The sociotechnical systems approach: A critical evaluation

A. H. VAN DER ZWAAN*

In this article first a very brief overview is given of the main sociotechnical concepts and authors. This is followed by a rather critical examination of this approach, viz. from a methodological and a system theoretical standpoint. After that some suggestions are given for an improvement in sociotechnical thinking, that might be fruitful with respect to the development of a theory.

Introduction

The concept of sociotechnical systems has for the last 20 years aroused great interest in organization theorists and organization consultants, after being introduced and promoted chiefly by the Tavistock Institute. This is not without good reason, because on the one hand this mode of thinking resists the 'machine theory' (Davis 1966, 1971) of the Taylorian scientific management school, and on the other hand the one-sidedness of the human relations movement; the former treats the organization only from a purely mechanistic viewpoint whilst the latter thinks the technical equipment and the nature of the work hardly worthy of attention. Another objection, raised by the sociotechnical approach, to both the above movements is their relatively closed approach to the organization. It is, therefore, difficult to deny that the open-systems approach, in which technical as well as social aspects of the organization are recognized, offers a sound starting-point for studying and (re)designing production organizations.

This, however, does not do away with the fact that this approach, which is, in principle, attractive, suffers a number of drawbacks worth mentioning. In fact, a critical consideration of the publications from this school leaves the impression that most of its followers are held so spellbound by these starting-points, which are undoubtedly worthy of consideration, that they overlook a number of theoretical and methodological weak points and misstatements. The objective of this article is to give a survey of these weaknesses. It will consist of three parts: the first will give a concise summary of the most used concepts and sociotechnical rules; the second enters at length into the theoretical gaps and logical mistakes; and, in the third part, it is pointed out how one might (or should) proceed to furnish a more justifiable theoretical contribution.

Sociotechnical views

An industry or organization is regarded as a system, i.e. as an entity of interdependent elements or factors. This, however, is not the characteristic

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* University of Technology Eindhoven, Faculty of Industrial Engineering, Department of Sociotechnics, The Netherlands.
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feature of this approach; in fact, the supposed and established openness of this kind of system is the new and the specific point. The organization is seen as interacting with its environment, in other words, there are mutual influences between system and environment (see, for example, Van Beinum et al. 1968, Brown 1967, Emery and Trist 1960, 1965, Thorsrud 1966, Allegro 1970). This extremely rough supposition is sometimes authorized by referring to von Bertalanffy (1950). Now openness (Emery 1969) as a characteristic feature involves the dynamic character of the system; for in a changing environment it will have to assume a continually different structure (Emery and Trist 1965, Davis 1970 and 1971). Therefore, the boundary conditions, in which the actual exchanging process takes place, are of the greatest importance to the system (Brown 1967, Miller and Rice 1967, Van Beinum et al. 1968, Emery 1969). Via the system boundaries information and goods are, indeed, continually exchanged with the environment (other systems). Consequently, an important part of directing or controlling a social system is the 'guarding' of this boundary traffic, or 'boundary control' (Rice 1958, Emery and Trist 1960).

An important but little elaborated concept in this connection is steady state. The abstract definition of this is: that form of mutual dependence between system and environment that guarantees that the potential energy to reach a goal is utilized to its maximum, despite changes in the environment (Emery 1969, Van Beinum et al. 1968). If in a changing situation (system and/or environment) these forces change with respect to nature and intensity, a situation of quasi-equilibrium can yet exist (Emery 1960). In this connection, the concept equifinality, likewise borrowed from Bertalanffy, is sometimes used, which means to sociotechnical theorists that one 'steady state' or 'primary task' (Rice 1958) is realized from various initial conditions and/or various (internal) processes (Emery and Trist 1960, Brown 1967).

The way in which these central concepts were treated is perhaps unsatisfactory, for the treatment is too concise and too vague. On the other hand, however, a more explicit elaboration of them would deviate from the relevant literature, since in it one also looks in vain for further elucidation. The same applies to the following theoretical aspect, viz. the meanings of the social and technical (sub)system and the relations between them. Many people are repeatedly putting forward the view that a great merit of the Tavistock work is the simultaneous analysis and a (more or less) equivalent treatment of the technical as well as the social subsystem and the study of the interrelations between them. It is stated that both systems show their own regularities and make their own demands, but that they are jointly coherent and affect each other. In the words of Emery (1966) they are "independent but correlative systems". The two subsystems should complement each other (Jordan 1963, Brown 1967, Cooper and Foster 1971, Allegro 1971, Van Beinum et al. 1968); in other words, when designing the two subsystems a joint optimization should be aimed at (Emery 1959, 1962, 1966, Davies 1971, Hill 1971). This can be realized because both the social and technical subsystems are considered to possess a certain amount of flexibility. In the technical sub-system slight modifications sometimes appear to be feasible, but the social subsystem, too, can be organized in all kinds of ways (Van der Vlist 1971). There is no technological imperative (Davis 1971), but there is a certain
amount of 'organizational choice' (Trist et al. 1963). This properly implies
that more forms of technical layout and also of social organization are always
imaginable from which an optimal combination may be chosen. Therefore,
all kinds of problems relating to productivity, motivation and the like are—
according to this reasoning—consequent upon a non-optimal combination of
a particular technical and a particular social design.

From the latter statements it already appears that this sociotechnical
model can be used not only for the purpose of analysis, but also for that of the
design of production systems (Emery 1972, Van Beinnum et al. 1968, Van der
Vlist 1970, Davis 1971, Emery et al. 1970). This, however, does not mean
that the sociotechnical model of analysis has been elaborated very clearly.
In so far as it has been elaborated, however, it can only be deduced to a
certain extent from the research actually carried out and from the literature
which presents itself as sociotechnical (see the following section). However,
a good manual for sociotechnical research workers has never appeared. Things
are different, however, with respect to the design element. Here, the sociote-
technical model has been developed considerably, in particular as regards the
social system. Concerning the latter, to which attention is extensively given
in almost all sociotechnical literature, the following is to be observed.

The actual research work demonstrates strong engagement with the
quality of the worker's job, with his job satisfaction and his alienation, in
conformity with the Human Relations philosophy. However, on the other
hand, the consultant-research worker is also thoroughly concerned about
management problems of productivity and efficiency. It is well known that
management usually demonstrates a very close concern with productivity,
especially at the lowest production level. The interesting part, now, is that
the sociotechnical researcher discovers a relation between the problems of
these two parties. He discovers, for instance, relations between the degree
of job satisfaction and the productivity level of workmen and small work-
groups. Hereabout the reasoning is as follows: There are a number of
human needs with respect to the work that are more or less general for people
and these needs can be deduced somewhat from psychological research. These
are the needs of social contact, recognition, and responsibility to make decisions,
of safety, of possibilities of getting on in life and of extending one's knowledge,
of meaningful work, and so on. If in the working conditions no provision
has been made respecting these needs, alienation will arise (Foster 1968) and
motivation and satisfaction will fall, usually with consequencies for produc-
tivity.

These given human needs require adapted tasks which exhibit the following
characteristics: they should offer optimum variation, they should be experi-
enced as meaningful, require a certain level of training and skill, offer responsi-
bility and a span of discretion and provide feedback on results. For group
tasks the requirements are: internal flexibility, a possibility of collective
control and decisions, of mutual help, of surveyability of the group task, etc.
From this it follows that leadership should be more distributed and more
delegated (Davis 1971, Allegro 1971); and this is one of the reasons why,
for instance, job design and work structuring are more or less parallel phe-
omena (Davis and Werling 1960, Davis 1966, Emery 1962, 1966, Willems 1969,
Kilbridge 1965, Van Vlist 1970). In short, more autonomy for the individual

The sociotechnical design model states, therefore, that technology must be so constructed that within it tasks (a part of the technical subsystem!) can be created that satisfy the above needs of working people (social subsystem). It is this ideal that was aimed at in the classical sociotechnical research and consultancy (Rice 1958, Trist et al. 1963, Herbst 1962, Jaques 1951).

Theoretical and methodological objections

One of the most important items of criticism that may be put forward refers to the impressive absence of definitions with respect to the greater part of the concepts handled. Proper definitions are doubtless a necessary condition for any theoretical construction, but in this case the consequences of this lack for the theory are probably even more serious than normally, because many very difficult system-theoretical concepts are concerned here. It is exactly the degree of difficulty of systems theory that demands even sharper definitions of quasi-stationary equilibrium, complementarity of subsystems, system boundaries, boundary control, self-regulation, and the like. This negligence, which excludes any consistent operationalization regarding the functioning organization, is, therefore, the main cause of the fact that it is never possible to indicate what is meant exactly by 'joint optimization', 'whole task', 'sentient and task system', 'autonomous group', 'organizational choice', and that, further, it is impossible to draw strict lines of demarcation between system and environment and between social and technical subsystems. Additionally it is, in fact, always difficult to distinguish between the analytical model and the action model (Van der Zwaan 1970). The theoretical model might show more coherence, if an effort was made to define and to interpret the system concepts (cf. Emery and Ackoff 1972, de Sitter 1974, Van der Zwaan 1972 and Van der Zwaan and Houben 1971, Van der Zwaan 1973). Only then is it possible to formulate operational hypotheses and to verify the theory. Only Emery (1959) admits this somewhat.

The second item refers to the system-environment relation. It is one of the intentions of the sociotechnical systems approach to furnish a theoretical contribution regarding the mutual influence between the organizational system as such and the environment. It is not without reason that the openness of the system is emphasized again and again. Particularly, concepts such as equifinality and system equilibrium raise great expectations in this direction. However, a study of the literature reveals that theoretically as well as
empirically little has been achieved in this respect (Van der Vlist 1970). No definition has been given of what is the environment relevant to the system (Silverman 1970), no attention has been given to structural factors of the system (Brown 1967, Peper 1971), and hardly has an attempt been made to describe the interaction processes between both. Only one exception to this has to be made, viz. for a theoretical start by Emery and Trist (1965), in which a rough typology of environments and the corresponding forms of behaviour of the organization are set up. To some extent and very partially this exception also holds good for Miller and Rice (1967). The remarkable thing here is also that regarding the system-environment relation, reference is sometimes made to Ashby's law of requisite "variety" (1965), for instance, by Cooper and Foster (1971) and Davis (1971), but that from it no conclusion for a theory is drawn at all. The most striking point, however, is that despite the lip-service to the openness of the system, one rather often seems to fall into precisely a closed system's approach (Peper 1971, Van der Zwaan 1970). This is because the greater part of the cultural influences on the industry as such are neglected owing to the unilateral emphasis laid on restructuring of work. In this case we mean that changes in the conditions and processes of exchange with the institutional environment, including the markets are rarely considered, as well as changes in the sphere of needs of the participants individually. These forces and changes are not being noticed or considered relevant. This refers in a high degree to what are called human needs. For example, an instrumental or a wage orientation (Goldthorpe et al. 1968) with respect to the work is, strictly speaking, not tolerated within sociotechnical thinking. Therefore, it is evident that in this way the dynamic character of the system's behaviour disappears proportionally from the analysis as more violence is done to the openess of the system.

A third aspect to which our criticism is directed is the assumed distinguishability and equivalence of the social and technical subsystem. As has been observed above, as long as no adequate conceptual and operational definitions of system, subsystem and partial system are available, it is impossible to differentiate these concepts. The best proof of this is by pointing to the ambivalent position of the concept of task. Although task structuring may be regarded as one of the central sociotechnical activities, it is obscure, particularly with respect to the concept 'task', whether it falls under the technical or the social subsystem. When reading any sociotechnical research report in which there is almost always a conversion of a collection of individual tasks into a group task answering the demands referred to above, one wonders whether this change has a social or a technical character or a combination of both. And, furthermore, in this last case it is impossible to decide which aspects of the changes in the task are technical and which social. The same applies to a series of other subjects, such as information and communication, abilities and skills of people. In an attempt to draw a somewhat plausible boundary line it appears that no objection at all can be raised to an ever widening displacement of that line in favour of the technical subsystem. Not a single reason can be put forward why for instance, the human activities and even factors like motivation and leadership cannot or must not be regarded as technical components. It is remarkable that even in the best examples of sociotechnical investigation, for example, Van Beinum et al. (1968) Van
der Vlist (1970), Kastelein (1970) and Allegro (1973), any discussion in this field is avoided. On the contrary, on all hands the primitive notion is met with that all features of 'hardware' belong to the technical subsystem, and all characteristics of people and their interrelations to the social subsystem. However it can be said of hardware (Van der Zwaan 1972) that it can mean either:

(a) the loose collection of machines, apparatus, and the like, i.e. the set of elements without defined relations; or

(b) the already structured collection of these, i.e. the concrete lay-out with specified geographical and functional relations.

As for the first possibility, it should be observed that the author cannot see how a loose collection (of machines) can be related to a social subsystem, since a collection of detached things cannot be considered a subsystem. Consequently, this possibility is dropped owing to system-theoretical inconsistency.

As regards the second possibility it should be emphasized that the structure realized between the hardware elements is based on a number of normative, but yet social criteria; and this not only concerning task criteria, but also with respect to social standards like productivity and efficiency. The layout of the apparatus is ultimately related to and dependent upon a number of (implicit) assumptions about human behaviour and on a number of (implicit) social standards for the (desired) behaviour of the organization. And within that system of social standards and assumptions the nature, function and place of so-called technical means of help are defined. An organizational system is primarily a social system. This means that the so-called technical subsystem actually is a derivative from the social system. In any case and in other words it means that it may not be treated as a subsystem and not on the same level as the social system; these two are not equivalent (Pepper 1971, Van der Zwaan 1973). Yet this suggestion is implied in the whole sociotechnical research work and literature, that is to say their equivalence in an analytical respect. With regard to the sociotechnical design model and action research two contrary opinions can be heard (Kuipers 1972). One states that sociotechnical action is a clear demonstration of engagement with the workers' problems (social orientation). On the other side, followers of this approach are also accused of attempts to introduce some kind of sophisticated scientific management (technical orientation).

With regard to the analytical model, however, in our opinion, there is non-equivalence in favour of the social system. This leads to the conclusion that optimization of an existing organization concerns primarily social variables, although in this view, too, an organization can be regarded as a 'technological' product (Ferrow 1965, Thompson 1967). Optimization, therefore, means a change, in a favourable sense, of the interrelations:

(1) within the system of preference with respect to goals and/or functions of the organization, adhered to by members of the organization or relevant outsiders (this is a social datum); or

(2) within the system of coordinates of handling activities of the members or parts of the organization, and hence of views regarding the more or less instrumental or functional values of the behaviour of handling (these are social data); or

(3) between (1) and (2).
In any case the layout and nature of the technical equipment will have been derived from these above changes; for the characteristics of the technical equipment have to be regarded as attributes of people, constraining or facilitating their behavioural variability.

From a system-theoretical point of view this means that only people may be regarded as the elements of an (organizational) system. For organizations are designed and maintained by men, and people are the bearers of value preferences and the bearers of assumptions regarding the instrumentality of structures and actions with respect to goals, but also the users of machines and skills. All these qualities are attributes of men. Next, starting from the fact that relations between elements are brought about via element attributes, it must be stated that all sorts of hardware have to be treated as attributes of men and not as a partial or a subsystem.

Just a few more words on the ethic equivalence. Maintaining for convenience the difference between social and technical subsystem for a moment, it might be stated that rather frequently strong emphasis is laid on a high quality and value of human labour. Moreover, it is suggested that for this purpose the rigidity of the technical subsystem need not be an obstacle because the latter is very flexible. However, on the other hand, it is seen that in many cases of mechanization and automation the technological development continues to operate so autonomously that it compels the adaptation of people to the technological development rather than the reverse (Van Zuthem et al. 1971).

This implies that ultimately, with many reorganizations people do not enjoy the greater priority, but technology does. In this way, sociotechnical action-research omits to prove that indeed the technical equipment is flexible; but, besides, it properly shows a very great rigidity, particularly with regard to organizational theory. In this approach, too, there is a lack of creative thinking about and experimenting with forms of organization.

One has given too little attention to existing values of working people on the one hand, and one was not able to get rid sufficiently of classical organizational ideologies. Organizational problems were tackled only superficially.

Closely connected with the above is the following and fourth objection. The serious incompleteness or lack of the analysis of norms, values and structures with regard to the social system. The too little sociological way of thinking degrades the so-called social system to a purely psychological system (‘psychotechnic’ according to Cooper and Foster 1971). The sociotechnical engineers have occupied themselves almost exclusively with psychological needs and their correspondence with the individual and minor-group tasks. This form of reductionism of the social system is very conspicuous (Brown 1967, Silverman 1970, Peper 1971, Van der Zwaan 1970). It discloses not only the relationship with the human relations movement, but also with that of psycho-analysis; this is even mentioned by Trist et al. (1963), Rice (1958), Miller and Rice (1967), Brown (1967). Our objections, briefly, are:

1. Too many values, norms, relations and their structures within the system have been neglected; thus it is impossible to maintain the pretence of an adequate analysis of the social system.

2. The ever recurring ‘psychological needs’ are conceived too normatively, in a much too generalized way, and too statically. That even the blue
collar population shows no generally applicable pattern of needs has appeared only too clearly from a lot of research (Turner and Lawrence 1965, Hulin and Blood 1968, Goldthorpe 1968); and that needs may change does not sound new either (Berting and de Sitter 1971, van Delden 1972). The consequence is that workstructuring and job enlargement are remedies that are not applicable to everybody in all places and at all times (Emery et al. 1966, Willems 1969). And further, a lot of empirical research has to be carried out to test all these hypotheses. We refer to Hackman and Lawler (1971) and Sorensen (1971) as good examples.

(3) From the preceding two points it may be concluded that it is indeed not to be wondered at that the sociotechnical engineers have moved on an elementary (in the systems theoretical sense) level of analysis as regards the organizational design, viz. only on the level of the ‘shop floor’, where work is done by very small groups and where small tasks are set (according to Rice (1958) effectiveness is highest when work is done by 6 to 12 persons per group). This, too, is comparable with the Hawthorne approach (Silverman 1970). Only some recent developments deviate from this trend (Hill 1971, Emery and Thorsrud 1969), i.e. from the analysis of the elementary level.

(4) In applying these approaches one has forgotten to investigate what are the conditions and influences of the more embracing structures with respect to these small groups; and in the same way it has been omitted (Allegro 1973) to trace the influences of workstructuring within small groups on the rest of the larger system (de Sitter and Waltz 1971). Hence, a rather isolated approach.

From the latter two items follows another gap in the sociotechnical mode of working. Although changes in organizations have been carried out and encouraged on a large scale, no theoretical contribution on planned change has resulted (Brown 1967, Silverman 1970). An exception has to be made for Foster (1972). For the rest, all has remained in the sphere of separate case studies without any start whatever to compare results and to evaluate strategies of change. A major cause is doubtless the consultant’s role which in most action-research work prevented accurate scientific verification. This has set its mark deeply on the work, not only in the sense that all sociotechnical work is clearly a form of action research, but also in the sense of the shortcomings under which it labours. Consulting work is apt to hinder exhaustive theoretical contemplations and therefore leaves more possibilities open for ideological viewpoints, emotional identification and uncontrolled engagement. In this case the consequence is the ease with which not too intricate assumptions of needs, non-defined concepts and poorly formulated hypotheses are dealt with.

There is, however, a fifth problem, ensuing logically from the foregoing, viz. that of research methodology. True, in almost every report on research a somewhat theoretical introduction is to be found, and often a fair amount of numerical data is presented to ‘prove’ or at least to support one’s statements. This does, however, not do away with the fact that the methodological demands normally made upon research work have often become neglected.
Generally, a theoretical model is lacking in which the variables (e.g. independent, dependent, intermediary ones) are arranged with the aid of specified relations. Adequate operationalizations of the abstract concepts are lacking for the most part, and so are well formulated hypotheses. This is rightly opposed by Van der Vlist (1970), and by Van Beinum et al. (1968), Allegro (1973) to some extent, and they make an attempt, successful in many respects, to escape these diseases. The usual procedure is, however, that from the background philosophy (already known), changes are started in task structures of work groups. After some time some measurements are made, with rather arbitrary measuring instruments it seems, of productivity or efficiency, of absence or turnover, or in the most favourable cases, of job satisfaction and motivation. The measuring results often show a trend considered positive, from which it is concluded that the 'theory' has been verified (see Van der Zwaan 1970, 1971). Our objection is that measurements are too arbitrary; in other words, operationalizations of particular relevant concepts are often too narrow or clearly absent, and often too many concepts are indicated by one operational variable. An example of the first-mentioned defect is that concepts like self-regulation, participation, discretion, surveyability are hardly or not translated into observable categories. Referring to the second imperfection, an example is that from an arbitrary measurement of satisfaction conclusions are made about motivation and autonomy; and from a measure of productivity about measures of flexibility and level of the 'steady state'. Further, the possibility of Hawthorne effects, which in this kind of research constitute a real danger, are rarely taken seriously. And, lastly, too little attention is given—other than in generally descriptive terms—to the process itself with respect to, for instance, processes of breakdowns, fluctuations in stocks, planning strategies, but also as regards changes in patterns of cooperation, processes of information and distribution of power. Precisely these categories are not only comparatively readily observable, but they also seem to be essential elements in sociotechnical system research, in spite of their actual omissions.

There are, of course, gradations of defects; and, for instance, projects, carried out by Van Beinum et al. (1968) and Emery et al. (1966) have to be considered to belong to the category of better justifiable research. Further, Herbst (1962) and Van der Vlist (1970) and Kastelain (1970), and Allegro (1973) for instance, show that it is possible to carry out accurate systematic analyses that meet a proportion of the objections stated above. However, they, too, present no solution to most of the theoretical deficiencies of the sociotechnical system 'theory'. To be capable of theory-testing research, attention will have to be paid to the very construction of theory. A very good starting point in this respect has been given by Ackoff and Emery (1972).

This is however stimulated and, on the other hand, facilitated by the fact that the interest of organization theorists in system theory is growing fast and the possibility of usability is being seen more and more. At any rate, the sociotechnical approach has, among others this merit, that it has also produced this new point of view.

A painstaking systems approach

As stated above, there can be no question of a theory when a number of reports on action-research are only larded with abstract concepts such as open
system, equifinality, optimization, technical subsystem, and the like. This applies particularly to system theory, not only owing to the confusion of tongues already existing, but especially, and this will be coherent with it, owing to the high abstraction level of the conceptual apparatus. Therefore, in constructing a system theory which is applicable to organizations it is of importance that:

(a) from the start the most accurate possible definitions of all concepts involved should be given;
(b) a consistent use of such concepts should be scrupulously maintained;
(c) the axioms forming the starting point for theory construction should be explicit;
(d) it should be clearly indicated what empirical indices are used to make theoretical concepts operational;
(e) finally, a theory should be formulated, i.e. a number of hypotheses that are logically interrelated because they are derived from one collection of basic axioms.

It is clear that these are no new principles for theory construction; however in socio-technical research these conditions are poorly met. To give an impression of how a sociotechnical theory should be developed, a concise exposition with reference to the above points is given here. As regards a synopsis of definitions of system, surroundings, element, subsystem, relation, structure, etc., and also to get an impression of the necessity for strict definitions, reference is made, for example, to Hall and Fagen (1956), Miller (1971), Ackoff (1971).

For the description and analysis of social systems, however, all system-theoretical definitions cannot be used without further interpretation. For social systems are entities setting goals and thus regulating themselves more or less. They are systems that interpret their environment themselves (Luhmann 1964 and 1967) and attribute sense to their own activities with respect to their environment (Emery 1969, Ackoff 1971). They are purposeful systems (Ackoff and Emery 1972). A social system is, therefore, in continuous interaction with its surroundings, viz. by its inputs and outputs; these are interchanged with the environment in the form of information and goods in a continuous process. Our definitions of systems concepts are determined in a high degree by this exchange axiom of social systems. This appears from the following elaboration.

A social system is a collection of elements and their relations, regulated (controlled) by a set of functional norms. It functions within an environment and is continuously involved in exchange processes with the environment (open system). The environment of the social system is that collection of elements or systems and their interrelations not belonging to the system, but still influencing or influenced by the system. This interaction process takes place through inputs and outputs of information and goods. If, for instance, a small work group is the subject of study, the remainder of the embracing organization forms an important part of the environment of this social system. Further, it is a datum of experience that in studying parts of organizations, therefore, the boundaries of the system have to be established very well and observed consistently. This is of importance because the input
and output categories are dependent on, and therefore co-vary strongly with, the boundaries and are influenced by where they are drawn. Thus the input of demand from the market directed to an industry—for instance, a demand for a product—will in most cases be quite different in character and formulated differently from the 'same' input passed on to one of the production sections of that industry. In system-theoretical descriptions of social systems the temptation to unconsciously confuse system levels appears to be rather strong. As stated above, a social system consists of elements (for instance people) and/or subsystems (for instance groups, departments). They are the smaller 'black boxes' of which the system (at that moment the unit of analysis) is composed. When people are the system elements, they are, in conformity with the definition, in relation with each other, viz. via their attributes (characteristics). In a social system, however, the concept relation may not be adequately defined through any of its current meanings; in fact, for studying individuals the interaction or exchange model is valid, too. This means that they also produce, in a purposeful way, outputs between each other and are influenced by each other via inputs. This in turn has as a result that a relation between individuals within a social system should be defined as a change in (an influencing of) one or more attributes of individual X initiated by a change in one or more attributes of individual Y. Now a relation which is interpreted in terms of a process in this way, is called an operation. An operation or a chain of successive operations between elements establishes the connection of (an) input with (an) output, called transformation. A transformation, thus, is an output coupled to one or more inputs. The real connection of these two, however, is realized by operations within the system.

Now for a social system the following two points are valid.

1. One transformation can usually be effected along more than one (chain of) operation(s), dependent upon the kind of input combinations ('organizational choice', equifinality).

2. One (chain of) operation(s) can bring about more outputs or functions (multifunctionality of a social process).

The variety of transformations and operations in a system can be equalled to external and internal variability, respectively, for the definitions of which reference is made to Ashby (1956).

Finally, the concept of structure. The structure of the social system can be taken to be the collection of all alternative (chains of) operations, which, as far as the memory of the system and its operational norms allow, are available in the system. From them a choice can be made depending on the transformations to be carried out. This description robs this structure concept of the implication of 'durability of relations or operations', which in social science is often associated with it. It is attractive to consider the aspect durability only as a dimension of the concept structure, just as the size of the number of alternative operations can be represented as another dimension. The structure conceived in this way we would call technology. There is, however, also another definition of structure which, it is also true, deviates from the meaning current in the behavioural sciences, but which is
nevertheless plausible from the system-theoretical point of view, viz.: structure is the collection of all transformations controlled by corresponding transformational norms for which the system possesses a state of readiness. This latter definition thus refers to the external variability and the former to the internal variability. In this view the same reality thus is covered by three concepts, viz. technology = internal variability = operational structure.

Now that the concept technology has come up again there is some sense in again seeking a connection with sociotechnical thinking, starting from the definitions given. First of all then there is the question of how the term 'technical subsystem' has to be translated. It has already been said that in fact primarily social systems are concerned, which led to the conclusion that there is no longer a place for a technical subsystem, at least not in the meaning of a subcollection of elements. This implies that what is found in the way of technical equipment within a social system may not be described as a subsystem. It is better to qualify the technical equipment as follows. Machines and tools can be considered as attributes of elements and subsystems. And these, indeed, are relevant attributes because they enlarge or reduce, the operational variability of the system, dependent upon their design, layout, capacity, etc. To a large extent, however, the transformational variability is dependent upon the operational variability. Therefore, one can state that the enlarging and/or the reducing characteristics of the technical equipment (with respect to the operational variability) do have an important impact on the transformational possibilities of the system. In this way the technical equipment may influence the degree of the system's flexibility with respect to the environmental exchange relations. Further, a relation can also be found between the operational variability and concepts of self-regulation, autonomous groups and democratization, for, a large range of operational alternatives is a necessary condition for operational self-control or self-regulation. And besides, the effect of these both will be that a larger number of transformational criteria can be satisfied.

The above is an introduction to the following theoretical interpretation of the sociotechnical system research performed in the past. With the aid of what has been defined one might introduce as an axiom: the law of Ashby (1956), which says that variability of the environment or external (transformational) variability can be reduced only by a proportional and adequate amount of internal or operational variability; in other words, that a system can operate optimally only when variability in the input (including the system functions required or desired) is absorbed by this requisite amount of internal operational possibilities. It is evident that these matters have to be operationalized and formalized for concrete research work, but this is not a point now.

From this axiom it might be stated, that almost every classical sociotechnical investigation satisfies the following interpretation. Via a redesign a social system, which owing to the required transformational functions has too little operational variability at its disposal, is changed into a system in which the operational (internal) variability is enlarged. The consequence of this enlargement is that the system is capable of meeting the required functions better than before. In most investigations, at first a centrally controlled social system is found consisting of elements with different and mutually little
or nothing in the way of interchangeable tasks and, moreover, a more or less series
connected production process. The change usually is the switching over to a
system which might be called reciprocal and in which operational decisions, for
instance, those referring to task assignment, rest partly or in a major way with
the system elements themselves. This is the classical process of system change
in the sociotechnical tradition. Indeed, when evaluating the change situa-
tion, some functions such as greater job satisfaction, greater productivity and
the like appear to be the criteria for the improved transformational adapta-
tion.

However, generally it does not appear that this theoretical interpretation
is used for the explanation of the change process. And in the same way, 
generally it has not been checked empirically and exactly whether the new
interadaptation of internal and external variability has been brought about by:

(a) a change-over from a series connected to a parallel or reciprocal
connected production system;
(b) a change-over from a central control to a decentralized control with
an increased amount of discretion for the elements;
(c) a change-over from a low to a high interchangeability-rate of individuals
with regard to tasks;
(d) a change-over with respect to the technical equipment;
(e) some combination of these possibilities.

Detailed analyses of this kind are absent in the classical sociotechnical
approach. This lack is, furthermore, probably closely connected with the
theoretical vagueness and intuitions.

Sociotechnical system research, however, can have a future; but only if
the above mentioned conditions are met.

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Dans cet article on commence par faire un bref compte-rendu des principaux
auteurs et concepts socio-techniques. On fait ensuite une critique assez poussée
de cette méthode d’approche à savoir du point de vue de la méthodologie et de la
théorie des systèmes. On suggère enfin plusieurs changements dans la façon de
penser socio-technique qui pourraient faciliter le développement d’une théorie.

In diesem Bericht wird zunächst ein kurzer Überblick über die hauptsocio-
technischen Konzepte und Autoren gegeben. Dem folgt eine ziemlich kritische
Untersuchung dieser Betrachtungsweise, d. h. von einem methodologischen und
systemtheoretischen Standpunkt aus. Danach werden einige Anregungen angeführt
zur Förderung des soziotechnischen Denkens, das zur Entwicklung einer Theorie
von Nutzen sein kann.

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