Papers

On Controlling Complex Systems - A Sociocybernetic Reflexion*)

Nina Degele

Introduction

Nearly half a century ago Norbert Wiener established cybernetics. Since then, two basic socio-cybernetic points of view have developed, which differ in the way they relate the science of monitoring and controlling technical and living systems to society. While constructivist sociocybernetics (or second-order cybernetics) focus on the highly individual operation mode of system-specific codes, Cybernetics IV concentrates on the identification of system dynamics and control corridors. As a consequence, the first mentioned discovers a certain scope for development and design, where the latter identifies limits of control capacities. These two strands at first sight appear incompatible, due to their differing sociological and system-theoretic foundation , but when applied show themselves to be complementary – such as when they are transferred onto the control of sociotechnical systems.[1] In order to approach this complementarity, it is however necessary to complete several analytic steps, which I intend to go into within this contribution. In a first step, I will discuss the dynamic and structural perspective on complexity. This will already unveil several theoretical pre-decisions, which are linked with the respective specific weighting of system logics and system dynamics (1). Due to these pre-decisions, the structural understanding of complexity corresponds with the concept of context control within the framework of theory of autopoietic systems (2), while the dynamic notion of complexity is rooted in the General System Theory, and works with the concepts of dual control (3). I would like to conclude by presenting just what an integration of both theoretic opponents could look like, by using an example taken from techno-sociology (4). However, I would like to begin by specifying the conceptual terminology: What renders systems complex, and what is control?

1 Complexity, Control and Sociocybernetics

Contrary to simple and complicated systems, complex systems may take on a variety of states within a short time. This renders them highly unpredictable, and even less computable (Ulrich/Probst 1990, 61; Flood 1987).

[1] We speak of socio-technological systems when technology is applied in a social context, „in which material and symbolic artefacts and social action functionally refer to each other and are organisationally linked“ (Rammert 1993, 32).

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The systems I will therefore term complex are those characterised by irreversibility, non-linearity, emergence, and interconnectedness under dynamic conditions: systems are emergent if after a critical mass has been exceeded, the behaviour of said system can no longer adequately be conceived as an aggregation of (its) parts (cf. Stöckler 1990; Hejl 1992; Heidelberger 1994; Garciá-Olivarez 1993, 14); they are non-linear if the system output is disproportional to the stimulus (DeGreen 1990, 160); irreversible if original states can not be repeated , or are not even achievable again (Taschdjian 1978, 178; 1982, 12), and interconnected if due to immanent limitations on the interconnective capacity of the elements the individual link can no longer be linked to all other links, at all times“ (Luhmann 1984, 46).

By contrast, classical system-theoretic concepts of complexity consider only the characteristics of interdependence and emergence. They then structurally determine complexity, namely by investigating the possible and realised relationships of the elements. What is described by theoreticians such as Herbert Simon, Warren Weaver and Niklas Luhmann, is actually static complexity, or complicatedness – complexity forces selection (not all possible relations are realised) and contingency (other relationships are possible) (Luhmann 1984, 46). In addition, complexity is based on hierarchy as one of the „central structural patterns“ – on a „ large number of parts that have many interactions“ (Simon 1978a, 95f). These „many interactions“ are based on the existence of interrelated subsystems. According to Simon, hierarchic (and therefore complex systems) are nearly, but not completely, decomposable, as „intra-component linkages are generally stronger than inter-component linkages“ (Simon 1978a, 111). According to Simon, their stability is mainly due to their multiply redundant architecture, and we can use this redundancy to simplify their description, however not on a level of basal components, but on an aggregated, higher hierarchical level. Simon wants to use these circumstances for simulations – as a foundation for „aggregative, but perhaps robust, policy manipulations“ (Simon 1978b, 121), actually interventions. With similarly pragmatic interest, Warren Weaver terms the relationships of elements (instead of their properties) as constitutive for processing organised complexity (Weaver 1978, 44). Weaver distinguishes the latter from simple complexity problems (i.e. linear contexts), as well as from disorganised complexity, which may be grasped statistically. Summarising, a „system, problem or decision field is the more complex, the more levels it has, the higher its connectivity is, the more important its consequences are (Willke 1993, 24)[2] Why does this not suffice for determining complexity?

The fact that the outlined concept is actually a description of complicatedness, is due to the insufficient consideration of the temporal dimension. A multitude of elements, hierarchies and interdependencies do not yet turn a system complex, but merely complicated. In order for it to be complex, it takes system state modifications, at high speed. For this, the system does not necessarily need to include a large number of elements. (Ulrich/Probst 1990, 61; Forrester 1971, 82). Actually, irreversibility and non-linearity are the dynamic components responsible

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[2] „Complexity is here defined as the degree of functional differentiation of a social system and the number of relevant reference levels (these are levels, which need to be differentiated analytically and empirically – e.g. individual, group, organization, as statements within the context of one level are not necessarily valid within the context of another level); connectivity describes the type and degree of mutual dependency betweeen parts as well as between parts and the whole; and the importance of consequences is determined by the number and severity of the causal chains and subsequent processes set in motion within the resepective social system by a certain decision; the term decision field refers to the fact that there is no complexity in itself, but only in view of a certain problem, which for a given system and in a given situation necessitates selection .“ (Willke 1993, 24 – translation: S.Ross) In order to formally describe static complexity, Todd LaPorte – using the term of structural complexity – determines the level of complexity as a function created by three factors: a number of systemcomponents, relative differentiation among these components, and interdependencies between these components. (LaPorte 1975, 6f)

for rendering systems difficult to decompose and to describe. In this sense, time is a complexity-generating factor, able to transform a complicated system into a complex one[3].

What does this mean for controllability? Let me first include a few remarks on the notion of control. The term control has been used since the 1970s (…). Amitai Etzioni writes about „control as the process of specifying preferred states of affairs and revising ongoing processes so as to move in the direction of these preferred states“ (Etzioni 1968, 45). He thereby emphasises the intentional aspect of control – steering aims at the achievement of preferred states. On the other hand, within the scope of his structure-functional theory on social systems, Talcott Parsons developed a cybernetic hierarchy of control, differentiating between conditional-energetic and informational-cybernetic hierarchies, and connected energy flows with control mechanisms (Ackerman/Parsons 1966; Parsons 1968). With respect to control, energy and information flows move in opposite directions: (Ackerman/Parsons 1976, 79) „ The aspects of a system with a high degree of information (and sense structuring) control those aspects, which exhibit a lower level of information, but a considerable level of energy; vice-versa, systems with high energy-levels, but lower levels of information create the conditions for activating and realising informational purpose and maintenance functions.“ One example for this is Freud's analogy of the horse and the rider. On an energetic level, the horse dominates, whereas from an informational point of view the rider is dominant. In order for a social exchange process to happen in a controlled way, generalised and symbolic control media are necessary (Parsons 1968, 302-305). As is well known, Parsons differentiates between the e-conomy (money), politics/goal-attainment (power), culture (commitment) and social /communal system (influence). They aim at safeguarding the notion of coordination, or integration methodically, and to keep the system in balance – that is, to control it. Parsons is actually not concerned with intentional goal-attainment, but in the coordinative function. (…). Within a wider understanding of the notion, "control" describes an integrative mechanism and serves to coordinate functionally differentiated social systems (Willke 1993, 214f; 1994, 85-91; Mayntz 1987, 92f). The narrow interpretation of „control“, on the other hand, presumes an intentionally acting subject with an identifiable steering objective, which takes measures for safeguarding goal-achievement (Mayntz 1987, 94; Bühl 1990, 180; Busch/Busch 1981).

If these steering intentions are identifiable, it is possible to separate between control activity and control effect. As this last step allows a differentiated analysis of empirical processes when dealing with complexity, I have decided to use the term control in this sense – as an attempt for dealing with complexity.[4]

After having discussed the central system-theoretic terms of complexity and of control, I will now focus on the question as to how they are used in socio-cybernetic theories. In socio-cybernetics, system analysis, modelling and the rationale for claiming for control or omitting of control. (Aulin 1986; Bühl 1990, 135-144; Dyke 1990, 119)

During the late 1970s, sociocybernetics adopted the notion or programme to consider and to explain complex systems as wilful, that is, not externally controlled systems, thereby a-bandoning the idea of a social technology as an applied social science (Geyer/van der Zouwen 1978, 1f). Still, its image within sociology is not a good one: sociocybernetic contributions

[3] By contrast, Luhmann focusses on the system-immanent method of coping with complexity: in his opinion, time facilitates a reduction of complexity („time is extension of choice“ Luhmann 1978, 97) as it allows a system to realise possible relationships one after another, instead of simultaneously). Luhmann calls this the „temporalisation of complexity“ (Luhmann 1984, 77)

[4] It seems evident to speak of control in case of steering effects, or actually handled or unhandled complexity. However, this is not the topic of this contribution. I have therefore decided to dispense with this terminological differentiation.

are rarely published in socio-scientific publications, but may mainly be found in system-theoretic publications.

And even worse: as „Thermostat-Theory" (Friedrich/Sens1976), it is equated with Norbert Wieners technical control circuit cybernetic model (1948), as cybernetics describes steering and control processes in „machines as well as in life-forms" (Wiener 1948, 32; also Friedrich/Sens 1976, 39; Geyer 1995, 7-12; Robb 1984, 21). And as a matter of fact, the 1940s' and 50s' paradigm was the thermostat, as a model of controllable feedback. Balance and system maintenance were seen as the research-guiding backdrop for the correction of external disruptions, the development of control systems and the construction of intelligent machines. These efforts, all of them predominating the 1950s, were committed to the paradigm of balance, and are therefore neither suited for the analysis of non-linear processes, nor for coping with social complexity.

The benefits of these early considerations to sociology may therefore not be found in a crude transferral of „steady state" or feedback onto social contexts. The focus is rather on the possibilities and limitations of rational control – social systems are not machines, and are therefore not controllable. Constructivist sociocybernetics and Cybernetics IV, which will both be discussed below, are both based on this state of knowledge – on the need to extend cybernetics. Instead of postulating cybernetic control circuits independent of observer, point in time of observation and the problem in question, these socio-cybernetic system theories move from a machine- to a circuit-oriented image, and focus on change processes instead of stability. They emphasise the subjective, time and observation-dependent character of knowledge, dismiss the option of external controllability of social systems, and take interest in the consequences of self-referentiality and –steering (Geyer/van der Zouwen 1978, 1f; Geyer/van der Zouwen 1991, 83; Geyer 1995; Bailey 1994, 127-135).

While constructivist sociocybernetics stress the control limits of social systems, which are due to these systems' operational closedness, cybernetics IV focuses on the identification of system dynamics and steering options/possibilities (or control corridors). In sociocybernetics, handling of social complexity is mainly achieved by the concept of context steering (Willke 1989), while cybernetics IV system-theoreticians prefer control concept, such as dual control (Bühl 1989). I would like to begin by discussing constructivist sociocybernetics.

2 Context Steering in Constructivist Sociocybernetics

When constructivist sociocybernetic theoreticians talk about dealing with, or handling complexity, the term they use is „intervention" instead of „steering". In their concept, steering is the „effect of wilful logic (order or regularity) of an operatively closed context of communication, which as a self-referential control system affects itself (internal control) or external events (= external control) (Willke 1993, 282). Interventions, on the other hand, aim at „initiating changes within a system and to facilitate them"(Willke 1994, 41).

One means for handling complexity is context steering, „the reflexive, decentralised steering of the context conditions of all subsystems and self-referential internal control of each individual subsystem" (Willke 1989, 58). What does that mean? The socio-cybernetic concept of context steering rests on two pillars: second-order cybernetics and the diagnosis of a functionally differentiated society. Second-order cybernetics is based on the work done by Heinz von Foerster (1981). By placing the relationship between the observer and the observed system at the centre of his considerations, he heralded a paradigm change in cybernetic thinking, by introducing „cybernetics of cybernetics" in the 1970s. He paved the way for a communication-theoretically based, constructivist epistemology. Since then, socio-cybernetic theoreticians have been more interested in the perspectivity of controlling than in the controlled system. Because: „that which is (given the role of being) >controlled< also controls that which is (given the role of being) the >controller<“ (Glanville 1987, 104). The introduction of such a meta-level of observation is expressive of a shift of control functions from the environment to the system. Niklas Luhmann (1984) provides an in-depth contribution by shifting the Autopoeisis –concept from biological to social systems: autopoeitic systems operate operationally closed, and the „primary objective of aotopoietic systems is always the continuation of the autopoiesis, with no consideration for the environment“ (Luhmann 1986, 38). If each external intervention is processed by the respective system only in view of its operational closedness, this will bounce off all measures that are committed/related to different system logic. This is why self-referential system composition results in an „abandonment of the idea of unilateral control“ (Luhmann 1984, 63).

These theoretic considerations are included in the diagnosis of operational closedness of highly differentiated societal //social systems of function, which is why //wherefore local interventions may lead to over-steering there. The modus of operation of the system-specific code is oriented towards improving performance, and due to its operational closedness may only be suppressed, but not influenced. The result may be a retraction of functional differentiation (as was the case in socialist states). In case of understeering, however, society fails to achieve a consensus, it „drifts“ (Willke 1993, 217, Etzioni 1968, 119, 466f). In order to avoid both under- and over-steering, a balanced ratio of control and consensus is required. In this case, Amitai Etzioni speaks of an active society; Willke calls it a context-controlled society. In other words, controlling functionally differentiated societies is therefore all about identifying the gap between under- and oversteering. (On the theoretic formulation of such a control corridor, Aulin 1986, 115). Decentralised context control and self-control of the subsystems are then not simply the steering poles. Context control and self-control are rather two sides of the same coin, as context control aims at mobilising a system’s powers of self-control//steering. This can succeed if the specific code of the subsystems is addressed. However, this does not yet provide any information on the control effects; these may at best be computable. The intervening agent may actually initiate processes; the effects are not within his control (Willke 1994, 52; 88-90). What is missing in this concept? The sketched concept of control is peculiarly non-temporal in its way of thinking. As constructivist socio cybernetics are mainly interested in the native, inherent logic of the respective system, social change processes do not receive a lot of attention: control problems arise from the cumulation of the subsystems’ inherent complexity, the emergence of lateral world-systems and the shifting of the time horizons into the future (Willke 1993, 265-268).

A principally open and viable future, time is viewed as an abstract background dimension, instead of finding consideration as a complexity-generating core of social systems. Still, it is worthwhile to consider constructivist sociocybernetics from a control-theoretical point of view. First of all, it does acknowledge that within the act of observation, the observer decisively influences the system, as the perception of social complexity is impinged by recursive, self-affecting processes. To a certain degree, complexity is therefore always a socially constructed reality[5].

And secondly, the emphasis of the inherent logic does suggest inclusion of a temporal perspective: social processes are subject to their own, inherent dynamics if they „move from within and without any external impact, thereby creating a characteristic pattern“ i.e. „if during the process the actors themselves create and amplify the motivations driving them“ (Mayntz/Nedelmann 1987, 648f). If the system states operate with themselves and develop eigenbehaviour (von Foerster 1988), complex systems therefore ?? their own reality with own

[5] Examples of this are provided by the practice of Systemic Therapy (Wiesner/Willutzki 1992). It views diagnostics not as an external access to the patient, but as part of the therapy (which the therapist as a part of the system merely kicks off). If this is so, the problem’s definition already contains options for its solution.

rules; actually, for coping with complexity, it is precisely these rules, which require identification in order to proceed.

3 Dual Control in Cybernetics IV

Until now, I have discussed the eigenlogic of systems from a structural point of view. The question was, how do boundaried systems function in relation to the environment, and what this entails for control. Now I would like to suggest a path, which is complementary to constructivist sociocybernetics, a path followed by sociocybernetics in the tradition of the General System Theory. Their cybernetic grounding is expressed by their choice of terminology as well as by their empirical-pragmatic approach. When Cybernetics IV addresses the topic of coping with complexity, they do not speak of steering, but of control. The objective is the congruence of explanation, prognosis and control model with the primacy of the control theory (Bühl 1990, 135-144).

For this, it does not focus on addressing a dominant code of the system to be controlled, but rather on the interaction between dynamics (Bühl 1990) and control processes (Busch/Busch 1981; 1984), which concurrently are at play within a given system. The assumption behind this approach is that through destabilisation processes complex systems keep moving back to so-called bifurcation points. At these points, or better, in these states the system is forced to choose between two branches to continue along (Taylor 1987; Bühl 1990, 126f). Controlling actors need to primarily observe the correct moment for interventions – as the most promising moments for interventions seem to be the bifurcation points (However, within Cybernetics IV, this theory has not yet been systematically elaborated, but has only been metaphorically made plausible). In order to clarify the relation between balance and imbalance processes, and of change-sensitive and change-resistant parameters, sociocybernetics are step by step including characteristics of societal complexity into Norbert Wiener's technical cybernetics (Maruyama 1963; Taschdjian 1976; 1978; 1982; Busch 1979; Busch/Busch 1981; 1984; Bühl 1990). How does this happen?

Using the control cycle as the cybernetic model of a self-controlling system, cybernetics was sufficient to explain technical control cycles as special purpose-programmed systems: using a set-actual comparison, back-coupling is used to adapt the system to previously defined target functions, and in an identified mechanism of negative back-coupling periodic fluctuations around a defined target state and adjustments of deviations always lead back to a state of balance.

The system elements may be multiply (hierarchically) interconnected, but do not behave predictably and time-dependant. The paradigm of negative feedback is therefore based on "punishment" , the conservation of the previous state. By contrast, in social situations, rewards ("positive reinforcements") play a much more important role: deviations lead to new system states, which is why Magoroh Maruyama (1963) introduced the mechanism of positive back-coupling (morphogenesis) into "Cybernetics II): „In t he light of the deviation-amplifying mutual causal process, the law of causality is now revised to state that similar conditions may result in dissimilar products."

On this level, systems have already ceased to behave in a linear and reversible way, but still move within a limited repertoire of behaviour. Only if negative and positive back coupling also happen concurrently, do system theoreticians speak of Cybernetics III. Systems are then equipped with a control system capable of processing symbols, not only signals, on the basis of which they are able to formulate their own goals (Busch 1979; Busch/Busch 1981) and to behave time-dependently: each decision made is an act of discontinuity, which first of all does away with other options and secondly is executed within a specific time horizon (Taschdjian 1978, 178; 1982, 12). The analysis of time-dependent systems is therefore no longer concerned with the system state to be examined, but with a series of different states at various points in time.

On the third level of cybernetics, it is still possible to assign the status of a goal-formulating control centre to the brain. However, if individual target objectives are in conflict with, complement or cancel out each other, the necessity for a super-individual, societal coordination in shape of conventions, norms, laws etc –of control arises. Cybernetics IV therefore expands the three cybernetics by society as an additional dimension (Busch 1979; Busch/Busch 1981; 1984; Bühl 1990, 12-14). If such a steering process is coupled with a consensus, the aspects of motivation, voluntariness and of self-steering move to the foreground: "If control is increased without increasing consensus-building, we expect a greater reliance on force." (Etzioni 1968, 482; also compare Beniger 1978, 24-26).

In the heterarchically connected, emergent, non-linear and irreversible and therefore highly complex Cybernetics IV-systems, steering processes are negotiated in shape of consensus and conflicts, which replace restrictive control. Precondition is the identification of the control vector, which converts from one system state to another, or is at least able to approximate it[6]..

The identified system states may be based on dynamics as diverse as cycles, catastrophes, fluctuations, but also balancing processes. If within context steering the wilfulness of the systems to be steered is in the foreground, Cybernetics IV emphasizes the time dependence of interventions. This circumstance is to be accommodated by the concept of dual control (Bühl 1989, 29): Target states are not predetermined from the very beginning on, but only arise by and by while the system acts and reacts. They are relative to the starting point and are changeable (Bühl 1990, 47). Practitioners gain their information on the system's behaviour only by conducting control tests. They therefore need to be more patient in planning, and need to leave ample time to their interventions for them to unfold their full effects. They are also required to again and again reconsider their original steering target. So instead of attempting to implement pre-defined plans and programmes true to the original, it is much more appropriate to maintain the system's capacity for interaction between over- and understeering.

In this sense, steering is something that "goes along with" the system: a good steerswoman or steersman determines the steering target, structurally, functionally and dynamically describes the system to be steered, reassess the steering target, differentiates between steerable and non-steerable areas, reconnects these results with the steering target, adapts the steering measures to the complexity characteristics of the system to be steered (a decision to be made problem-specifically) and controls this process. Such a cybernetic model of self-regulation for handling complexity operates recursively, as ongoing action and evaluation (monitoring) (Sirgy 1990; Flood/Carson 1993, 97-131; Ulricht/Probst 1990, 114-220).

So what does sociocybernetics actually gain from the confrontation between the two antagonists? First of all, it defines handling of complexity as an infinite, and predominantly incremental process. As there is no optimal solution, the existing options are maximized and / or costs incurred by mistakes are minimised. This pragmatically motivated approach is commensurate with "as best is possible", and is also called "satisficing"(Perlstadt 1981).

The term allows for the idea, that mistakes are unavoidable, but may at least be reduced and their effects may be controlled. This cautious approach to steering is compatible with the concept of context steering, which rejects punctiform and direct interventions. The latter goes

[6] The connection between control object and subject is created by indirectly functioning, generalized control media, such as money, market, information, public opinion, etc. Examples for direct contol and steering instruments are ordinances, police interventions, taxes, etc (Bühl 1990, 180). The steering concept involved is an acteur-based one.

one step further, by refusing to provide any positively formulated development directions[7]. Here too, the intention is to avoid undesirable developments, in as far as this is possible. Still, both schools of thought have deficits. Constructivist context steering kicks off eigen-logics and facilitates them; however, it lacks the temporal positioning of system behaviour. This gap is filled by "dually controlling" Cybernetics IV". It focuses its attention on breaks and transitions in the dynamic, initiates them and/or accompanies them, but does not provide any theoretically-justified criteria for its diagnosis. Beyond, its consideration of the closedness of eigenlogics in its steering concept of dual control is insufficient. But still: context steering and dual control are mainly derived from the insight that in handling complexity complete and total knowledge is impossible, and that there needs to be constant feedback between reality and its modelling[8]. In spite of its macro-sociological origin socio-cybernetic models are also suitable for handling complexity on a meso-level. Even more: this is what renders complementarity even more visible. As a conclusion, I would like to exemplify this by an example, for which I have chosen the development and the application of software in organisations.

4 On the Integration of Perspectives

System logics and system dynamics – these are the respective pivotal points of the two socio-cybernetic perspectives. But only in an integrated perspective do they prevent misconceptions concerning the steerability of socio-technical systems. To illustrate this point: the development and the application of software are mostly planned as a sequential, directly steerable succession of phases – a complete misapprehension. A famous and well-documented example of such a misunderstanding is the configuration programme XCON by the computer manufacturer DEC. In spite of its "successful" technical realisation it generated massive consequential organisational problems[9].

From a system-theoretic point of view, this career is extremely instructive. To begin with, in development and application there are several overlapping phases, which are not coupled sequentially, but recursively. The theoretic framework for this is provided by Cybernetics IV. Secondly, software projects often suffer from collisions of the logics from differently institutionalised reputation systems (scientific research laboratory, industrial R+D departments, operation application departments) with a variety of actors (computer scientists, engineers, users) (Degele 1996). From the point of view of constructivist sociocybernetics, all of these systems operate based on their own, system-specific code, which are not able to irritate the other subsystems. I would like to include a short presentation of these arguments:

Let me begin with a few remarks on the operational closedness of the subsystems. To software-engineers, functional efficiency is predominant – a programme needs to work. System-theoretically, the code governing R+D-processes is innovation: "The symbiotic mechanism eventually shows in the functional artefacts." (translated by S.R.)

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[7] This is the credo of systemic consulatation of organisations. here, an intervention is already expressive of a different perspective (König/Volmer 1994, 39-43; Willke 1994, 205; Wimmer 1992, 67-70).

[8] In such an incremental procedure//approach the process of modeling can become more important than the model itself – this is something even „hard“//“hard-core“ (in the sense of formalising) system theoretics of „System Dynamics“ (Dash 1994) have documented as the result of 30 years of experience with simulation.

[9] After programming was finalised, it took three years until XCON showed the precentage of correct results required for commercial application, which is 90-95%. After this had been achieved, the system was entirely intransparent. The company was forced to contract John McDermott, its developper from the Carnegie-Mellon-University, in order to conduct a complete re-implementation and maintenance measures. User-compatibility and fault tolerance replaced technical elegance and formal correctness as the decisive factors for success. This was something nobody had been able to foresee. The possible conclusion is: development and implementation of a programme such as XCON need to be handled as a complex problem, as in addition to technical factors, a host of economic, organisational and other factors enter mutual dependencies – and may quickly become incontrollable (Degele 1994, 15-23).

(Mambrey/Paetau/Tepper 1995, 153) The cognitive structure of engineering sciences is therefore dominated by efficiency. They have generated a language code, which is largely self-referenced, thereby contributing to maintaining their professional powers of definition and of design. “Technological terminologies are characterised by exactness, brevity and non-evaluativeness.” (translated by S.R.) (Mai 1994, 451; cf. Degele/Holzer 1996).

On the contrary, software users are interested in simple and robust problem solutions. Brevity and elegance of mathematical assertions of correctness or the originality of the programme’s design are of no consequence to them. However, users cannot simple use a programme. Unlike a toaster or an electric iron, software does not come with clearly defined user instructions or rules; these may not even exist. In order to sensibly use the programme, users need to actively appropriate it. In order to do so, they revert to their own store of experience, using this to derive more or less systematic routines and rules. As the modular, i.e. multifunctional configuration of information-technological artefacts offers users the opportunity to use the system in a totally different way than was originally intended by the contractor and the developer (and the way it is usually done), management’s and development’s control options are limited.

What about the second argument, the phase-specific localisation of the different logics? If the development and implementation of technology is not viewed as the product of a targeted, and thereby controlled process, but as the result of an antagonism of various mechanisation processes, then actors with specific visions of mechanisation assert themselves either in cooperation or in competition with the other actors, in various phases of the technological development.

This is what technology genesis research focuses on[10]. System-theoretically reformulated, it traces the development and the application of technology as a multi-tiered selection process, which is characterised by intersections between scientific, engineering and user logics (Rammert 1992, 18). For an analysis of the development and application processes, such an amendment of system-specific codes by the dimension of time is definitely useful: the pressure exerted on the user, to appropriate software, generates new knowledge, new practice and regulations, and a new (operational) reality. Management, which normally kicked off these processes –usually without intending to do so-, may use this to develop new systems or to enhance existing programmes.

In this case, the creative appropriation of technology by the user flows back into the development of new systems or the improvement of old one, thereby becoming recursive (Degele 1997). Whether this actually happens, is not predictable; success is not guaranteed. This is why managers and software developers often view software-use deviating from the “prescribed” application as failed projects. However, if one views software development as a recursive, and not as a sequential process, the socio-cybernetic punch-line is the fact that such a process cannot be controlled directly, but can only be initiated and facilitated (Willke 1994, 41), and that at different points in time such facilitation needs to take into consideration the various, variously effective system logics. For example, the question as to the scope of user-participation in software development is much less relevant that the question as when user-participation takes place. If, for example, user participation sets in with the formulation of the catalogue of requirements, the wrong course has already been set (Weltz/Ortmann 1992, 76).

[10] At the Wissenschaftszentrum Berlin several case studies were conducted on the generating and the introduction of the mechanic typewriter (Knie/Buhr/Hass 1992), the combustion engine (Knie 1991) and the Internet as cultural realm//sphere (Helmers 1994).

Conclusion

In a dynamic control perspective, software development and application appears to be a process within which the different systemlogics do not only collide, but also link up. If steering interventions fail, then the systemic dynamics of software projects are not the only factor to blame. An aspect dual control theorists tend to neglect (because they reject its assumption of operational closedness) is the importance of the momentum of (socio-technical) subsystems (Bühl 1987, 245). The conclusion to be drawn is: one strand of cybernetics needs to learn from the others, as steering of complex systems (indirectly) starts with the context, instead of directly in the system.

The awareness for this is improved by constructivist sociocybernetics. And Cybernetics IV emphasises the fact that this process is iterative (repetitive) instead of sequential (successive efforts), and that it operates on a long- rather than a short term basis. It further underlines the necessity of a long-term perspective, as interventions on a context-level only rarely show immediate and visible effects. It is the system itself, which decides whether and in which way to react on interventions, to translate them into its own logic or to ignore them (which is the focus of constructivist cybernetics). All of this takes time. This is why the “realistic control theory” of Cybernetics IV is concerned with describing the time-dependency of systemic behaviour, or more precisely “recording end explaining the phase transitions between balancing processes and imbalance processes, and to record their respective basic conditions and progressions, as well as the subsequent dynamics.” (Bühl 1990, 144). (translated by S.R.) .

A constructivist control theory sets its hopes in “grabbing” the system at its own logic heel. However, an integration of system logics, action orientations and system dynamics seems advisable, also from the perspective of the disciplines. More recent techno-sociological papers bemoan the circumstance that the practice of delineation of product development phases, which has so far been in use in social sciences, has failed when it comes to examining software projects: a process of de-differentiation takes place not only between development and application, but also between technology and organisation. Product and process innovation may no longer be differentiated, micro and macro level dissolve into inner- and inter-operational networks (Verbund sozialwissenschaftlicher Forschung 1995; Kubicek/Seeger 1994).

All of this clearly advocates a level-, phase- and sub-system-comprehensive perspective and integration. The current state of socio-cybernetic theory-formation offers good conditions for this. Within both cybernetics, there is agreement that steering already represents the design of institutional basic framework conditions. While practicioners consider the major problem to be that within complex systems they can no longer identify a control centre on which to focus, constructivist sociocybernetics view this as an excellent opportunity: the autonomy of the interconnected parts renders central steering superfluous; system elements become stronger and the entire system more adaptable. Instead of improving steering capacities from top-down, they promote bottom-up steering ability. The necessity for external intervention decreases as the system’s self-regulatory capacity increases (Aulin 1986). Viewed in this context, if steering of socio-technological systems relies on the evolvement of recursive and eigen-dynamic processes, instead of sequential processes, and if steering is merely able to positively or negatively influence institutional framework-conditions (Rammert 1995, 103), then context steering and dual control on an institutional level promote the creation of a deviation-tolerant environment. This may entail the inclusion of redefinitions in software solutions, by users, into the development (Schlese 1995, 361f); it may entail built-in functional redundancies in technical systems, so that occurring faults may be handled (Perrow 1989, 392-400), or that system components spread on various levels are loosely interconnected and appropriate communication relationships are installed (Bühl 1990, 16, 38).

On a techno-political level, this would support the abolishment of technical monocultures (Rammert 1993, 61f). And there is one final conclusion to be drawn: for cases such as those outlined here, sociocybernetics offer the suitable tools for the formulation of the problem. The problem's solution needs to come from the system itself.

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Prof. Dr. Nina Degele, Albrecht-Ludwigs-Universität Freiburg, Institut für Soziologie
Nina.Degele@soziologie.uni-freiburg.de