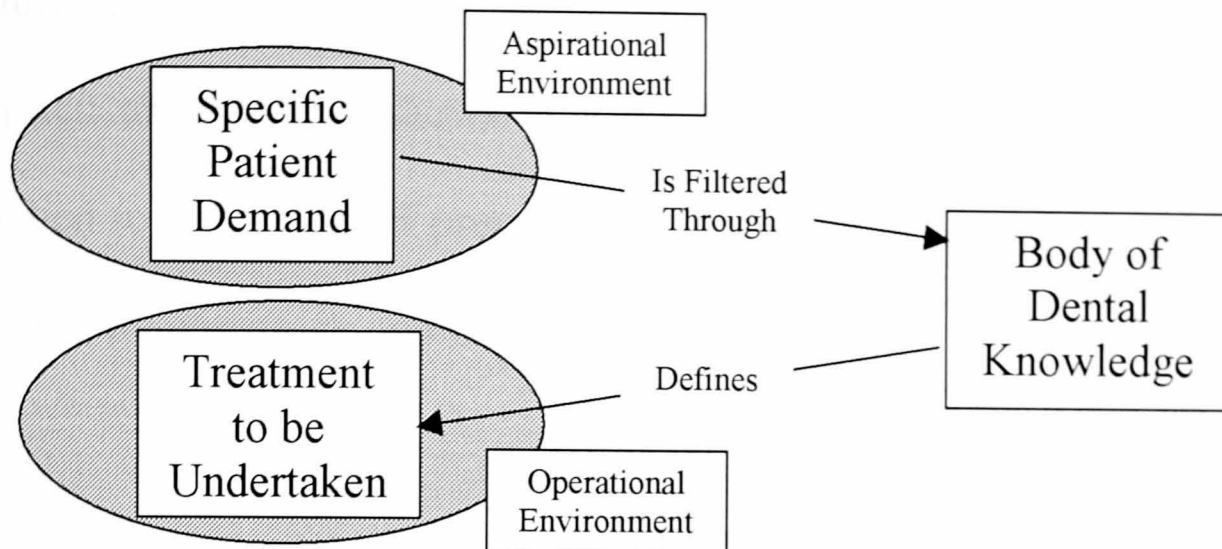


Figure 1: Defining a Specific Treatment

What is clear from this example (and from personal experience in other sectors) is that *exemplar* descriptions of practice are impracticable in a time constrained environment. Even at the level of detail given in the example it is clear that there exists another level of consideration that *assumes* the clinical competence necessary to carry out the individual procedures described. Thus at Zubnich, in common with other dentists (and other professional service providers, e.g. actuaries, physicians, etc. where the ‘service’ is either delivered by, or its delivery is the responsibility of, a single professional) the provider is expected to have internalized the exemplary model before hand — in short, he or she is expected to have learned how to carry out the procedure.

The situation in figure one is, in effect a simplification of the model presented by Dudley and Beckford (1998, adapted and contextualized as

figure 2) which makes the application of professional knowledge explicit and, further, shows how the body of knowledge is iteratively applied to the results of previous decisions and/or actions to ensure that desired outcomes are approximated.

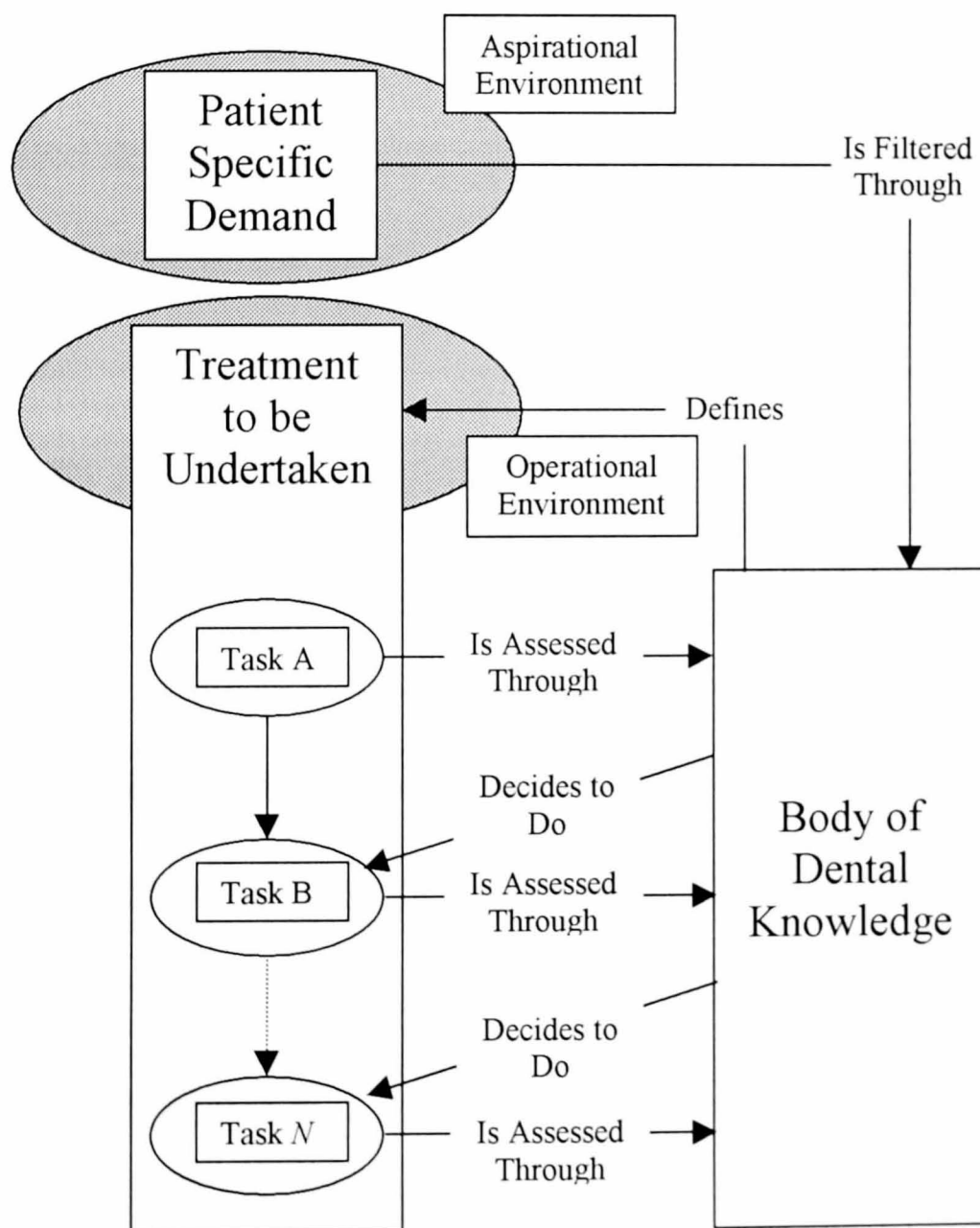


Figure 2: A contextualized adaptation of Dudley and Beckford (1998)

Here it can be seen that the apparently linear chain of events which constitute the chosen treatment (i.e., tasks A...N) is continually

monitored and modified in reference to the outcomes of the action being undertaken *and* the body of knowledge that informed the selection of the treatment (as would be predicted by the model developed in the earlier chapters *and* Beer's (1985, p. 124-126) "ethos".

Thus the "body of knowledge" is the main determining factor in the detailed definition of the treatment to be undertaken. The problem that this presents to the management of the quality of the service is that, because of the interactive nature of this process (i.e. the "negotiation" between the clinical professional and the patient), *there can be no exemplar* against which to judge this quality. It is the *clinical judgement* of the professional dentist (or other provider) exercised as a result of demonstrable competence in the application of the body of knowledge which determines the treatment — and, beyond the direct subjective experience of the patient, also determines the measures and indicators of the quality thereof.

This can be made apparent in the operation of the "client feedback" facility identified in the previous section.

Assume a client 'complaint' of undue pain following a surgical procedure.

Such an event is first pre-filtered to exclude the possibility of 'settling down' problems⁴ (note that definition of the settling down period and what constitutes "undue" pain is an exercise of professional judgement).

If this first filter is passed the next step is a re-examination of the work undertaken and the condition of the affected tissues (by either the same or another dentist using their professional judgement within the same body of knowledge), followed by a decision regarding further and/or corrective treatment (using the same body of knowledge)

If the matter is not resolved at this stage and is regarded as being especially grave, the matter may be referred to **the General Dental Council**⁵ where the treatment originally undertaken will be reviewed to determine whether the dentist was reasonable in his or her actions or whether there are grounds for action on the basis of negligence or

⁴ Surgical procedures often tend to remain painful for a number of days following the treatment and, therefore, the experience of pain is considered 'normal' if it is within the expected "settling down" period.

incompetence. Here one should note that the review body will also be applying the same body of knowledge.

Thus the measure of the quality of the service provided is the demonstrable ability to apply the body of knowledge. And, because of that, the only effective method for approximating quality provision in such a field is to ensure that the people responsible for provision are appropriately qualified or skilled for the task⁶.

The word “approximate” in relation to quality provision in the previous sentence is used intentionally because the nature of the achievement in this context is one of *assurance* rather than *control*. This type of service provider does not have the facility of pre-delivery inspection, indeed the service provided is an emergent property of its delivery. The control element of such provision can only ever be *historical* “complaint management” — hence the necessity of the client feedback function at the level of the operational environment of the practice as a whole.

⁵ The dentistry equivalent of the General Medical Council, which has the power of censure and, in the extreme, the power to strike the offending dentist of the Register, thus preventing legitimate practice.

⁶ Which is, of course, precisely what is done. The legal ability to practice dentistry in the UK is dependent upon registration with the General Dental Council (see General Dental Council, 1997).

The immediate nature of the provision and the fact that it (and therefore its measures of success, which include legitimacy⁷) is defined on a case by case basis supports the conclusion that the service received by any, and all, *individual* patients (in the absence of malice) can only be in any way affected *in advance* of delivery by affecting the ability of the deliverer to perform it — its, to use the word broadly “skill-based”. The formal *control* of the service, being necessarily historical, is by “trial and error” representing a progressive approximation of the environmental demands placed on the practice (whether customer service *or* legalistic) as would be inferred from Ashby’s (1960, pp. 82 ff.) consideration of the ultrastable system.

What this means for Zubnich is that there are three core elements to the management of the perceived quality of the service provided:

the performance of the core service (i.e. the dental treatment), which is based on the skills and knowledge of the clinical professional;

⁷ Note the case of Dr Shipman — the G.P. convicted of fifteen murders through the misapplication of the body of medical knowledge, and the furore surrounding how it was possible that these events went uninvestigated — and the potential dangers of an ineffective environmental control become more evident.

the historical legitimacy of the treatments provided, initiated by client feedback but defined by peer review either at the level of the practice or the professional body (with legal sanction); and,

the surrounding 'administrative issues' which, at the level of the core service, are mainly related to punctuality.

Thus the questions an effective quality management system must answer for Zubnich are:

Are we appropriately qualified (i.e. skilled)?

Is our application of these skills legitimate?

Are we applying them when we say we will?

Assuring Service Quality

Within the context of the previous discussion the *assurance* of the quality of the core service at Zubnich is based on the planned provision and availability of the skills necessary. However (see note six), the permission to practice as a dentist in the UK is regulated by law.

However this legal regulation in no way invalidates the remainder of this section once it is realized that the possession of the qualification (i.e. the award of the BDS) also implies the possession of the skills (both physical and intellectual) necessary to the award. Hence the use of the qualification certifies some (defined) minimum level of competence within the body of knowledge.

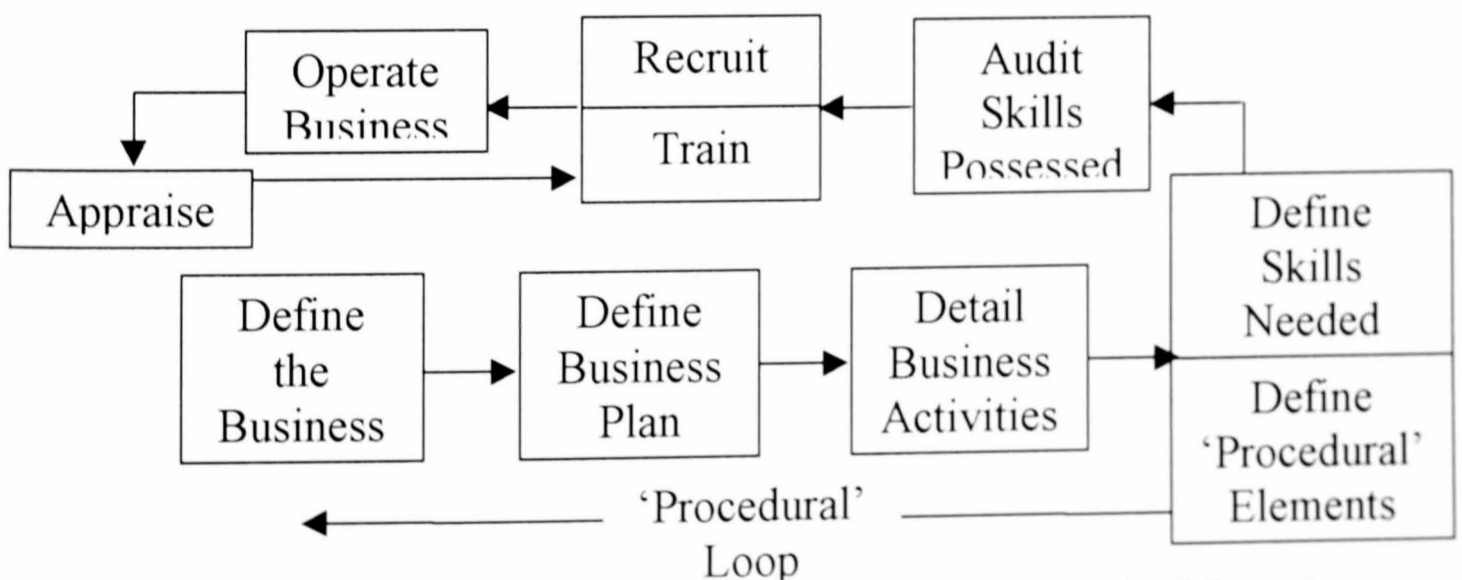


Figure 3: Skill Provision

This planned provision of skills can be set within the context of the practice as per figure three.

Figure three is a simplification of the top loop of the diagram given as “figure one” in chapter two; and it has the same implicit closure, between “operate business” and “define business⁸”, provided of course by the environment. This diagram (excluding “operate” and “appraise”) also represents a “3-4-5” homeostat insofar as:

the feedback from the environment gives information relating to the relevance and/or legitimacy of the service provided (and, therefore the skills used), a system four role;

the “define business” function is the system five decision of systemic identity and therefore the effective definition of the “operational environment”;

the “definition of business activities” and the separation of these activities into “skills” based and “procedural”

elements is a result of the operation of the “3-4-5” homeostat as a whole determining the internal structure of the system; and,

the “recruit/train” element is a system three resource allocation function.

Outside the “3-4-5” homeostat, “operate business” is system one (and to some extent this implies system two) and the “appraise” element represents the three star channel relating to the adaptive provision of skills (with the arrow back to “train” implying an adaptive response).

Performance and Non-Core Activity Control

In the same manner as for the core activity quality assurance (and again with the environment providing the closure) it is possible to include, this time on the bottom loop of the diagram, a representation of the approach that allows for the adaptive (re)design of the non-core activities undertaken in the practice (see figure four). In the case of the application

⁸ Operate business” is the point at which the organization delivers its output to the environment and “define business” the point at which the “aspirational environment” becomes the “operational”

at Zubnich this element is constituted by all, relevant but, non-clinical activity.

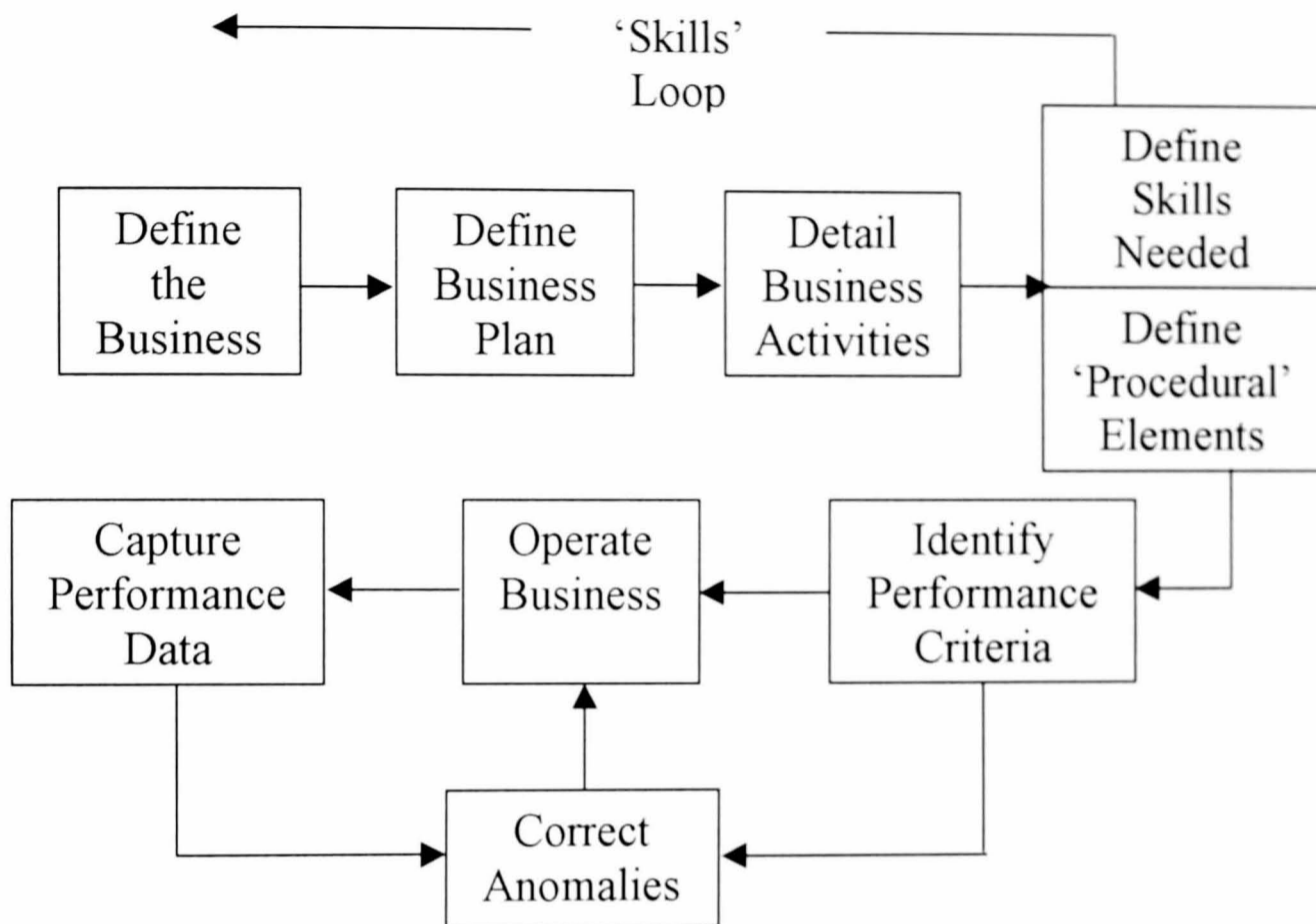


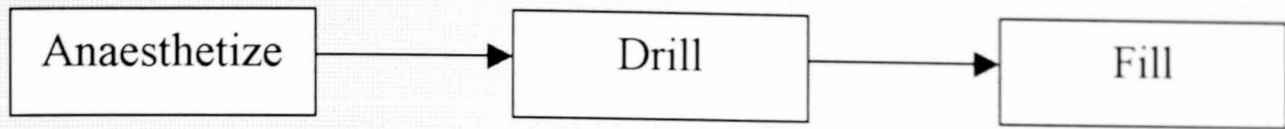
Figure 4: The "Procedural" Loop

As will be seen, in the next section, the activities in the practice were divided into a number of "categories" for administrative reasons. one of these was nominated "technical" to identify that group of activities that related to the immediate support of the core service, and required specialist knowledge or skill, but were not "dentistry" (largely the preserve of the dental nurses). The denomination was applied to differentiate these activities from the "clinical", a denomination that was

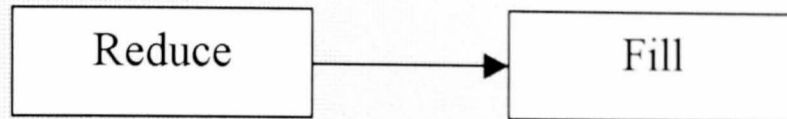
reserved for the core activities and which required a specific professional qualification in order to practice.

For the purposes of this section of the argument these non-clinical activities have been separated out, and are discussed under the ‘catch-all’ term “procedural”, because they *are* susceptible to being described (and having their performance or quality indicator levels determined) in advance of their delivery or enactment. This predictability is because, unlike the core *service* (where the function of the assurance model is to *increase* the potential variety of output to match the potential variety of demand), the intention here is to *standardize* the outputs or results of the activities — that is, to make the outcomes *the same* every time and to match some pre-determined criteria.

The market positioning of Zubnich (i.e. the definition of the business) determines a need for the introduction of new dental technologies which reflect an operative capability (and therefore image) which reflects this. Therefore it can be accepted, as part of the business planning process, that a decision is taken to introduce this new form of tooth reduction. This in its turn forces a revision of the “process” of, for example, filling a tooth from:



to



The skills element of the process must now also change to reflect the use of the new technology and will follow the path shown in the previous section (including the sourcing of the information and/or training courses needed and the decision as to who, and in what order, will attend). And will also tend to influence future recruitment decisions in favour of applicants/potential partners who already possess the required skills.

The introduction of the new technology will also impact upon what I have called “technical” activities (i.e. those that support the provision of the core service (the “clinical activities”) *and* require their own set of skills. This being because the preparation of the equipment (i.e. the sterilizing regime, pre-use protocols, etc.) will be different for the new equipment. One should note here that the measure of the “quality” of the technical activity is an objective measure of performance (which may or may not be subject to decomposition), e.g., “Is the equipment sterile?” leads to the lower level questions “Has the manufacturer’s protocol been followed?” and “Is the

equipment functioning correctly?”. And, if the answer to both these questions is “Yes”, then the answer to the first, higher level, question is also “Yes”.

This example should also make clear the difference between the two elements of the approach, and the necessity of their integration.

The quality of the “skills-based” element is assessed as the result of the application of a *judgement*, based either upon the application of a body of knowledge or some personal experience. And because of the *negotiated* nature of the events to be assessed can only be *assured* in advance.

The quality of the “technical” element is assessed as the result of the application of an objective observation of fact or measurement the criteria for the acceptability of which *can* be stated in advance. Because of this the conditions necessary for their successful execution can be *controlled*.

Integration at the management level is necessary to ensure the existence of a *coherent* model of self in the light of adaptive change in the organization, and, therefore a (possibly statistically) effective model of overall control. For example, there is little perceived quality in attending a highly skilled dentist who infects you with HIV because of improper sterilization of equipment, nor is there in attending one where the equipment *is* sterile but who causes undue damage to your teeth or pain due to improper use of the equipment.

A QMInformationS for Zubnich

The database structure described in this section *has been* implemented for the Zubnich practice. However, it must be remembered that the database itself is only a small part of the wider *information system* used to support the successful operation of the practice. At Zubnich this information system contains *both* formal and informal elements and employs *both* manual and automated technologies.

The terms of reference for the design and implementation of the database model were for a “stand-alone” tool capable of integration with other IT applications in use at the dentist and capable of supporting the management of the service quality of the practice. These terms were agreed because, at the time of commencement:

the practice had a mix of manual and technology based systems for carrying out the administrative functions of the practice — thus issues of redundancy of effort and communications protocols arose — therefore the final

design should include explicit reference to points of overlap but remain a discrete entity;

the practice was negotiating with a specialist software supplier for the design and implementation of an integrated diary, patient record and financial management package — this would cover some of the necessary functionality of the wider model possible as outlined earlier and, it was assumed (correctly as it was later proved) that such an implementation (as was proposed by the software supplier) would be initially unstable and its connexion to any other external software therefore to lead to technical and/or contractual complications.

Establishing the Skills Base

The first task in the construction of the model was the establishment of a structure for containing the elements of the “skills-base”. This, as is shown in figure five, was hierarchical, starting with the most general “Run Practice” and ending with ‘detailed’ descriptions of the elements of the “tasks”, i.e., running the practice requires the “Clinical”, “Technical,

“Managerial”, “Administrative” and “Customer Service” activities, these constitute the “Categories”. Within these categories there are “Tasks” to be undertaken, and these tasks will each have an associated set of procedural elements or “Processes” and “Skills” that will need to be brought to bear in their execution. Individual processes (at whatever level they are represented, i.e. from the generic statement of the clinical tasks to the highly specific of the technical) will each have a “procedure chart” or (either graphical or verbal as is most appropriate) description of the elements of the task to be undertaken which includes (as appropriate) the control points and performance measures applied. Skills, on the other hand, will have “levels” of achievement or competence accompanied by a description of behaviours exemplifying that level of competence.

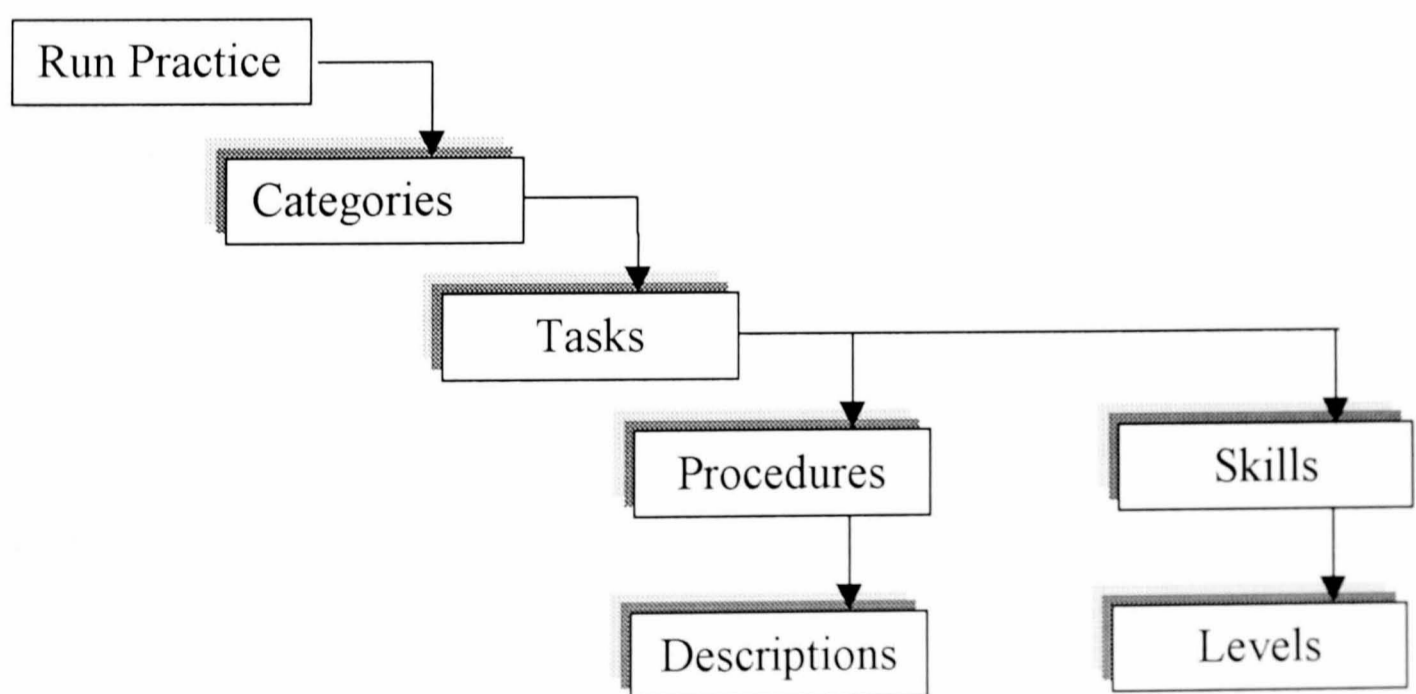


Figure 5: A Hierarchical Structure of Practice Activities

Each of the boxes in figure five (with the exception of “run practice”) represents a table in a relational model with each of the downward arrows representing a “one-to-many” relationship (i.e. one task may have many skills and/or procedures; with the exception of “procedures” to “descriptions” which is, by necessity “one-to-one”).

The completion of this element of the database provides the facility to identify those skills (and the level of competence for each) that the practice utilizes in normal operation. Thus providing the basis for a “skills based” quality assurance model.

Roles and Incumbents

Within the practice, in common with other businesses, there are a number of discrete “roles” each with a more or less tightly defined area of responsibility. Within the relational model begun in the previous section “roles” are defined as being comprised of tasks, i.e. those activities that must be carried out to fulfil the responsibilities of the role. However, tasks may be common to more than one role, and so there is a

“many-to-many” relationship between “roles” and “tasks”⁹ (see figure six). This has the advantage of ameliorating the potential redundancy in the “tasks” and “categories” relationship¹⁰ and of identifying the potentially multi-category nature of certain roles.

“Roles”, in their turn, are filled by people. And, as each role may have many occupants and each person may have many roles, this also requires an effective “many-to-many” relationship. In practice this relationship is again achieved using an intermediate table “incumbents” which operates on a complex primary key (as above).

People have skills. Or they have qualifications which, as discussed above, is effectively the same thing except that the skills possessed are *certificated at a higher level of aggregation*. And the inclusion of “skilled” people closes the logical loop (see figure six).

⁹ In practice this is achieved by creating an intermediate table operating with a “complex” primary key rather than as a direct relationship between the tables.

¹⁰ Note that this is consequence of the “one-to-many” relationship. Each task may belong to one, and only one, category, thus requiring discrete category/role naming conventions. The need for this was located in this relationship because it was thought to be (numerically) less of a problem here than elsewhere.

Static Quality Assurance

With these final elements completed, i.e. with the data for the practice entered, it is possible to demonstrate:

for all tasks — the skills (and levels of competence therein) necessary for their satisfactory or adequate performance;

for all people — the skills (and levels of competence therein) possessed;

That the people in any given role possess the skill set necessary to its performance.

At this level of development it is possible for the practice to demonstrate “in principle” or potential compliance with the quality criterion that all tasks are to be undertaken by appropriately qualified persons as a result of the Boolean search:

$$\{\text{Skills Needed}\} \cap \{\text{Skills Possessed}\} \neq \{\emptyset\}$$

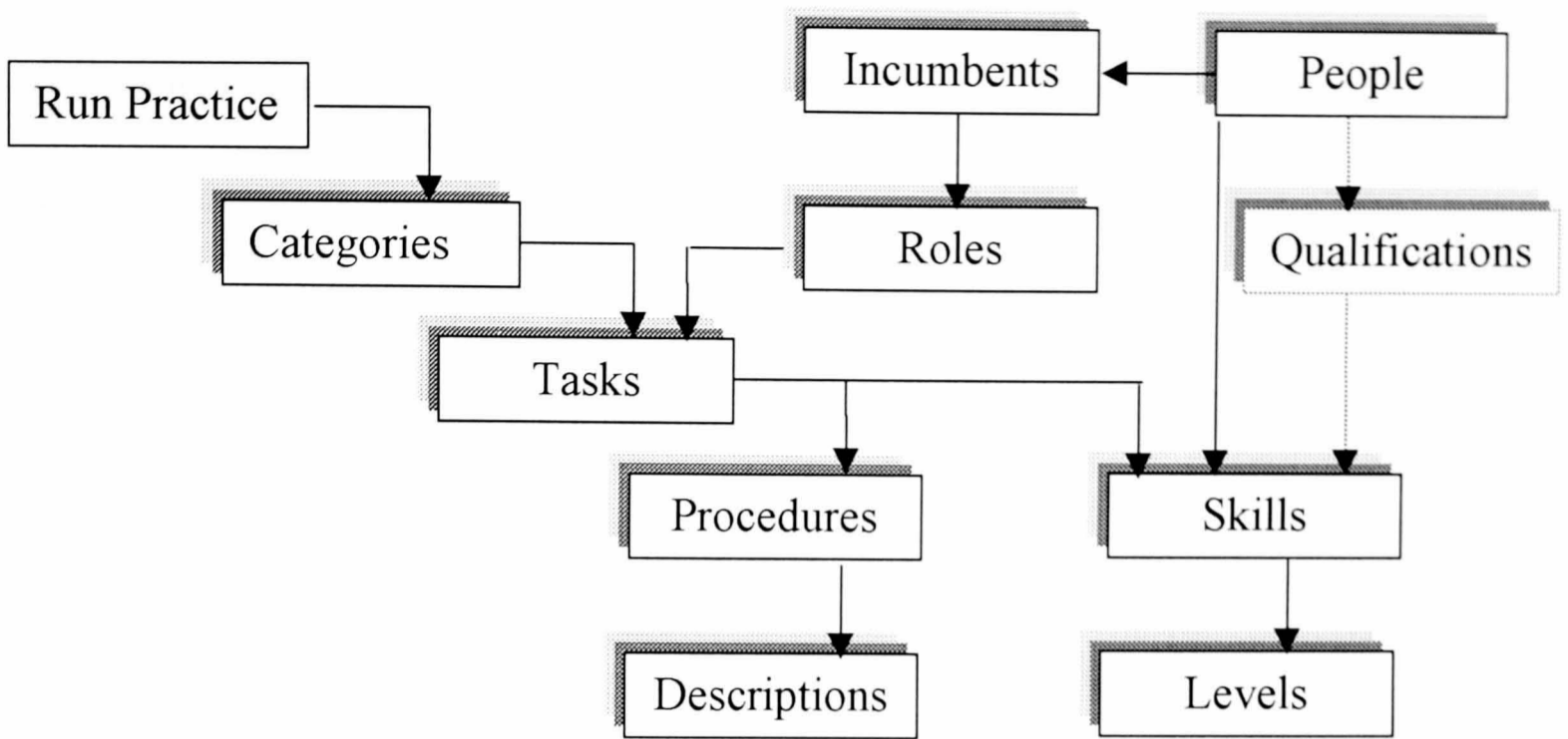


Figure 6: Linking “Skills Needed” and “Skills Possessed”

Where “Skills Needed” are those identified as necessary along the left hand side of figure six and “Skills Possessed” those identified as possessed by individual staff members along the right. Such a search can be undertaken at the level of the practice, i.e., by applying the search to the “people⇒skills” and the tasks⇒skills tables in isolation thereby determining whether the practice as a whole has the skill necessary to function; or in terms of role suitability by running the query as:

$$\{\text{Role-Skills Needed}\} \cap \{\text{Incumbent-Skills Possessed}\} \neq \{\emptyset\}.$$

Because of the legal constraints on the provision of the core services (i.e., only a qualified and registered dentist can offer dental treatment) it can be assumed that the practice possesses the baseline “skills-base” necessary to competent operation. This baseline provides the foundational “model of self” for the operation of the practice and (for reasons of practical expediency) is linked together by “Role” for the “Clinical” tasks¹¹.

Thus the detailed demonstration of compliance to the quality criterion is facilitated by demonstrating, for each service event that the “Task(s)” has been carried out by an “Incumbent” of the appropriate “Role”. This requires as a minimum, for the clinical “events”, that they have role names and “legitimate deliverer” information.

In practice the “Events” record draws on a number of related tables to uniquely identify each service event by capturing:

Patient Name;

Which element of which treatment was provided;

¹¹ The legal requirement and the assumed subsumption of skills below qualifications (see figure six)

Who provided this treatment;

The date of the appointment;

The due start time of the appointment;

The actual start time of the appointment;

The duration of the appointment;

The delivery site.

The two emboldened items provide the information necessary to this part of the discussion.

The information for the first item is drawn from the tables “Treatment Cost” and “People”.

“Treatment Cost” contains the fields:

Treatment Name;

Visit Number;

By Role;

Duration.

make this a practical solution for the “Clinical” tasks. The (legally) unconstrained “procedural”

The table contains a complex “primary key” comprised of “Treatment Name” and “Visit Number” to uniquely identify the elements of any given clinical service. And is related, by “Treatment Name” to another table “Treatment Price” containing fee charging information relating to the treatment as a whole. This structure reflects the model of provision contained in the appendix, and is able to support the fact that some treatments require more than one visit (each with different durations) and/or the services of more than one clinical role, but that the fee for the service is an inclusive charge.

In the case of the treatment NP2 (Complex Consultation), for example, the patient is required to make two visits (which may or may not both be on the same day).

Visit 1 with the Dentist	—	duration	15
minutes			
Visit 2 with the Oral Health Educator	—	duration	15
minutes			

However the patient is charged 40-00 for the whole service.

“People” is a simple staff list containing the fields:

elements will utilize a more detailed statement of skills needs.

Forename1

Forename2

Surname

Staff Number

“Staff Number” is a unique numerical identifier, and forms the basis for the interface between this database system and the other tools in use at the practice.

Data entry for the quality assurance of each service event is entered directly via:

A drop down list for the treatment name;

Manual entry of the visit number;

A drop down list of staff members¹².

Once this information is available it is possible to demonstrate *detailed* compliance to the quality criterion by searching using the criteria:

FOR “Task Name” = X AND “Visit Number” = Y

FIND "By Role"

(from "Treatment Cost")

FOR "Staff Name" = *X*

FIND "Role"

(from "Incumbent")

This can then be used to generate an exhaustive report for manual investigation. More practicably it could be used to generate an exception report detailing only non-compliance, i.e.,

FOR "Task Name" = *X* AND "Visit Number" = *Y*

FIND "By Role"

(from "Treatment Cost")

FOR "Staff Name"

FIND "Role"

(from "Incumbent")

WHERE "By Role" < > "Role"

¹² Drop down lists are used to ensure consistency of input, visit numbers are input manually because potential variation between treatments makes a list inappropriate.

In this manner it is possible to demonstrate that the quality of the treatments provided has been *assured* — on the assumption that possessing the skills to carry out a task will lead to it being carried out to the required standard — within a *static* set of circumstances.

Static Performance *Control*

In the previous section I discussed the way in which the quality of the core-service at Zubnich was assured using the “feed forward” oriented “skills-base”. In this section I shall turn to those elements of quality provision that utilize objective measures, “duration”, defined in the model of self represented by the “Treatment Cost” table, and “lateness” identified earlier as an indicator of the *perception of quality*.

Both of these elements are captured on the “Events” form (along with the assurance information) and stored (as either “numeric” or “time” fields) directly in a table named “Events”.

“Lateness” is a derived value calculated from the manual input of “Due Start Time” and “Actual Start Time” and duration is manually input as the number of minutes taken to perform the service.

Thus it is possible to calculate for punctuality:

The number of late starts as:

WHERE "Actual Start" > "Due Start"

COUNT "Actual Start"

The percentage of late starts as:

COUNT "Actual Start" AS X

WHERE "Actual Start" > "Due Start"

COUNT "Actual Start" AS Y

$Y/X \times 100$

The average delay as:

WHERE "Actual Start" > "Due Start"

COUNT "Actual Start" AS X

SUM "Actual Start" - "Due Start" AS Y

Y/X

And for any given treatment:

Durations as:

WHERE "Treatment Name" = X AND "Visit Number" = Y
"Duration"

Average Durations as:

WHERE "Treatment Name" = X AND "Visit Number" = Y
COUNT "Duration" AS N
SUM "Duration" AS P
 P/N

Duration overruns as:

WHERE "Treatment Name" = X AND "Visit Number" = Y
AND Events "Duration" > Treatment Cost "Duration"

Events "Duration" - Treatment Cost
"Duration"

Average Duration overruns as:

WHERE "Treatment Name" = X AND "Visit Number" = Y

COUNT "Duration" AS *N*

SUM "Duration" AS *P*

$P/N=A$

A- Treatment Cost "Duration"

All of which can be calculated for individual clinical professionals or sites (which may become relevant when the new surgery begins operation), or both, by including in the search conditions the additional term:

WHERE "Staff Name" = ??;

or

WHERE "Site" =??.

However, it is suggested that in addition to these *controllable* elements, i.e., punctuality — "Did the appointment start on time?"; and duration — "How long did the appointment last?" which may have 'knock-on' effects on punctuality; there is a third, the *conditions* necessary for the

assurance of core service quality — it is possible to control the *extent to which* they are met.

The “event report”, implemented as an on-line data entry form, can be seen to represent part of the “three star” channel passing performance data relating to the provision of individual service events to the practice management function. The completion of this information, thus far, is provided by the detailed patient notes held separately to this information system for reasons of security and patient confidentiality¹³.

Operations Management

If the information captured above is compared with that identified as necessary to *efficient* operation in chapter ten, i.e. “... confirmation of ‘work carried out’, by whom and its actual duration” it can be seen that the only additional information carried here are the two values “due start” and “actual start” necessary to the calculation of “lateness”. And that the “confirmation of work done” will form the link between the clinical professionals and the “Administer Payments” activity (figure

¹³ Note that there is an element of redundancy in this as, prior to the implementation of the IT tool, the patient record would have played the role of the three star channel in its entirety. The additional value provided by the database is in the punctuality and duration data, and in enhanced accessibility.

seven, chapter ten) providing the basis for the cost of operations (and total cost) calculations identified as the primary role of system three in previous chapters.

Using this information, within the logic of this level of the model, for the management of quality at Zubnich it can be shown to be sufficient (in conjunction with the 'model of self', see appendix one) to answer the questions raised earlier. That is, it *is* possible to ensure that *only* appropriately qualified people have carried out the controlled (i.e. clinical) tasks, and that they were (or were not) carried out when it was (implicitly as per the appointments made) agreed they would. Noting that the *legitimacy* of application, for this level of consideration, is implied in the detailed descriptions given in the 'model of self', i.e., the model of self assumes its own validity as the result of past organizational experience and the demonstrable fulfilment of legal constraints¹⁴.

Because the method of the allocation of patients (as raw material) is controlled at the reception and because of the various codes of ethics of

¹⁴ That is to say that the model of self is the result of organizational learning/adaptation in the operational environment and, as such, is perceived as a stable reference point for the assessment of operational activities. It is, however, subject to alteration in consequence of environmental stimuli or changes in organizational identity.

the practitioners it is highly unlikely (at Zubnich) that an unqualified person would be used to carry out clinical procedures. Therefore the effective quality management measures available to the operational management function relate to the approximation of the model of self currently applied, that is, punctuality and the duration of actual treatments provided.

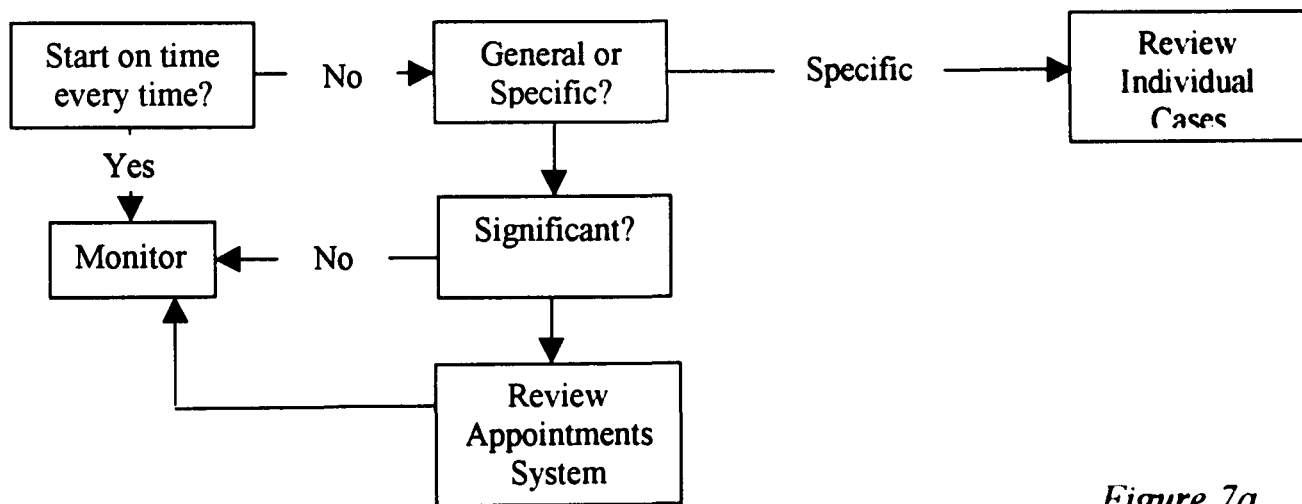


Figure 7a

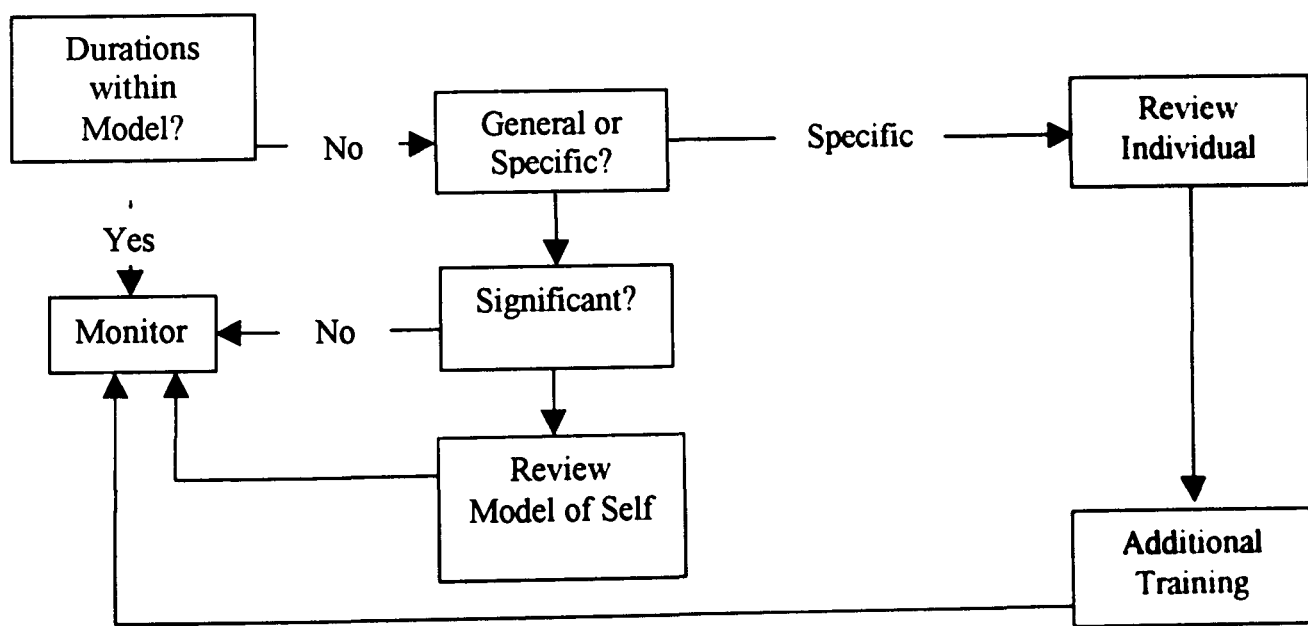


Figure 7b

Figures seven a, and seven b, show possible decision procedures for rectifying quality problems related to the model of self (note that the appointments system is constrained by it insofar as it must employ appropriate allocation procedures). In both cases, however, the resultant changes can only be internally focussed, i.e. any changes made to the model of self are legitimate only so far as they do not breach the conditions for legitimacy established by the *external* operational environment. Thus changes that can be made relate to the timings of appointments (and the mixes that are permissible for multiple appointments) and the times allowed as durations (e.g. it will be possible to extend the model duration time but *not* to change the “By Role” designation).

Note also that a differentiation is made between “general” and “specific” mis-matches. This is because it is assumed that a “general mis-match will be the result of a practical inaccuracy in the model of self, i.e. the model does not reflect the reality, whereas a specific mis-match is assumed to be caused by the circumstances surrounding and individual practitioner (as shown in the example) or operational site (this being

why, in the duration example (7b), the procedure ends with “Additional Training”¹⁵).

The final closure of this level of the model is provided by the legitimization of the model of self and the client feedback, both of which are functions of the operational environment scanning facility provided by system four. In practice these functions are fulfilled for Zubnich via communications and updates regarding best practice from the General Dental Council, the professional development undertaken by the practitioners and a complaints/queries procedure operated by the practice as shown in figure eight.

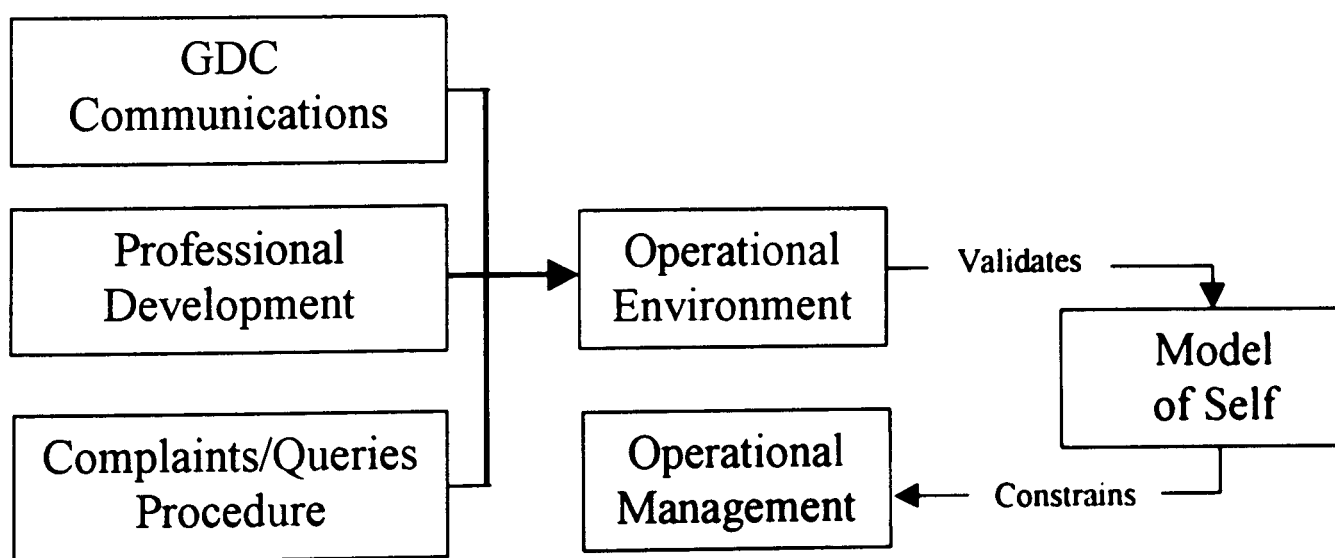


Figure 8: External validation of the Model of Self

¹⁵ Note that this additional training would be expected to be met out of the “Discretionary Budget” (see figure seven, chapter ten) as it is necessitated as an integral part of the approximation of operational goals. This is another of the points where the “effectiveness” model of chapter ten connects back into the quality model.

Thus the “Model of Self” can be seen to be tested for utility both by internal performance *and* external demands and, although it is perceived (and spoken about) as being stable for operational purposes (a perception that is enhanced by the variety absorption of organizational identity), is however a dynamic element of the model.

The perception of stability of the model of self is a function of the variety absorption of the identity of the organization, which is to say that, the potential for infinite variation in the solutions of the “environmental demands and operational capacity” equation is attenuated by the value set that Zubnich (as the practice owner) brings to bear on the definition of the value set of the practice. In short, an ‘informed’ decision is made as to what services the practice will offer in the light of the law, the market demand and the operational ability to provide. Thus the model of self is a concretization of this decision and forms the basis of the operational definition of “quality” for the practice. And will remain valid insofar as it is legitimated by the operational environment and continues to accurately reflect internal activities.

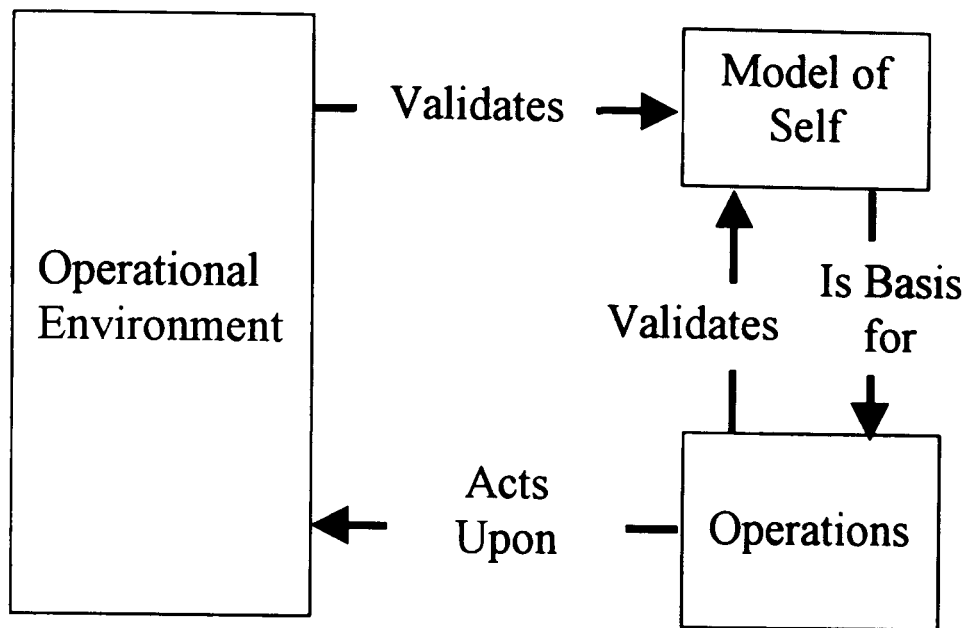


Figure 9: A Dynamic Model of Self

Issues Tracking

To the extent that the operational management at Zubnich receives the information captured by the “Events” report (and the legitimation feedback from the operational environment) it is able to monitor and act upon the quality of the services provided by the practice. However, although this information may allow a parsimonious basis for decision making, the lack of the richness of discursive information was assumed to be limiting in a social context. In an attempt to overcome this, and to utilize the human potential for problem solving, a second feedback channel was developed. The “Issues Tracking” database was adapted from an earlier consulting project¹⁶ and provided a platform for

¹⁶ Lyubov and Meerski, the client in this project, are a financial services provider with a strongly people centred corporate culture. In that context it was considered appropriate for employees to be

“explanations” of procedural failures or the airing of worries or concerns about service provision by the members of the practice. This gives the advantage of being able to capture (within a similar structure) those elements of the quality of practice provision that are not directly susceptible to numerical representation or analysis.

The structure of the database was based on the categories used to segment practice operations i.e.:

Administration;

Clinical;

Customer Service ;

Management;

Technical.

The raising of an “issue” leads to the initiation of a process leading to its resolution incorporating management meetings and utilizing the technology both to track progress and ensure that all such issues are brought to the attention of the appropriate manager.

encouraged both to learn from past mistakes and to engage in the debate to ensure better performance

Issues are (initially) raised by individual employees who are asked to provide the following information:

Their name;

The date the issue occurred;

The category it falls under;

A description of the issue; and,

A proposed solution.

This information is then passed to the practice review meeting for discussion, where it is decided:

What should be done to resolve the issue (the agreed solution);

Who is to carry out (or be responsible for) the agreed solution; and,

When it is to be completed by.

This information is also entered into the database.

in the future. Thus the issues tracking facility allowed for an explanatory input to be given along side

On completion of the activities to be undertaken as a solution:

The file is tagged “complete”;

The name of the person that “signed off” the activity is entered;
and,

The date it was completed is entered.

From this structure it is possible to determine the progress of an issue from entry to completion, i.e.:

Extant raised but not “Complete” and not “Active” — the first elements of the file have been entered but there is no agreed solution, the solution has not been tasked to any person and the completion date has not been entered, and the “Complete check box has not been activated, there is no “sign off” entry and no completed date;

Active raised but not “Complete” — the first and second elements of the file have been entered, i.e. there *is* an agreed

the more mechanistic performance measurement.

solution, a person tasked to carry out the solution and a complete by date, but the “Completed” box is not activated, there is no ”sign off” information and no completed date;

Complete all elements of the file have been entered and it is possible to audit the progress of the issue through the system.

It is possible to use these definitions to automatically provide an agenda for practice meetings by printing three reports thus:

New Issues = print “Extant” — thus solutions can be agreed and people tasked to carry the solutions through;

In Progress = print “Active” — thus progress reports can be requested and resources amended as necessary;

Completed = print “Complete” — thus it is possible to ensure proper completion and that completion was achieved within

the timeframes agreed and/or imposed at previous meetings¹⁷.

Because of its discursive form and the fact that it is not driven exclusively by internal events (i.e., as opposed to the performance monitoring element fed by the “Events” report which is numerical (how many, how often, how long) or logical (the ‘yes’ or “no” of the role-task link) this issues tracking database is able to allow more subtlety of data capture and allow a formal input into the system of environmental information. For example client feedback or complaints, changes in the law, or new products could be entered under appropriate category headings and filtered for relevance at practice meetings¹⁸.

Figure ten shows the “Quality Loop” positioned within the operational management model (system three) from chapter ten. In the diagram the elements of operations management presented in chapter ten are depicted with solid lines and further surrounded by a box, the “Act” element

¹⁷ For operational reasons the “Complete” report is constrained to those issues completed since the previous meeting and, therefore, has the additional constraint “AND “Completed Date” > “Last Meeting”.

¹⁸ It should be noted at this point that clause “8.2.1” of the ISO/CD2 9001:2000 standard requires that “Customer satisfaction shall be used as one measure of system output...” (BSI, 1999a) and that this facility provides a method for capturing this. However in a larger host organization this level of

affects *all* the other activities within this box. It is possible to see how the elements of the database correspond to the VSM and how it is possible, within the principles of chapter eight, to take action to control the quality of the output of the practice as defined in relation to the operational model of self. For example:

If a clinical treatment is discovered to have been carried out by an unqualified person the appointments process is controlled to ensure that only qualified people are assigned clinical tasks.

If an individual professional is found to take longer than is allowed in the model of self discretionary resources may be applied to allow for extra training, or the appointment times allowed may be extended, or extra nursing support (i.e. shared resource) may be allocated.

If an individual professional is found to be subject to an unusually large number of complaints (note that any at all may be unusually large) fees may be withheld until the situation is investigated or rectified¹⁹.

support may not be sufficient and the construction of a dedicated database (i.e. one separate from the issues tracking database) may be necessary to fully satisfy the requirement.

¹⁹ In the case of Zubnich this information would become apparent through the (negative) use of the issues tracking database to identify the *illegitimate* use of the skill set as represented by a valid complaint.

If punctuality is seen to be a problem action can be taken to re-orient the bookings of appointments or the mix (i.e. a system two activity) allowable for maximizing time utilization.

Thus in this way it can be shown that the database tool provides the mechanisms to allow the Zubnich practice to approximate the *static* quality implicit by its approximation of the ideal represented by the operational model of self.

Dynamic Quality

Where operational quality at Zubnich is defined as, and controlled to achieve, the approximation of the operational model of self (i.e. the *static* model), *dynamic* quality can be seen as the active redefinition of the *identity* of the organization in response to environmental pressure (or the teleology of the owner). Using the terminology of chapter eight, managing dynamic quality is equivalent to changing the organization such that the operational environment moves towards the aspirational environment, i.e. a desirable “outside and then” becomes an extant “outside and *now*” for which an effective (and perceived as stable) operational model of self can be constructed to deal with.

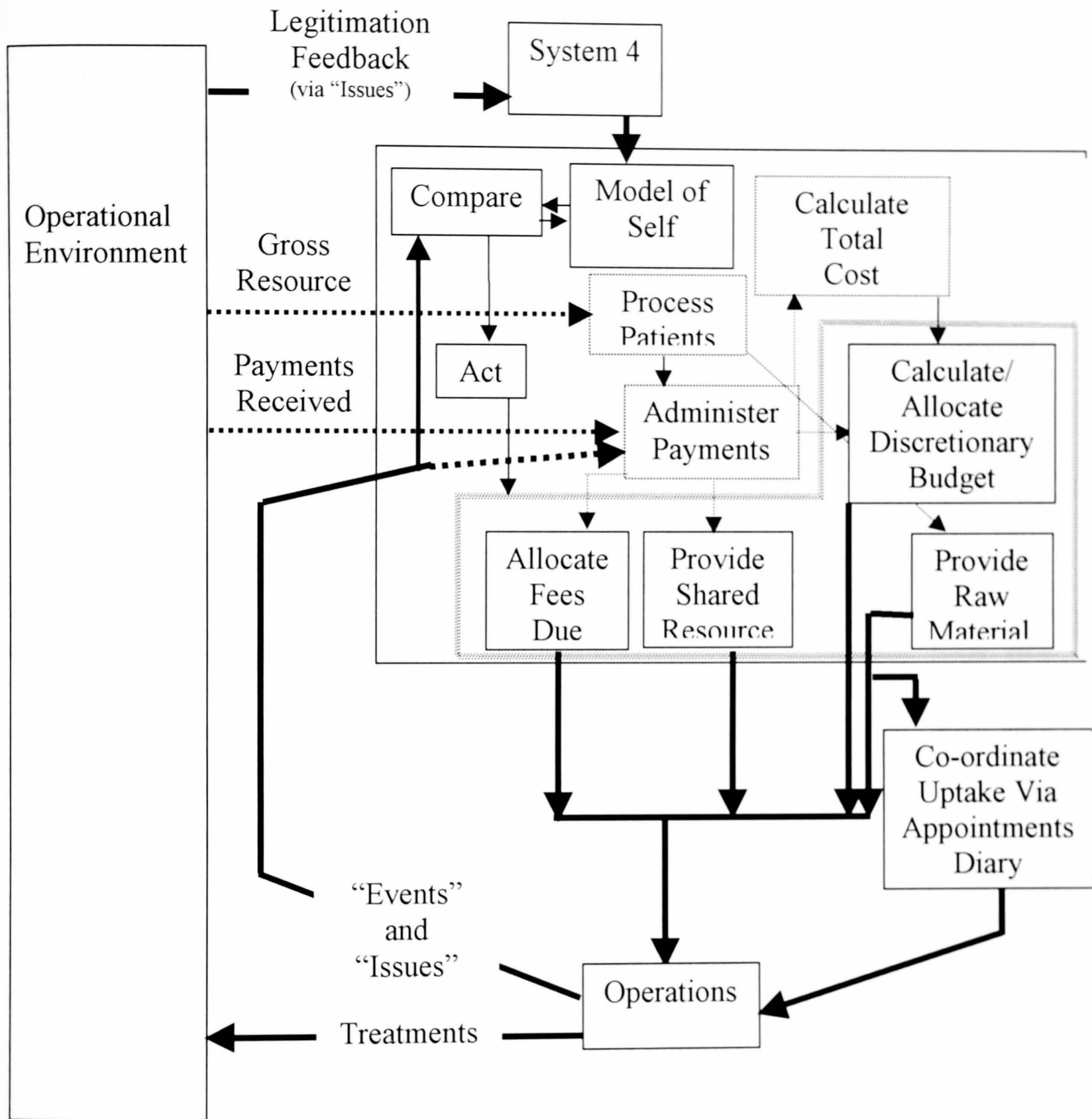


Figure 10: Operational Quality

The quality of service at Zubnich, as can be seen in the discussion above is based on the skill of the clinical professional (i.e., by and large, the dentist) and is assured by ensuring that only qualified people (i.e.

dentists) carry out the tasks (i.e. dental treatment). This implies a baseline level of competence in dentistry evidenced by an accepted dental qualification²⁰. However “being a dentist” in the general sense which allows for the quality assurance is extended in practice to “being a dentist at Zubnich”. This can be demonstrated within a model established for another client²¹, where the structure included “generic skills”, “job specific skills” and “professional skills”.

GENERIC	PRACTICE SPECIFIC	PROFESSIONAL
e.g. interpersonal, basic administrative, IT literacy, etc., i.e. those common to most or all areas of the practice.	i.e. skills that relate to “how we do things <i>here</i> ”, the role specific skills that extends baseline competence <i>within</i> the body of knowledge.	i.e. the wider body of knowledge that underpins “how we do things here”.

²⁰ That is, one that is acceptable to the General Dental Council (GDC) as sufficient to allow entry onto the “Register”.

²¹ Again Lyubov and Meerski, as some of the roles there were regulated by the Financial Services Authority (FSA) professional qualifications were necessary to their practice. However, the internal training related to the firm specific procedures for the provision of services and the possession of less specific skills such as the knowledge of filing procedures and the ability to use the ICT equipment

Thus, to “be a dentist at Zubnich” is to possess:

- a) the baseline competence in the body of knowledge appropriate to the award of a recognized dental qualification;
- b) an extension to this competence by way of the ability to operate the practice specific procedures established for the provision of the treatments offered. That is to say, the legal and clinical ability to deliver the operational model of self; and, less importantly within the context of professional service quality,
- c) the generic skills necessary to function as a member of the practice.

Thus where, in the static model, the designation “is a dentist” was sufficient to assure quality — because a static quality measure implies a static body of knowledge implies the sufficiency of a static qualification — is, here, no longer sufficient. The discretion implied by a dynamic body of knowledge generating multiple valid approaches to treatment requires that the practice state explicitly those additional (i.e. beyond the baseline competence implied by the qualification) skills it uses. And, leaving aside the “generic” skills although this approach applies equally

to them, as the wider body of knowledge is externally determined this means the specification of “the way we do things here” or the skill set relating to the operational model of self (see figure eleven²²).

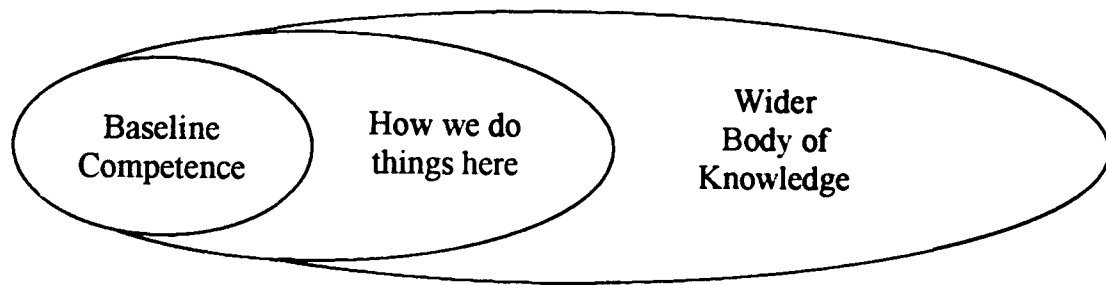


Figure 11: Nested Skill Sets

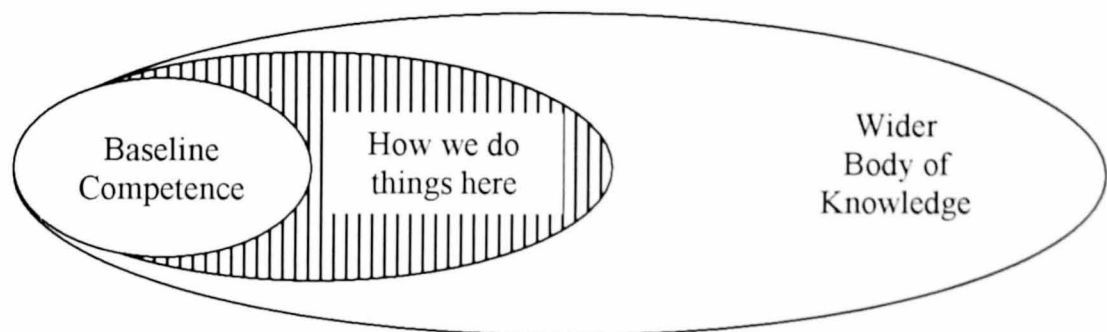
When the nested model presented in figure eleven is overlaid with the operational and aspirational environments it can be seen that the area representing current practice will, in most cases, coincide with the “operational environment” and that some sub-set of the “wider body of knowledge”, up to and including complete coincidence, represents the *valid* “aspirational environment”. Thus an adaptive response can be triggered if either:

the operational environment moves away from current practice, i.e. current practice is de-legitimated; or,

²² Note that this representation does not include a mechanism for the extension of the body of knowledge. Equally it does not preclude it, however as the intention is to show the relationship between baseline competence and a specific set of practices within the legitimating “wider body of knowledge” it is not relevant to this discussion.

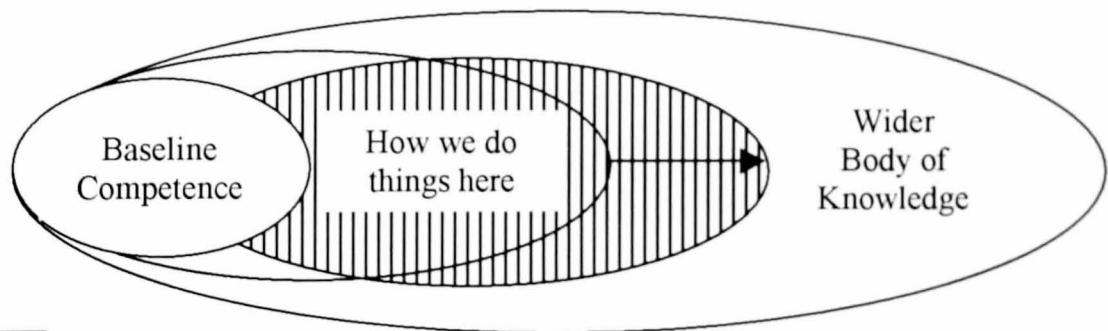
the practice, by whatever mechanism, decides to extend or change its service offering or target market.

These three circumstances are shown as figures twelve a,b and c respectively.



Operational Environment

Figure 12a: Normal Operation



Aspirational Environment

Figure 12b: An enforced change in the operational environment

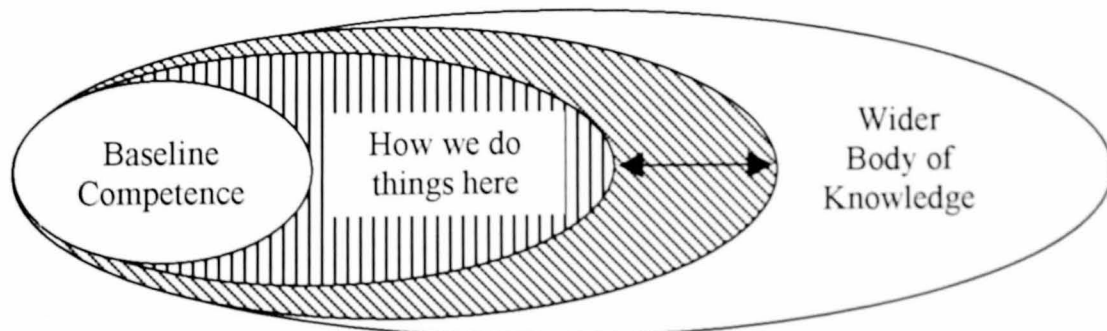


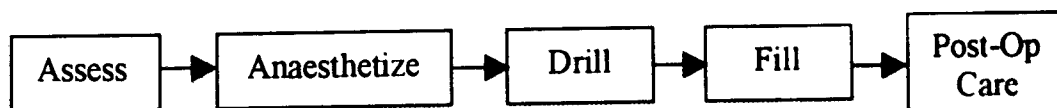
Figure 12c: The definition of an aspirational environment

Figures twelve b and c appear to show the same event, i.e. the change in “how we do things here” to meet new operational demands and, in terms of the adaptive response, this is correct. However there is a difference of focus, and of urgency, which is not immediately apparent. In the case where the operational environment moves away from current operations not only is there a need to determine new operational sub-models to address the new environmental demands, but also an effective de-legitimation of some of the services offered. Thus the organization would be *driven* to change in order to survive. On the other hand, in the case of the extension of the aspirational environment the organization is able to re-define itself in a more relaxed manner, obsolete services can be replaced *when their successors are in place* rather than being forcibly prevented from being offered. In the first case the imperative is “Change or get out of the market”, i.e. die. The actual change (or decision not to) being a question of identity and, as would be expected from earlier discussions, constrained by the “ethos” established by system five. In the second case the imperative is “We are going to become *this*”, the decision to change, and into what, has been made and is constrained only by the necessity for and availability of resources to fund it, which is to say that it is constrained by the operational capacity for change.

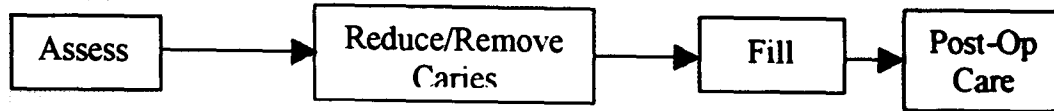
In both cases the response is the re-definition of the operational model of self which, in the skills based model, implies a change in the skill set available to the practice.

The introduction of ultrasonic tooth reduction, as a result of Zubnich's desire to be a technological leader (and, therefore, an *aspirational* imperative) will serve as an example.

Having defined the aspirational environment as including the demand for ultrasonic tooth reduction treatment (and having ensured that the capital is available to acquire the equipment — which is another element of the model of self) it is necessary to review the operational model for each of the services that the new equipment will affect. For example filling a decayed tooth. The pre-existing procedure can be represented, simply, as:



With the associated skills and knowledge implied by competence in the body of knowledge, e.g. precautions for the administration of anaesthetic, the use of the drill, preparation of amalgams, etc. However, with the new equipment the procedure is now:



The procedure is not only shorter (i.e. it contains fewer elements) but requires a different skill set, i.e. it is no longer necessary to administer anaesthetic, but it *is* necessary to be able to use (and maintain) the new machine.

Thus in order to demonstrate competence (i.e. quality) it is necessary to re-define the treatment protocol (i.e. the model of self), ensure the availability of the new skills to support it and demonstrate that these skills have been used in its provision.

The example demonstrates how it is possible for the skills held and utilized within the practice can migrate over time in response to (aspirational and operational) environmental needs and how this affects the model of self that is maintained. It is this migration that necessitates the existence of a more detailed record of the skill sets possessed by individuals within the practice.

Here it is necessary to return to the skills acquisition element of figure three (this chapter). When a new skill is needed the options are either to recruit a new person that has it, or to train an existing member.

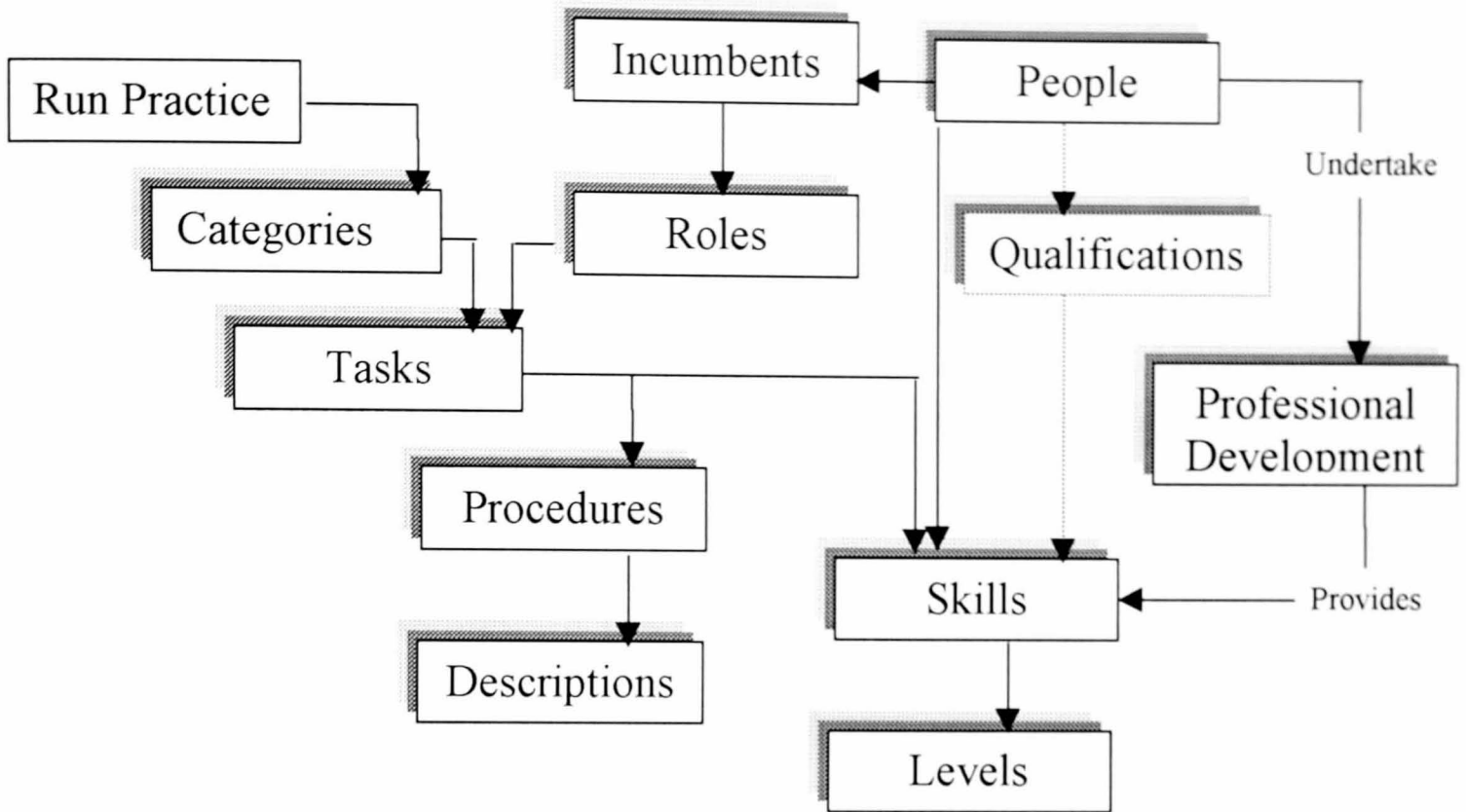


Figure 13: the addition of "Professional Development"

A final addition to the relational model shown as figure six (this chapter) completes the database tool implemented for Zubnich and provides documentary support for the migration introduced above, a "Professional Development" file. Thus figure six becomes figure thirteen.

The link between "People" and "Skills" is through a table "People Skill" which contains the fields

Name;

Skill;

Level; and

Evidence.

Which identifies the skills currently held by individuals, the level of achievement and/or competence and the evidence used to support the claim to possession (“Evidence” can accept the values “qualification” (i.e. a formal qualification that conveys or subsumes the skill listed), “APEL” (i.e. accreditation of prior experiential learning) or “CPD” (i.e., continuous professional development). “CPD” also acts as a “catch-all” category for formal training courses that do not lead to the award of a formal qualification

The “Professional Development” element is supported with a table that contains details of development activities using the fields:

Name;

Activity Number;

Year;

Category;

Objective;

Activity Description;

Start Date;

End Date;

Cost;

Review By Date; and,

Review²³.

Thus in the case described in the example above it would be possible to search the “People Skills” table to discover whether or not any member of the practice possessed the ability to use the new machinery (and on what basis they were claiming such possession), and whether or not the practice had used formal training for this purpose in the past (and how effective it was assessed to have been). Where the practice either did not have the skills (or a management decision was made that more members needed them) action could then be taken to identify an appropriate source of provision, thus acquiring the competence to provide.

In this way the adaptation of the practice (represented in this case by the migration of the skill set) is documented in a manner that renders it accessible for inclusion as part of the operational model of self on which the assessment of operational quality is based.

This, I think, makes it clear that the practice is adapting to new conditions by adapting the skill set it utilizes, which is consistent with assertions made elsewhere in this document. Thus the structure applied to the data is that shown in figure thirteen (i.e., it is the *skills* that can be brought to bear that are important, the *qualification* (shown with dotted lines) providing only a useful shorthand representation of their possession)²⁴.

Adopting the “skill” rather than the “qualification” as the basic unit of quality assurance also has another practical advantage — it allows for the generalization of the structure to *all* members of the practice (the focus of a later stage in the implementation). In this way it is possible to recognize and manage the skills needs of multiple roles within a consistent framework and extend the adaptive capacity of the planned development of the CPD approach to all members of staff.

²³ The “Review By” and “Review” fields are included to allow for the additional management facility of provider assessment.

²⁴ Although it would be possible to develop an automated module within the database which carried a detailed description of the skills available to a newly qualified graduate the effort expended in maintaining this would outweigh the benefits in a single implementation such as that at Zubnich. It must also be noted that the legal requirement of registration with the GDC in order to practice makes the inclusion of this qualification necessary for the clinical professionals.

Summary

In this chapter I have introduced a detailed model of quality assurance and control (based on the abstract model developed in chapter eight) implemented at the Zubnich Dental Practice and detailed the data structures, search procedures and decision points used to support it. The guiding principle was that quality at Zubnich, as a professional service provider, was dependent upon the skills of the individual professional clinical personnel. And therefore that in order to manage the quality of the service provided to patients it was necessary (with the exception of punctuality and the duration of treatments) for Zubnich to be able to monitor and manage the skills available to the practice.

The primary elements of this were the “Events” report used to acquire and store information relating to the delivery of treatments (i.e. start times, durations and who the treatment was carried out by), the “Issues Tracking” facility and the current (i.e. perceived as stable) model of self²⁵. Operational quality at Zubnich was defined as being the approximation of actual performance to the criteria, both explicit (e.g., *this* treatment will take *this long* to perform) and implicit (e.g., the

expectation that an appointment for treatment *will* begin on time) within the environmental constraint that the activities performed are legitimate.

This level of quality management (assuming the ongoing legitimacy of the model of self) was described as “static” in that the goal state remained constant (as would be expected given a stable model of self) and, therefore that the organization could, assumedly, attain a perfect state where *all* quality criteria were met all the time. The mechanism for this, being directly derivable from the model introduced in chapter eight, allowed for ‘management’ activity to change performance by the selective application or withdrawal of resources as reward (or sanction) for (non)achievement or development or efficiency purposes (within the discretionary budget calculation), or for some limited re-definition of the model of self²⁶.

Because of pressures from both the environment and internal operations the validation of the *current* operational model of self was shown as

²⁵ Which, as can be seen from appendix 1, contains information relating to acceptable duration times and acceptable provider roles.

²⁶ For example the ability to adjust the duration of a treatment where it became apparent that the set time was not achievable and where this was causing ‘knock-on’ problems with, e.g. punctuality. But it would *not* be possible to alter the treatment provision as this would be an action reserved for the definition of “identity”, a system five, or, more correctly within my interpretation, the “3-4-5” homeostat role.

being driven from two sources. Internally it must accurately reflect current *practice* (hence the facility for some limited re-definition) and externally it must be capable of satisfying environmental constraints. In order to allow for this at the level of operational quality the notion of the “operational environment” was introduced (an “outside and now” as opposed to Beer’s “outside and then”) to reflect the assumptions the organization had made in formulating its operational model of self. In the context of service quality this environment, for Zubnich, was assumed to comprise legislative and professional constraints (i.e. the law and the codes of practice of the relevant professional bodies of the clinical professionals, mainly the GDC) and patient feedback.

At Zubnich the only one of these external sources that may require management at an operational level²⁷ is patient feedback. Here the legitimation is *negative*, i.e., the assumption is made that, in the absence of complaint, the treatment provided is valid — this underlines the reliance of on professional competence and, where the absence of malice is *not* assumed, raises questions for the regulation, and establishment of safeguards in the provision, of such services.

Where the operational or static model is described as being concerned with performance in relation to a set of relatively stable criteria (i.e. the operational model of self) the *dynamic* model was described as being concerned with the identification of these criteria and facilitating the moves between them. In the case of Zubnich this amounted to the definition of skill sets appropriate to the provision of identified services.

These services were “identified” as an informed judgement of the appropriate response to external demands or internal desires and, as such, created what I termed the “aspirational” environment. This identification of appropriate services and the skills sets necessary to provide them constituted a re-definition of the operational model of self. Thereby allowing for the migration of skills *currently* held to a stage where the practice possessed the skills *needed* to be held to satisfy the new model of self.

The constraints on this mode of management were also discussed in this (and the previous chapter). Where it was suggested that whilst

²⁷ This being for the pragmatic reason that, because of the timescales involved, changes in legislation

operational activity was constrained by the ‘ethos’ of the higher level this higher level “aspirational” change was also constrained — this time by the availability of resources provided by the operational level. This strengthens the assertion that it is necessary to integrate quality, efficiency and effectiveness management in order to achieve organizational goals, however they are set.

The final element of the database tool, i.e. the facility for monitoring professional development, provided this link by including, in addition to data directly related to the development activity, the cost information (and, therefore the ability to communicate with the financial model of the practice) and a review section (thus allowing Zubnich to comment on the *effectiveness* of the activity).

Figure fourteen gives a schematic representation of the database tool in context (the dotted areas represent activities which are supported by the database but do not form part of it). And must also be viewed in the context of the *organizational* (as opposed to quality) model presented in chapter ten²⁸.

and or professional codes of practice are unlikely to impact on the day-to-day running of the practice.
²⁸ An added practical validation of the database model is the recent (Feb 2000) proposal from the Hong Kong Dentists Association to collaborate in the extension of the core database model to include

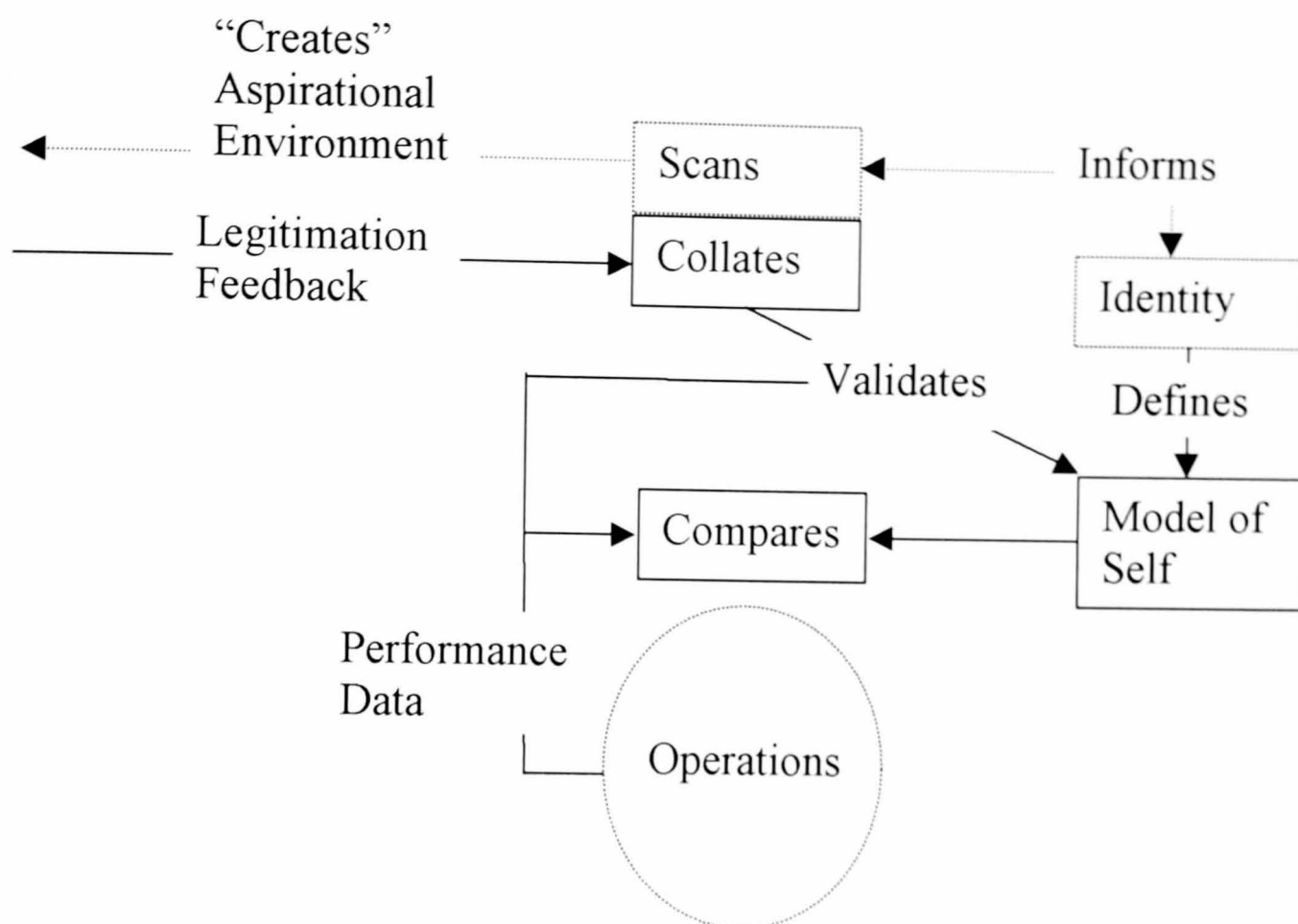


Figure 14: A Schematic of the quality model

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Chapter 12

Conclusions

Review of Approach

To conclude this report it is necessary to return to the questions the research project was intended to answer, i.e.:

“Is it possible to construct an effective model of quality management that is applicable to service quality management using cybernetic principles?”; and,

“If so, *what would it look like?*”.

When these questions are asked in the context of the method applied during the project (presented in the introduction, see figure one) it is possible to ‘tease out’ a number of implicit methodological issues.

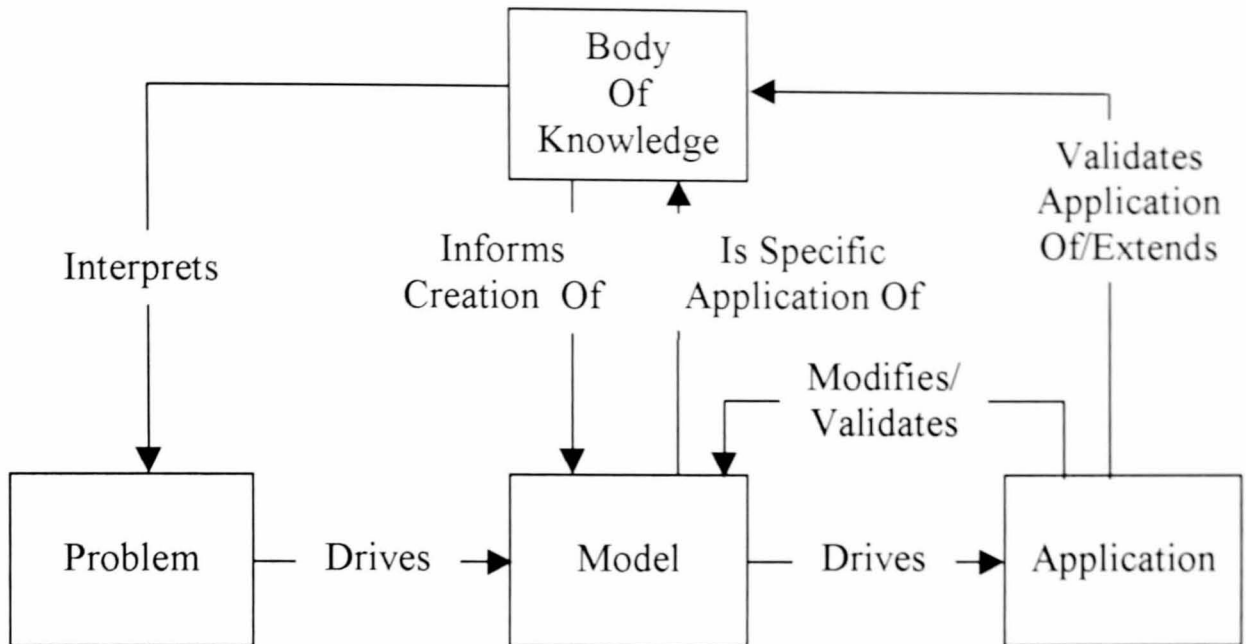


Figure 1: The Methodological Model

Here it can be seen that both the model (in the form presented) and the research questions assume the definition of the ‘problem’ and the choice of ‘body of knowledge’ as given. Clearly a ‘decision’ as to what constitutes the ‘problem’ and, therefore, the ‘body of knowledge’ appropriate to its ‘solution’ was taken but is not evident in the model as it stands. The decision criterion employed at this stage was a matching of the perceived characteristics of the problem situation with the capacity of various approaches or methodologies to address them. Using an approach similar to the “choice” phase of the Total Systems Intervention approach suggested by Flood and Jackson (see, Flood and Jackson, 1991, pp. 51/2; Flood, 1995, pp. 36-41), cybernetic theory was selected. This was because of its ability to address the “complex-unitary” (Flood and

Jackson, *ibid*, p. 35) issues considered characteristic of quality management in the service sector.

Thus there is a ‘pre-engagement’ element (given as figure two) not shown in the initial version of the model that allows for the (nominally) rational selection of an appropriate ‘body of knowledge’. And it is by detailed interpretation of the problem situation through the body of knowledge that this situation is turned into a defined ‘problem’¹.

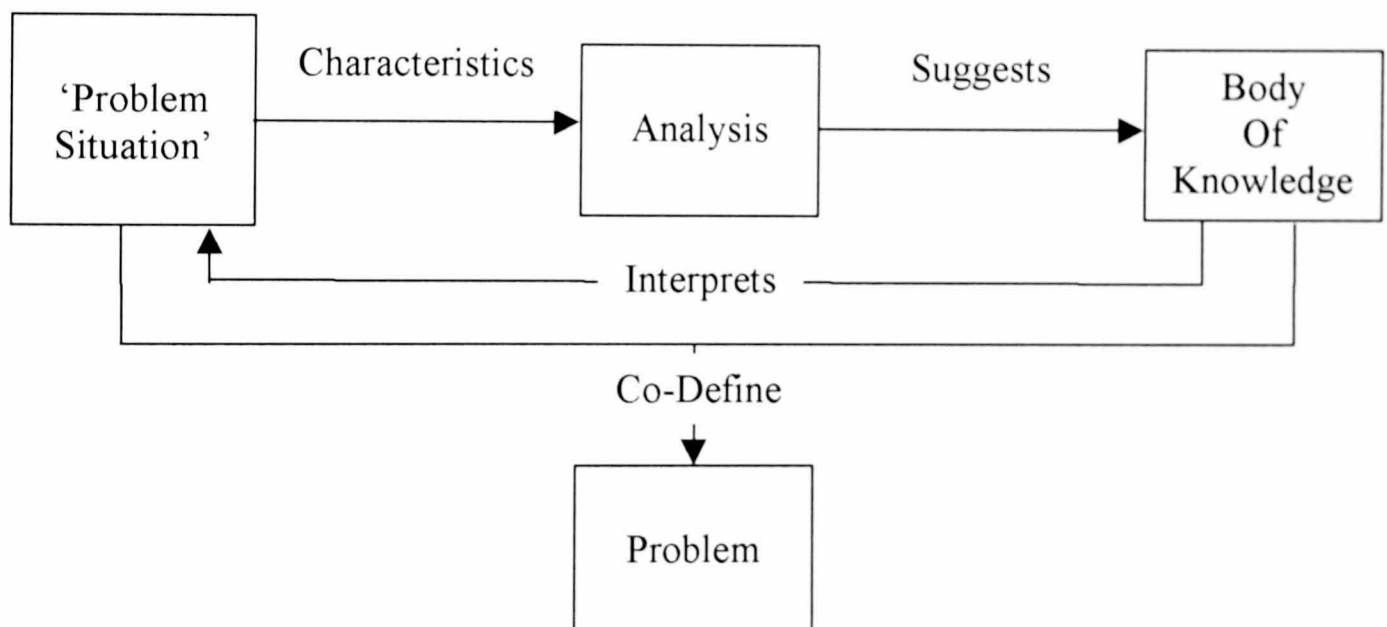


Figure 2: A Model of the ‘Pre-engagement’ Stage

¹ It should be noted here that the *rational* model requires that the characteristics of the ‘problem situation’ determine or inform the choice of the ‘body of knowledge’. However should a *preferred approach* be adopted uncritically (e.g., should a house method be applied regardless of the nature of the problem) it is possible that “the problem” will be defined in terms of the capabilities of the theoretical base. This effect can be demonstrated (crudely) in this context by assuming that:

- a) the problem is viewed as one of database design – where the emphasis would be expected to on data capture, storage and manipulation, thus little attention would be given to wider organizational issues such as change, learning or profitability;
- b) the problem is one of achieving ISO 9001 certification – where the prime emphasis would be focused on formal achievement of stated requirements, thus leaving little or no scope for the detailed consideration and integration of the wider needs of service providers.

As the project is a report on the execution of a consulting contract the utility of being able to state or define a “problem” in this way lies in the fact that it also (in principle) allows the statement or definition of what would constitute a “solution”. Which is to say that, by defining the *relevant* aspects of the “problem situation” its apparent complexity is reduced, both numerically (i.e. there are *fewer* things to consider) and pragmatically (the things that *are* left for consideration fall within the competence of the body of knowledge).

Checkland draws a similar distinction between “problems” and “problem situations” thus:

“... the definition of structured problems implies what will be accepted as ‘a solution’, unstructured problems ... are conditions to be alleviated rather than problems to be solved.” (Checkland, 1981, p. 155).

The selection of a model (or the design of an approach) for the ‘solution of the problem’ (from within the body of knowledge) is, when viewed in this way:

“... the evaluation of the efficiency of alternative means for [the achievement of] a designated set of objectives” (Ackoff, 1957, quoted in Checkland, 1981, p. 155).

This is consistent with the role of the consultant in a professional and/or contractual relationship with a client (insofar as it allows for a definition of the scope, extent, and, therefore, the cost of the work to be provided), but also *assumes the validity (and/or legitimacy) of the body of knowledge applied*². Thus the construction or (as in the case of this project) selection of a model to apply to the ‘solution’ of the ‘problem’ is a function of the interpretation of a ‘real-world’ problem situation through the ‘body of knowledge’ (i.e. the “problem”). And it is this abstraction that leads to the perceived numerical and pragmatic complexity reduction mentioned earlier.

However, in practice the pre-engagement stage of a consulting project (in personal experience) often involves extensive *negotiations* with the client as to what constitutes an *appropriate* ‘problem’ for solution. This involves, *inter alia*, an exploration of the perceptions of the problem

² As, within the constraints of chapter one, does the applied element of this project

situation³ and possible improvements as an integral part of the discussion. This creates a second set of constraints on the choice of model to be applied. As can be seen (simplified) in figure three, the model finally chosen (or constructed) is an outcome of both the (negotiated) perception of the problem situation represented by the “problem” and the researcher’s (consultant’s) reflection⁴ (either in isolation or in negotiation) upon the perceived solution(s) of it through the body of knowledge.

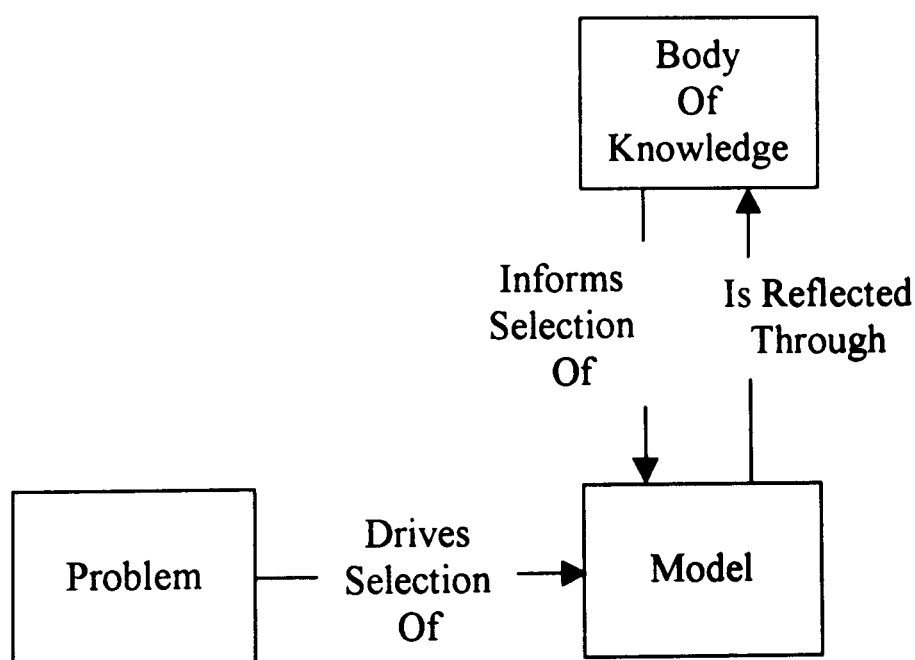


Figure 3: Selecting (Constructing) the Model

As a consulting contract, the project was ‘client-focused’ (i.e., client pays consultant for *solution*), having agreed (in more or less detail) the characteristics of a solution (see discussion above) it became necessary to

³ Thereby allowing a greater degree of confidence in any diagnosis eventually arrived at and, to some extent, addressing the possible concerns of the “soft” school.

provide *it*. This ‘outcome focus’ has the effect of fixing the goal state and rendering the approach to it variable⁵ (see figure four).

Thus the criterion of *practical* success is the delivery of a ‘solution’ to the ‘problem’ (or an “alleviation of the dis-ease” caused by the problem situation). By explicitly allowing for the modification of the model in response to its inability to meet this criterion *theory* is shown to be secondary to *practice*. *Theoretical* value, on the other hand *is* gained if either:

a successful practical *and* theoretically valid solution is achieved, thus allowing the model to be used in other interventions in this field; or,

the modifications necessary to achieve a successful practical solution exhaust the theoretical resources of the body of knowledge (i.e. a theoretically valid solution *is not* possible, and therefore the body of knowledge can be considered invalid in this field.

⁴ Note that this “reflection” can (as in this case) lead to modifications of the ‘basic’ model in order to better tailor it to the perceived solution *before* beginning any formal intervention.

⁵ As opposed, for example, to the mathematical problem “calculate π to X decimal places” where the algorithm π/d is fixed and run until “decimal places” = X and the solution emerges.

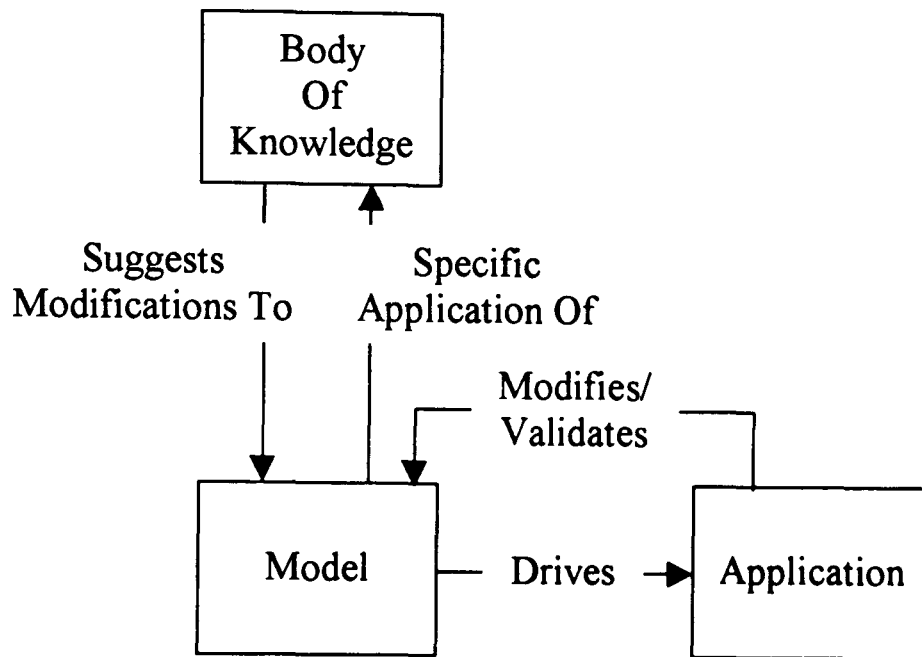


Figure 4: The Relationship of the Model to "Reality"

Thus is the project a *de facto* test of the validity of cybernetic principles in the area of service quality management.

However, in this manner of intervention, i.e. a single empirical test, failure cannot provide a definitive *negative* answer to the first research question. That is to say that, the inability to create a "model of quality management that is applicable to service quality management using cybernetic principles" cannot definitively answer the question "Is it possible?" beyond the reply "Not in *this* case".

In order to render the test of cybernetic principles “scientific” in the Popperian (see Popper 1934, pp. 133 ff.) sense it is necessary to reformulate the (working) question in such a manner that it is *falsifiable* by a single empirical test. Given the problems with this in positive phraseology (and the investigative phraseology of this project) discussed above it is necessary to state a *negative hypothesis*, i.e.:

It is not possible to construct an effective model of quality management that is applicable to service quality management using cybernetic principles.

This has the dual advantage of:

- a) being falsifiable given a single instance to the contrary, that is, if a successful practical quality management system *is* constructed using cybernetic principles the hypothesis can be rejected; and,
- b) being susceptible to rigorous testing by the prototypical approach adopted, as this will tend to ‘hunt’ feasible solutions by progressively improved approximation.

In this way it is possible to drive the (consulting) project forward towards an effective solution for the client through iterative application of the process shown as figure four, whilst retaining the rigour of the theoretical outcomes through a ‘reverse pass’ from solution to theory as shown in figure five.

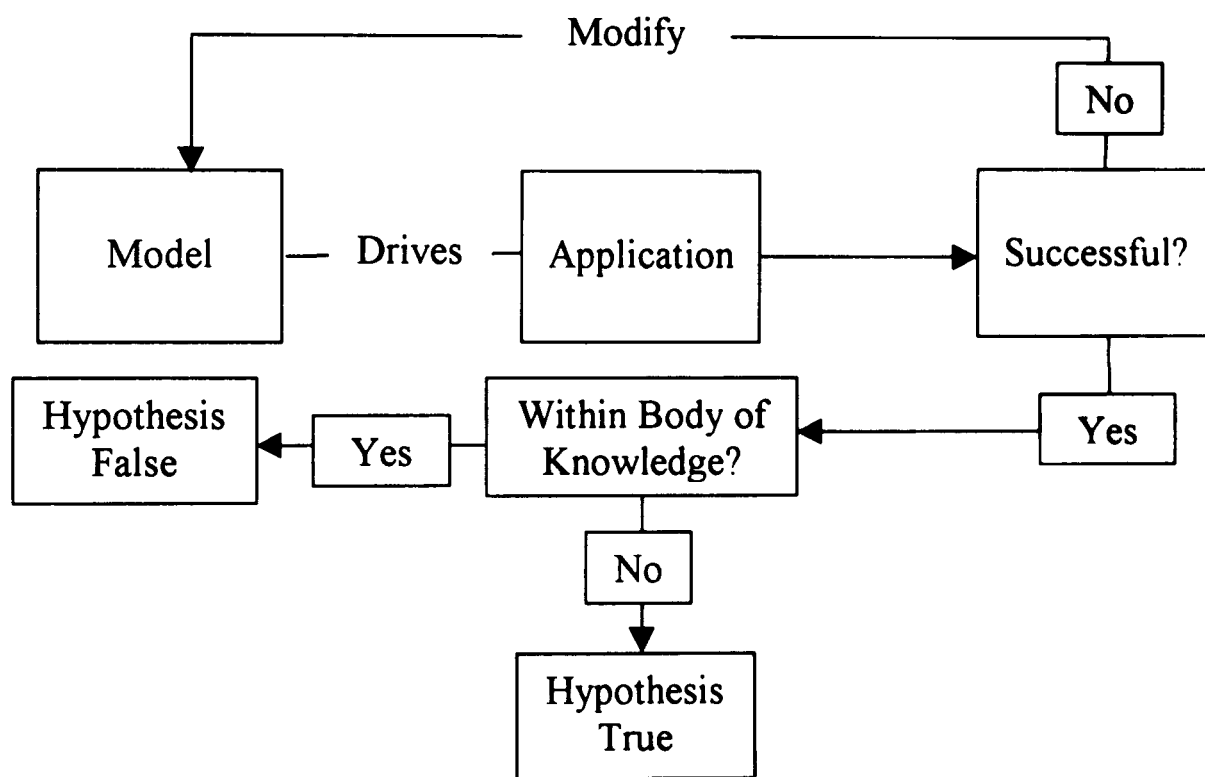


Figure 5: Reverse Pass Testing for the Negative Hypothesis

In order to complete this ‘reverse pass’ it is thus necessary to address two main areas:

- 1) the practical success of the project, that is to say the extent to which the database implementation and the model of quality management that it supports has achieved the goals that were set for it; and,

2) the theoretical considerations raised by the project, including the extent to which the model developed (primarily) in chapter eight contributed to the practical success of the implementation and the extent to which its ‘predictions’ were experienced in practice;

In addition to this there are possible areas of further study, extensions or applications of the model, not addressed in this report, where the insights gleaned may be beneficial or whereby some of the illustrative constructs used may be made more rigorous. I believe this to be necessary because although the project was based on an established model of organization, i.e., Beer’s “Viable System Model” (VSM), the interpretation of it actually used during the consulting interventions required a re-consideration of the fundamental principles on which it was based. This led, especially in chapters seven and eight, to an operational version of the VSM which looks somewhat different to the “pure” version outlined by Beer in his work and which may, therefore, offend those adopting a pedantic reading of the model.

The Practical Success of the Project

That the project as a whole can be regarded as a *practical* success can be demonstrated in three ways:

1. in the acceptance of the database tool by the client;
2. in the recognition of effectiveness at “industry” level; and,
3. in the recognition of more general applicability to quality management.

The Database Tool

A database with the structures outlined in chapter eight has been constructed and is populated with ‘live’ data. The prototyping approach adopted during the construction allowed for the logics to be tested at the completion of each module and on its integration into the wider suite. This enabled the operation of the database to be validated by the client on an ongoing basis, thus ameliorating the complexity of final pre-delivery checks. A significant advantage during the construction of the database was provided by first hand knowledge (a first degree in information systems) of structured systems methods. And similarities can be seen between the approach used here (e.g., in the use of the VSM (as a data

flow diagram) the relationships between the functional elements of the organization (as “relational data analyses”) and the necessity for “normalization” of the base data tables, and structured information systems design methods, e.g. *Structured Systems Analysis and Design Methodology* (SSADM) (see, e.g., Hares, 1990).

The database is now undergoing “interface” refinements, i.e. the final layouts of the input forms, menus and report formats are decided and produced. This activity is intended to enhance the accessibility of the tool in order to maximize perceived benefit.

In relation to the terms of reference agreed with the client it has been accepted that the database has fulfilled the brief and *is* capable of supporting quality management at Zubnich.

Industry Acceptance

The logic of a quality management system based on the VSM suggested that it was necessary to include elements of ‘effectiveness’ management as an integral part of the model. The constraints of the brief agreed at

Zubnich precluded this (and the mechanization of a number of elements that would formally constitute part of a quality management system).

A parallel prototype (i.e. one based on the same core design) that *included* the patient records module and the effectiveness management module was presented to (and accepted by) the Hong Kong Dentist's Association as an effective model for dental practice management.

This demonstrates that the general model has captured the necessary elements of dental practice (as perceived by dentists) and can, thus be considered successful at this level.

More General Applicability

At the level of the model (i.e., the non-database elements of this interpretation of the VSM) the arguments presented in chapters two to four and nine to eleven inclusive were considered sufficient (by the Hong Kong Quality Assurance Agency) to form the basis of a series of courses for auditor training. The first of these courses, for auditors will be responsible for the inspection of companies seeking certification to the ISO 9001:2000 standard, was delivered early 2000. This wider

acceptance is, I believe, sufficient to justify the qualified definition of service quality and the approach taken to its delivery outlined in chapter one.

Thus it is also possible to assert that the model has a more general applicability, i.e. beyond the 'industry' for which the prototype system was developed.

Taken together, or in isolation, I believe that the three examples given are sufficient testimony to the *practical* success of the project.

Theoretical Considerations

There are two streams of 'theoretical consideration' needing to be addressed here, the extent to which the "practical success" of the project as a consulting exercise supports the theoretical assertions made (thereby validating the model proposed), and, the extent to which these assertions are cybernetical (thereby allowing a formal answer to the research questions).

cost for its provision, and the *adaptedness* of the system can be measured by the ability to provide it for lowest⁶ cost. Therefore (and as with most elements of the model) cost becomes relative as the wider system “satisfices” (see, e.g., Simon, 1981, p. 36) the provision of necessary information (see also the discussion regarding evolution (in *or* out) of the “eye” in chapter eight)⁷.

The next element is not so much a modification as the result of taking to the extreme Beer’s assertion that:

“The metasystem ... should make only that degree of intervention that is required to maintain cohesiveness...” (Beer, 1979, p. 158).

In fact, taking literally the assertion he makes in the same context that:

“The minimum is in principle zero” (Beer, 1979, p. 158)

This minimal level of intervention allows for the maximal autonomy of the operational units (as is predicted by Beer’s model) which is the

⁶ This may be lowest *marginal* cost assuming that it is possible that the (sub)system in focus may already fulfil another function.

outcome required in *professional service management*. This is because it maximizes the extent to which the complexity created as a result of the *negotiated* element of service provision is absorbed by the professional competence of the operational unit.

The logical extension of this to allow for resource input at system three (which *is* an apparent modification of the VSM) allows for the creation of a resource laden *milieu* for the operational units to draw upon within their internal (or systemic structural) constraints and imperatives)⁸. This element of the revision is supported, in the context of the Zubnich case by:

- a) the proprietorial rights of the practice (i.e. the gross resource, patients, *belong* to the practice);

⁷ Note also that, within the constraints of the *cosine* efficiency model of chapter eight it is possible to derive a *utility value* for the management function in this way.

⁸ It should be noted that, whether this system three contact with the environment is 'actual' (i.e. the system three physically receives the resources) or 'conventional' (i.e. the resources are collected directly by the systems one and made available to system three for allocation) is not strictly relevant to the argument. It could reasonably be argued that the milieu created by system three *constitutes* the environment to which the systems one are connected and, therefore, *both* views are correct. However, in defence of the 'milieu' view, it removes the 'problem' of resources being always received at the next lower level of recursion, i.e., not formally ever received at the level of recursion of the system in focus.

- b) the allocation or uptake of resource according to the internal capacity of the operational unit to carry out the necessary transformation (i.e., only dentists carry out dental surgery, etc.);
- c) the freedom of the operational (i.e. professional) unit to carry out whatever activity deemed appropriate once a resource is allocated (within the presumed constraints of the body of professional knowledge) as long as these activities do not transgress the rules of viability of the wider system (and, thereby cause the collapse of the resource milieu).

The “toxicity” model of co-ordination (which provides one of the mechanisms for applying the constraint mentioned in “c” above, in the extreme ‘starvation’ is the other⁹) was suggested by Margulis’ comment that “No organism feeds on its own waste” (Margulis, 1999, p. 115), therefore a system existing in an environment *constituted by* its own waste¹⁰ will die. Within the complete freedom implied by the “milieu” argument sub-systems with a ‘positive growth’ imperative¹¹ (i.e. systems

⁹ Whether socially (i.e. contractually) in the context of management or actually in the biological realm

¹⁰ See discussion below.

¹¹ Note that for the purposes of this discussion a ‘positive growth’ is assumed to demonstrate the potential for negative control. However it is also possible to envisage ‘positive’ controls to counter depressed performance based on the presence of hormones in biological systems, e.g., motivational exercises, growth programmes, etc.

which are in some way programmed to exploit all possible resource availability would lead to a situation where:

“... elemental operations (in pursuit of their individual targets) would inevitably exhibit activities that were not consonant with each other — and which might be downright contradictory” (Beer, 1979, p. 158).

When the ‘milieu’ is viewed as an ‘eco-system’ (constrained only by *total* resource availability) surviving as an entity on the basis of the balance of the interactions of its constituent elements, it is apparent that an overactive element may disrupt this balance. As all biological systems produce waste and that, in a relatively closed ‘eco-system’ this waste must either be taken up as input by other elements of the system or removed in some other way, at any given point in time there is a limit to the amount of waste received from the element in focus the eco-system is capable of maintaining. Thus , as the level rises, the accumulation of waste reduces either the amount of resource available to the element in focus (i.e. it drowns) or the capacity of the element in focus to process the available resource (i.e. it produces a toxic response), or the eco-system collapses. The integrity of the eco-system is enhanced by the

inability of the constituent elements to process their own waste. In this way the co-ordination of the eco-system is a function of the output of the constituent elements in the context of the resource availability (i.e., the milieu representing system three) and the (internal and external) structural constraints on their interactions. This is entirely consistent with Beer's (1979, pp. 182 ff) remarks concerning system two and strongly suggests that the co-ordinative system two information at any given level of recursion is received into the next lower level systems as 'environmental' and, i.e., through system four.

Moving this into the managerial domain (using the vehicle of the VSM) it can be suggested that (viewed traditionally) the output of an organization is an emergent property of the interaction between its constituent elements on their respective inputs. This implies that there is some (possibly many, as implied by the application of the "eigen-system model) sustainable¹² *set of interactions* between them leading to sustainable *whole systemic* outputs, and therefore that there exist acceptable mixes (as opposed, necessarily to *levels*) of "elemental" outputs which correspond to them. The co-ordination of these levels (i.e.

¹² Sustainability is a requirement for the viability of the system.

the maintenance of the 'mix') through the mechanism of output toxicity maintains a balance of resource distribution by depressing the capacity for resource uptake in the presence of (relative) excess supply. Thus the output of a given constituent element provides the basis of the mechanism of its co-ordination.

Support for this interpretation was experienced at Zubnich in the co-ordination of capital resource utilization, where the professionals operated on a percentage of turnover fee (and therefore where the pressure on individuals was to maximize individual turnover). Social and/or managerial sanctions could be applied to individuals whose activities reduced the availability of contracted capital resource to other members of the practice.

When taken in the context of the discussion relating to autopoiesis (chapter seven, see also Maturana and Varela, 1980, p.78/9), i.e., in regarding the *organization* as a self-creating entity the above observation increases confidence in the assertion that the *product* of the organization is, effectively the *waste* product of the production of the organization itself. And, thus providing the basis for the co-ordinative mechanism.

The final “theoretical consideration” capable of evaluation through the case study is that of the “operational” and “aspirational” environments. These were described as being resultant upon interactions between “system three and system four constrained by the ethos defined by system five”, and “system five and system four constrained by the resources made available by system three” respectively. These environments were *suggested* by events arising during analysis of the case and were, on this basis, included as an iterative modification of the model. This modification permitted, in practice, the formal location of both quality management initiatives and information sources and organizational change within the wider model. As such they must, by definition, be regarded as supported by the case study.

Is It Cybernetics?

Although the model eventually presented (in chapter eight) contains many modifications none of them, I believe, transgress the rubric of the VSM. The functional necessities Beer defines as the elements of the VSM (i.e., systems one to five) are still demonstrably present and are both connected and functioning in the manner that Beer describes. This,

it is suggested, is sufficient to consider the model I have presented to be legitimately called cybernetical. However a more rigorous assertion of ‘class membership’ can be made using the original definitions of the concerns of the body of knowledge itself.

Wiener (1948) determined the modern definition of the field in the statement:

“We have decided to call the entire field of control and communication theory, whether in the machine or the animal, by the name *Cybernetics*.” (ibid, p. 11).

Ashby, (1966) accepts this definition but adds that:

“It does not ask “what *is* this thing?” but “*what does it do?*” ... It is thus essentially functional and behaviouristic” (ibid, p. 1).

Beer (1985) completes the set by stating that:

“Cybernetics is the science of effective organization” (ibid, p. ix).

From these extracts it can be shown that:

The model satisfies Wiener's broad definition insofar as it suggests both practical and theoretical mechanisms that facilitate *communication* between the elements of which it is comprised, and that the purpose of this communication is the *control* of these elements to achieve organizational goals.

The model satisfies Ashby's extended definition in that it defines the *functional* necessity of the elements subject to control. And makes explicit (through the autopoietic argument) that, at any given level of recursion, it is the outputs (i.e. apparent, to the controlling level, *behaviour*) of the controlled system that is of interest.

The model satisfies Beer's definition by default, by being explicitly based upon, and obeying the principles of, the Viable System Model, which is Beer's definition of the functional elements necessary to "effective organization".

This demonstration is considered sufficient to support the claim for 'class membership' and, therefore to complete the analysis necessary to the answering of the research questions (see figure six).

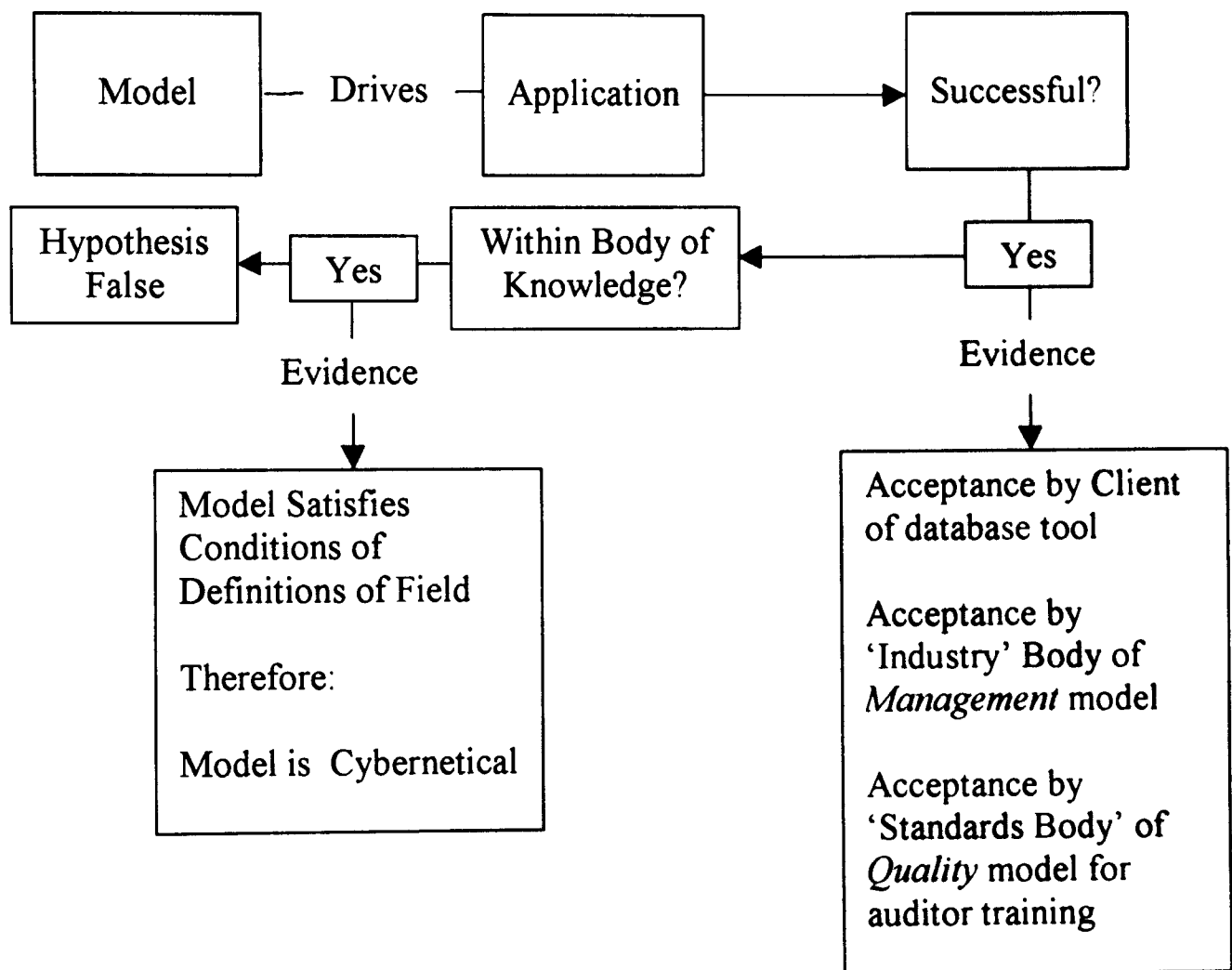


Figure 6: Proving the Hypothesis

Thus, with the hypothesis:

It is not possible to construct an effective model of quality management that is applicable to service quality management using cybernetic principles.

shown to be false, the answer to the first research question, i.e.

“Is it possible to construct an effective model of quality management that is applicable to service quality management using cybernetic principles?”

is “yes” and to the second, i.e.:

“If so, what would it look like?”.

the answer is “One demonstrable possibility is the database (and the theoretical model on which it is based) presented here”.

Further Study

In addition to the theoretical elements of the model (discussed above) which were either directly supported by the practical implementation, or so much an integral part of those elements that they could be regarded as supported by association, there are those which, whilst not proven false, could not be tested in practice. These are the “eigen-system”, the “mix vector” and the “hypersphere” model of environmental transfer.

Whilst all three are based in established bodies of theory and appear logically consistent the fact that they are (here) utilized outside their accepted area of relevance renders them conjectural. And, although they provided great illustrative value¹³, the constraints of the case study and the fact that, although interesting in themselves, they were not key to the success of the implementation meant that they could not be fully dealt with in this project.

Because of their mathematical nature, computer simulation is suggested as a more appropriate evaluation of these ideas. In this field, were they to be shown to be valid, there are obvious contributions they could make to the field of artificial intelligence or artificial life research. However such research requires specialist facilities. Simulation of such complex *combinative* systems requires significant computing power. And even 'paper' representations of the models may require the development of a novel area of mathematics (one that allows vectors, as opposed to their scalar products, to be used as index values) in order to evaluate them fully.

¹³ Note, in this respect, that the model they informed is *internally consistent* and was validated

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Although, in its pure form, this area of further study does not fall within the area of management research it could be expected to provide a more rigorous basis for the generalization of the model (and, therefore the beginnings of a theoretical link between diverse areas of study).

Although here it is possible to return to the comments of Parker and Stacey (1994) in that they:

“... might give us a deeper insight into how human organisations function ... [because] (w)e can certainly do with all the new insights we can get, bearing in mind how difficult managers seem to find it to design and sustain creative organisations ...” (ibid. pp. 11/2, brackets added).

operation of a business, this project establishes a rigorous theoretical basis for “Quality Management” based on the notion of benefits accruing to the host organization.

As a result of their being based on a development of the VSM, the outcomes of the project suggest a structure within which management decision making can be effectively undertaken, and which identifies both the types of *decision* made and the *information* necessary to make them.

In a more particularistic mode, the project identifies the characteristics of quality management for professional service providers and suggests methods for both its assurance (i.e., skills-based quality management) and the improvement of the *results* of service delivery events. In this manner the model developed *reduces* the perceived complexity of the management task using cybernetic insights and information technology (i.e. software tools) designed using cybernetic principles.

In addition to the direct contributions mentioned above, the development of the model can be expected to contribute to management research by defining a context for the undertaking of discipline specific research.

The two most obvious areas of which being a) the design, implementation and exploitation of information technology (in, for example, management information and/or decision support systems), and human resource management (in, for example, staff development and/or appraisal management).

From a more abstract point of view the model suggested provides a formal integration of the notion of autopoiesis and the rubric of the VSM. Here the autopoietic imperative (i.e. the necessity for the organization or system to *create itself*) can be seen to be reflected in the necessity for the accrual of *business benefits* to drive systemic action. The advantage to using the VSM here derives from Beer's "system five" (which as he says "... *supplies the closure*" of the system (1979, p. 261) thus providing a basis for the definition of systemic value. Thus business benefits can be viewed as those outcomes to action that satisfy some *internally defined* criteria of goodness.

The model also explicitly develops the supplementary notion of the "product as *waste product*". This idea, that the *output* of any given system can usefully be viewed as those materials unused in the activity of

processing the *inputs* from its environment into itself, derives directly from the idea of autopoiesis and is entirely consistent with Beer's view of "viability". And provides a coherent framework for understanding the potential for multiple rationalities within an organization. This being because, at any given level of recursion, the system in focus has a rationality emphasizing the production of *self* whilst the next higher level operates a rationality emphasizing the management of its *output* (i.e. its *waste* product).

The attempt to determine a method for managing the "product as waste product" lead to the interpretation of points of input across systemic boundaries. From that the formalization of the connexions *between* levels of recursion (particularly the identification of system three as the point of resource input and the classification of the environment into "aspirational and operational) was possible. This formalization can be used to inform two further areas of study:

- a) the construction of computer models of the VSM as, within this logic, it is possible to define a recursive programming object; and,

operates a rationality emphasizing the management of its *output* (i.e. its *waste product*).

The attempt to determine a method for managing the “product as waste product” lead to the interpretation of points of input across systemic boundaries. From that the formalization of the connexions *between* levels of recursion (particularly the identification of system three as the point of resource input and the classification of the environment into “aspirational and operational) was possible. This formalization can be used to inform two further areas of study:

- a) the construction of computer models of the VSM as, within this logic, it is possible to define a recursive programming object in the manner of *Object Oriented Programming* (see, e.g., Meyer, 1988); and
- b) b) identifying the advantage to be gained by a given system by being part of a wider embedding system, in that there are potential variety management (and therefore operational resource) gains to be made by not having to support the infrastructure necessary to the management of a large “aspirational” element in the environment scanning function of system four.

The model for assuring professional quality, presented in chapter eleven, makes explicit reference to the need for the ongoing *legitimation* of the outputs of the organization. This is to say that it is not sufficient to professional quality to be merely *technically* competent in operation. There is also a need to be (in some way) *appropriate* in the choice and application of this technical operation. The determination of this appropriateness (i.e. its *legitimacy*) comes, necessarily, from the client constituency (narrowly the patients, and more widely the professional and legislative frameworks) within which the provider operates. Which is, according to the rubric of the VSM (and as was suggested in this project), captured by system four.

The external determination of the legitimacy of the output of the system can, according to the principles presented in this document, be seen to be a functional prerequisite of the effective *control* of the system in focus.

Note this passage from *The Social Contract* written in 1762:

The passage from the state of nature to the civil state produces a very remarkable change in man ... Although, in this state, he deprives

himself of some advantages which he got from nature, he gains in return others so great ... that, did not the abuses of this condition often degrade him below that which he left, he would be bound to bless continually the happy moment that took him from it ... What a man loses by the social contract is his natural and an unlimited right to everything he tries to get and succeeds in getting: what he gains is civil liberty and the proprietorship of all he possesses ... *natural liberty ... is bounded only by the strength of the individual, ... civil liberty ... is limited by the general will ...*” (Rousseau, 1973, 195/6, italics added).

The italicized section of this extract refers to the individual (*system* in our case) operating *in* society. Here it can be seen that membership of society (Rousseau’s “civil state”) requires the subjection of the unlimited freedom of the individual to acquire or possess through strength, to the ‘greater good’ of the “general will”. Thus the legitimation of individual (*systemic*) action is legalistically (conventionally) determined and thereby necessitates the existence of some mechanism (either positive or negative) for the communication and reception of the legitimating message. And the inclusion of the “legitimation” element in the system

four function of the model presented in this report can be seen to fulfil this¹⁵.

However, this line of argument *assumes the legitimacy of the legitimating body*. That is, it assumes that the legalistic determination of the “general will” is truly general¹⁶. Thus there is a second element to the the legitimation of (*systemic*) action — that which concerns the system *as* society.

A second reading of the extract from Rousseau can be given, stressing not the responsibilities incumbent upon the individual in return for the benefits of the civil state, but the responsibility of the state to maintain its legitimacy. Not *right over might*, but the *rightness of right*. Here Ulrich’s (1981) critique and the concerns raised by Wiener (1950) and Beer (1994) become relevant.

Here the problem is not the (external) legitimation of the output (representing the individual in society) but, to state the situation in the

¹⁵ Note that independent (and contemporary) support for this general assertion can be found in a research project reported as Midgely, et al (1998).

¹⁶ And, of course, that this *generality* is sufficient to legitimacy.

language of the VSM, the (internal) legitimation of the “3-4-5” homeostat (representing the values, and mechanisms of legitimation and enforcement, of society itself). This is problematical for the cybernetic model when applied in the social sphere because the social system is not subject (at a constitutive level) to the laws of physics or physical biology and therefore not, in the strict sense of the physical sciences, subject to “... structural collapse ... following a radical disruption of its ... constituent parts” (see chapter seven).

This means that illegitimate acts on the part of those institutions in society that constitute the “3-4-5” homeostat, will not *necessarily* cause the collapse of society (as would be the case in the event of a similar physico-biological act) because, in principle, it is open to these institutions to legitimate and use coercive measures¹⁷ to render the act *possible*.

Where such an act is still perceived to be illegitimate the analogy of the “radical disruption of the parts” from the physical model is rebellion — whether violent revolution, or civil or industrial action — with the aim of

disruption of normal operations. There is, although the state normally reserves the right to use force for itself, a history of such action, e.g. the English Civil War, the French and Bolshevik Revolutions, Gandhi's programme of civil disobedience, the Peace marches in 1960's America, etc. And the right to the withdrawal of labour is enshrined in (British at least) employment law. All such actions can, when viewed using the principles of the model in this report, be seen as volitional internal disruption in response to some perceived injustice (i.e. illegitimate act) on the part of a "3-4-5" homeostat.

A second possibility within the rubric of this interpretation of the VSM is the utilization of an extension of the role of the "algedonic" channel. The *extension* is in the formal (i.e., contractual given that this is a social system) right of the individual (people, groups, etc.) members of the organization to raise matters of legitimacy *outside the scope of their contractual obligations and capacities to produce* as members of the organization, and, the formal *obligation* of the "3-4-5" homeostat (however constituted) to *act upon the receipt of such notification*. Thus creating an internal *control*.

¹⁶ Note that this activity may include the *delegitimation* of the means to render such acts visible as

It is suggested that entities such as trades unions, works councils, and employee directors, and, in the extreme, general elections in representative democracies operate in (partial) stead¹⁸ of this function. And, from the systems literature, Beer's (1994) "syntegration" model and Ulrich's (1981) "critically normative systems paradigm" can be seen to be devices intended (although in design rather than ongoing operation or learning mode) to fulfil this role.

The possibility *in principle* of such a mechanism allows for the assertion that some nascent "*intrinsic motivation*" is possible within the cybernetic model insofar as the primary purpose of the system is to produce itself. And, when taken in conjunction with the model of external legitimation possible to assert that the system is internally *and* externally motivated to modify its behaviour (i.e. treatment of members and output) in order to ensure *survival*¹⁹. Further investigation of the role of the legitimation function identified in this discussion can be expected to be of significant

illegitimate.

¹⁸ Only the general election fulfils the function fully because of the constitutional (i.e., contractual) *right to vote* and the constitutional *obligation to leave office* on losing a general election. Note also that the election of directors by shareholders (that are not, as a body, wholly members of the organization) is *excluded* from this category, potentially raising interesting issues relating to the legitimate control of capital.

¹⁹ Note that this survival can be modelled as being an outcome of the eigen function argument

benefit to management, rather than management science in isolation, research.

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Appendix 1

The Model of Self

Code	Treatment	Dentist Time (mins)	OHE Time (mins)	Price
NP1	Initial New Patient Examination	30	0	39-00
NP2	Complex Consultation	15	30	40-00
E1	Routine Dental Examination	10	0	25-00
E2	Routine Exam with scaling or X-Ray	5	0	40-00
OHE	OHE visit	0	30	12-00
XR	Other Small X-Rays			5-00
OPG	OPG			15-00
SP	Scaling on separate appointment	15	0	25-00
RP1	Root planing (1 quadrant per visit)	15	0	35-00
RP2	Root planing (2 quadrants per visit)	20	0	48-00
MG1	Mouth guard (soft splint)	15	15	35-00
MG2	Mouth guard (bi-laminar)	15	15	55-00
MG3	Mouth guard (Michigan type)	15x2	0	95-00
AM1	Small amalgam filling	15	0	30-00
AM2	Medium amalgam filling	20	0	48-00
AM3	Large amalgam filling	30	0	70-00
AM+	Special difficulty or with pins or amalgam bonding	15 mins extra	0	25-00
TC1	Small tooth coloured filling	15	0	32-00
TC2	Medium tooth coloured filling	30	0	72-00
TC3	Large tooth coloured filling	45	0	95-00
TC+	Special difficulty t/coloured filling	15 mins extra	0	25-00
FS2	Fissure sealants (per pair)	15	0	30-00
PRR	Preventative resin restoration	15	0	32-00
C1	Crown (grade A)	75 mins and 30 mins	0	420-00
C2	Crown (grade B)	60 mins and 30 mins	0	320-00

C3	Crown (grade C)	45 mins and 15 mins	0	195-00
C4	Crown for implant	90 mins and 30 mins	0	560-00
C5	Shade at laboratory	0	0	60-00
PC1	Lab made Post and Core Crown (A)	60mins and 30 mins	0	550-00
PC2	Lab made Post and Core Crown (B)	60 mins and 30 mins	0	370-00
PC3	Lab made Post and Core Crown (C)	45 mins and 30 mins	0	260-00
PC4	Direct Post and Core Crown (A)	45,60 and 30 mins	0	550-00
PC5	Direct Post and Core Crown (B)	30,60 and 30 mins	0	370-00
PC6	Direct Post and Core Crown (C)	30, 45 and 30 mins	0	260-00
B1	Bridge (per unit) grade A	90 and 30 mins	0	300-00
B2	Bridge (per unit) grade B	75 and 30 mins	0	250-00
B3	Bridge (per unit) grade C	60 and 30 mins	0	225-00
AB1	Adhesive bridge (per unit) grade A	45 and 15 mins	0	275-00
AB2	Adhesive bridge (per unit) grade B	45 and 15 mins	0	225-00
PR1	Provisional bridge (per unit)			60-00
F1	Facebow and/or guidance table	15	0	90-00
V1	Veneer grade A	45 and 15 mins	0	275-00

V2	Veneer grade B	45 and 15 mins	0	195-00
RCT1	Root treatment (1 canal)	15 and 30 mins	0	125-00
RCT2	Root treatment (2 canals)	30 and 45 mins	0	165-00
RCT3	Root treatment (3 or 4 canals)	45 and 45 mins	0	215-00
EX1	Simple extraction	15	0	40-00
EX2	Complex extraction	30	0	85-00
AP1	Apicectomy (1 root)	60 and 5 mins	0	140-00
AP2	Apicectomy (2 roots)	75 and 5 mins	0	180-00
D1	Simple partial acrylic denture	15 and 15 mins	0	195-00
D2	Complex partial acrylic denture	15, 30, 15 and 15 mins	0	330-00
D3	Full upper <u>or</u> lower acrylic denture	15,30, 15 and 15 mins	0	350-00
D4	Cobalt chrome precision metal denture	15, 30, 30, and 15 mins	0	550-00
D5	Full upper <u>and</u> lower acrylic denture	30, 45, 30 and 15 mins	0	625-00
D6	Laboratory reline	15	0	75-00
D7	Chairside reline	45	0	95-00
D8	Addition of tooth to denture	15 and 15 mins	0	75-00
FBT1	Fresh breath treatment	15 and 15 mins	30	95-00
TW1	Tooth whitening (full mouth)	15x4	30	250-00
PR1	Relief of dental pain (surgery hours)	15-30	0	40-00
RA	Relative analgesia (happy gas per visit)			45-00
EM1	Emergency out of hours			90-00

Appendix 2

Clinical Procedure - Assessing the potential replacement of a simple amalgam

Dental Nurse greets the Patient and guides him or her to the Treatment Room. Whilst greeting the Patient the nurse assesses the Patients nervous state giving a warning if necessary to the Dentist when performing the introduction.

The Dentist greets the Patient, observing his or her behaviour and silently confirming or rejecting the Nurses assessment.

Once seated in the chair the Dentist ensures that the Patient is comfortable and reclines the chair whilst the Dental Nurse prepares the Patient and retrieves or opens the Clinical Notes.

The Dentist undertakes a preliminary survey of the Patients teeth and gums whilst the Dental Nurse is reading the recent notes aloud to remind the Dentist of the planned treatment.

The Dentist continually assesses a range of indicators from the Patient – breathing rate, skin colour (i.e. flushed, pale etc.) – whilst beginning the formal assessment of the subject tooth or teeth.

Clinical diagnosis continues with a brief conversation between Dentist and Patient in which the Dentist attempts to evaluate any symptoms associated with the tooth, e.g. whether or not the tooth is sensitive to heat or cold, whether or not the tooth is causing any discomfort or pain, the age of the filling (if not already recorded in the clinical notes).

The Dentist simultaneously assesses the ‘Clinical Indicators’. This commences with a surface examination of the tooth looking for indications of caries, fracture or damage to the filling, poor margins (whether or not the filling is sufficiently wrinkled at the edges, whether it is inadequately wrinkled or too wrinkled). The Dentist examines the surrounding tooth seeking any damage to the tooth cusp considering whether or not a crown may be a more appropriate treatment. He or she will seek to ensure that the condition of the tooth will not cause damage or potential damage to other surrounding teeth and to ensure that there is no risk of damage or fracture through inadequate cuspal coverage.

Continuing the examination the Dentist will consider whether there is poor contact with other teeth, poor marginal ridges or overhangs. The Dentist will examine whether there is evidence of inadequate restoration of other teeth. He or she may at this point consider taking a radiograph of the subject and surrounding teeth in order to reveal whether or not there is other, currently hidden, damage or decay which should be considered in deciding on a course of treatment.

The Dentist, having considered all of the above (including the results of any current and historical radiographs) will decide on a treatment, or range of treatments and recommend a course of action to the Patient.

The Patient will accept or reject the proposed course of treatment whereupon the Dentist, having decided WHAT to do, will then consider HOW to provide the treatment.

