

THE EVOLUTION OF ORGANIZATIONAL CYBERNETICS

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ABSTRACT. The purpose of this contribution is to give an overview of the origins and further developments of Organizational Cybernetics, its transdisciplinary nature and its links to different areas of science, i.e., both natural sciences and the humanities.

1 Origins of Management Cybernetics The origins of Organizational Cybernetics are closely bound up with Stafford Beer (1926-2002), the founder of Managerial Cybernetics, who - by the way - was also this author's mentor.

Beer's academic advisers were the fathers of Cybernetics: Norbert Wiener, Ross Ashby and Warren McCulloch.

Norbert Wiener, a professor of mathematics at the Massachusetts Institute of Technology, officially coined the term "Cybernetics", although others had used it before him, e.g., André-Marie Ampère (an early leader in electromagnetism) to refer to the art of government and the philosopher Plato with reference to the art of navigation¹.

Wiener is the author of *Cybernetics or Communication and Control in the Animal and in the Machine* (1948). He not only identifies communication, closed-loop structures and feedback as pervasive phenomena in both natural and artificial systems. He also discerns an "essential unity" among problems in the different disciplines that center on these phenomena. Wiener was also interested, however, in the human and social domains; see for example his book *The Human Use of Human Beings* (1950).

Most important, with cybernetics Wiener founded a new field of study. He championed a different way of looking at the world, in which the emerging focus fell on information rather than energy, and on digital, numerical processes. In retrospect, it is surprising that Wiener believed that the emphasis on digital computers was a mistake. With Stafford Beer he shared the vision of a machine that, like the brain, combined digital and analogue modes; indeed, they both believed that the future would lie with this kind of machine (Beer 1994a: 281). Both men were far ahead of their time.

Ross Ashby was a psychiatrist, the director (1947-59) of research at Barnwood House Hospital, Gloucester and later director of the Burden Neurological Institute in the Department of Electrical Engineering at the University of Illinois, Urbana (1961-70). A study carried out at the State University of New York identifies Ashby as the most influential person in the systems movement (Klir 1978: 985ff.). Probably this is mainly due to his Law

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¹It was common among the writers of ancient Greece to use the term *kybernán* to denote guiding or governing.

of Requisite Variety²: "Only variety can destroy variety" expounded in his *Introduction to Cybernetics* (1956). Usually this law is stated as "Variety absorbs Variety" (this is the way Stafford Beer rephrased it). *Variety* here is what we also could refer to as *repertory of behavior*. The essential implication of Ashby's Law is that in order to control a system the regulator must embody a variety which is equivalent to the variety of that system. Another quotation from Ashby's notebooks relates this theme to the distinction between actuality and potentiality: "The Cyberneticist observes what might have happened but did not" (Cybernetics Society 2000-2004).

The Law of Requisite Variety was extended in the famous Conant/Ashby-theorem: "Every good regulator of a system must be a model of that system" (Conant & Ashby 1981). In other words: The result of a management process cannot be better than the model on which it is based (which one must qualify by adding "*except by chance*"). Ashby was a pioneering researcher in the field of organization, developing both the homeostat and the principle of self-organization.

Warren McCulloch is an eminent neurophysiologist and cybernetician. After his studies he first took an internship at a New York hospital and returned to academia at the age of 35, working at Yale and the University Illinois. Later, McCulloch moved to the MIT Research Laboratory of Electronics, dedicating himself primarily to neural network modeling. His path-breaking work provided the foundation for certain brain theories. Among the most famous of his papers are 'A logical calculus of the ideas immanent in nervous activity' (1943) and 'How we know universals: the perception of visual and auditory forms' (1947). The latter, written together with Walter Pitts, demonstrated that the neuron was the basic logical unit of the brain. The paper 'What the frog's eye tells the frog's brain' (1959, with Lettvin and Maturana) is about the discovery that the eye provides the brain with information that is already, to a certain extent, organized and interpreted. These articles were re-published in McCulloch (1988 and 1989).

McCulloch became the founder of the American Society for Cybernetics and was Stafford Beer's principal mentor.

Other important influences on Stafford Beer came from Claude Shannon and Heinz von Foerster.

Claude Shannon is the originator of information theory and has also been called the founding father of the age of electronic communications. He was a mathematician who worked for AT&T Bell Labs and then changed over, at the age of 42, to become a professor at MIT. Already in his Master's thesis in mathematics and electrical engineering he applied Boolean algebra to the construction of digital circuits. His pioneering work 'A Mathematical Theory of Communication' (Shannon & Weaver 1949), which also is his main opus, was published while he still worked at Bell Labs. In this theory, Shannon and Weaver concentrated on the efficient transmission of information. They elaborated the conditions under which a signal transmitted via an information channel can be decoded at its destination, without loss of information. The theory refers to the concept of entropy from physics, which is demonstrated to be equivalent to a shortage of the information content in a message.

²Klir enumerates several more detailed reasons for Ashby's great influence, such as the superior quality of his writings, his outstanding capacity for recognizing important principles where others see only trivialities, his great gift for essence-preserving simplification, his broad interests, which encompassed both cybernetics and general systems research, his meticulous scholarship, etc. (Klir 2001: 49).

Shannon's genial contributions to the solution of technical and engineering problems within the communications industry were fundamental for both the computer industry and telecommunications. But he also was a prolific inventor, e.g. of a mechanical mouse (called Theseus, 1950) which could orientate itself in labyrinths, and an early chess computer (in the sixties).

Heinz von Foerster, a physicist from Vienna and a nephew of the philosopher Ludwig Wittgenstein, is the father of second-order cybernetics – that is, the cybernetics of cybernetics. The focus here is on self-organization, self-reference, the role of the observer and eigen behaviors, in order to explain complex phenomena (see: von Foerster 1984, 1995). Von Foerster distinguished the 'cybernetics of observing systems' from the 'cybernetics of observed systems' (first-order cybernetics). Another famous distinction of his is between trivial and non-trivial machines. A trivial machine is analytically determinable, independent from previous operations, and thus predictable. For non-trivial machines, however, this is no longer true: The structure of the machine cannot be deduced from its behavior, i.e., the problem of identification becomes unsolvable.

As the founder and long-term director of the Biological Computer Laboratory at the University of Illinois, Heinz provided an transdisciplinary rallying point for mathematicians, logicians, neurophysiologists, information scientists, psychologists and social scientists who were jointly inquiring into the nature of cognitive processes. He had a crucial influence on many cyberneticians, cognitive scientists and constructivists.

A great mentor, Heinz also was a conjurer. Since his youth he mastered his magical tricks with great dexterity. His lectures and seminars were saturated with original ideas, puzzling propositions (because they were new and often revolutionary), e.g.: "The world, as we perceive it, is our own invention", one of the key tenets of the constructivist school of which he was a founder.

Then, there is **Gordon Pask**, the youngest of the lot. He was Stafford Beer's pal for more than 40 years. In his youth Gordon had his own firm (Systems Research), and later he was associated with various universities, especially Brunel and the University of Amsterdam. Together with his life-long collaborator Robin McKinnon-Wood he built astonishing machines such as the Self Adaptive Keyboard Instructor (SAKI) and MusiColour, a light show that held "conversations" with musical performers. He also developed computers in various media, of which the chemical/dendritic computer is the most significant. This work on the mechanical embodiment and organisation of computing has a following in the Artificial Life movement.

Gordon's interest in interaction led to the development of his masterpiece, Conversation Theory - a reflexive theory which is, in effect, a theory of theory building (Pask 1975a, 1975b, 1976). Conversation was conceived of as a process that is sustained between teacher and learner, in which learners 'teach back' and in which both parties could negotiate agreements about what had been (and could be) learnt. Pask's groundbreaking work has laid foundations for a more humane understanding of human action, and an intelligent interaction between humans and computers (Glanville 1997).

Figure 1: Pioneers of Cybernetics

(Upper row, left to right: Claude Shannon, Norbert Wiener, Warren McCulloch, Ross Ashby; lower row, left to right: Gordon Pask, Stafford Beer and Heinz von Foerster).



Now, here is **Stafford Beer**, at the intersection of all these great minds which produced an intellectual climate for the unfolding of his genius (Figure1).

Stafford Beer was a widely educated and interested, brilliant man, a genial thinker and a powerful agent. He held managerial positions in various companies at every level from Production Controller to Director of Development and Chairman of the Board, and he was also an international consultant. He worked at the governmental level in twenty-five countries, and for many international agencies. Stafford was a visiting professor in approximately 30 universities in Britain, Europe and North America, including Manchester, where he lectured for 24 years. He was awarded several honorary doctorates and also served as President of the World Organization of Systems and Cybernetics, which awarded him its Norbert Wiener Gold Medal.

When Stafford went to MIT in 1960, to meet Wiener and other cyberneticians, he was the head of Operations Research at British Steel. At that point he had already built simulation machines, developed avant-garde methods for industrial organization, and published a number of highly innovative works, including two books. The journey to the U.S. triggered in Stafford new insights. In the following years he made a plethora of scientific contributions.

With his main works, Stafford created a totally new perspective on management and organization. Already in his early books, *Cybernetics and Management* (1959) as well as *Decision and Control* (1966), he laid the foundations of Managerial Cybernetics.

Stafford created a huge body of knowledge which is eminently transdisciplinary. His vantage point was in fact based on that notion: '... to me, all worthwhile thinking is essentially transdisciplinary.' (Beer 1994b:19). The sources Stafford drew upon - in addition to the cybernetic basis - range on the one hand from information theory to biology (especially neurophysiology), mathematics, philosophy, psychology, engineering and architecture.

On the other hand, a wide and deep concern with practical problems and issues broadened his perspective and enabled him to form his theories. Stafford maintained that complex issues should be looked at from the widest possible angle.

Altogether, he was moved by an impetus to improve the human condition and a quest for a holistic approach to the world, as were his colleagues. Two assertions are indicative

of this mentality, the first from Warren McCulloch: 'The world is one and so are we'. The second is Beer's own: 'Reductionism is the rock on which Western science is founded; and it is the self-same rock on which society has foundered' (Beer 1988: 5). Both of these statements also show the strong affinity which the cyberneticians' perspective has with the holistic view from the proponents of General Systems Theory, Ludwig von Bertalanffy, Kenneth Boulding, Ralph Gerard, James Grier Miller and Anatol Rapoport, the founders of the Society for General Systems Research (for details see Hammond 2003).

Beer's work offers concepts and tools for dealing with high levels of complexity, which are a ubiquitous issue in organizational life. His most influential theoretical contributions are the Viable System Model and the Team Syntegrity Protocol. The next two sections will elaborate on these two exemplary conceptual devices.

2 Instance I: The Viable System Model The **Viable System Model (VSM)** is essentially based on a structural invariance: By means of homomorphic mapping of an organization on the neurophysiological structure of the human central nervous system, features essential to organizational viability can be ascertained and fleshed out. This is a powerful approach to the diagnosis and design of organizations of any kind.

The VSM was first elaborated in a set-theoretical form and later in a topological structure. In this model, a set of functions is distinguished which provide the 'necessary and sufficient conditions' (Beer, *passim*) for the viability of any human or social system.

These functions and their interrelationships are specified in a comprehensive theory, the propositions of which can be summarized as follows:

1.) Components of the model: An organization is viable if and only if it exhibits a set of management functions with a specific set of interrelationships, identified and formalized in the model (Figure 2):

- *System 1:* Regulatory capacity of the basic units (A, B, C, D); autonomous adaptation to their environment, optimization of ongoing business (e.g., the business areas of a company).

- *System 2:* Amplification of self-regulatory capacity; attenuation of oscillations and co-ordination of activities via information and communication (e.g., information systems, service units and co-ordination teams, standards of behavior, knowledge bases).

- *System 3:* Management of the collective of primary units (basic units with regulatory capacity); establishment of an overall optimum among basic units; providing for synergies as well as resource allocation (e.g., the executive corporate management).

- *System 3*:* Investigation and validation of information flowing between Systems 1-3 and 1-2-3 via auditing / monitoring activities (e.g., operations analysts, special studies and surveys).

- *System 4:* Management of the development of the organization; dealing with the future - especially the long term - and with the overall outside environment; diagnosis and modeling of the organization in its environment (e.g., corporate development, strategy, research and knowledge creation).

- *System 5:* Balancing present and future as well as internal and external perspectives; moderation of the interaction between Systems 3 and 4; ascertaining the identity of the organization and its role in its environment; embodiment of supreme values, norms and rules - the ethos of the system (normative management).

In this structure, the primary units (basic units with the regulatory capacity supplied by System 1) must dispose of high autonomy in order to be able to adapt to their respective environments or milieus. The combined activities of Systems 1, 2 and 3 (including 3*) provide for management of the present and short term, while System 4 is the fulcrum for long-term adaptation and System 5 is the embodiment of the ethos - the basic principles governing the orientation of the organization as a whole.

Systems 1-2-3 (including 3*) comprise the operative level, System 4 in interaction with System 3 the strategic level, and System 5 the normative level of management. These correspond to the three logical levels of management as outlined elsewhere in the Model of Systemic Control (Schwaninger 2006a).

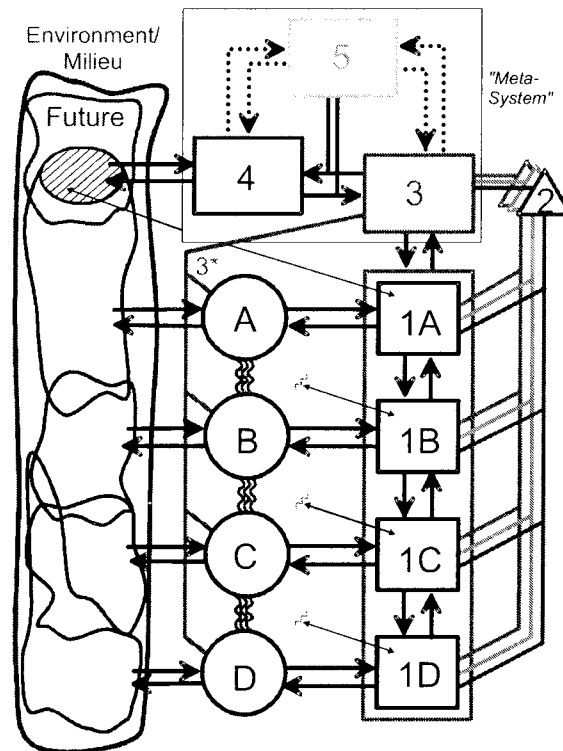


Figure 2: The Viable System Model - Overview³

2.) Diagnostic power: Any deficiencies in this system, e.g., missing functions, insufficient capacity of the functions and faulty communications or interactions between them, weaken or jeopardize the viability of the organization. The VSM can be represented in different degrees of detail. To avoid overloading the reader, the version chosen for Figure 2 is somewhat simplified in relation to the most sophisticated one available. However, a good understanding of this representation of the VSM can already enable a manager to gain powerful diagnostic insights and to find innovative approaches to organizational design.

³This is a slightly adapted version. For the full-fledged original, please see: Beer 1985: 136; and: Beer 1979, 1981)

3.) Recursive organization: The viability, cohesion and self-organization of an enterprise depend upon these functions working *recursively* at all levels of the organization. A recursive structure comprises autonomous wholes within autonomous units (Figure 3). Moreover, a viable organization is made up of viable wholes and is itself embedded in more comprehensive viable wholes. Each unit, inasmuch as it is accomplishing the organization's task, rather than servicing or supporting this producing, replicates - in structural terms - the totality in which it is embedded. That is, it has all the functions outlined under (1.), to be able to manage, from start to finish, the processes which serve the purpose of its existence.

The structural invariance denoted by the term "recursive organization" shows the features we find across different disciplines other than management science:

- *Fractal organization:* This term comes from mathematics and denotes systems which have a dimensionality which can also show a fraction of a whole number. Fractally organized systems perpetuate kindred structures along different levels of subsystems, a feature called "self-similarity".
- *Holographic organization:* This term comes from physics, where it denotes systems whose parts contain the same information - more exactly, equally structured information - as the whole system, albeit in a condensed fashion.

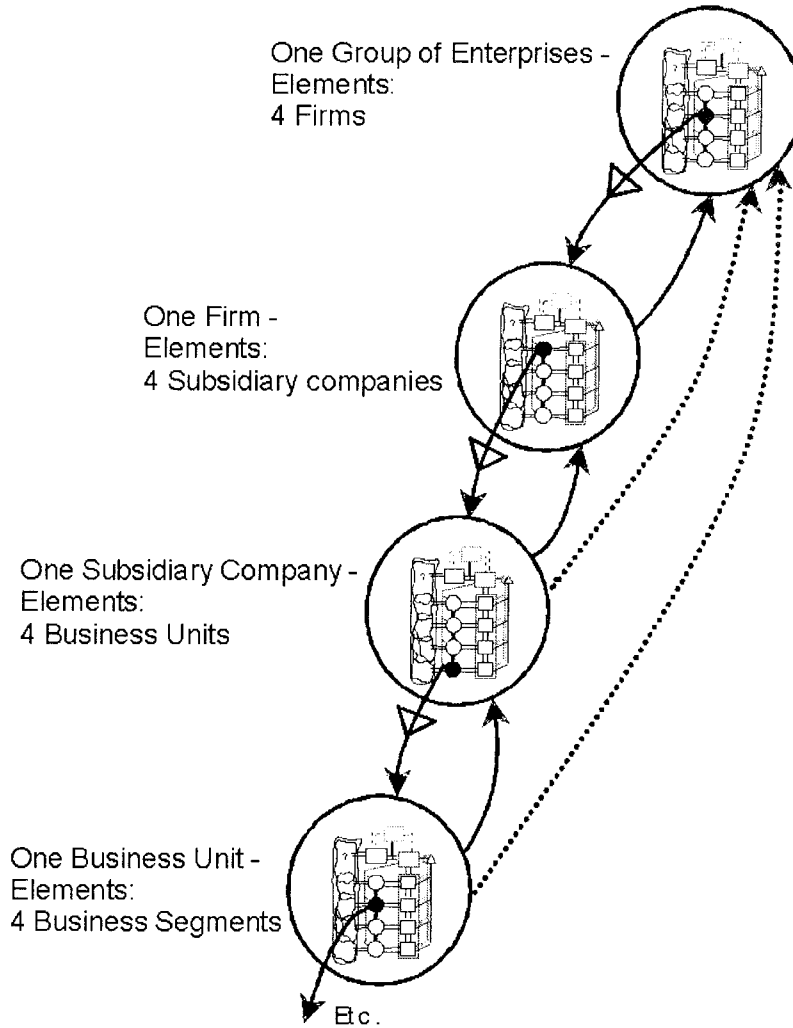


Figure 3: Recursive Structure of Viable Organizations (after Beer 1979)

The Viable System Model has been translated into the language of business and applied to organizations of all kinds, as documented in several books (e.g., Espejo/ Harnden 1989, Espejo/ Schwaninger 1993, Espejo et al. 1996, Christopher, forthcoming), and on a CD-ROM edited as a "Festschrift" (commemorative volume) for Stafford Beer (Espejo/ Schwaninger 1998). In particular, the aspect of recursive management and an underlying cybernetic theory of human action in organizations have been elaborated in detail by Espejo et al. (1996), with reference to real-world applications.

The VSM has also been used in the design of national government (Beer 1989) and public institutions (Reyes 2000), as well as for a diagnosis of the Swiss democracy on the VSM which has arrived at important insights (Willemsen 1992), to name just a few examples of the many applications to be found in different contexts.

The VSM is applicable to any kind of social body, organizations small and large, private and public, and even to whole societies. Stafford claimed only that it is primarily a model for the purpose of diagnosing viability. Indeed, its diagnostic power alone is enormous, but the model has also turned out to be an extremely effective device to orientate organizational design. In two recent papers the model has been described both as a) a diagnostic device for a number of organizations of varying purposes and sizes, and b) a conceptual device for a design that would enable humanity to cope with the ecological challenge, by organizing for sustainability at all levels, from individuals to enterprises to nation states and finally the whole world (Schwaninger 2006b, 2006c).

3 Instance II: Team Syntegrity Team Syntegrity is an architecture dedicated to making the work of large groups productive. It is complementary to the Viable System Model, and is meant to be a concrete approach to the design of the System 3 - System 4 relationship (Beer 1994c). Moreover, it is a model for democratic management.

It is grounded in a mathematical structure which was used, for example, by Buckminster Fuller in the realm of architecture. Team Syntegrity builds on Fuller's proposition that all systems are polyhedral. The term *syntegrity* results from a combination of *synergy* and *tensile integrity*. Synergy is the cooperation among actors who thereby produce a combined effect greater than the sum of their individual effects. Tensile integrity is the structural strength provided by tension as opposed to compression (Fuller/ Applewhite 1982).

Beer proposes a formal model for an infocet that deals with complex challenges or problems, establishing a protocol based on the structure of polyhedral shapes (Beer 1994c). The icosahedron (a convex polyhedron of 30 edges, 20 triangles and 12 vertices) is considered an epitome of these forms, being particularly suited for applications to large groups (figure 4).

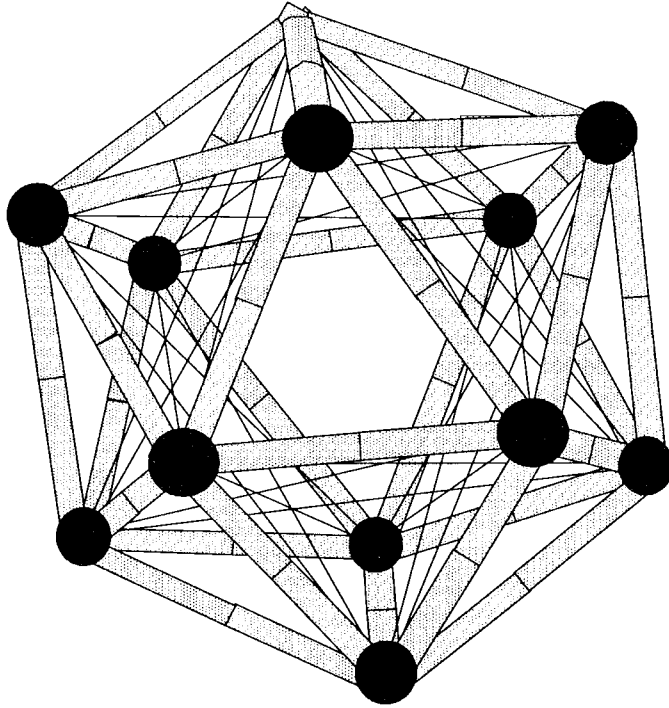


Figure 4: Icosahedral Architecture for Team Syntegrity

An infoset is a set of people who have a common concern, are in possession of pertinent knowledge connected with the subject, and are motivated to tackle the shared issue. The *Team Syntegrity model* supplies the structural framework for the synergetic interaction of such an infoset. In a typical syntegration process, organized mainly as a workshop, members of the infoset work on the issue-in-focus by condensing it into a broad initial question. This opening question then becomes the general topic of the syntegration.

In the typical case, thirty members of the infoset embody the edges of an icosahedron. Altogether, each person is a member of two teams of five, represented by the vertices. The total number of vertices, i.e., teams, is twelve. Each member of the infoset also serves as a critic to two other teams (struts of the icosahedron), and as an observer of all the teams of which he or she is not a member.

The protocol, which is also applicable to numbers other than 30, provides a mechanism for a heterarchical generation of the agenda and a precise structure for the sequence of discussions of teams with their critics.

The process of the syntegration starts with the joint creation of an agenda ('Problem Jostle'): Each participant hands in contributions that seem important to him or her (Statements of Importance). Subsequently these statements are discussed and combined into Aggregated Statements of Importance. These are filtered, clustered and finally condensed into twelve Final Statements of Importance, i.e., the topics to be worked on.

What follows is an exploration of these topics in teams ('Outcome Resolve'), which meet

several times (usually in three iterations). Finally, each group writes up a summary of its results to share with the whole infonet. The purpose of this interaction is an integration of multiple topics and perspectives towards a shared body of knowledge and hopefully the emergence of new knowledge in the process.

As the same issue with its different but interconnected aspects is continually and iteratively processed by the same set of people, who gather in alternating compositions (topic teams), strong reverberation develops. This process fosters group cohesion and shared mental models (cf. Jalali 1994), and it also induces a self-organizing dynamics with high levels of knowledge integration. There is no need for a central authority whose task it is to integrate the multiple efforts; integration just happens 'by itself'.

Although the Team Syntegrity model is highly formalized, it has been applied by many corporations with results that corroborate the experimental evidence. The first experimental applications were held in 1990 at Manchester Business School, U.K. and at the University of St. Gallen, Switzerland. At present, the number of applications amounts to more than 200, ranging from issues of corporate strategy and organization development to the work on ecological issues and regional planning. The common denominator of these very different types of endeavors is that they are complex, often innovative and deal with ill-defined, barely structured issues. Team Syntegrity is neither appropriate nor necessary for working on routine tasks.

So much for these two models created by Stafford Beer, which at least give a taste of what Management Cybernetics is about. For the established science of management and administration, Beer's work is highly innovative and even revolutionary. Therefore, it has been assimilated only to a small extent. However, as the application literature demonstrates, its potential for dealing with the complexities of today's world is enormous. This explains the vigorously growing interest in Beer's work among practitioners and academics.

4 Further Evolution Although Stafford had no intention of founding a school, nevertheless he has acquired a considerable number of disciples and followers. These continue to spread his ideas around the world and to influence the further development of *Organizational Cybernetics*.

There is also a substantial body of protagonists from the next generation who are promoting the ideas of Organizational Cybernetics. These youngsters come from all kinds of backgrounds, e.g. from engineering, economics and management, mathematics, medicine and biology.

The term *Organizational Cybernetics* lends expression to the fact that an evolution is taking place in which Managerial Cybernetics absorbs new stimuli, expands its repertory and shows new features. Among these are:

- the inclusion of a hermeneutic-interpretivist perspective (e.g. Roger Harnden 1989).
- the adaptation or application to new issues (e.g. heterarchies, virtual organizations: Markus Schwaninger 2000).
- methodological innovations (e.g. the Viplan methodology by Raúl Espejo: Espejo

1989, Espejo/Bowling/Hoverstadt 1999; new forms for Team Syntegrity: Truss/Cullen/Leon 2000).

- IT-support (e.g. the VSMoD software by José Pérez Ríos: Pérez Ríos 2006)
- conceptual innovations (e.g., Ralf Türke's and Camilo Olaya's applications of the VSM in the contexts of sociological and political theory: Türke 2006, Olaya 2007).
- strengthening of theoretical foundations (e.g., Christina Crisan Tran's test of the propositions of the VSM: Crisan 2006).
- synthesis with other methodologies (e.g., Integrative Systems Methodology, a synthesis of Organizational Cybernetics and System Dynamics: Schwaninger 2004).

This listing does not claim completeness, either in terms of features enumerated or in terms of literature sources mentioned. It is merely an overview which should give some idea of the evolution currently taking place.

Over the last few years, Organizational Cybernetics has been influenced by theories and concepts emanating from Second-order Cybernetics, biology, network theory, informatics, philosophy and sociology. One of the stronger influences is that of Social Systems Theory (e.g. Luhmann). Also, a dialogue with other streams of the Systems Approach is taking place, namely with General Systems Theory, System Dynamics, Computer Aided Systems Theory, Complexity Theory, Soft Systems Methodology, and Critical Systems Methodology.

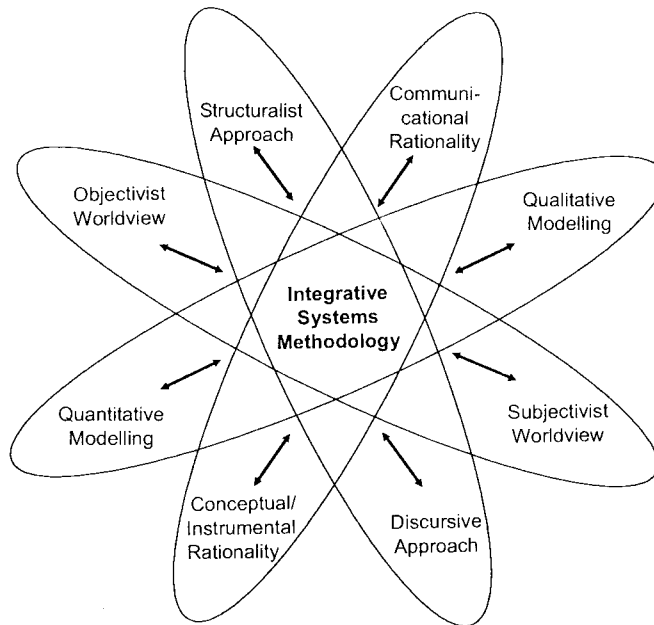
5 Conclusions The evolution of Organizational Cybernetics has come from a positivistic tradition in which structuralist-functionalist, quantitative, objectivist viewpoints and instrumental rationality dominated. On the other hand, a hermeneutic, interpretivist tradition existed, in which discursive, qualitative, subjectivist aspects and communicational rationality ruled. This second tradition, with eminent systems thinkers such as Vickers, Bateson, Watzlawick and Checkland, has not been spotlighted here for the sake of parsimony, even though it has also had some influence on Organizational Cybernetics. Figure 5 shows the vision of a synthesis of the two streams, as developed under the label *Integrative Systems Methodology*.

Figure 5: Two methodological streams - Vision of a synthesis (Schwaninger 2004)

The path toward the future is probably one of convergence. The two traditions are heading for a synthesis. This convergent trend expresses a necessity stemming from the limitations of each one of these approaches, and also from the need to leverage synergies that can materialize only when the two traditions meet.

This paper has traced the origins of Organizational Cybernetics since the beginning of Cybernetics in general. We have seen how a bunch of polymaths developed a completely new field of research. More than that, they created a distinctive approach to the world, which enabled more effective ways of dealing with complexity than traditional disciplines had until then afforded.

Cybernetics is a transdiscipline which makes available a formal apparatus for the purpose of dealing effectively with complexity. Its formal language is less precise than the language of mathematics, even though it has its fundamental mathematical building blocks and also its mathematical variants, as is the case in control theory. In sum, we may say that within the context of organizations Cybernetics is the most appropriate conceptual approach for



coping with complexity. Therefore it is not surprising that the science of managerial and organizational cybernetics has emerged.

All the pioneers mentioned here were at the top of the respective sciences in which they were rooted. Their legacy is gigantic. But the time of great achievements has not yet passed. The potential of Organizational Cybernetics has been activated only to a small extent; certainly much more is to come. The future of Organizational Cybernetics has only gotten underway, and I am delighted that all over the world we have a force of enthusiast young researchers dedicated to the subject.

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