Management Cybernetics

Joseph Sisti

Abstract The purpose of this chapter is to examine Management Cybernetics as a primary underpinning for Complex System Governance (CSG). The origins of Management Cybernetics and how the Viable System Model (VSM) can be used to model systems (organizations) as a means of understanding control and governance within an organization are suggested. The central tenets of the Management Cybernetics field are surveyed. The essential background for the Viable System Model (VSM) is provided as a critical foundation for CSG. This background includes the historical basis of the VSM, basic laws of cybernetics, the characteristics of the VSM, and the relationship between cybernetics and control for the VSM. The approach to system modeling with the VSM is provided. The five systems of the VSM are presented in detail with respect to their unique role within the model. Additionally, interactions within the VSM are examined. The communication channels within the VSM are explained. The chapter closes with a set of exercises.

Keywords Management cybernetics · Viable System Model (VSM)

1 Introduction

1.1 Management Cybernetics

Management Cybernetics is the "science of control"; cybernetics can be management's "profession of control" [10]. Cybernetics gets its roots from Norbert Wiener, an American mathematician (1894–1964), who studied the control and communications associated with living organisms and organization operations. Cybernetics is "concerned with general patterns, laws, and principles of behavior that characterize complex, dynamic, probabilistic, integral, and open systems" [15, p. 19]. Cybernetics highlights the existence of circular causality (feedback) and the concept of systems

J. Sisti (✉)
National Centers for System of Systems Engineering, Old Dominion University, Norfolk, VA 23,529, United States of America
e-mail: jsisti@odu.edu

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having a "holistic" behavior. The holistic behavior is described as belonging to the system and not the individual parts [9, 22]. Beer [9] states that a system "consists of a group of elements dynamically related in time according to some coherent pattern" [9]. The observer of the system is the one that recognizes the purpose of the system; i.e., what the system does [9]. The characteristics of a system emerged from the interaction of the parts, actions from whose individual parts, together created reactions not otherwise understood by looking at the individual parts separately [15]. Stafford Beer's *The Brain of the Firm* proposed the use of a nuerocybernetic model to be used as the model of a viable system for any organization. The underlying theoretical foundation for the VSM is based on cybernetics. It is here that Stafford Beer suggested that the human nervous system stipulates the rules whereby an organization is survival worthy and that it is regulated, learns, adapts, and evolves [9].

1.2 Three Basic Laws of Cybernetics

The laws of cybernetics are founded around three basic laws: (1) The Self-Organizing Systems Law; (2) Feedback; and (3) The Law of Requisite Variety.

- The Self-Organizing Systems—The Self-Organizing System Law states *complex systems organize themselves; the characteristic structural and behavior patterns in a complex system are primarily a result of the interactions among the system parts.* [15, p. 26]. Within this realm is a sub-law or subordinate that "complex systems have basins of stability separated by thresholds of instability" [15, p. 27]. "The mechanism through which complex systems organize themselves is, to a large extent, through sets of interlocking feedback loops. Parts A interacts with Part B and Part B affects Part A and they tend to continue to interact with each in some region of stability under the conditions provided by the other" [15, p. 40].
- Feedback—The Feedback Law states: *The output of a complex system is dominated by the feedback and, within limits, the input is irrelevant.* [15, p. 24]. Within this realm is a sub-law that states "All outputs that are important to the system will have associated feedback loops" [15, p. 30].
- The Law of Requisite Variety—The Law of Requisite Variety states: *Given a system and some regulator of that system, the amount of regulation attainable is absolutely limited by the variety of the regulator*" [15, p. 36]. The Law of Requisite Variety highlights the importance of continuous interactions between the system and the regulator. Variety is the technical expression for complexity of the systems or the number of states a system may have. Ashby's Law of Requisite Variety: "control can be obtained only when the variety of the controller (and in this case of all the parts of the controller) is at least as great as the variety of the situation to be controlled" [10, p. 41].

> The paradigm conflicts somewhat with our traditional images of science and ways of thinking about complex phenomena such as organizations. The cybernetic paradigm developed herein

> builds and broadens our image of what constitutes science and thereby provides powerful new ways of dealing with extreme complexity [15, pp. 44–45].

The measure of complexity is "variety" and Beer [9] refers to "variety" as the measure of the "number of possible states of whatever it is whose complexity we want to measure" [9, p. 23]. Ashby's Law describes the conditions under which a complex system can be externally controlled [16]. Understanding these conditions under which complex systems can be controlled is an underpinning for the understanding of how the VSM works.

1.3 VSM in Terms of Systems View: A Brief Perspective on System's View

Within an organization, governance of complex systems is needed to navigate the business world. Understanding what a system is paramount to the organization's ability to govern itself. There is a way of looking at creation which emphasizes the relationships between things equally with the things themselves. A brief perspective of a "system's view" is described by [16] below:

1. A system is a bounded collection of three types of entities: elements, attributes of elements, and relationships among elements and attributes. Both attributes and relationships are characterized by functions called "variables," which include the familiar quantifiable variety as well as the non-numerical types described by Warfield and Christakis (1987). The "state" of a system at any time is the set of values held by its variables at that time.
2. The values of certain variables of the system must remain within physiological determined limits for the system to continue in existence as the system; these are called "essential" variables [2, p. 41] of the system; examples are blood pressure and temperature in human systems and cash flow and net income in the firm.
3. Many system variables display equilibrium; that is, a tendency toward a single or small range of values, and when displaced form these values, a tendency to return. This quality, exhibited by all living systems, is known in teleological or goal-seeking behavior.
4. Within the category of living goal-seeking system is the class of systems whose goals and reasons for existence are consciously set by man, called "purposive" [3] or "purposeful" (Ackoff and Emery 1972) systems.
5. Most natural systems are "complex," which means that their possible states are so numerous that they cannot be counted in real time. The unit of complexity is "variety." The variety of a dynamic system is the number of distinguishable states that it can occupy. The essential quality of a complex system is that its variety is so great that it cannot be controlled or managed by any method that depends on enumerating or dealing sequentially with its states.

6. Ashby's Law of Requisite Variety states that to control a complex system, the controlling system must generate at least as much variety as the system being controlled: "Only variety in the control mechanism can deal successfully with variety in the system controlled" [3, p. 50].
7. The concept of systemic "control" operates at two levels. First is physiological control, required to allow the system to continue in existence (see 3 above); the values of all the essential variables are held within physiologically set tolerances. If physiological control fails, the system dies.
8. The second level is operational control, or the control of one system by another. This also requires the presence of physiological control, but in addition requires the maintenance of the value of a set of variables (essential or otherwise), chosen by the controlling system, according to its purpose for existence (see 5 above and 9 below), within tolerances set by the controlling system. If operational control fails, the system can still live, but (by definition) it fails to accomplish its purpose. Ashby's law governs both types of control.
9. An "organization" is a complex purposive system that man brings into being (or maintains in being) for the purpose of creating some desired change in the environment (i.e., society, organization, etc.). In order to accomplish its societal purpose, the organization must have the ability and power to influence and cause change in other organizations and the other complex natural systems that make up its environment. The organization must operationally "control" some part of the environment, which requires (Ashby's Law) that it must possess—contrary to normal expectations—at least as much variety as the societal systems it strives to control [10].
10. In classical cybernetics, there are only three methods that an organization (or any system intent on operationally controlling another complex system) can use to establish the variety surplus it needs: it can amplify its own variety beyond that of the system to be controlled; it can exactly match its variety to that of the system to be controlled (a special case); or it can reduce the variety of the system to be controlled to less than its own.

Cybernetics as a "science of control" examines the "holistic" system verses just its individual parts [10]. The cybernetic basic laws and the law of Requisite Variety described above form the foundations used for the VSM. The variety and complexity of describing organizations using the systems view was articulated by Beer [16] and described in the previous ten points as the emphasis of the relationship between things equally with the things themselves; things being the components of the system.

2 Characteristics of the Viable System Model (VSM)

The Viable System Model (VSM) is a model of the organizational structure of a viable system developed by Stafford Beer [7, 9–12]. Beer [9, 10] has explained how management manages a process within an environment and how the interactions of these processes reflect the two-way communications between those components of these processes. Organizations can use this model as a framework for Complex System Governance. Beer [9, 10] explains the levels of communication between the components as being “variety” (the measure of complexity). Variety is seen as the number of possible states of the system. Beer [9, 10] further describes the organization as having multiple operations that require management.

The five systems of the model are shown to communicate with each other in the Viable System Model and work to balance the system to ensure that variety generated within the system is absorbed. A system “consists of a group of elements dynamically related in time according to some coherent pattern” [10, p. 7]. A Viable System Model can be seen in Fig. 1 to highlight the systems and their interactions organization.

The VSM can be used to develop a model of a complex organization (or project) to clearly show how this organization functions as compared to the way the organization may be perceived to be functioning. Once developed, the model can be used to identify areas where changes could be made to improve the governance of the organization. These changes may be for streamlining the organization or to make it more effective in its working environment [10]. The Viable System Model is intended as a diagnostic tool [10]. The diagram is setup to have logical not organizational implications [10]. Beer further states that a researcher can “map the exact organization onto the model, and then ask whether the parts are functioning in accordance with the criteria of viability, as these have been set forth in neourocybernetic language” [10, p. 7]. Mapping will be described in the characteristics area for systems and channels in Sects. 6 and 7. The mapping does not create an organizational chart, but rather focuses on the process and communication aspects of the organization [10]. The processes are not assigned to one person as in a hierarchical chart, but are seen to be spread out throughout the organization. Following these processes and the communication associated with these interactions help define the underlying aspects of the VSM. The variety of roles required of the viable system is spread throughout the activity. The VSM, when modeling a branch within an organization, similarly follows the same conventions when describing the divisions above or when describing the project operations below the branch level of organizations. “The whole of the chart is reproduced within each circle representing a division, and of course this means in turn that (if we could write or read that small) the whole chart would be reproduced in each division of each division—which is to say in each little circle within every big circle” [10, p. 156]. This makes this a “competent chart for any organization” [10, p. 156]. The hierarchical chart is referred to as the “machine for apportioning blame” that the organization chart comprises [9].

Beer discusses in *Decision and Control* [7] the concepts and the three essential characteristics of a viable system:

1. “Viable systems have the ability to make a response to a stimulus which was not included in the list of anticipated stimuli when the system was designed. They can learn from repeated experience what the optimal response to that stimulus is. Viable systems grow. They renew themselves—by, for example,

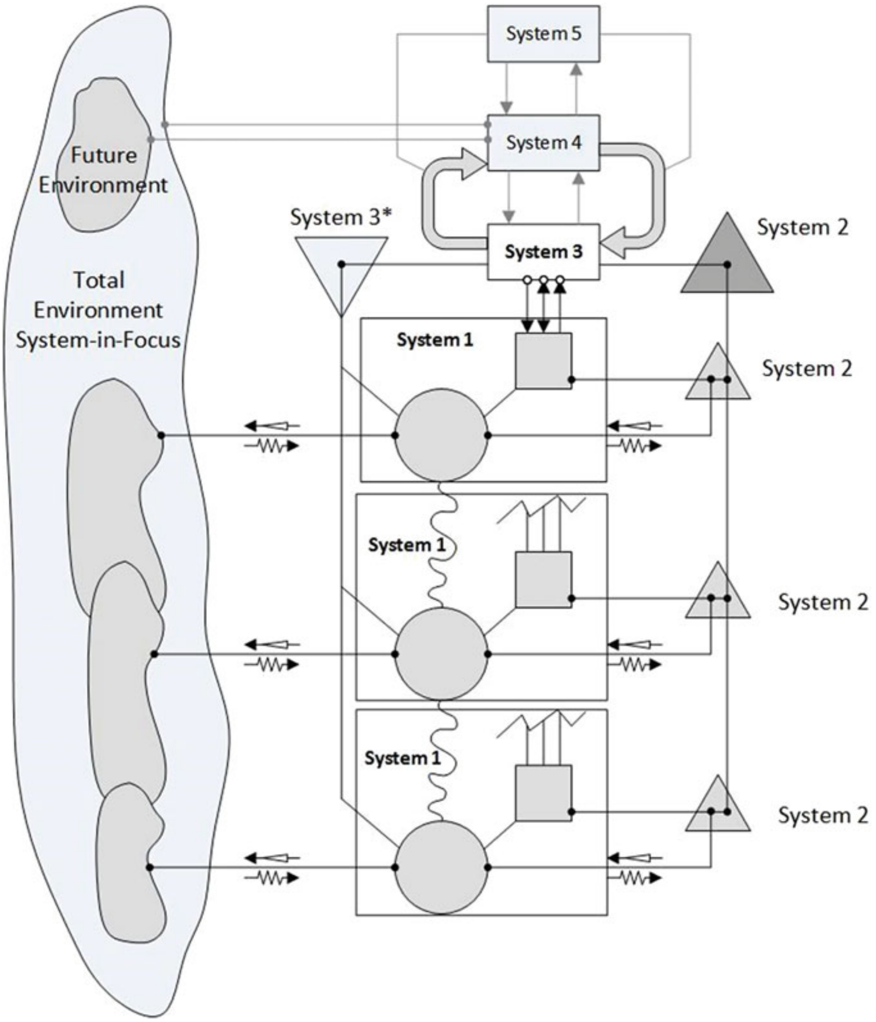

Fig. 1 Viable System Model {Adapted from [18, p. 49]}

self-production. They are robust against internal breakdown and error. Above all, they continuously adapt to a changing environment, and by this means survive—quite possibly in conditions which had not been entirely foreseen by the designer" [7, p. 256].

2. "Viable systems maintain equilibria behavior only by multiple contact with whatever lies outside themselves" [7, p. 257].
3. "It is characteristic of a viable system that all its parts may interact; not indeed to the extent that all possible permutations of all possible parts with all other

possible parts must manifest themselves, but to the extent that subtle kinds of interaction drawn from all these permutations can and do take place" [7, p. 257].

Beer summarizes these three attributes of a viable system as the systems innate complexity, complexity of interaction with the environment, and complexity of internal connectivity [7].

3 Understanding the VSM: A Discussion of Cybernetics and Controls

The Viable System Model (VSM) developed by Stafford Beer is explained by describing the conceptual components that make up the model and the relationship to how these components form the model. As modern management has developed so too has the complexity of the organizations that need to be managed [10]. Complex System Governance as an emerging field can use the VSM as a framework of analysis. The desire to gather and maintain all the data in one huge database to be used by managers to make the best decisions is often perceived as the way to manage [10]. What is really needed is a control system for change where the manager is the instrument of change [10]. The study of control science is the basis of cybernetics which is the science of communication and control through which management makes decisions [10, 11]. Management Cybernetics is the science of effective organization [11]. With the increase in available data, the interface between man and machine (computers for example) has become more complex. Cybernetics offers a managerial methodology for the management of complex control requirements within an organization [10]. Management is the profession of regulation, "and therefore of effective organization, of which cybernetics is the science" [11]. To understand the concepts of cybernetics and the modeling accomplished by using the VSM, one must understand the language that describes the decision-making process. The principle of control requires that the controller is part of the system that is being controlled [10, 11]. The controller is part of the system as it is and develops within the system as it evolves; it is not something that is attached to the systems, but rather part of the system architecture [10]. The control of the system are through the channels of communications between the systems. With a VSM, the communication channels link to the systems allowing communication and control between the systems. This can be seen in Fig. 1.

Within the VSM, an understanding of how the system is stimulated, and how the system is made aware of this stimulation, is important in describing how the system is to be controlled. Stimulation of the system is how the operation of the system is changed; whether the system accepts the stimulation for the better or rejects it due to its disruptive behavior are both important aspects for the manager to be able to be aware of, and in control of, within the system [10]. The mechanisms to allow the manager to be aware of changes and the effects within the organization are important aspects of the control of the system [10]. "Control is what facilitates the existence and the operation of a system" [10, p. 27]. The control of the system affects the internal stability of the system [10]. The manager needs to have a control system that has "a way of measuring its own internal tendency to depart from stability, and a set of rules for experimenting with responses which will end back to an internal equilibrium" [10, p. 27]. The stability pertains to not only known stimuli but the unknown events that occur to the organization as well [10].

The system design should be designed to allow the system to maintain stability in a complex environment where not all variables are known. In cybernetic terms, ultra-stability is when a system can survive in arbitrary and un-forecasted interference [10]. Anything within a system that can register and classify the existence of a stimulus is known as a sensorium [10]. Within this area, a decision is made that compares the outcomes of making a choice against its criterion of stability [10]. This is where there must be a mechanism that registers something has happened and is able to translate it into terms that have meaning to the control, so that it understands the stimulus and can react accordingly [10]. This detection is made within the system as this device is part of the system, not the stimulus itself [10]. The "bringing across" of the stimulus into the system is defined as the transducer [10]. The Sensory Input Channel (SIC) is the channel along which this information flows to bring the information into the system [10]. The Motor Output Channel (MOC) refers to the effects (output) caused by the stimulus [10]. It is this function of input and output that reflects the balance of input and output. When large numbers of input stimulus and the associated outputs are produced, they are often grouped together; as each individual input–output is too complex and exponential in number to describe [10]. This network or area of inputs/outputs within a system can be called reticulum, and the variety of reticulum in cybernetics is called anastomotic [10]. Anastomotic refers to the fact that many branches of the network intermingle to such purpose that it is no longer possible to sort out quite how the messages traverse the reticulum [10]. The idea is similar to understanding that if you add a bucket of water to the tub, you know that the tub has more water in it than before the water was added, but you do not know exactly where it is in the tub, nor is it deemed important to the overall description as to the amount of water in the tub [10]. Another analogy is the understanding of our heart within our own body. We know our heart is there but we do not consciously control it, but we know it is being controlled by our body.

Stability of a system is to be designed into the system [10]. Stability is "a self-regulating mechanism which does not rely on understanding causes of disturbances but deals reliably with their effects" [10, p. 34]. This begins to help describe the term feedback which is an adjustment to the input, so that the existing transfer function determines a corrected output within the system [10]. The pattern of the output as described by a plot of all the inputs over the range is this transfer function. Beer stated that "negative feedback corrects output in relation to fluctuating inputs from any cause. It does not matter what noise gets into the system, how great it is compared to the input signal, how unsystematic it is, nor why it arose. It tends to disappear" [10, p. 36].

There are three fundamental components of the control system: an input setup, an output setup, and the network that connects the two together [10]. An input arrangement may be a set of receptors which transmits information about some external situation into the affective channels, and concludes with a sensory register (or sensorium) on which this information is collected [10]. The capacity to distinguish detail at each end of the input arrangement should be equivalent in efficient systems [10]. The capacity to transmit the information between receptors and sensorium must be sufficient to take the traffic [10]. This needs to occur for the output arrangement—the second component of the control system [10]. The third part is the anastomotic reticulum which connects the sensory to the motor plate [10]. This means that there needs to be the same capacity to generate the inputs as there is on the output area for the outputs to go [10]. This balancing of the control systems creates the desirable stability the manager seeks; it is the management of complexity [11]. In cybernetics, the number of distinguishable items is called the "variety" [10, p. 41]. "Variety is a measure of complexity, because it counts the number of possible states of a system" [11, p. 41]. In cybernetics terms, then the input variety of the system as a whole must equal the output variety of the system as a whole to maintain a state of stability. This is an application of Ashby's Law of Requisite Variety which states "that control can be obtained only if the variety of the controller (…range of the controller) is at least as great as the variety of the situation to be controlled" [10, p. 41]. To understand the importance of variety, one must understand the scale to which variety can proliferate within a system; it often is exponential [10].

The scale of variety within the system and from nature can be enormous, but managers still need to choose effective solutions and reduce the variety for decision making [10]. "We may devise variety-generators in control mechanisms, just as nature disposes of variety-proliferators in proposing problems of control" [10, p.45]. Variety that is reduced to a set of possible states is referred to as attenuated variety [11]. "The real problem of control, the problems which a brain is needed to solve, is the problem of connecting an input pattern to an output pattern by means of an anastomotic reticulum" [10, p. 46]. We must understand that there is a fundamental degree of uncertainty in nature already [10]. This added to needed decision making by managers contributes to the complexity of managing an organization.

"There's a capability inherent in natural systems to self-organize the anastomotic reticulum in ways in which we do not properly understand" [10, p. 52]. To help distinguish these two terms they needed to be defined: algorithm and heuristic. "An algorithm is a technique, or a mechanism, which prescribes how to reach a fully specified goal" [10, p. 52]. Examples include a flight path for pilots, a math formula for calculation area, and the program a programmer has set up on a computer. "An heuristic specifies a method of behaving which will tend towards a goal which cannot be precisely specified because we know what it is but not where it is" [10, p. 52]. "These two notions are very important in cybernetics, for in dealing with unthinkable systems it is normally impossible to give a full specification of a goal, and therefore impossible to prescribe an algorithm. But it is not usually too difficult to prescribe a class of goals, so that moving in some general direction will leave you better off (by some criterion) than you were before. Instead of trying to organize it in full detail, you organize it only somewhat; you then ride on the dynamics of the system in the direction you want to go" [10, p. 53]. "These two techniques for controlling a system are dissimilar…we tend to live our lives by heuristics and try to control them by algorithms" [10, p. 53]. It is like making plans to a destination and then trying to get there. Beer points out 13 points to be made about heuristic controls [10, pp. 54–57]:

1. An heuristic will take us to a goal we can specify but do not know, and perhaps cannot even recognize when we reach it.
2. If we give a computer the algorithm which operates the heuristic, and wait for it to evolve a strategy, we may find that the computer has invented a strategy beyond our own ability to understand.
3. This being the case, it is time to start recognizing the sense in which man has invented a machine "more intelligent" than he is himself.
4. "Computers can do only what they are told" is correct, but highly misleading.
5. The argument that the output of a computer is only as good as its input, summed up in the phrase "garbage in, garbage out….is true for algorithms specifying algorithms, but not for algorithm specifying heuristics.
6. The mechanism we are using is precisely the old servomechanism discussed much earlier, in which error-correcting feedback is derived by a comparator from actual outcomes contrasted with ideal outcomes. But the outcome is measured, not in terms of the input data transformed by a transfer function, but in terms of the whole system's capacity to improve on its results as measured in another language.
7. The servomechanism's feedback does not operate on the forward transfer function as such. It operates on the organization of the black box which houses the transfer function. It experiments with the connectivity of the anastomotic reticulum. As effective structure emerges, this is what cuts down the capacity to proliferate variety.
8. Feedback dominating the outcome still holds. Hence, everything depends on the other- language criteria which the system is given to decide what to learn and what to unlearn.
9. There must be another control system, using the output of the first system as input, and operating in another plane. This higher-order, other language system would experiment with the fluctuating outputs of the first system, and produce new outputs in the other plane. Feedback from there (compared with some other-plane criteria) would establish the meaning of "better" or "worse" for the first system.
10. The second system needs a third system to evaluate its outputs in a higher-order language, and to say what counts as more or less profitable. This third system would experiment heuristically with the time-base of the second system's economic evaluations.
11. This argument continues until the hierarchy of systems, and the levels of language that go with them, reach some sort of ultimate criterion. It can only be survival.
12. And what is true of the firm in this generation of management, and true of this man, son of his father, becomes true of the firm as a continuing entity in perpetuity, and of all men, fathers of their sons. The training process for here and now is the evolutionary process for the epochs ahead.

13. So when we said that a heuristic organizes a system to learn by trying out a new variation in its operation control strategy, we might equally have said that a heuristic organizes a family of systems to evolve, by trying out a new mutation in its genetic control strategy. The aim of adaptation is identical.

The controls described above sets up a meta-language—a language of a higher order in which propositions written in a lower order language can be discussed [10]. Virtually any language must contain propositions whose truth or falsity cannot be settled within the framework of that language of which logical paradoxes are the familiar example [10]. These propositions will then have to be discussed in the meta-language, at which level we understand what is paradoxical about them [10]. "Activities can create an algedonic mode of communication between two systems which do not speak each other's language" [10, p. 59]. This is used to translate between the two systems. Errors in communication occur. The vital point is that mutation in the outcome is not the absolute enemy we have been taught to think, it is a precondition of survival [10]. The flirtation with errors keeps the algedonic feedback toned up and ready to recognize the need for change [10]. The systems' errors are wasted as progenitors of change, and change itself is rarely recognized as required [10]. "All the managerial emphasis is bestowed on error-correction rather than error-exploitation" [10, p. 62]. Errors themselves are reiterated and are deemed as being essentially bad. "Thus it follows that when change is really understood to be necessary, people resist the need, because to attempt to change is automatically to increase the error rate for a time, while the mutations are under test" [10, p. 62]. "We use organizational charts that are really devices for apportioning blame when something goes wrong. They specify 'responsibility' and the 'chain of command', instead of the machinery that makes the firm tick" [10, p. 75]. "Models are more than analogies, they are meant to disclose the key structure of the, system of study" [10, p. 75]. If we want to understand the principles of viability, we had better use a known-to-be-viable system as a model. It turns out our body is a familiar analogy to the model and will be used in describing the VSM [10, p. 76]. "Once the issues are properly understood, there will be no real need to remember the details" [10, p. 77].

It still holds true today that control in a business "has to do with the information of an extent and complexity beyond the capacities of those senior people to absorb and interpret it. It has to do with the structure of the information flows, with the method of information handling, with the techniques for information reduction, and so forth. All these features of information's role used to be determined by the cerebral capacities of the senior staff" [10, p. 80]. "There exists today a capacity to cope with information vastly in excess of the human capacity, with the result that the manager is no longer the arbiter of sophistication in control. He must delegate this role to the electronic computer" (or the information available and presented) [10, p. 80]. The manager has to organize the team and information flow. The need for a new language to be used with the VSM differs from the hierarchical models and languages often used in representing organizations [10]. The language associated with the VSM differs and hence enables better articulation of the model proposed as opposed to using the language associated with the hierarchical model. "We are constrained by our own experience as well as informed by it" [10, p. 82]. "We have a managerial culture in which some things, distinctively modern, cannot be expressed although we know them" [10, p. 82].

4 VSM: Modeling Systems

The purpose of modeling has different perspectives from different people [10]. "A model's scaling down to transfer the functions to a more manageable size allows workability in describing an organization that is complex" [10, p. 83]. "A good model is one that is appropriate and one is able to learn something about the thing that is being modeled" [10, p. 84]. Beer presents that the self-reproduction of a viable, system is usually thought of as the outstanding characteristic of that viable system, but it is continuous and regenerative self-production that is an underlying characteristic of its identity [11]. These are the characteristics of a learning organization.

> "Models are more than analogies; they are meant to disclose the key structure of the system under study" [10, p. 75]. Beer [10] suggests we look at the body as a model of a system where we have subsystems such as the heart and lungs. We have a body and we understand it, but not necessarily the "how it happens" part of things [10]. The importance of the model is to allow the reader to understand how the project works as opposed to how the project is said to work [10]. To reiterate, the VSM is intended as a diagnostic tool that can "map the exact organization onto the model, and then ask whether the parts are functioning in accordance with the criteria of viability, as these have been set forth in neourocybernetic language" [10, p. 7]. The mapping does not create an organizational chart for the project, but a framework of analysis of the viable functionality of the project as a whole. The variety of roles required of the viable system is now seen spread throughout the activity as compared to a hierarchical model. The VSM can be used to map the project or organization into Five Systems and six primary communication channels.

"The criticism of the organization chart as a model of a firm is that it is not appropriate as modeling those aspects of the firm we most wish to understand—which have to do with control" [10, p. 84]. The organizational chart was never intended for control anyway [10]. If you want to look how control is accomplished in an organization, it makes sense to use a control system as a model [10]. Control systems are the topic of study of the science of cybernetics [10]. "The trouble is that control systems of sufficient complexity to serve as adequate models of the firm are themselves so complicated that cybernetics does not fully understand them—except through models" [10, p. 84]. "Cybernetics is actually done by comparing models of complex systems with each other and seeks the control features which appear common to them all" [10, p. 84]. The VSM seeks to learn about the structure of control in complex systems. "That would mean deriving a model of a complex system in which control was already recognized as highly successful. Such a system could teach us about structure, provided that the rules of the modeling were followed carefully [10, p. 85]. "Scaling down, transferring, and investigating workability in an appropriate description would be essential, but the cybernetician is used to doing this job" [10, p. 85].

The VSM is based on a nuerocybernetic model with similarities of the way an organization is controlled [10]. The modeling after the human nervous system is also very familiar to many. “A useful model must be able to handle the differences in scale, transference, workability, and appropriateness in convincing style” [10, p. 87]. The “Nuerocybernetic model pursues and hunts down organizational invariances in large, complex, probabilistic systems within the methodology of model-building” [10, p. 87]. Invariance is when one thing is invariant with respect to something else,does not change as the other thing changes [10, 11]. Invariant in this case is a factor in a complicated situation that is not affected by the changes surrounding it [11]. “There are invariant rules governing such a system, which is derived from the theory of probability and expressed mathematically. It does not matter whether we are dealing with a brain or a firm” [10, p. 87]. Within the VSM, information within the model needs to be inspected to see whether the information coming up is appropriately dealt with at specific levels [10]. A modification of the information is passed on and upwards according to the rule sets instilled into the organization [10]. There is a filtering of information within a model as the variety or amount of information must be reduced or amplified to adequately manage the levels within the model of this organization [10, p. 93]. A filter is a variety reducer, which acts as an attenuator for variety [10, p. 94]. “There has to be a central command axis, and specialized controllers have to be integral to it—even if they are operating in a different mode…they all have their tasks to be performed” [10, pp. 95–96]:

1. Testing incoming data and recognizing any on which command action should be taken; taking the action, and sending on the original information, suitably modified.
2. Test and recognize any data which have to be filtered at this level, compressing, facilitating, and inhibiting the ascending path (handling the data at this level).
3. Store a record of these transactions in case details have to be retrieved.

We are confronting what seems to be a five-level hierarchy of systems contained within a major computer configuration…..five being somewhat arbitrary [10, p. 98]. “All five systems are serially arranged along the vertical command axis of the firm, and they model the somatic nervous system of the body” [10, p. 98]. “The middle three of the five are divided out of the cord and the brain stem” [10, p. 98]. “The cord itself is at the lowest level, the medulla and pons are grouped together next” [10, p. 98]. The third of the three echelons is the diencephalon along with the thalami and basal ganglia [10]. You see two subsystems when looking at the outer part of the five subsystems: the lateral axis which mediates afferent and efferent information and the cerebral cortex itself [10]. The upper level creates a homeostasis of stability of its system one’s environment, despite each of the systems having to cope with the unpredictable external environment [11]. “What matters to the firm’s top management is not so much the ‘facts’ as ‘the facts as presented’, and the presentation chosen can govern the outcome of even the most important and well considered decision” [10, p. 98]. “Just as the cerebral cortex is not in direct touch with peripheral events at all, but receives only such data and in such form as the subordinate echelons pass on, so top management should be presumed to be isolated from actual events” [10, p. 98].

"The exteroceptors are looking outward at captured information from the outside world" [10, p. 100]. "Telereceptors work at a distance to see whatever functions are responsible for example: examining markets, economic conditions, and the credit-worthiness of customers" [10, p. 100]. There are chemical and cutaneous receptors as well that are all analogous to any kind of data-logging signal in a distant production plant [10]. The receptors are there to detect delicate situations that may be arising [10]. The idea of this is to describe how information is detected and retrieved at the lowest level within the VSM and analogous to the human nervous system; this information is collected and disseminated along the lateral axis [10]. "The cortex, we said, has to do with intellect,it is the seat of consciousness. Its functions are incredibly complex, but they seem concerned with one thing: pattern" [10, p. 102].

"Large areas of complex organizations should be autonomous" [10, p. 103]. Autonomous means that the branch or function indicated is "responsible for its own regulation" [10, p. 103]. "The autonomic function is essentially to maintain a stable internal environment" [10, p. 103]. "Autonomic control must correct imbalances to the internal environment; the first necessity is to detect the change; receptors then alter their state, transducing the change into efferent impulses which then go to the control center" [10, p. 103]. "The impulses are then computed and associated adjustments are made through the motor part of the system (the autonomic reflex)" [10, p. 104]. Hierarchical control is "not the only dimension of control" [10, p. 105]. "The main pathways up and down the central command axis are used to inter-relate the activities of the different departments and functions within the total plan" [10, p. 105]. "If the managers in the line kept everyone fully informed with details, the major planning networks would become overloaded" [10, p. 107]. "There is a complete society of peripheral management, which operates for the most part at the social level, and whose control language is not hierarchical in the sense of the line command, but informational" [10, p. 107]. The internal balance within the organization has a goal of a general 10homeostasis [10, 11]. There can be checks and counter-checks to maintain stability and the conscious and unconscious processes are put in place for stability [10]. "For the management scientist, the model provides the bridge between practical problems of control in the enterprise, and apparently too simple, too analytic, too demanding computable models of servomechanisms" [10, p. 113]. "In autonomic control, a basic operational system and a basic set of instructions are taken for granted and then proceeds to keep what is happening in balance and in economic health. Of course consciousness can take control when it wishes" [10, pp. 116–117].

5 Application Areas of the VSM

The VSM as developed by Stafford Beer [10, 11] has been used extensively in many different application areas around the world. Applications have centered on organization structures and how to diagnose, develop, or reorganize from a cybernetics perspective. In the following development, examples of the global application of the VSM area are discussed.

Designing a Viable Organization [14] talks about the usefulness of the VSM as "a tool for anticipating, planning for, and implementing large-scale organizational change" [14, p. 49]. The model was used "as part of a research and consultancy intervention with Telecom (NZ) Limited during a period of extensive reorganization and downsizing" [14, p. 49]. The authors determined that the " VSM framework provides a useful tool for thinking about the workings of any system, particularly business organizations" and "provide a pictorial representation" to organizational questions [14, p. 51]. The authors summarize and state the VSM "provides a common framework that allows one to capture organizational idiosyncrasies, each organization's systemic strengths, and unique weakness" [14, p. 51].

"*Designing Freedom, Regulating a Nation: Socialist Cybernetics in Allende's Chile*" [21] examines the history of "Project Cybersyn." This was a project that developed "an early computer network…in Chile … to regulate the growing social property area and manage the transition of Chile's economy from capitalism to socialism" [21, p. 571]. Medina points out that "Beer recognized that his cybernetic toolbox could create a computer system capable of increasing capitalistic wealth or enforcing fascist control" [21, p. 599]. This is an example where the cybernetic use of the VSM could be used as a political tool for monitoring and controlling a nation.

Another unique article, "Design for viable organizations: The diagnostic power of the viable system model" by Markus Schwaninger [23] set out to document five applications of the VSM. The five cases were:

1. Transformation of a Swiss insurance company.
2. Redesign of a meta-system for Aditora Abirl—a company famous for journals, magazines, and travel/cultural books.
3. Enhancing a small chemical corporation, Togo, from three separate companies into one.
4. Developing a strategy for health Services Company: Kur- und Klinikverwaltung Bad Rappenau.
5. Examining the corporate ethos of the national auditing institution of the Republic of Colombia: Contralia de la Republica.

The interesting significance of this article was that they were using case studies at the organizational level as their research method. The author states "VSM has proved to be an extraordinary instrument. It not only enables a better understanding of the cases under study, but it facilitates the work enormously" [23, p. 965].

And finally there is an example of VSM being applied to the healthcare services area. "Improving Practice: A systems-based methodology for structural analysis of healthcare operations" by Keating [18]. This article introduces a systems-based methodology for conducting analysis of organizational structure for healthcare operations. The methodology enlightened higher orders of learning through structural inquiry. Several contributions to this methodology included a better method of understanding the organizations identity, an analysis that supports establishing priorities for structural improvements, decision support for better utilization of resources, and identification of its use across a wide range of applicability for structural analysis of other organizations within context [19].

The preceding examination demonstrates how the VSM has been used as an organizational analysis tool in a variety of applications areas to include: organizational structural change within corporations, government organizational reform, insurance services industries, chemical corporations, auditing institutions, and healthcare service industries. The following sections explain the systems and channels integral to the VSM.

6 Characteristics of the VSM's Systems

6.1 System One

The System One (the productive function) as described by the VSM is related to the operational units of the organization that deliver the product or service that the organization is built around. An element of control in this area centers on the detection of patterns of achievement that can be reported through System Two (coordination) to the organization [10, pp. 171–172]. System One is embedded in a meta-system, which is in fact an operational element of another system at a higher level of recursion [10, 11]. The set of embedded productive functions is known as the System One of the System-in Focus [11].

"System One must produce itself. This is the one criterion of viability that everyone seems to accept. It means that the existing enterprise has to go on being itself….the investment required to enable System One to produce itself is mandatory" [9, p. 254].

Figure 2 shows the VSM with Operational units of System One identified. The meta-system is highlighted to focus on operations and management areas.

System One is responsible for the production and delivery of organizational goods and services to the environment [18]. System One is made of operational organizational units (each of which is a complete viable system), each of which is responsible for an activity or product [18]. The other units play a supportive role and are non-viable regulatory units; that is to say they are unable to exist independently outside of the organization, unlike System One units [18]. The following describes the relationship between System One and the other units [18]:

1. With corporate management (System 3) via the three kinds of fundamental relations represented by "receiving instructions and guidelines," "accountability," and "resource bargaining."
2. With its specific environment comprising, among others, its market or the addresses of the services offered by the unit.
3. With its regulatory unit (System Two).
4. With the auditing function (System 3*: Specific information channel).
5. With the other operational units (System One components).
6. With the management of the various operational units.

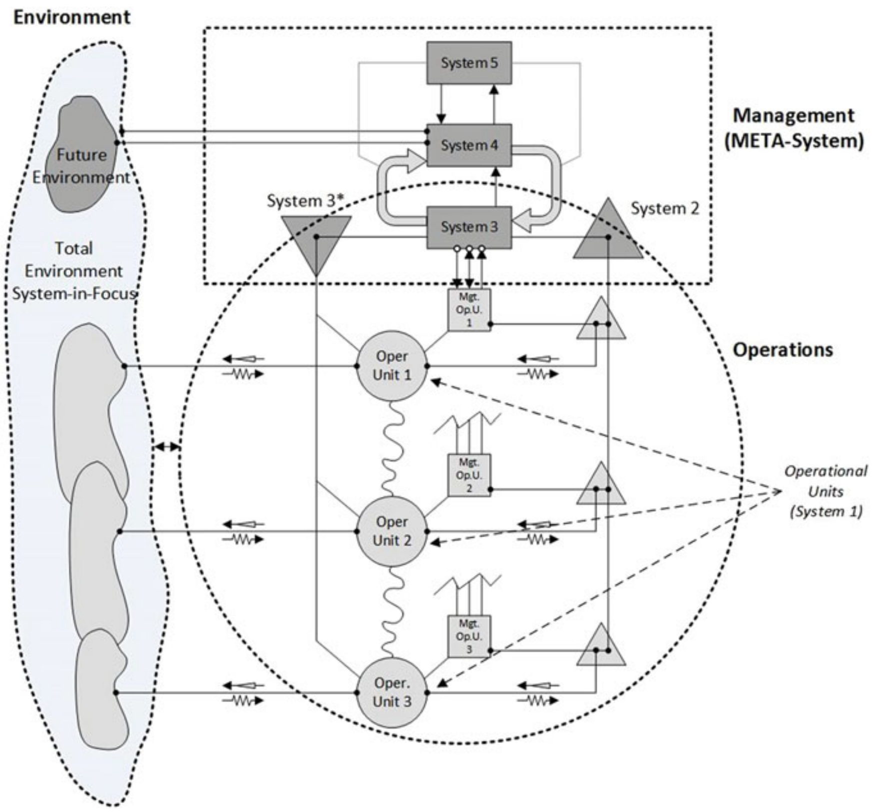

Fig. 2 VSM with operational units noted {Adapted from [18, p. 26]}

7. With the metasystem via algedonic channel.

System One controls execution in response to policy directives and overriding instructions from above in response to the environment and other divisional needs [10, p. 167]. The metasystem (in its role as an operational element of the next level of recursion) may know something affecting oscillatory behavior of our System One that is not seen by System One [9, p. 182]. System One is seen as the operational level of a project.

A Management Cybernetics Vignette—The Black Box

When modeling System One's with the VSM, logical groupings that reflect an autonomous grouping allow development of communications within other systems within the model to be clearly visualized. Modeling a shipbuilding organization, for example, may have the pipefitters, electricians, welders, accounting departments, etc. each described as a unique System. Each has unique roles and responsibilities and have unique controls and communications within their group. This 'black box' approach would be described by its input and output *communications as seen within the organization while its internal characteristics describe it's autonomous structure of operation.*

6.2 System Two

System Two acts as "an elaborate interface between Systems One and Three" whose purpose is to prevent uncontrolled oscillation between these operational areas [10, pp. 172–173]. "System Two is logically necessary to any viable system, since without it System One would be unstable—System Two would go into an uncontrollable oscillation" [9, p. 177]. This back-and-forth disagreement between operation units over resources and procedures is an example of this oscillation that is to be mitigated through the System Two functional areas. "The viable system engages the services of System Two to cut down the variety of its operational interaction insofar as they are inherently oscillatory—and *only* to that extent" [9, p. 177]. "System Two is not dedicated to the performance of routine procedures of whatever kind, but only to those routines that are anti-oscillatory" [9, p. 184]. This is important to distinguish as System Two is cybernetic discovery [9]:

1. Although every enterprise dedicates much effort to anti-oscillatory activity, under all manner of guises, there is no orthodox managerial correlation available to match it.
2. System Two failures are extremely common—to be corrected it must be understood that this whole question of oscillatory behavior is endemic to System One, and of System Two as an antidote.

Viability is the ability of a system to maintain a separate existence and depends on a number of necessary conditions [9]. System Two's main role can be seen to prevent oscillation within the System One—System Three areas. It is also an amplifier of the self-regulating capacity of the units themselves [18]. Examples of System Two are [18]:

1. Information systems.
2. Production planning or task programming tools.
3. Knowledge basis.
4. Accounting procedures.
5. Diverse types of operational norms intended to provide behavior standards.
6. Activities associated with personnel policies, accounting policies, the programming of production and operations, and legal requirements.

The System Two mechanism deals with the transmission of information which is taken from the operational units and once filtered, forwarded by the central regulatory unit to System Three [18]. System Three will then decide whether or not to act as a function of the information provided from System Two [18]. The System One's communicate with their associated System Two to update the upward channels of their operational status, its System Two collective role is to filter and forward to System Three the needs and balance the System Ones.

Figure 3 shows the System Two portion of the VSM. It is here where the anti-oscillatory actions occur between the System One's.

A Management Cybernetics Vignette—Part 2

The System Two coordination within the system can be described similarly with the shipbuilding example given previously. The electricians and pipefitters may have IT resources that need to be balanced across the organization. Warehousing, material, and space access to ship working areas critical to each of the systems needs to be coordinated to ensure meeting scheduling and performance goals. Elements of safety between the trades require the coordination of resources as each group can affect other system members as they work in the same shipboard environment as an example.

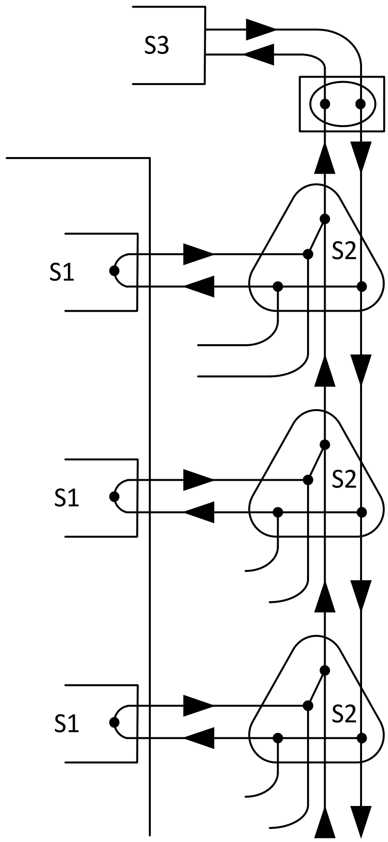

Fig. 3 System two (S2) {Adapted from [10, p. 173]}

6.3 System Three

System Three is "the highest level of autonomic management and the lowest level of corporate management" whose purpose is to "govern the stability of the internal environment of the organization" [10, pp. 175–176]. It is here in System Three where routine information about the internal regulation is available to System Four. Systems Three characteristics include the following [9, p. 202]:

1. It surveys the total activity of the operational elements of the enterprise.
2. It is aware of what is going on inside of the firm in the current state.
3. Direct links with all managerial units – real time.
4. It is aware of System Two—its own subsystem.

Figure 4 highlights Systems Three, Three* (Star), Four, and Five.

System Three is usually handled by corporate executives since they are positioned to have the time to overview without the operational concerns of the working division level personnel [9, p. 203]. "Common services that contribute to synergy are

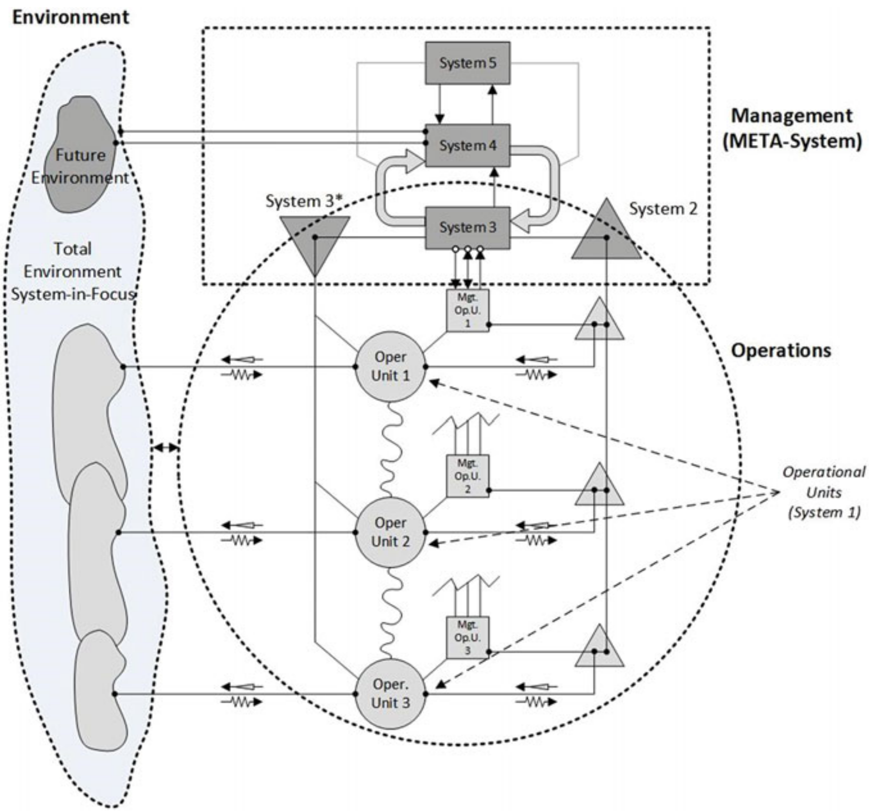

Fig. 4 VSM highlighting systems 3, 3* (Star), 4, and 5 {Adapted from [18, p. 26]}

always System Three functions" [9, p. 204]. System Three has the task of managing the set of operational units comprising System One sometimes being referred to as the "Operational Management" of the organization [18]. System Three is fundamentally interested in the "here and now" [18]. It should always be remembered that the direct involvement by the vertical line of authority has to be limited to special circumstances so as not to jeopardize the autonomy of the operational units which need this autonomy to directly absorb most of the variety generated in their specific environments [18]. Functions may include [18, pp. 32–35]:

1. Transmitting information from "management" on aspects related to the organization's aim or purpose.
2. Information concerning the policies of the organization and operational instructions to the operational units.
3. Receives information on the organization's internal situation (includes the algedonic signals that give warning of extreme risk).
4. Modifying goals.
5. Changes needed in System One as suggested by System Four.
6. Negotiation of resources.
7. Should have fluid communication with System Four on functioning and opportunities/difficulties of modifying System One.

*6.4 System Three * (Star)*

System Three * (Star) is a support system for System Three getting information of the status of System One; information that does not follow the normal direct channel of communication [18]. The purpose of System Three * (Star) is to ensure that the information between System One and System Three is complete [18]. Information and activities include [18, pp. 35–39]:

1. Quality audits.
2. Opinion surveys.
3. Compliance with accounting procedures.
4. Work studies.
5. Operational research.
6. Surveys.
7. Special studies.
8. Information gathering techniques.

6.5 System Four

"System Four can be described as the "development directorate of the firm" [10, p. 181]. "System Four provides all the information to System Five, the highest level of decision making within the organizational unit" [10, p. 183]. "System Four demonstrates recursive logic as it mirrors or maps the totality it serves by self-duplication" [10, p. 192]. System Four's principal responsibility is connected with the future and the external environment of the organization [18]. System Four is seen to expand variety by "contemplating rather than creating alternatives" and is able to reduce variety by "mental elimination of those alternatives" [9, p. 230]. "We hope to acquire the degrees of freedom needed to promote mutation, learning, adaptation, and evolution (in a word survival-worthiness, or in another word VIABILITY) by *stimulating* the amplification and attenuation of variety" [9, p. 230]. System Four activities may include research and development, market research, corporate planning, and economic forecasting [9]. These areas are constantly changing and in need of continuous attention.

"It's quite normal, in a large enterprise, for the elements of System Four to have virtually no knowledge of each other's activity" [9, p. 232] because: (1) each member is part of the staff of some other director or vice president, and (2) top people believe they are affecting the integration themselves. "The "integration" of System Four entails an involvement between its elements at the level of their own variety generation" [9, p. 233]. "Every regulator mechanism must contain a model of that system which is being regulated" [9, p. 234]. Beer proposed using the model as a "screen," to obtain the "focus" that would manifest "integration," exemplifying sound cybernetic underpinnings [9]. System Four can be considered the "outside and then" level [9]. System Four performs the following actions to achieve its task or functions [18, pp. 39–46]:

1. Make use of prospective study tools (example Delphi studies).
2. Scenario analysis.
3. Sensitivity analysis.
4. Simulation modeling.
5. Operational room to make strategic and operational decisions.
6. Looking at the past, present, future, and real-time data.
7. Development and innovation.
8. Market research; other research.
9. Prospective studies; projects.
10. Financial innovations.
11. Analysis of relations with the environment.

"System Four must be ready to handle the variety input generated by System Three and to design the attenuation filter that conveys that variety to System Five" [9, p. 238]. "System Four is the innovation generator that uses "existing channels and transducers through which to stimulate and interrogate the problematic environment" [9, p. 238]. The unique design of the return channel is the difference in organizations. "Innovators devise new attenuating filters and new transducers, in order to understand the novelties which (by definition) they are not aware of in advance" referred to as feedback [9, p. 239].

System Four is designed to handle the regulation of the System Three environment of the System One operations environment and the larger organizational environment. An organization needs to invest in itself to ensure its own viability [9]. System Four develops these areas where investments are advised. Investments in time, talent, care, and attention are needed [9]. As most resources go to the System One areas, the balance is divided primarily to System Three and System Four; again an area of resource competition. System Four uses its resources to expand its ability to absorb System Three variety by contemplating versus creating alternatives [9]. System Four reduces variety here by the mental absorption of alternatives [9]. Some elements of System Four that allow for the variety changes are from functions such as [9, pp. 230–231]:

1. Research and development.
2. Market research.
3. Corporate planning.
4. Economic forecasting.
5. Market development.

These functional areas are typically dispersed among different areas of the organization and not centralized to one specific area [9]. System Four's goal is to focus the goals for each of the functional areas to the goals of the desired organization [9]. System Four then is able to have a model of the organization as it is "now" and how the organization should strategically be "then". By comparing the elements of the models, System Four is able to make recommendations for changes [9]. It is here where [9] says that every regulator must contain a model of that which is to be regulated. When two different models converge into one, learning is said to have occurred [9]. System Four's goal is to make recommendations based on the functional inputs that would allow their individual models of the organization's goals to be merged into one organizational model to be called the corporate strategic model [9].

System Four has to manage the functional elements in their normal interactions with their environment as well as the larger environment [9]. The focus area is called the kernel. "An Operations Room, considered as the physical manifestation of our focus—in which in particular the kernel of the System Four model of itself is displayed—might take on any form. But outstandingly it must be an ergonomically viable locale" [9, p. 243]. System Four consists of people who spend the money that is made in System Three, the resource area [9]. Beer states that synergistic behavior derives from the recognition of mutual support between the operational elements [9]. Synergy as the sum is greater than the aggregate productivity of constituents [9].

6.6 System Five

System Five is the highest decision point within the organization unit and forms the policy for the rest of the organizational unit [10]. The power to balance the natural tension that exists between Systems Three—System Four resides in the equation of variety between System Three and System Four [10]. System Five can delegate power, if the machinery associated with System Four is in place. Beer [9, 10] reiterates that variety absorbs variety. All that remains for System Five to do is monitor the regulatory machinery—to ensure that it does not embark on an uncontrolled oscillation [9]. Recursiveness embraces the notion of local closure at any given level of recursion [9]. Within any one viable system, System Five is the metasystemic administrator of Ashby's law [9]. System Five is then seen to absorb the residual variety of the System Three—System Four interaction [9, p. 263]. System Five representatives can be representatives of management, shareholders, investors, unions, potential workers, and project managers. System Five represents the identity of the project or organization. Responsibilities of System Five would include [18, pp. 46–49]:

1. Determining the vision, mission, and strategic goals of the organization.
2. Monitoring organizations stability and internal equilibrium.
3. Ensure organization such that identity is maintained.
4. Manage stakeholders.

The four responsibilities are the major areas that System Five must perform as part of the defining identity of the system (project).

Figure 5 also shows the recursive nature of the VSM as noted by the embedded VSM within the operations area.

A Management Cybernetics Vignette—Part 3

System Five can be seen as the organization's owners and board of directors. They are the face to the customers and give vision to the internal management teams. With the shipbuilding organization example, reputation for quality work is paramount for future work for this organization. Managing budgets and customers stakeholders expectations and concerns occurs here. The board of directors provides answers to the external world, and the image of the organization is projected from here.

7 System Interactions Within the VSM

When developing the foundations of the model, three divisions of management will be recognized to suggest that the "large part of their activity, perhaps eighty percent of it, is purely anti-oscillatory" [9, p. 180] as below:

1. Interventions on the vertical line from the metasystem to System One which constrain horizontal variety for legal reasons.
2. Interventions on the vertical line from the metasystem to System One which constrain horizontal variety for the sake of institutional cohesiveness, as judged from the *purpose* of the institution.
3. System Two activities, which are purely anti-oscillatory.

"The second proposal is that all documentation dealing with the accounting functions (1) and (2) should be distributed uniquely as a sign that they relate to mandatory interventions on elemental variety" [9, p. 181]. "Without a System Four clearly in

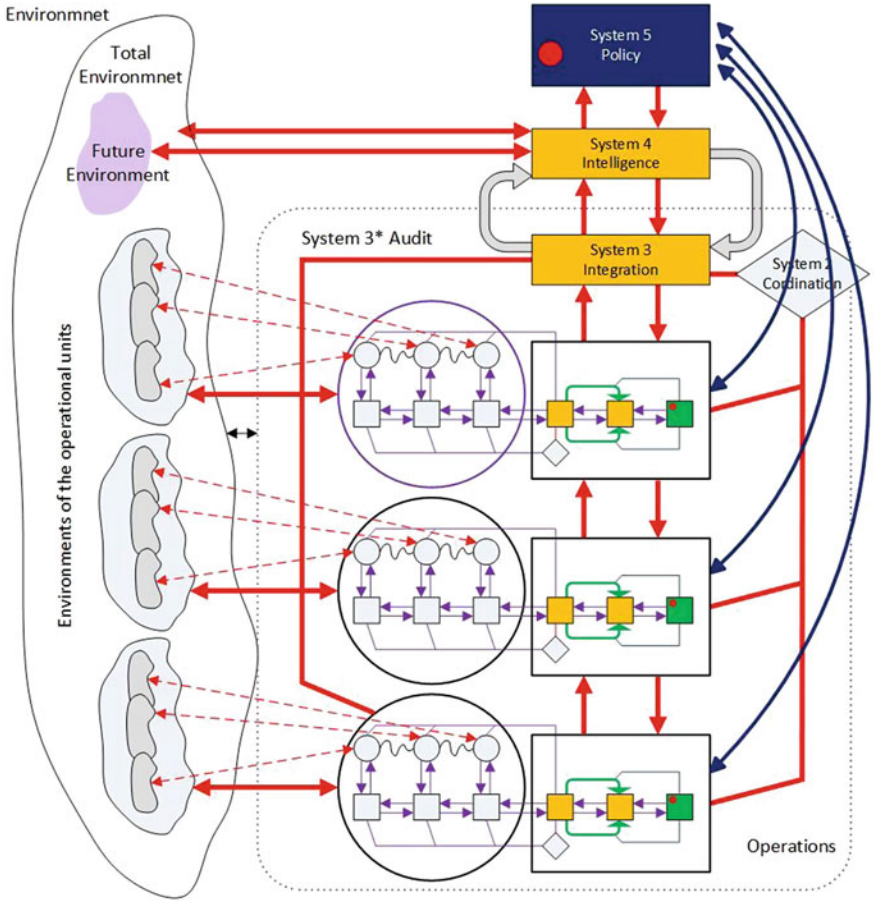

Fig. 5 VSM showing system five {Adapted From [18, p. 60]}

place, and with a System Five whose very nature is ambiguous, there is no System Three - System Four interaction, and no System Five monitoring of that interaction" [9, p. 181]. In this case, the whole metasystem collapses into System Three. "The operation of the first three principles must be cyclically maintained through time, and without hiatus or lags" [9, p. 258]. This is instantiated with the concept of an Operations Room where "System Three and System Four would exhibit themselves to each other, in a continuous mode, and absorb each other's variety" [9, p. 258]. System Five will monitor the balancing operation between Systems Three and System Four. Systems "Three-Two-One plus Three-Four-Five is a viable system - where the second group is metasystemic to the first" [9, p. 259]. "What is beyond System Five is the next level of recursion, of which this fivefold viable system is an operational element" [9, p. 259]. The "boss" within System Five supplies closure.

Beer has identified the necessary interactive elements of the viable systems as he states below [9, p. 261]:

> Our cybernetic enquires … have elicited Six interactive elements in the vertical plane, all of which appear to be necessary to a viable system, all of which can be identified with logical precision, all of which can be measured in terms of variety exchanges under the three principles of organizations

All are present in every viable system; normally five of them are not formally recognized or studied as vertical components of the system and should be to determine requisite variety [9].

A division is run by its directorate, shown on the diagram as a box square on the vertical command axis [10]. A division is essentially autonomous. "That means it 'does what it likes' within just one limitation: it continues to belong to the organism" [10, pp. 158–159]. Practical managerial constraints include the following [10, pp. 159–161]:

1. Operate within the intention of the whole organism.
2. Communicate down the vertical command chain.
3. Accountability….by ascending lines in that axis.
4. Operate within the Coordinating framework of System Two.
5. Submit to the Automatic Control of System Three itself.
6. Sometimes the needs of one division must be sacrificed…to the needs of other divisions.

The first three managerial constraints are the variety-interconnections in the vertical plane of the environmental, the operational, and the managerial domains [10]. The fourth managerial constraint are the channels of the metasystemic intervention, the anti-oscillation channels that innervate System Two, and the operational monitoring channels of System Three [10]. The last three are "there to contain the residual variety not absorbed by the first three, given the *purposes* of the enterprise as a corporate entity" [10, p. 260]. Beer suggests that the first three variety absorbers just happen (but must be recognized) and the second three must be recognized and then designed [9, p. 261]. First Axiom of Management states:

> The sum of horizontal variety disposed by n operational elements = the sum of. vertical variety disposed on the six vertical components of corporate cohesion (Beer 1970, p. 261).

It is a question of creating a language that will discuss a viable system and then using this language to describe how enterprises actually *are* run" [9, p. 225]. "To use this work, in short, it is VITAL to know at all times at exactly which level of recursion one is operating. And since many managers operate at different levels of recursion, in different roles, confusion often occurs" [9, p. 226]. The environment of the viable system is the environment that has to be considered as an operational element of the metasystem (a level of recursion higher) [9]. The use of the VSM necessitates the understanding of the system boundaries chosen and their relationship to the boundaries established at the next higher level of recursion.

8 Characteristics of the VSM's Channels

Communication paths exist within the elements of the VSM [9]. "From the standard organizational chart, one would think communication would be one vertical channel up and down the chart and would be called the "command channel where authority is delegated downwards and in return the acceptance of responsibility and accountability would flow upwards" [9, p. 216]. Beer had identified six primary channels that operate along the vertical plane and handle the channel variety associated with the viable system [9]. The first three primary communication channels Beer describes are the "variety-interconnections in the vertical plane of the ENVIRONMENTAL, the OPERATIONAL, and the MANAGERIAL domains" [9, p. 216]. Beer describes these as:

> "Proliferating variety is absorbed by the interactions of elemental units among themselves. Environments can never be disconnected. Operations are invariably connected, although their interactions may be strong or weak – and therefore may absorb much or little of each other's variety. In the vertical managerial domain, managers necessarily curtail the variety of their colleagues as the stamp of their own personalities on the behavior of the elemental units becomes manifest, and as each learns to tolerate the resulting performance profile of adjacent units is a willing spirit of teamwork" [9, p. 216].

The second three primary communication channels Beer describes are the channels of "METASYSTEMIC INTERVENTION (normally confused with inherited 'chain of command'), and the ANTI-OSCILLATION CHANNELS that innervate System Two, and the OPERATIONAL MONITORING CHANNELS of System Three" [9, p. 216]. Beer describes these as:

> "These are all management activities that result from the embedding of System One in a metasystem. Unlike the first three variety absorbers, which are given in the nature of the enterprise for that particular System One, these three variety absorbers are subsystems of the metasystem itself. They are there to contain the residual not absorbed by the first three, given the purposes of the enterprise as a corporate entity. The first three variety absorbers just happen, but must be recognized. The second three must be recognized, and then designed" [9, p. 216].

The communication channels in the VSM are the elements that connect both the diverse functions specified in the VSM and the organization with its environment(s) [18]. The channels provide the equilibrium, balance, or homeostasis of the internal environment of the system in view. The six primary channels and one additional channel of the VSM can be characterized as follows [18, p. 61]:

1. Channel One–C1—Channel connecting and absorbing variety between the environments of each elementary operational unit.
2. Channel Two–C2—Channel connecting the various elemental operations (operational units making up System One).
3. Channel Three–C3—Corporate intervention channel (System Three-System One).
4. Channel Four–C4—Resources bargaining channel (System Three – System One).

5. Channel Five–C5—Anti-oscillatory channels (Coordination) (System Two).
6. Channel Six–C6—Monitor channel (Auditor).
7. Algedonic Channel—Transmits alert signals concerning any event or circumstance that could jeopardize the organization. Travels straight to the top through existing links.

The primary VSM communication channels can be seen in Fig. 6.

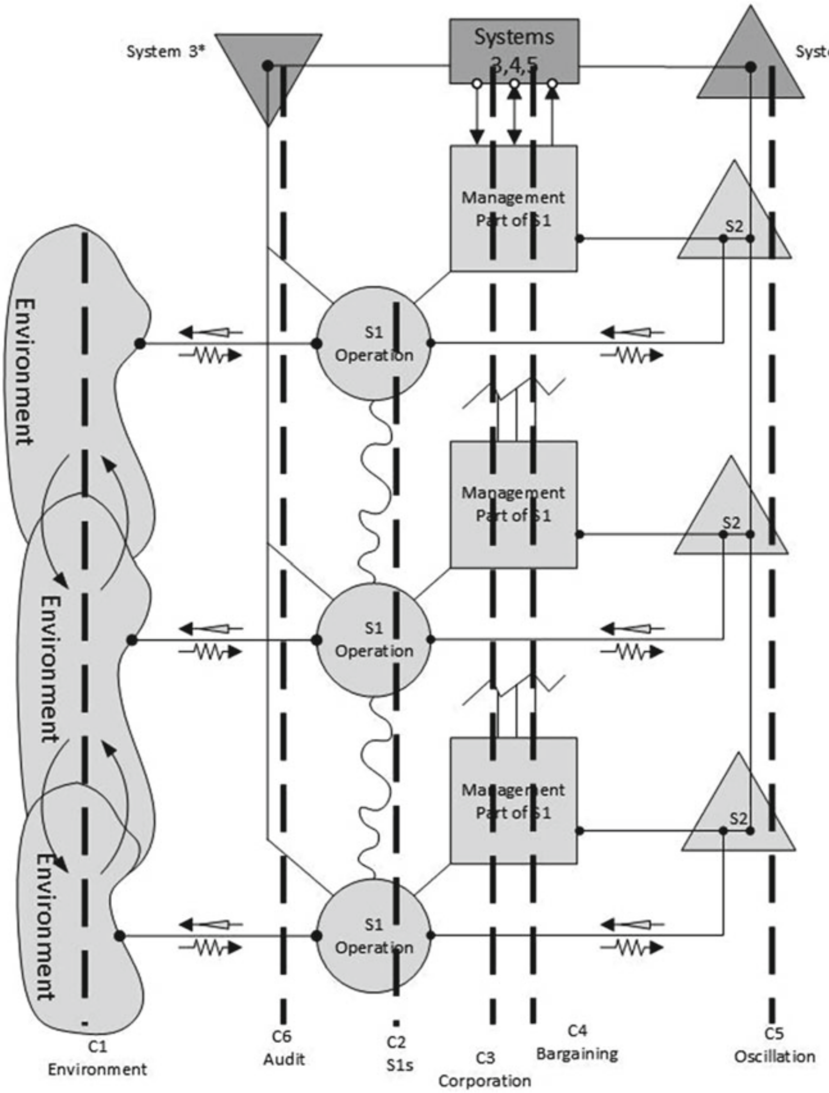

Fig. 6 VSM six primary channels {Adapted from [18, p. 61]}

The communication channels include those between the environment and the systems called C1. The C2 channels are between the S1's. The C3 cooperation channels are between the management portion of the S1's up and including the management portion of S3. The C4 channels provide the bargaining that goes on between the S1's and managed by the S3. The C5 channel monitors and controls oscillation between the S2's. The C6 channel that provides the auditing function of the S1's using unfiltered data and managed as a S3* (Star) function. The Algedonic channel provides the emergency channel directly to the top without filtering from the lower systems.

The systems and channels of the VSM were described above in the previous paragraphs. These systems and channels are the elements of the model that are used in the VSM lenses into the system of interest for the framework.

9 Summary

This chapter has introduced the field of Management Cybernetics and the Viable System Model (VSM). The origins of Management Cybernetics were established, and the field was anchored in cybernetics and the concepts of control and Requisite Variety. The VSM was introduced as the primary instantiation of Management Cybernetics. The background for the VSM was examined, and the model was anchored in cybernetics and dealing with complexity in systems. Management Cybernetics is one of the three fields, along with systems theory and governance, that are intersected to inform the conceptual/theoretical foundations for CSG. The five constituent systems of the VSM were examined in detail. The utility of the VSM to support modeling of complex systems was established. Additionally, the communication channels role in the VSM were examined. These channels provide for the flow and interpretation of information within the viable system as well as between the system and the environment.

Exercises

1. Think of your own organization as a system of interest. Choose an area within the organization (branch, project or overall organization itself) and identify the Five Systems that would make up a VSM representing your organization.
2. Identify how your "systems" maintain control from anti-oscillation "forces" between themselves.

Glossary of Terms

Algorithm A comprehensive set of instructions for reaching a known goal [10, p. 401].

Anastomotic the variety of reticulum expected to see in cybernetics; refers to the fact that the many branches of the network intermingle to such purpose that it is no longer possible to sort out quite how the messages traverse the reticulum [10, p. 30].

Autonomous A law onto itself; function indicated is responsible for its own regulation [10, p. 103].

Cybernetics concerned with the general patterns, laws and principles of behavior that characterize complex, dynamic, probabilistic, integral, and open systems [15, p. 19] about the manner of control, all kinds of structure, all sorts of systems [17].

Feedback The return of part of a system's output to its input, which is thereby changed. Positive feedback takes an increase in output back to increase the input; negative feedback takes back an output increase to decrease the input—and is therefore stabilizing in principle [10, p. 402].

Feedback Law "The output of a complex system is dominated by the feedback and, within limits, the input is irrelevant" [15, p. 28].

Filter A variety reducer [10, p. 94].

Heuristic Serving to find out; specifies a method of behaving which will tend towards a goal which cannot be precisely specified because we know what it is but not where it is [10, p. 52].

Holistic Systems Systems whose important characteristics are not ascertainable from the properties of the system components [15, p. 26].

Homeostasis Wherever one system impinges on the other, it recognizes a match which is normal to their coexistence [10, p. 145].

Invariant A mathematical term; one thing is invariant with respect to something else; it doesn't change as the other thing changes [10, p. 87].

Models More than analogies; they are meant to disclose the key structure of the system under study; a model is good if it is appropriate [10, p. 75, 84].

Regulation to select certain results from those that are possible [15, p. 70].

Requisite Variety Law Given a system and some regulator of that system, the amount of regulation attainable is absolutely limited by the variety of the regulator" [15, p. 36].

Self-Organizing Systems Principle Complex systems organize themselves; the characteristic structural and behavior patterns in a complex system are primarily a result of the interactions among the system parts" [15, p. 26].

Sensorium anything within a system that can register and classify the existence of a stimulus [10, p. 28].

SIC Sensory Input Channel.

State of the system is defined as a particular allocation of forms to events, given a particular configuration of events [10, p. 144].

Variety The total number of possible states of a system, or an element of a system [10, p. 403]. The measure of the "number of possible states of whatever it is whose complexity we want to measure" [9, p. 23]. The technical expression for complexity of the systems or the number of states a system may have.

ViabilityPrinciple ViabilityThe ability of a system to maintain a separate existence and depends on a number of necessary conditions [9, p. 199].

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