An anthology of the socio-technical systems design (STSD) paradigm : from autonomous work groups to democratic dialogue and integral organizational renewal

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Manuscript

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Manuscript
Rough Draft
First Concept for a Monograph

This manuscript contains a broad outline of the history of the Socio-Technical Systems Design paradigm from 1951 up until the present time (1991). An effort is made to cover the wide range of ideas and elaborations in this field, using original papers and sources of different kinds. The author has expressly avoided to produce yet another review along established lines, but rather to give a personal and additional contribution to this subject area, which is based on the literature. The manuscript is a synthesis of more than 10 years of researching the paradigm by the author, and resulted from editing, compiling and expansion of earlier (unpublished) papers, discussions with colleagues and some field work in industry.
This monograph, designed as an anthology of Socio-Technical Systems Design, is not only specifying concepts, methods and projects, but is also explaining the epistemological and methodological foundations of the paradigm. And last but not least, sound and constructive criticism is presented, which is as much as possible corrected for pre-judgements or 'second source'-myths, and is solidly based on facts and analyses of the paradigm.

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Abstract

This monograph contains an anthology of the Socio-Technical Systems Design (STSD) paradigm, documenting the period from 1951 until 1991.

- As is put forward in *Chapter One*, this theoretical study embraces all forty years of development and expansion of the paradigm, from its semi-autonomous work group-based inception at Tavistock up to the present network-oriented Scandinavian Democratic Dialogue and the Dutch Approach towards Integral Organizational Renewal of the firm. The study is designed as a historic account. It presents a shaded picture, carefully reconstructed on the basis of the available literature, and where possible corrected for distortions caused by information from secondary sources.
- In *Chapter Two* a general outline of the STSD paradigm is given in terms of method(ology), content and phases of growth.
- *Chapter Three* documents four distinctive development trajectories, i.e. the Pioneering Phase, and the phases of Classical, Modern and Post-Modern Socio-Technical Systems Design. Placing emphasis on the highlights, these stages first of all are described as anecdotes. Moreover the development of methods and concepts is characterized by giving short descriptions.
- In *Chapter Four* the epistemological and methodological foundations of STSD come to the fore. Scientific-philosophical points of departure, systems methodology and model cycles, and some theories of concepts and process are discussed.
- In *Chapter Five* a phase-based impression is given of STSD projects as reported in the literature. The diffusion of the paradigm is illustrated both in terms of geography and in terms of company type.
- *Chapter Six* contains a critical evaluation of the STSD paradigm in terms of methodology, theory and practice. The critique itself is contrasted with some widespread pre-judgements and knowledge gaps which exist among authors using secondary sources.
- In *Chapter Seven* the future of the paradigm is discussed.
- *Chapter Eight* contains a (full) bibliography which has been produced by carefully cross-checking each reference as it resembles in the literature. It is designed as a main reference base of the STSD paradigm.

This theoretical study, which was also made possible through a contribution of the research stimulation programme TAO (Technology, Work and Organization), industrial sector, is dedicated to Eric Trist, the nestor of STSD. The author would like to extend special thanks to Fred Emery, Hans van Beinum, Friso den Hertog and Ulbo de Sitter for their useful suggestions and additions to earlier versions and variants of this monograph.

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Chapter One

Introduction

This study documents the Socio-Technical Systems Design (STSD) paradigm. A broad outline is given of the history of STSD that does justice to the wide range of ideas and elaborations in this field. For the author, not belonging to the first-generation of developers of the paradigm, this has not appeared a simple task. In order to succeed in such a delicate attempt, there had to be some striving for completeness. But because of the overwhelming amount of details, such an endeavor is of course doomed to failure. This has placed the author in some sort of a dilemma. Looking back at the development of the manuscript, the notion of a 'personal reconstruction' seems appropriate to characterize the way out of this delemma. The most relevant aspects of the history of STSD are reconstructed on the basis of the available literature. Because STSD has in fact always operated at the crossroads of different disciplines, attention is given to authors from various backgrounds. Issues regarding methodology and conceptualisation will receive particular attention. When considered important for a clearer understanding, the author will also refer to developments in science theory and systems theory. Whenever concepts regarding content and process are discussed, priority is given to the general idea rather than details, referring always however to specialised literature and giving a brief explanation of key concepts.

Thus, the accents placed provide a quite personal reconstruction of the development of STSD. An attempt is made to present a (further) introduction into the extensive and specialised area of STSD.

About the author: Dr. Frans M. van Eijnatten (40) is an associate professor (UHD) at the Graduate School of Industrial Engineering and Management Science at Eindhoven University of Technology, the Netherlands. For years now he is researching the history of the Socio-Technical Systems Design Paradigm. He produced several English language review articles on the subject as well as a comprehensive bibliography of the paradigm. Dr. Van Eijnatten assisted in editing a documentation of the Dutch Sociotechnical Variant which was presented to an international scientific forum. In Holland he co-edited a book on the management of technological innovation and was invited to contribute to a polemic discussion about STSD organized by a Dutch journal. He also published about methodological aspects of the paradigm. Dr. Frans M. van Eijnatten is a member of the Dutch Research Stimulation Programme TAO (Technology, Work and Organization).

Chapter Two

Socio-Technical Systems Design as a Scientific Paradigm

Since its inception in the fifties, the sociotechnical design paradigm of organizations has never left the socio-scientific and management literature. Socio-Technical Systems Design (STSD) plays an important role in giving shape to the plants, offices and government institutions that follow modern patterns.

Sociotechnical systems design is an applied science which is aimed at improving the functioning of both man and organization through adaptation or fundamental redesign of contents and organization of technology and human tasks. In the past four decades, many authors contributed to the development of this broad-minded approach, which is basically a management approach.

In sociotechnical systems design, social and technical aspects are considered and fine-tuned to one another in their mutual connection. Such an orientation is nowadays referred to by the term 'integral'. Before we describe the actual development of STSD on the basis of a division based on phases, we first give a general characterization of methodological starting points and aspects regarding its content.

2.1 Methodological Starting Points

For a long period of time, STSD in its strive for integration - with the structure of the organization as object of study and integral (re)design as its objective - was (considered) an odd one out. Such a holistic, design-oriented science did not quite fit into the ossified academic disciplines developed at the universities. STSD was not only new as design theory in terms of its contents, it also implied a clearly different paradigm in terms of methodology. In order to obtain insight into the actual meaning of STSD, scientists and staff officials had to take a different attitude in various respects. Not only did they have to learn to think in terms of new schemes, they also had to change their work habits.

- The fundamentally different way of thinking implied a shift from the 'machine' approach to the 'system' approach (Eyzenga, 1975). The main characteristics of the *machine approach* are: the emphasis being placed on reduction (converting wholes into parts; disaggregation); the emphasis placed on analytical thinking (explaining the behaviour of entities from the addition into the behaviour of parts); as well as the emphasis being placed on mechanistic thinking (in terms of the uni-causal cause/effect relationships). The object of the study is viewed here as a machine. The main characteristics of the *systems approach* include emphasis being placed on expansion (the parts are included in ever-expanding entities; aggregation); the emphasis on synthetic thinking (explaining behaviour from the role of the parts and how they function in the larger whole); and the emphasis on theleological thinking (determining and changing objectives, adaptation; cause is essential though not sufficient for a certain effect). The object of the study is viewed here as an 'open system' which interacts with its environment.

- The fundamentally different way of working implied a shift from the use of a predictive model cycle to a regulatory cycle on the one hand, and a different attitude of the researcher on the other; from distant to co-influencing. The empirical or predictive cycle (De Groot, 1980) accentuates the testing of hypotheses that are derived from an *a priori* formulated theory by means of the following steps: observation, induction (generalising general connections from observed connections), deduction (formulating ideal-types/hypotheses), test (verifying/ falsifying), evaluation. The regulatory or design cycle (Van Strien, 1986) stresses actual designing and, on the basis of that, developing a theory for practice through the following steps: problem definition, diagnosis, plan, action, evaluation. The role of the researcher is no longer distantly observant, but more involved and in fact co-influencing. The relevant process is referred to as 'action research'. It may be clear that many researchers have had difficulty with such a radical methodological changing paradigm. Illustrative of this is Hackman's lamentation: 'It may be that the only good way to comprehend a sociotechnical message is to move from the library to the shop floor and then finally to understand'. Ah ha! That's what it means.' (Hackman, 1981, p. 76).

2.2 Brief Characteristics of Content

The contents of the sociotechnical approach can be characterized as a reaction to the unilateral emphasis placed in previous paradigms (Scientific Management: Taylor, 1911; Bureaucratic: Weber, 1947; Human Relations: Mayo, 1933) on either the technical or the social aspects of the organization. In the new perspective, both factors are integrated as being components of one single 'sociotechnical entity'. Following Trist (1981), and renewing the attempt to give a brief and concise typification of STSD, Van Beinum (1990a) lists nine characteristics of content of what he refers to as 'the new organizational paradigm', which he puts in contrast with the characteristics of the 'old paradigm': the Tayloristic bureaucracy (cf. box 1).

In his characterization he makes the following comparisons:

- *Redundancy of Functions versus Redundancy of Parts.* Rather than maximizing the labour division (overcapacity of persons having only one function within the organization), STSD suggests a minimal work division (overcapacity of functions in each person within the organization). Everybody is expected to be able to carry out different tasks, which leads to personnel being available for multiple jobs.
- *Internal versus External Coordination and Control.* Self-regulation rather than step-wise supervision is considered to be of paramount importance in the sociotechnical paradigm. Emphasis is being placed on small organization units with internal coordination and semi-autonomous control.
- *Democracy versus Autocracy.* The aim of STSD designers is direct participation of personnel in decision-making. The approach is based upon democracy in the workplace.

Box 1. Brief characterization of STSD

"**The old paradigm**
* redundancy of parts
* external coordination and control
* autocracy
* fragmented socio-technical system
* technological imperative - man as extension of machine, a commodity
* organizational design based on total specification
* maximum task breakdown, narrow skills
* building block is one person - one task
* alienation

The new paradigm
* redundancy of functions
* internal coordination and control
* democracy
* joint optimization of the socio-technical system
* man is complementary to the machine and a resource to be developed
* organization design based on minimum critical specification
* optimum task grouping, multiple broad skills
* building block is a self-managing social system
* involvement and commitment"

Adapted from: Trist (1981), p. 42
Van Beinum (1990a), p.3

- *Joint Optimization versus Fragmentation.* STSD prefers to take an integral as opposed to a partial approach, which implies optimization of various aspects rather than maximizing the own job-specific aspect.
- *Man as Resource versus Commodity.* The sociotechnical paradigm considers the working man as being complementary to the machine, and not as its useful extension. People are the most valuable asset of an organization, which must invest in them.
- *Minimum Critical versus Total Specification.* STSD designers will prevent an organization from designing its structure in a detailed manner. They start with the idea that only the contours need to be determined; the remaining parts are filled in by the users according to their own insights and needs. The current situation is of course a condition relevant to the actual organization of work.
- *Maximum Task Breakdown versus Optimal Task Grouping (Narrow versus Broad Skills).* The sociotechnical paradigm strives for complex jobs in a simple organization rather than simple jobs in a complex organization. This means that personnel must have multiple skills.
- *Individual versus group.* In STSD, the smallest organizational unit is the group, not the individual. In this way it is possible for individuals to take control of the organization of work.
- *Alienation versus Involvement and Commitment.* Job erosion leads to alienation. Sociotechnically redesigned labour systems are characterized by 'whole tasks': It is meaningful work, thus promoting personnel commitment.

2.3 Milestones and Development Trajectories

The history of STSD is a sequence of major and minor discoveries, projects, conceptualizations and developments of methodologies. The literature about it is very fragmented. English handbooks are lacking, whereas a number of key publications have for a long period of time not gone beyond the stage of 'internal report'. All of this combined makes it a difficult task to give a reasonably valid outline of its historical development.
Other authors have recently made an attempt to record the history of the sociotechnical organization paradigm. Merrelyn Emery (1989), for example, distinguishes a number of important 'milestones':

- As a first relevant fact - basically not more than a pace-setter - she mentions Lewin's leadership experiments just before the Second World War (cf. Lippit & White, 1939). These laboratory studies pointed to three basic types of organizational structures: the autocracy (bureaucracy), the democracy, and the 'laissez-faire' type (structure-less variant).
- As a second relevant fact - the first factual milestone of STSD - Emery refers to the British mine studies (cf. Trist & Bamforth, 1951; Trist *et al.*, 1963). In these field studies, researchers discovered an alternative form of work organization (the so-called 'semi-autonomous work group'), which they tried out on a limited scale.
- As a third relevant fact - the second factual milestone of STSD - Emery mentions the Norwegian 'Industrial Democracy Project' (cf. Emery, F. & Thorsrud, 1964/1969/1976). In this project, employers, employees and the government for the first time jointly carried out research into and improved the democratic quality/content of industrial sectors.
- As a fourth relevant fact - the third factual milestone of STSD - Merrelyn Emery (1989) refers to the development of the so-called 'Participative Design' methodology in Australia (cf. Emery, F. & Emery, M., 1974). Here, the employees themselves were given the opportunity to carry out the whole trajectory of sociotechnical analysis and redesign by means of 'participative design workshops' and 'search conferences'.
- In addition to Emery, Van Beinum (1990a) has proposed a fourth factual milestone in the development of STSD, namely 'large-scale and broadly based organizational change process with 'democratic dialogue' as the leading element on the conceptual as well as on the operational level' (cf. Gustavsen, 1985; 1988). This has been brought into practice on a national scale. In the long run, the Dutch approach to Integral Organization Renewal (De Sitter *et al.*, 1990) may compete with the fourth 'milestone' classification.

The above-mentioned four milestones form sequential steps in a process of democratizing the workplace.

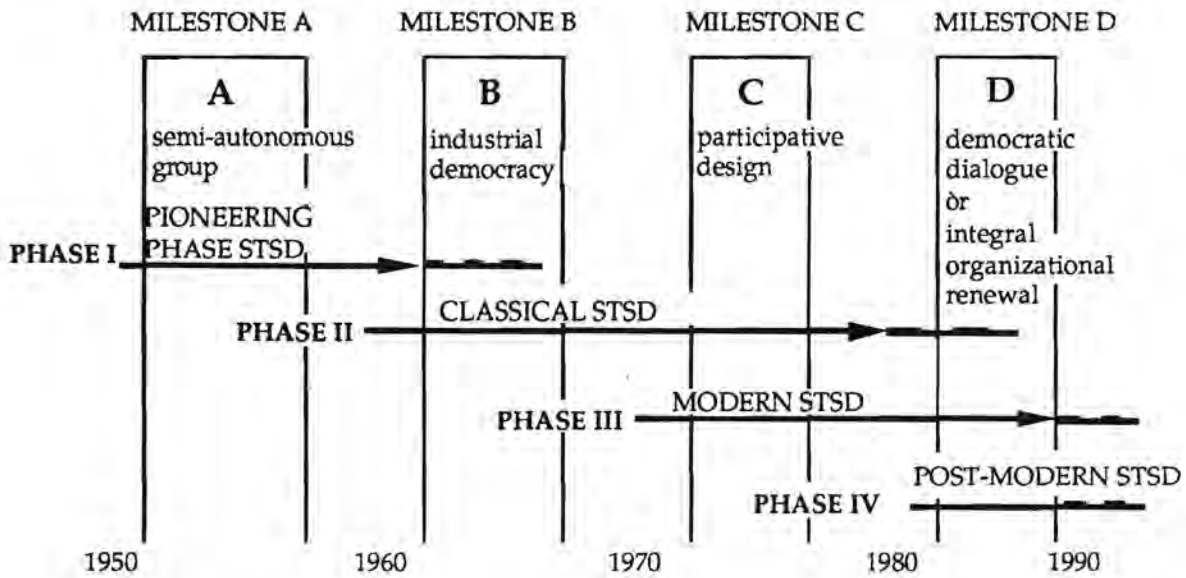


Figure 1. The phases and milestones in the development of STSD.
Adapted from: Emery, M. (1989); Van Beinum (1990a).

Based on a bibliometrical analysis of the literature (cf. Van Eijnatten, 1990a/b) and where possible corrected by changes in the actual sequence of events (Fred Emery, 1990 - personal correspondence), we have attempted to categorize the historical line of STSD into phases. The four development trajectories can be distinguished as follows:

- Phase I (1949 - 1967+): The period of the Socio-Technical Pioneering Work;
- Phase II (1959 - 1986+): The period of Classical STSD;
- Phase III (1972 - 1989+): The period of Modern STSD;
- Phase IV (1981 - xxxx): The period of Post-Modern STSD.

Figure 1 gives a representation of the phases thus distinguished, combined with the milestones previously mentioned. What immediately strikes the eye, is that the trajectories partly overlap in time. Sometimes, there almost exist parallel flows. Two main causes can be given for this. Firstly, from time to time the inventors/developers of the paradigm regroup to discuss new ideas, while the implementors/consultants continue to follow the course taken for some time. Secondly, the development of STSD is a-synchronous in the different countries and continents: One country is already in the next phase whereas the other has yet to start the previous one. It also happened (for example in the United States) that the entire development started off only after a number of years. This makes it difficult to link concrete end-dates to the various stages. Anno 1991 Classical, Modern and Post-Modern STSD coexist abreast as professional approaches at separate locations. This situation not seldom causes confusions of tongues among new-comers in this field.

Chapter Three

Some Anecdotes and Characteristics of Distinctive Development Trajectories

In the previous chapter the history of STSD is divided in four distinctive development trajectories. In this chapter each phase will be described below by means of anecdotes. Apart from the theory, we will respectively discuss the discovery of the Semi-Autonomous Work Group (Phase I), the Industrial Democracy Project (Phase II), Participative Design (Phase III), and Democratic Dialogue and Integral Organizational Renewal (Phase IV):

- The first development trajectory is referred to as the 'Socio-Technical Pioneering Work', roughly spanning the period from 1949 to 1967. In paragraph 3.1 attention will be given to the inception and careful development of the STSD paradigm by staff members and visiting scientists of the Tavistock Institute of Human Relations in London. The well-known projects pass in review briefly, and the theoretical foundation from the early years will be discussed as it emerged from the practising of systems thinking;
- The second development trajectory is shortly referred to as 'Classical STSD'. A global time indication is the period 1959-1986. In paragraph 3.2 there will be a description of the first full-scale test of STSD in Norway, and the further spreading of Classical STSD. Also the development of concepts and methods during this period will be looked upon;
- The third development trajectory is referred to as 'Modern STSD', spanning the period from 1972-1989. This trajectory, which will be discussed to some extend in paragraph 3.3, is characterized by shifting the scene to Participative Design. Apart from the particularities, the model behind it will be presented as well as the diffusion of the approach to other countries and continents;
- The fourth development trajectory is referred to as 'Post-Modern STSD'. This period started in 1981 and is still continuing. As will be illustrated in paragraph 3.4, several innovative approaches typify this stage, with new systems methodology, network-oriented content or process analysis and design methods, and theory of concepts.

3.1 Phase One: The Pioneering Role of Tavistock

(general intro - still to be written)

3.1.1 Ken Bamforth's Re-Discovery of a Work Tradition

The cradle of STSD can be found in the postwar British coal mines. In the early fifties, a new, spontaneous form of work organization came into being which today is referred to as 'self-managing groups'. The turbulent British coal industry - which was continually plagued by labour conflicts and which was nationalized and further mechanized after the Second World War was not exactly a working area that was easily accessible to social scientists. Yet, Ken Bamforth, ex-miner and a new researcher of the Tavistock Institute of Human Relations in London, was given the opportunity to visit the mine he used to work in, the Elsecar mine in South Yorkshire, which was closed to many other researchers. During his visit he observed an unknown form of work organization in a new coal seam, called 'the Haighmoor'. Due to the short coal front, the usual mechanization, the so-called 'longwall' method, could not be applied in this seam. Thanks to the fact that he was a former colleague, the local management gave him permission to carry out descriptive research together with Eric Trist. However, it proved to be difficult to obtain the management's permission to publish their findings. After some commotion, the mine management eventually agreed to a strongly censored version.

In their now famous article - carefully included in an elaborate description of the mechanized coal mining process which was unravelled in small sub-tasks - Trist and Bamforth (1951) represented, in guarded terms, a unique underground alternative work organization that was built up of so-called 'composite work groups': small, relatively autonomous work groups consisting of eight miners, who were responsible as a group for a full cycle in the process of coal extraction. This 'new' form of work organization much resembled the manual situation as it had existed before mechanization.

The work organization observed in Haighmoor proved that there were other, even better, ways of designing the work organization within the same mine. This was flatly opposed to the prevailing 'one best way of organizing' practice 'that fused Weber's description of bureaucracy with Frederic Taylor's concept of scientific management' (Trist, 1981, p. 9). Here actual practice showed that within the same mine there were different, and even better ways to structure the work organization (the latter principle of 'organizational choice'). This so-called 'all-in method' soon developed into a success story, the starting point of a new scientific paradigm: Socio-Technical Systems Design.

Box 2. An 'eye-witness' report of the difficult start of the sociotechnical paradigm

"In the autumn of 1949, I went up to Elsecar Colliery in N.E. Division, Ken Bamforth's old pit, and found autonomous work groups in the Haighmoor seam. Improved roof control enabled them to mine it. (...) Teams of eight men interchanged tasks on shift and each shift took over where the last left off. (...)
The method, called the all-in method had been conceived by Reg Baker then Area General Manager No. 3 Area, N.E. Division, formerly manager at Elsecar. (...)
The project was an immense success - human-wise, productivity-wise and every otherwise. I began to study it with Ken (...). It was both moving and exiting to talk to the men about the value they placed on their experience in the newly formed autonomous groups. (...)
I read a paper with Ken on the 'all-in method' and its significance as a new paradigm (...) in the winter of 1950 (...).
I then asked Baker about publishing an expanded version of the paper in Human Relations. He had to task N.E. Division who refused. (...) They were frightened of the consequences of letting news about the 'all-in method' get out in the industry. They said it contained dynamite. (...) This is why the original Trist-Bamforth paper (...) was published simply as an analysis of the conventional longwall with only indirect references (which are nevertheless plentiful, the model provided by the ripping team) to there being something of another kind on the way. This something was suppressed. (...)"

Trist's private communication, 1977
Emery (1978), p.5-6

As Trist later recalled in his correspondence with Emery, the start of the sociotechnical paradigm did not exactly go without a hitch (see box 2). In fact, the pioneering phase came about in fits and starts.

The research by Trist and Bamforth (1951) in the British coal mines is generally considered the starting point of the Socio-Technical Systems Design paradigm. This study was later the subject of numerous elucidations and discussions by many authors (cf. for only a handful of references: Katz & Kahn, 1966; Hill, 1971; Klein, 1975; Cummings & Srivastva, 1977; Buchanan, 1979; Kuipers & Van Amelsvoort, 1990).

Real experiments with autonomous groups were carried out in the Bolsover mines in the East Midlands coal field (Shepherd, 1951; Wilson & Trist, 1951; Emery, 1952; Trist, 1953). During his sabbatical leave from Australia in 1952, Fred Emery visited this mine, where he found that autonomous groups had been introduced in seven locations. However, here too the National Coal Board was terrified of the consequences and cancelled a proposal for further diffusion. From January 1955 until March 1958, Trist c.s. performed a series of descriptive case studies and field experiments with semi-autonomous work groups in the mines of North-West Durham. The reason for this was the 'discovery' of 'the working of a conventional, semi-mechanized, three-shift longwall cycle by a set of autonomous work groups' (Trist, 1981, p. 16). Trist reported enthusiastically that groups consisting of 40 to 50 miners worked here while exchanging their various tasks and also drawing up the shift schedules themselves. Amongst one another they had worked out an adapted 'fair' rewarding system. Compared to an identical situation but with a traditional work organization, the output here was 25% higher, the costs lower, and absenteeism had been cut in half! A large number of reports were published pertaining to this Bolsover case (cf. Herbst, 1958; Higgin, 1957/1958; Murray, 1957a through g; Pollock, 1957/1958; Trist, 1956/1957). A collected description of these mine studies can be found in Trist *et al.* (1963).

Parallel to this, two field experiments were carried out from Tavistock in the textile industry (the Jubilee and Calico Mills in Ahmedabad, India; cf. Rice, 1953/1958/1963). Both in an automated and in a non-automated weaving mill a system of semi-autonomous groups was introduced, in the latter with lasting success (Miller, 1975). Trist (1977) reports that in the fifties autonomous groups were observed in both the London harbour and British retail trade, but efforts to study those all failed.

Yet another early sociotechnical reorganization is known in Scandinavia. In Sweden autonomous groups were introduced to the Stockholm telephone switchboard (cf. Westerlund, 1952). In Holland Van Beinum (1959) carried out a sociotechnical-tinged field experiment at the Dutch Giro Service in the Hague.

3.1.2 Latent STSD and the Contagious Spreading and Adoption of an Open-Systems View

The start of the STSD paradigm spontaneously took place in the subterranean galleries of the British coal mines. Despite the advancing mechanization, in some coal seams miners chose to pursue their own old work tradition. It was an ex-miner who reported this phenomenon to the academic world. By the time these natural occurring field experiments had shown some good results in practice, the scientific explanation only just began. Initially the formulation of theories was strongly influenced by the psycho-analytical orientation at 'The Tavistock'. The very first conceptualisations were hence based on the group theory (cf. Klein's object relations (1932/1948); Bion's 'leaderless group'/group dynamics (1949/1950); and Lewin's field theory/group decision-making (1947/1951). Soon, however, the promising and simultaneous development of the systems approach inspired the STSD pioneers from the very beginning. Tavistock researchers were very much interested in the 'open system' way of thinking, which initially emerged from biology in particular, but later also from cybernetics. New concepts are adopted with enthusiasm and tried out in practice to test their usability (cf. table 1).

Table 1. Outline of systems concepts from biology, logic and cybernetics dating before 1959, adopted by the Tavistock researchers.

Concept	Reference	Discipline
- adaptation	Tomkins, 1953	biology
	Sommerhoff, 1950	biology
- closed/open system	Koehler, 1938	biology
	Prigogine, 1947	thermo-dynamics
	Von Bertalanffy, 1950	biology
- coenetic variable	Ashby, 1956	cybernetics
- co-producer	Singer, 1959	philosophy
- directive correlation	Feibleman & Friend, 1945	philosophy
	Sommerhoff, 1950	biology
- entropy	Schrödinger, 1944	biology
	Prigogine, 1947	thermo-dynamics
- negative entropy	Von Bertalanffy, 1950	biology
- equifinality	Von Bertalanffy, 1950	biology
- functional equivalent	Nagel, 1956	biology
(- gestalt	Köhler, 1929	psychology)
- goal-directed behavior	Sommerhoff, 1950	biology
- goal-seeking behavior	Schützenberger, 1954	biology
- homeostasis	Canon, 1932	biology
- joint environment	Ashby, 1952	cybernetics
- learning	Tomkins, 1953	biology
	Sommerhoff, 1950	biology
- morphogenesis	Spiegelman, 1945	biology
- multi-stable system	Ashby, 1952	cybernetics
- requisite variety	Ashby, 1958	cybernetics
- self-regulation	Roux, 1914; Weiner, 1950	cybernetics
	Von Bertalanffy, 1950	biology
	Sommerhoff, 1950	biology
- (dynamic) steady state	Hill, 1931	biology
(Fliessgleichgewicht)	Von Bertalanffy, 1950	biology
- (holistic) system	Angyal, 1941	logic
- theory of feedback mechanisms	Wiener, 1948	cybernetics

Due to the lack of both time and resources at 'The Tavistock', it was difficult to develop its own concept in a systematic manner. The researchers from the very beginning were inspired in their observations by the emergence of systems thinking, which was initially propagated from biology, and later also from cybernetics. They enthusiastically adopted the new concepts and tried them out in actual practice.

- Thus, the generally known 'Gestalt' notion (Köhler, 1929), renamed the 'holistic system' (Angyal, 1941), makes it possible to look at the *whole* coal mining situation, i.e. at both social and technical aspects and their mutual connection.
- By means of the 'open system' notion (Koehler, 1938; Von Bertalanffy, 1950), attention is also directed towards the environment. Thus, the man-hostile and unpredictable work situation in mines can become explicitly involved in the research.
- The researchers place the concept of 'self-regulation' at the basis of the semi-autonomous group (Roux, 1914; Weiner, 1950; Von Bertalanffy, 1950; Sommerhoff, 1950). Self-regulation of *all* steps of the coal mining process is most effective in an unpredictable environment, and 'requisite variety' (Ashby, 1956a/b, 1958) - in other words, allround miners in the semi-autonomous group - are a prerequisite for that. This is exactly what Trist and Bamforth found in the Elsecar mine in South Yorkshire: small semi-autonomous work groups consisting of eight miners, each of them equally rewarded, who as a group were responsible for a full production cycle in the coal mining process. The ever-progressive labour division, which was so typical of the mechanization of the industry at the beginning of the twentieth century, was all of sudden rigorously broken down. Actual practice provided all the necessary ingredients for developing a new organization theory, but its exact concept was not elaborated upon until the early sixties.

3.1.3 STSD-Specific Concept Development to Support the Next Phase

The next phase in the development of STSD was heralded by Fred Emery's joining Tavistock in 1958 and the leaving of its director Wilson. As a result of increased tension, the sociotechnically-oriented researchers, under the guidance of Trist, were separated from the 'Human Relations'-oriented researchers which were led by Rice. The latter had had close connections with psycho-analysts since Tavistock was founded. Trist's HRC group (Human Resources Centre), which Emery was also a part of, continued the developing of STSD, but Rice and his CASR group (Centre for Applied Social Research) *also* continued for some time to publish sociotechnically-oriented literature - mainly because of opportunity reasons ('profiling') - (cf. Menzies, 1960; Rice, 1963; Miller & Rice, 1967), which did not help in improving the mutual understanding between these two groups.

When Trist finally succeeded in obtaining financial support for sociotechnical concept development, Emery, supported by Herbst and Miller, turned his energies to the difficult task of tying up the numerous loose ends from the pioneering phase. Three documents (Tavistock 526-528; cf. Miller, 1959; Emery, 1959; Herbst, 1959) mark the transition from the pioneering phase to that of Classical STSD. At this point, the rupture with the Human Relations tradition is final (personal communication with Emery, 1990).

It was not until the late fifties that the first area-specific systems concepts were published (cf. table 2).

Table 2. Outline of area-specific STSD concepts.

Concept	**Referentie**
- composite work group	Trist & Bamforth, 1951
- dissipative structure	Emery, 1963
- disturbance control	Herbst, 1959
- joint optimization	Trist *et al.*, 1963
- organizational choice	Trist *et al.*, 1963
- primary task	Bion, 1950; Rice, 1958
- primary work system	Miller, 1959; Rice, 1963
- responsible autonomy	Trist & Bamforth, 1951; Wilson & Trist, 1951; Trist *et al.*, 1963
- semi-autonomous work group	Herbst, 1962
- socio-technical system	Emery, 1959
- task and sentient system	Miller & Rice, 1967
- technology, time, territory (boundary)	Miller, 1959
- work method/task continuity	Trist & Murray, 1958

Some of these concepts will be described more in detail below, because they belong to the basic notions of (Classical) STSD.

- The 'socio-technical system' concept is central in the 'open'-system approach. Only Emery (1959) made a serious attempt to demarcate and define this concept, unfortunately in an internal paper which has up until now not been integrally published. A sociotechnical system consists of a (in Emery's terms) technical and social *sub*-system. In Trist's (1981) view these technical and social sub-systems are mutually independent in the sense that the former follows the laws of the natural sciences, and the latter those of the human sciences. However, they are mutually dependent, since they need each other in order to fulfill the production function: this concerns a link a heterogeneity. According to Emery (1959) the economic aspect does not constitute a separate third sub-system as Rice (1958) - whispered in his ear by Trist - had previously suggested, but can be considered an instrument used to measure the effectiveness of the socio-technical whole.

- The concept of 'joint optimization' (Emery, 1959) refers to the most important sociotechnical objective: to achieve the 'best match' between technical instrumentation and social work organization. In 1963 Emery pointed to 'the ideal of joint optimization of coupled but independently based social and technical systems'. The sociotechnical entity should be optimized. According to Emery and Trist, attempts with the sole purpose of optimizing either the technical or the social system will necessarily lead to what they call 'sub-optimization' of the sociotechnical totality.
- The key concept of 'organizational choice' is implicit in the latter notion. In general it refers to the possibility to achieve one common goal through different means. More specifically it indicates that - given a certain technology - different forms of work organization are possible. In fact this rejects the idea of technological determinism. Van Dijck (1981) states that the concept of 'organizational choice' has its direct origins in the biological system concept of 'equifinality' (Von Bertalanffy, 1950) and the cybernetic law of 'requisite variety' (Ashby, 1956).

According to Emery (1959) the application of the open-systems concept to the production organization leads to the distinction of a 'socio-technical system'. A sociotechnical system consists of a social and a technical component. In other words: men and machines. This system considers the technical component as being the 'internal environment' of the organization. After 1959, Emery also continued to work on the formalization and methodological foundation of STSD as an open systems approach (cf. Emery, 1963a through d/1967). Jordan's message (1963) that man is supplementary to, and not an extension of machines, inspired him to elaborate the design principle of 'joint optimization'. In the early sixties, Emery also carried out pioneering work in the area of science theory and methodology. For example, he further developed Von Bertalanffy's (1950) 'open systems' concept, so that a definition of the process of 'active adaptation' was facilitated, and he based STSD on Sommerhoff's (1950) methodology of 'directive correlation' 'as a rigorous framework for contextualism' (Emery, personal communication, 1990). The methodology of 'directive correlation' presented by Emery in 1963 belongs to the absolute core of the sociotechnical paradigm, and encompasses in brief the fundamentally symbiotic relationship between an open system and its environment. The way in which these continuously follow from one another, was and still is not fully understood by many people, and it has been Emery in particular who has pointed this out time and time again (see also chapter 4, paragraph 2).
Because of their revealing character and despite their difficult accessibility, the epistemological and methodological documents mentioned above have been of essential relevance to anchor STSD as a scientific paradigm. The well-known environment typology can be viewed as being a direct result of this foundation process.

3.2 Phase Two: Classical Socio-Technical Systems Design

(general intro - still to be written)

3.2.1 The Inspiration of the Norwegian Industrial Democracy (ID) Programme

One of the highlights in the period of Classical STSD was undoubtedly the Norwegian 'Industrial

Democracy' (ID) programme, spanning the period between 1962 and 1969. After the mine studies, it was practically impossible in the United Kingdom to carry out action research. The 'Purfleet Power Station' project was an exception (cf. Emery & Marek, 1962). In the early sixties, a favourable climate for larger-scale experiments arose not in the United Kingdom, but in Norway. Employer and employee organizations formed a joint committee early in 1962 in order to study problems surrounding industrial democracy. Later, the government also joined this committee. Research in this area was initially subcontracted to the Trondheim Institute or Industrial Social Research (IFIM), which called in the Tavistock Institute. Eric Trist brought about the initial contacts, but from The Tavistock it was Fred Emery, together with Einar Thorsrud of the Norwegian Work Research Institutes (WRI) in Oslo, who gave actual shape and guidance to the ID project (cf. Emery & Thorsrud, 1964). The most important item of the research programme was formulated as 'a study of the roots of industrial democracy under the condition of personal participation in the work place' (Emery & Thorsrud, 1976, p. 10). The programme included sequential field experiments in which alternative forms of work organization (mainly concentrated around semi-autonomous work groups) were developed and tried out; subsequently, their effects on the participation of employees were examined at different levels within the organization.
The firms participating in these projects had been carefully selected by the experts of the 'Joint Committee' from the most important sectors in Norway: the metal, paper and chemical industries. This selection was based on a rudimentary diffusion theory (Emery *et al.*, 1958, see also section 3.3). After 1967 a minor project was still running in the shipping industry (cf. Roggema, 1968). The following is a brief description of the four main projects:

- The first project started in 1964 in Chistiana Spigerverk, a wire draw plant in Oslo (cf. Marek *et al.*, 1964; Emery *et al.*, 1970). Group work was introduced by the research team, but the rewarding system immediately posed all kinds of problems. The change process was not under control in this pilot project. Local unionists and management had too little involvement, and therefore the project was cancelled when after more than a year the research team left the plant.
- The second project was started in February 1965 after careful orientation and extensive consultation with unions and management at the chemical pulp department of the Hunsfos paper mill located in Vennesla, Kristiansand (cf. Engelstad *et al.*, 1969; Engelstad, 1970). The change process was better controlled here: the introduction and formation of 'extended groups' was accompanied step-by-step by project and work groups composed of representatives of employees, bosses and management. However, the project really fell into its stride when the research team withdrew to the background and the (top) management committed itself in a more pronounced way. In 1966 the new work organization flourished and the effects of group work and multi-skilled personnel was proved convincingly, but early in 1967 the project got bogged down as a result of a crisis in the paper industry and the associated priority changes in management. In the seventies the Hunsfos employees themselves took over and began to breath new life into the project (cf. Elden, 1979).

- The Industrial Democracy programme has faced more setbacks. After an initial refusal of the management to join the programme as a result of political circumstances within the firm, the third ID project was initiated - more than two years after the first application - in December 1965 at NOBØ household appliances/metalware in its establishment in Hommelvik near Trondheim (cf. Engelstad, 1970; Thorsrud, 1972). Here too, an experiment with semi-autonomous groups took place, carefully embedded within the organization, and has now been elaborated upon for a new production line for electric radiator heaters. This project has become the actual demonstration project of the ID programme, which attracted many interested people from Norway and Sweden. Later, when a new plant had to be put into use in view of higher production, the employees succeeded in maintaining the new organization.
- The fourth ID project was initiated in 1967 - at the request of the firm itself - in the chemical concern Norsk Hydro, more specifically in the reorganization of the old and design of a new fertilizer plant in Heröya, Porsgrun (cf. Bregard *et al.*, 1968; Gulowsen, 1972/1974/1975). This project, in which Louis Davis also participated, was the umpteenth variant to the introduction of a group structure supported by a training programme and a rewarding system adapted to group work. It became a big success: The two plants with this sociotechnically based work organization functioned well until the late seventies.

The four demonstration projects described above received a lot of attention in the literature (cf. Emery & Thorsrud, 1969/1976; Engelstad, 1972; Gustavsen & Hunnius, 1981). Their aim was to indicate the practical feasibility of the new sociotechnical organization principles, but unfortunately these examples were seldom followed. In spite of the fact that the experiments were successful (cf. Gustavsen & Hunnius, 1981), they were largely limited to the department or the plant where they had been started. In their turn, the 'experimental gardens' became isolated from the rest of the organization, which even built up some kind of resistance against such a change. This phenomenon was referred to by Merrelyn Emery (1989) as 'paradoxical inhibition'. Although various diffusion programmes were set up, the programme stagnated in Norway around 1970.

3.2.2 The Spreading of Industrial Democracy: Idiom versus Replica

Things were much different in its neighbouring country Sweden, where a cooperation project carried by employers and unions similar to that in Norway was initiated. Because of its slow progress, the employers soon decided to start their own programme in more than 500 firms (cf. Jenkins, 1975). They also promoted a sociotechnical programme when new plants were built (cf. Agurén & Edgren, 1980). Apart from Saab-Scania, where parallel production groups were already formed in 1972, Volvo in particular has the reputation of developing a whole range of pioneering new forms of work organization, in which the one in Kalmar has become most well-known (cf. Agurén *et al.*, 1976/1984). For a more elaborate overview of the Volvo projects, see Auer & Riegler (1990).
In 1965, the Industrial Democracy programme was rehashed in the United Kingdom. The Norwegian example was 'copied', so to speak, at Avon Rubber, Shell and RTZ (personal communication with Emery, 1990). However, one important element was lacking here: a steering

group which was composed of employers and employees. 'The Shell Philosophy program was an innovation but not a change in trajectory. It was developed because we could not get in the UK a sanctioning body of the union and employer leaders, as we had in Norway' (Emery, 1990).
The Norwegian ID programme and its variants are characteristic of the period of Classical STSD, in which the *expert approach* flourishes.

3.2.3 The Methodical Approach towards Industrial Democracy

In giving shape to and working out the ID programme in Norway, a great deal of attention was given to a systematic elaboration of the project approach - amongst other things, because of its demonstration character (cf. box 3). This has led to important 'breakthroughs' in the development of methods and concepts.

Box 3. The methodological approach of the Industrial Democracy programme in Norway

"1. Establishment of a Joint Committee representing labour and management;
2. Choice of experimental company;
3. Systematic analysis of the company as a system and its environment;
4. Choice of experimental sites;
5. Establishing action committees;
6. Socio-technical analysis of experimental sites:
   a. description of variations in input and outputs and sources of variations;
   b. estimation of relative importance of different variations (matrix);
   c. description of formal organization;
   d. analysis of communications network;
   e. base-line measurement of (dis)satisfaction;
   f. analysis of wage and salary system;
7. Description of company policy;
8. Formulation of program for change, containing:
   a. multi-skilling of operators;
   b. developing measures of variations and data analysis methods for control by operators;
   c. attachment of local repair men;
   d. institutionalising of meetings;
   e. training of foremen;
   f. design and introduction of new bonus arrangement;
9. Institutionalisation of a continued learning and organizational change process;
10. Diffusion of results."

Emery & Thorsrud (1976), p. 150-154

In the ID project approach the whole process of change was defined and monitored in phases and steps. The starting point was a thorough sociotechnical analysis of the business situation found. The notions 'variance' and 'variance control' (cf. Engelstad, 1970; Hill, 1971) were highly important here. Based on Herbst's (1959) concept of 'disturbance control', this principle of 'signalling occurring disturbances and their control by the employees themselves as close to the source as possible' was brought into practice through projects. The application of this principle took place by means of the so-called 'variance control matrix', a table with specific disturbance sources as one input and (factual) disturbance controls as the other. This procedure was the first and most important formal sociotechnical method. This 'traditional variance analysis' technique was applied for the first time at the Hunsfos paper mill (cf. box 4).

Box 4. A brief illustration of the original 'variance analysis' technique applied in the period 1965-1967 by Engelstad at Hunsfos

" 1. Identifying key success criteria;
2. Drawing the layout of the system;
3. List the steps in the process in order;
4. Identify unit operations;
5. Identify variances;
6. Construct a variance matrix;
7. Identify key variances;
8. Construct key variance control table;
9. Suggest technical changes;
10. Suggest social system changes."

Engelstad *et al.* (1969)

A year later the technique was applied from the Tavistock at the Stanlow oil refinery of Shell-UK (cf. Foster, 1967; Emery *et al.*, 1967; Hill, 1971). Although the number of steps mentioned in the literature varies to some extent, this method is known as the 'nine-step method' (cf. Emery & Trist, 1978). It was originally developed for application in the processing industry, but was also later used for the analysis of discrete production situations and for mapping administrative processes. Emery was opposed to this.

The 'technical variance' analysis method described above was introduced in combination with the design criteria (see 3.2.4) in 1967 in (North) America when Louis Davis returned to his country and Eric Trist arrived at UCLA from Tavistock.

3.2.4 An Outline of Basic Concepts in Classical STSD

The period of classical STSD is characterized by the further elaboration of concepts. As regards the basic concepts, a clear 'idiomising' occurs whereby concepts from systems/rigid thinking are no longer adopted so to speak 'unthinkingly', but rewritten and where necessary interpreted or simplified.
From the start of the sixties onwards a large number of publications further developed or refined the basic concepts of Socio-Technical Systems Design. An outline of these concepts can be found in table 3.

On the basis of the study by Tolman & Brunswik (1935) and using Sommerhoff's (1950) 'directive correlation' methodology and Ashby's (1952) concept of 'joint environment', Emery & Trist

(1963/1964/1965) developed an environment typology which is based on 'causal texture', consisting of four categories increasing in complexity and *un*predictability. They make a distinction between: 1. placid, randomized environment; 2. placid, clustered environment; 3. disturbed-reactive environment; 4. turbulent field. This typology, a logical next step in sociotechnical conceptualization, stresses the increase in (changeable) demands affecting the organization from its environment, since organizations, being viewed as open systems, have a constant exchange relationship with their environment. Adaptations of the organizational structure to changes in that environment are crucial in order to survive. Jurkovich (1974) refined this scheme further into a system distinguishing between 64 factors. The original Emery & Trist typology was later expanded by the hyper-turbulent 'vortex' variant: 5. vortical environment (Crombie, 1972; McCann & Selsky, 1984; Babüroglu, 1988).

Table 3. Outline of important basic concepts in Classical STSD.

- environmental uncertainty	Emery & Trist, 1963/1964/1965/1972 Emery, 1967/1977
- directed action	Chein, 1972
- job redesign principles	Emery & Thorsrud 1964/1969/1976
- motivation theory of directed action	Susman, 1976
- sociotechnical design principles	Emery & Trist, 1972 Herbst, 1974 Emery, 1974/1976 Cherns, 1976/1987
- sociotechnical system	Cummings & Srivastva, 1977
- unit operations	Davis & Engelstad, 1966
- variance control	Engelstad, 1970 Hill, 1971

- Davis and Engelstad (1966) adopted the concept of 'unit operations' which was originally worked out in chemical engineering (A.D. Little Inc., 1965), and used it to describe the work of operators in terms of changes of state in the transformation process in the context of 'technical system analysis'. Emery *et al.* (1966) rejected the concept in favour of directive correlations (cf. doc. 900).
- The Norwegian ID programme was the first solid opportunity to test the usability of the sociotechnical basic principles developed by the HRC group at Tavistock in actual practice. These tryouts showed that a number of norms were still lacking at workplace level. Therefore, Emery (1963d) and Emery & Thorsrud (1964) developed a series of job redesign principles on the basis of the work of Louis Davis (1957) from the United States (cf. box 5), to be used for the actual experiments with Industrial Democracy at the Norwegian company Hunsfos in particular. These so-called 'structural propositions for joint optimization' served as criteria for the assessment of

the existing and newly created work situations. They were repeated in various publications afterwards (cf. Thorsrud, 1968; Emery & Thorsrud, 1969/1976; Cummings, 1976; Cummings & Srivastva, 1977; Trist, 1981), and taken as point of departure by Hackman and Lawler (1971) and Hackman and Oldham (1976) in an altered form for the development of the JDS model.

Box 5. Detailed principles for the redesign of tasks

"Individual level:
- optimum variety of tasks within the job;
- a meaningful pattern of tasks that gives to each job a semblance of a single overall task;
- optimum length of work cycle;
- some scope for setting production standards and a suitable feedback of knowledge of results;
- the inclusion in the job of auxiliary and preparatory tasks;
- tasks include some degree of care, skill, knowledge or effort that is worthly of respect in the community;
- the job should make some perceivable contribution to the utility of the product to the consumer.

Group level:
- providing for 'interlocking' tasks, job rotation or physical proximity;
  + where there is a necessary interdependence of jobs for technical or psychological reasons;
  + where the individual job entails a relatively high degree of stress;
  + where the individual jobs do not make an obvious perceivable contribution to the utility of the end product;
- where a number of jobs are linked together by interlocking tasks or job rotation they should as a group:
  + have some semblance of an overall task;
  + have some scope for setting standards and receiving knowledge of results;
  + have some control over the boundary tasks;

Over extended social and temporal units:
- providing for channels of communication so that the minimum requirements of the workers can be fed into the design of new jobs at an early stage;
- providing for channels of promotion to foreman rank which are sanctioned by the workers."

Adapted from:
Emery (1963d), p. 1-2; Emery & Thorsrud (1964), p. 103-105;
Emery & Thorsrud (1976), p. 15-17.

- From the perspective of the entire organization Emery (1967), Emery and Thorsrud (1969), Emery and Trist (1972), Thorsrud (1972), Herbst (1975) and Susman (1976) made a set of sociotechnical design principles grouped by Cherns (1976/1987) into a logical consistent whole and complemented them (cf. table 4).

This simplification of concepts used here is remarkable. In the practice of sociotechnical design, the complex and little user-friendly design principle of 'joint optimization' is replaced by the concepts of 'participant design' (Emery, 1967; Emery and Trist, 1972) and 'compatibility' (Cherns, 1976). Similarly, the new multi-functional design principle (Cherns, 1976; 1987) substitutes the complex systems concepts of 'equifinality' and 'directive correlation'.

Table 4. Outline of sociotechnical design principles of Classical STSD.
* emphasis on process of change.

- compatibility/participant design *)
  (Emery, 1974/1976; Cherns, 1976/1987)
- minimal critical specification (inspired on Beurle, 1962)
  (Herbst, 1974; Cherns, 1976/1987)
- the socio-technical criterion/variance control
  (Emery and Thorsrud, 1969; Cherns, 1976/1987)
- the multifunctional principle/redundancy of functions
  (Emery, 1967; Emery and Trist, 1972; Cherns, 1976/1987)
- boundary location
  (Susman, 1976; Cherns, 1976/1987)
- information flow
  (Cherns, 1976/1987)
- support congruence
  (Cherns, 1976/1987)
- design and human values
  (Thorsrud, 1972; Cherns, 1976)
- incompletion/Forth Bridge principle/double loop learning *)
  (Cherns, 1976/1987; Argyris and Schon, 1978)
- power and authority/Admirable Crichton principle
  (Cherns, 1987)
- transitional organization *)
  (Cherns, 1987)

- A sidetrack development is Susman's (1976) attempt to develop a motivation theory appropriate to the sociotechnical framework. Based on a link of Klein's (1932) concept of 'object relations' and Chein's (1972) concept of 'directed action', Susman's 'theory of directed action' departs from motives such as behaviour, as actions of human beings who are considered 'purposeful system'.
- Finally, during the period of Classical STSD a more acceptable definition of a sociotechnical system is also established as being a symbiosis between a technical system consisting of equipment and process layout, and a social system in which people carry out the tasks:

'A socio-technical system is a non-random distribution of social and technical components that co-act in physical space-time for a specific purpose.'

Cummings & Srivastva (1977), p. 1

This definition leaves room for both an open- and a closed-system perspective. Moreover, it allows for consideration of steady states in both social and technical systems, at different aggregation levels.

- Elaboration of the concept of 'variance control' (Engelstad, 1970; Hill, 1971) is highly relevant to the development of Classical STSD. Based on Herbst's (1959) concept of 'disturbance control', this principle of the control loop in projects was further developed and put into operation. Recently Pasmore (1988) has once more systematically listed a set of 'technical system design principles', which is largely based on this concept:

1. 'Variances should be controlled at their source;
2. Boundaries between units should be drawn to facilitate variance control;
3. Feedback systems should be as complex as the variances which need to be controlled;
4. The impact of variances should be isolated in order to reduce the likelihood of total system failure;
5. Technical expertise should be directed to the variances with the greatest potential for systems disruption;
6. Technological flexibility should match product variability;
7. Technology should be appropriate to the task;
8. Inputs should be monitored as carefully as outputs;
9. Core absorbs support;
10. The effectiveness of the whole is more important than the effectiveness of the parts.'

Pasmore (1988), p. 62-68

3.3 Phase Three: Modern Socio-Technical Systems Design

(general intro - still to be written)

3.3.1 The Australian Paradigm Shift: Fred and Merrelyn Emery's 'Little Golden Book'

When Fred Emery returned to Australia in 1969 after spending a period of ten years in Europe, he was swamped with applications for projects similar to those he had carried out in the United Kingdom and Norway. To some extent, he was forced to have firms set up and implement their own design projects. Inspired by the good experiences with a 'vertical project group' (top-down cross-section of the hierarchy) at Hunsfos, Emery developed the so-called 'vertical slice approach'. This approach implied the upgrading of 'Industrial Democracy' up to the level of the organization being an entity through the formation of 'self-managing design groups', consisting of employees, foremen

and managers at various levels, who cooperated on the basis of equality.
Emery had learned a great deal from the negative ID diffusion experience in Norway, and attributed the disappointing results mainly to the expert approach used by the researchers. The projects had been insufficiently supported by the (persons directly concerned within) firms. Such an expert approach was no longer acceptable in view of the changed spirit of times (the students' rows in Paris were still fresh in everyone's memory).
Sociotechnical researchers like Emery began more and more to understand that an entirely new democratic system of value was hidden at the basis of the semi-autonomous work group in the UK and the principles for task redesign developed in Norway. Emery and Thorsrud (1969, p. 105) initially spoke of 'a limited number of general psychological requirements', but Emery (1977, p. 68) refer to 'a set of workable and relevant values (...), things (...) valued in work regardless of sex, nationality or race'. He summarizes these values as follows (p. 68):

1. "Freedom to participate in decisions directly affecting their work activity;
2. A chance to learn on the job, and go on learning;
3. Optimal variety;
4. Mutual support and respect of their work colleagues;
5. A socially meaningful task;
6. Leading to some desirable future."

Trist (1976) also talks about new values, which enable us to cope with the increasing complexities concerning the environment, such as self-actualization, self-expression, and 'capacity for joy'.
The technique developed by Emery in 1971, referred to as the 'deep slice' method of Participant Design, enables employees, (middle) management and union representatives to jointly take over the task and organization design from the start of the project. This was supposed to eliminate any resistance against change. The initial applications of this technique took place at the South Australian Meat Corporation SAMCOR (Yearling Hall), the Royal Australian Airforce, and Imperial Chemical Industries ICI. Even before the now well-known, 'little golden book' consisting of 14 pages was published (cf. Emery, F. & Emery, M., 1974/1975) the method had been 'exported' to India (cf. Nilakant & Rao, 1976), the Netherlands, and Norway. The long expected diffusion came about in Norway after all in 1972, because the firms assumed control of the development themselves, but not until the disappointed researchers had retired.

'Participative Design' (PD) is described by Merrelyn Emery as being 'an environment for conceptual and experiential learning about democratic learning organizations' (cf. Emery, M., 1989, p. 114). In the seventies, two such environments have been further elaborated upon: the Participative Design Workshop (Emery & Emery, 1975; Crombie, 1978; Williams, 1982), and the Search Conference (Emery & Emery, 1978; Williams, 1979; Emery, M., 1982; Crombie, 1985).

- The '*Participative Design' (PD) Workshop* is a meeting lasting anywhere from 1.5 to 3 days in which four to ten members selected from all layers of the organization ('deep slice') are brought together in order to map the working situation on the basis of equality and under the guidance of a so-called facilitator. The basis of its content which is at the core of this self- managing design group can be found in part I of the 'little golden book' (Emery & Emery, 1975). This part places the six psychological requirements mentioned above next to the 'genotypes' of the bureaucratic ('redundancy of parts') and the democratic ('redundancy of functions') structures, and gives a concise description of the advantages of the latter. The methodical basis which is at the core of the operation of the 'total design team', can be found in part II of the golden book. The different personnel functions are assessed on the basis of the six psychological job requirements, and the process flow is analyzed. Also, training requirements are derived from a so-called 'multi-skilling table', which evaluated skills per person for each (group) task. The aim of the PD workshop is to achieve structural organizational change by those involved. Its set-up is 'anti-expert-oriented', and is based on the assumption that 'the most adequate and effective designs come from those whose jobs are under review' (Emery & Emery, 1975). Emphasis is not placed on content, but on the participative process, in which the members of the organization create their own evolutionary learning process.

A specific collective learning environment for Participative Design is the so-called 'Development of Human Resources' (DHR) Workshop (cf. Emery, M., 1988). This is a training programme given at a university for (recently composed) teams from various organizations. For an illustration of the content of such a workshop, see box 6. A PD workshop ahead of its time was the informal European network group which was composed in the early sixties by sociotechnical researchers from the very beginning. Apart from researchers from the UK and Norway, this group included Hans van Beinum and Mauk Mulder from the Netherlands.

- Continuing on from the PD workshop, Fred and Merrelyn Emery developed the so-called 'Search Conference'(cf. Emery & Emery, 1978; Williams, 1979; Emery, M., 1982; Crombie, 1985). This is a non-hierarchical, policy-preparing meeting based on the principle of 'redundancy of functions' involving a maximum of 35 persons, who cooperate two to three days in order to give shape to the future on the basis of equality. The sociotechnical search conference makes use of the indirect or 'broad front' approach, and is directed towards the joint development of 'desirable and probable future scenarios'. Special attention is given to the possibilities and limitations of the environment, with the history of the firm taken into account. This participative form of pro-active planning assumes that people are pragmatic and strive for meta-objectives (ideals); that they are willing to learn and wish to determine their own future. Its explicit objectives are: establishing policy, planning and learning in a non-dominant democratic structure. The very first search conference ahead of its time was held at Tavistock in 1959, when Emery and Trist listed the theories of Bion, Selznick and Asch.

Box 6. The programme of a Development of Human Resources (DHR) Workshop

"Plenary, Final briefing, expectations Collection of data about changes in the extended social field
Small groups work on desirable and probable futures Connections are made to democratic structures
Plenary. Briefing on concepts and tools
Mirror Design Groups. Two disparate groups work together A + B analyse and redesign A's organization. C + D do the same for C's
Plenary presentation and discussion of designs
Reverse mirror groups. A + B redesign B's; C + D redesign D's
Plenary reports as above
Team groups and/or plenary. Next steps. Strategy."

Emery, M., 1989, p. 115

3.3.2 Participative Design and the Open-System Model aimed at Diffusion

At the core of PD is an explicit diffusion strategy, which came about gradually, and which was recorded by Herbst (1976) and Emery, M. & Emery, F. (1978). The starting point of this strategy was the diffusion model developed by Emery *et al.* (1958) for an agricultural renewal programme in South-East Australia. Further diffusion took place after innovations had been successfully introduced with those farms that were respected most. Within the agricultural community, which was characterized by an aggregate structure with relatively homogeneous components, these model firms were considered as being a sufficiently large 'critical mass'. Thoralf Qvale (1976) has made a concise summary of the findings of Emery *et al.* (1958) (see box 7).

Box 7. Results of the diffusion study of Emery et al., 1958

"a. Diffusion of new principles must start within the existing structure, and in a way flow from one level of leaders to the next.
b. Generally, external scientific advisors will only influence the diffusion process through the leaders.
c. Oral and written communication is rarely enough to lead to change, except on the level of leaders.
d. Outside the level of leaders diffusion depends upon the force of the example. In order to be effective the demonstration must be such that everyone can see the similarity with his own condition.
e. A well-respected person or group must be behind the example."

Qvale (1976), p. 459

With the aim of explaining the (Norwegian) democracy experiments, Philip Herbst (1976) further elaborated this diffusion theory. The characteristics of the diffusion process depend upon the structure of the *total* system. The network concept is put central in Herbst's theory. According to him (1976, p. 33) a network group can be described as being the reverse of an autonomous work group. It is a temporary organization of similar thinking people at *different* locations, who meet occasionally for consultation. Such a meeting is sometimes referred to in the literature as a 'flocking session' (cf. Davis & Cherns, 1975). Flocking is a phenomenon which involves different people with common interests coming together for a few days to intensely confer, without making new arrangements for another meeting. According to Herbst (1976) flocking by members of a network is likely to occur, and it supports a network's objective, namely maintaining 'long-term directive correlations'. The process consists mainly of stimulating one another in reaching a common, though not (fully) defined objective. The primary function is its common learning process. Emery, M. & Emery, F. (1978) base their PD paradigm on a open-system model, which in their view is applicable to the diffusion process (see Figure 2). The 'system' is composed here of the members of a PD workshop, search conference or network of firms, the 'environment' consists of 'the extended social field of directive correlations' (Emery & Trist, 1981). In other words, the changed society as a whole. The input function is called 'learning', the output function is called 'planning'. Both Merrelyn and Fred Emery state in general that the level of the environment complexity determines the form assumed by the learning and planning functions in practice.

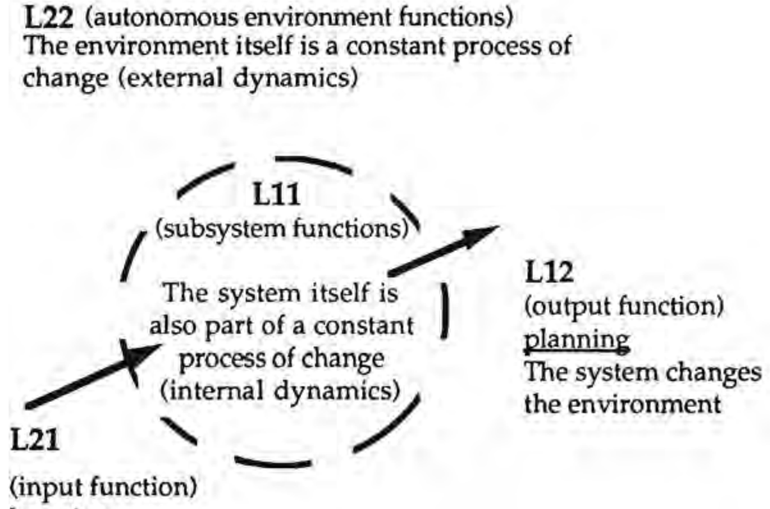


Figure 2. An open-system model for diffusion

Legend: - system = PD group or network, search conference;
- environment = societal institutions and firms;
- the indication 'L' stands for systematic coherence;
- the code '1' stands for system; code '2' stands for environment.

Adapted from: Emery, M. & Emery, F., 1978, p. 259/260; Emery, M., 1986, p. 416; Emery, M., 1989, p. 183.

In a competitive 'type III' environment ('disturbed, reactive', compare section 2.1) the learning function will assume the form of 'problem solving', and the planning function that of 'optimizing, using only technical and economic criteria'. In a turbulent 'type IV' environment (rapid, unpredictable changes, disturbed ecological chains) learning takes place through 'puzzling' (Angyal, 1965), and planning through the active and adaptive development of 'desirable future scenarios' (Emery, 1977).

Puzzling is a form of learning - in the literature it is also referred to as 'double loop learning' (cf. Argyris, 1970/1976; Argyris & Schön, 1978) - in which individuals try to discover the more fundamental key questions in a non-hierarchical, friendly ambience. They try to find trends in an excess of data, filtering 'the leading part' (Emery, 1967). Planning subsequently occurs step-wise plotting, evaluating and adapting a strategy consisting of jointly formulated 'desirable future scenarios'. According to Einar Thorsrud (1972) this type of policy- making is a form of active, adaptive planning, which is basically a continuous learning process. The actual motor behind PD is the pleasure experienced during this learning process. Rather than assuming an expectant attitude, one is willing to get to work. In the PD workshop, members start working as a group to adapt the working situation (in their own firm) all by themselves; in the search conference, participants develop future scenarios.

Another important item is that they do not necessarily aim for consensus: the aim is 'rationalization of conflict' rather than 'resolution' (cf. Emery, M. 1987). One tries to arrive at common starting points in a broad area. According to Merrelyn Emery (1989), the *process* of PD apply cross-culturally, in contrast with its *product* (actual design as a concrete result). This process is described as the creation of possibilities for open-ended self generative learning, 'learning to learn', of 'searching for ends instead of means'. PD is an evolutionary process which involves the democratization of the working situation. It is certainly not a 'T-group' training oriented towards personal relationships! It is a type of 'democratic planning', described by Roos (1974, p.218) as "Man's conscious and collective self-control of the development of a system".

The emphasis being placed on the diffusion process rather than on the changes regarding the content itself is a main characteristic of the period of modern STSD. In this context, one speaks of the difference with the previous phase as a 'figure-ground reversal' (cf. Herbst, 1976; Emery, M. & Emery, F., 1978; Emery, M., 1986). The 'figures' refer to our factual structures (the plants, offices, institutions), the 'ground' to our lifestyles and values. The object of change is reversed, a change in attitude is at stake now: learning to participate.

Max Elden (1979) has summarized the characteristics of PD step by step (see box 8).

Box 8. Characteristics of the period of Modern STSD

"1. A design team representative of (if not elected by) the employees: at the very least, employees agree to a change effort and union representatives usually are redesign team members.
2. Employees receive some training in work redesign concepts and techniques.
3. Participatory search processes initiate the change effort and are not necessarily limited to the design team.
4. The design team develops its own criteria and alternatives (little reliance on installing some pre-designed package).
5. All employees concerned participate at least in evaluating alternatives.
6. There is a high degree of participation in all phases of the redesign process (planning, developing alternatives, evaluating, etc.) which is focused and paced by the people affected (not primarily by management or change experts).
7. Outside experts have a share learning role that changes over time (from some teaching to learning with the participants and eventually to learning from them). There is a supportive network of co-operative relations between design teams from
8. different organisations who learn from each other's experience (they are not entirely dependent on experts for the necessary learning)."

Elden (1979a), p. 250-251; Elden (1979c), p. 373-374

3.3.3 Further Diffusion of the Diffusion Model

PD as Modern STSD has not been as widespread (yet) as its classical predecessor. This is probably connected with the anti-expert character of the new approach, which puts consultancy agencies on a sidetrack. In the seventies, PD workshop projects were confined mainly to Scandinavia, India, Great Britain and the Netherlands. Only a minority of these projects have been documented in the literature.

- Even before the 'golden book' was published, 'off-site/do it yourself' workshops were regularly held in Norway as from 1972. Per Engelstad and Lars Ødegaard (1979) reported the monitoring of five of such consecutive year groups, each consisting of six teams from a total of 25 different firms (mass manufacturing, processing industry, batch industry and service sector). In 1975, Max Elden initiated a PD project in a bank (cf. Elden, 1974/1976/1977/1979b; Herbst, 1975; Herbst & Getz, 1977). In the shipping industry, the Work Research Institutes (WRI) in Oslo also performed several PD projects (cf. Roggema & Thorsrud, 1974; Rogne, 1974; Roggema & Hammarstrøm, 1975) Johansen (1975/1976/1979) reported on a PD project on the newly built merchant ship/trading vessel MS 'Balao'. New legislation in Norway provided support for the PD paradigm.
- The same holds for Sweden (cf. Qvale, 1975; Mills, 1978). Unions are allowed to negotiate with the management regarding all kinds of items. With the Industrial Democracy Act, which was adopted by Parliament in June 1976, Sweden led the way in Europe (cf. Gunzburg & Hammarström, 1979). As mentioned in section 2.3, the diffusion of Industrial Democracy projects in Sweden were successful. In 1975 the so-called Demos project started (cf. Sandberg, 1979). The project is concerned with democratic decision-making and (corporate) planning and is aimed at

supporting the activities of unions at various levels (centrally and locally - from workplace analysis to negotiations). This project is backed by more fundamental research into the preconditions and limitations relative to democracy, planning and self-determination (Sandberg, 1976).

- In Denmark projects were performed between 1969 and 1973 which could fall under Modern STSD. Agersnap *et al.* (1974) report a number of experiments involving new kinds of cooperation in seven firms in the metal industry (N. Foss' Electric, Hilleroed; Højbjerg Machine Factory, Aarhus; Philips Radio, Copenhagen; Danfoss, unknown location; Haustrup, unknown location; Nordic Cable and Thread Manufacturers NKT, Glostrup; Scandinavian Airlines System, Copenhagen).
- Participative Design was also successful in India (cf. Nilakant & Rao, 1976). In the mid-seventies, the National Labour Institute (NLI) organized seven PD workshops throughout the country. In 1975 a classical Industrial Democracy project was initiated at Bharat Heavy Electricals Ltd. (BHEL) in Hardwar. In 1976, this project was extended with a three-day workshop organized by the BHEL in conjunction with Einar Thorsrud. Apart from a number of departments of this firm, representatives of the National Bank, the postal services and an insurance company participated in this workshop. As Nilakant and Rao (1976) illustrate, Emery and Emery's (1974) directions were closely followed, in terms of both the workshop's organization and the method applied (evaluation of psychological job requirements and the use of the multi-skilling table for outlining a training programme). Subsequently, PD workshops were held in the National Bank and the insurance company.
- Great Britain also gained a great deal of experience with PD. From the Tavistock, projects were carried out from 1974 until 1979 within the Job Satisfaction Research Programme, in conjunction with the Work Research Unit (WRU) of the Ministry of Employment. Researchers actually made use of the PD workshop at Associated Biscuits in Bermondsey. Supported by Margaret Butteriss and Archie MacKenzie of WRU, Mary Weir (1979) organized a PD workshop in Glasgow. Once again, Einar Thorsrud acted as introducing speaker for the teams coming from five Scottish firms (Scottish & New Castle Breweries Ltd., Edinburgh; Philips Ltd., Hamilton; Ladybird Ltd., Glasgow; Ailsa Trucks Ltd., unknown location; Tannoy Products Ltd., location unknown). The work of Enid Mumford is worth mentioning here. She applied the participative approach in a British supplier company, a bank, an engineering firm and an insurance company (cf. Mumford, 1979). Her explicit line of approach included the introduction of computer systems in office settings.
- In North-America and Canada, a careful application of Participative Design has only recently emerged (personal communication with Fred Emery, 1990).

3.4 Phase Four: Post-Modern Socio-Technical Systems Design

(general intro - still to be written)

3.4.1 Bjørn Gustavsen's Democratic Dialogue (DD)

If there is a fourth, post-modern phase in the development of STSD at all, Scandinavia, and in particular Sweden, is without doubt the candidate to take the credit for this 'milestone'. We are referring here to the initiation of a "large-scale change process in a broadly based societal context with democratic dialogue as vanguard" (Gustavsen, 1985/1988/1989). Basically, it is a reaction to the Participative Design approach while placing emphasis on the formation of networks and the development of local theories. According to Gustavsen & Engelstad (1986) the 'Democratic Dialogue' (DD) approach assumes that all interested parties can and should participate. In order to promote DD, the authors mentioned above have defined the conditions in which a democratic dialogue may take place (cf. box 9).

Box 9. Criteria for participation, public arena, and legitimacy

"1. There must be a clear definition of arena(s) (...) It does (...) imply that the outcome of the conference is built primarily on what has emerged on the official arena.
2. Public issues are the only legitimate ones. This is a corollary to criterion (1).
3. Resource persons act only on the public scene. This is a further expression of criterion (1). Resource persons, such as researchers, (...) can only be used in public and not made accessible to 'off-the-record' consultations.
4. Analysis, problem solving, and decisions, have to build on what has emerged through the public proceedings. (...) For democratic processes to be possible, it must be clear to everybody what facts and other premises for decisions are relevant. (...) Again, the point is to avoid 'hidden' alternatives to which everybody does not have access.
Personal grievances and frustrations are topics which often tend to surface in
5. developmental efforts. They should, however, as far as possible, be kept out of the encounters. Democratic encounters provide a training ground in democratic competence, and are not therapeutic events. (...) However, personal grievances are not without significance (...) it is not easy to distinguish between their 'personal' and 'structural' sides (...) people should as far as possible turn towards the 'structural' side of the issues. In this way, a certain amount of training in democratic dialogue can take place before the more personal issues are allowed to enter the scene. (...)"

Gustavsen & Engelstad (1986), p. 109

A democratic dialogue can be given shape particularly at organized network meetings. Thus, conferences used as a platform for exchange are placed in a central position in this approach. The DD network philosophy should be placed against the background of years of experience with democratization of the working situation. More specifically, it is a reaction to the modest results of PD. In Scandinavia, PD was brought into practice at (some) large firms in the seventies, but it was far from being a big success in small and medium-sized companies. This was attributed, amongst other things, to the lack of adequate mutual networks. Both in Norway and in Sweden an attempt was made to change this by means of DD.

In Norway, a national basis emerged for the development of local networks in 1982, when employers and employees jointly agree to support network-oriented activities both professionally and financially. On the basis of the regional experiences gained in this context, the so-called 'Development Organization' (DO) approach develops gradually (Engelstad, 1990). This is a more indirect approach to PD, with the aim of creating a suitable platform for mutual exchange - also for

SMEs - and of improving the quality of the mutual dialogue. The DO approach is based on five pillars:

1. the strategy forum;
2. 'company-wide' conferences;
3. project groups beyond departments;
4. basic groups within departments;
5. sociotechnical changes in the daily work organization.

In particular, the first two pillars call for an additional elucidation. The strategy forum is not a steering group in the traditional sense, but the semi-open conditioning body of the network which is also accessible to invited external experts. In order to prevent to the best extent possible drop-outs as a result of employee turnover over years, the forum is composed of two members of each participating party. The strategy forum formulates general objectives, brings together (groups from) the participating cores in the organization network, stimulates fruitful discussions, and maintains contacts with the whole 'broad front' of activities.
With regard to the conferences, it can be said that these were initially largely built up in the same manner as those in the PD tradition. However, they became gradually more focused. Based on the experiences gained with projects in a specific line of business, so-called 'branch projects' (cf. for example the garage-owner project: Engelstad, 1990), the 'Dialogue Conference' (DC) method is developed, a type of PD workshop or search conference for network development. It starts from the assumption that the quality of the dialogue is an important vehicle for the change process. The DC method can be divided into three successive phases:

1. adoption in the branch network;
2. business development process;
3. expansion of the (supporting) network.

During phase 1, the demonstration conference takes place, the strategy forum is composed and regional promotion conferences are held. In phase 2, a 'whole- company' conference is organized, and a part-time expert is admitted to the firm as a 'scholarship holder', paid and supported by the national programme. In phase 3, a 'network development' conference is held to expand the number of participating firms and supporting institutions. The strategy forum acts as initiator and coordinator in all these activities.
The content of the conferences is largely left to the groups participating. However, the order of the sessions and composition of the groups are carefully planned in advance. Take for example the regional promotion conference. This conference is held under 'social island' conditions and lasts two full days. Some 30 to 55 participants from 4 to 7 firms take part, composed as 'vertical slice' groups varying in size from 5 to 10 persons. The plenary opening of the promotion conference is followed by four parallel sessions involving 10 persons at maximum and a plenary reporting session (Engelstad, 1990). In the *first* session, in terms of function homogeneous groups (executive personnel and

management) from *different* firms discuss the experienced business environment and its future developments. In the *second* session, the homogeneous manager groups are divided over the groups with executive personnel. These heterogeneous groups discuss the improvements required in a product and in the working environment in each department. In the *third* session, homogeneous groups of executive personnel from *one single* firm are formed together with managers from *other* firms. These heterogeneous groups discuss what *radical other* organizational structures are needed in order to achieve better results. Finally, in the *fourth* session, only personnel from one single firm are brought together, in order to talk about the process of change rather than its structure. The starting point is that *each* individual employee should take part in such change *during* working time.

Box 10. Main features of the LOM programme

"1. magnitude: more than 80 enterprises and public institutions and about 50 researchers from different institutions all operating within a loosely arranged common framework and forming networks of learning and diffusion. (...)

2. unit of change: a cluster of organizations collaborating with each other and with research. Broadly based approaches within and across organizations feed into processes of intra and interorganizational learning. The strategy is to link these clusters to other enterprises and clusters to form larger diffusion networks.

3. process of organizational change: based on and guided by the uniques of each local development. It rejects a general model for change and works with the notion of developing local theory, that is the local generation and continuous reconstruction of different patterns of work organization. Social research is in a support role to local action.

4. ongoing process: the actual existing experience is to form the base line for each project which therefore cannot be defined as a zero point but is defined in terms of an ongoing process. Participation in the programme commences with a project development conference in which representative vertical slices of the various enterprises jointly make decisions about the organization and direction of their local projects.

5. vanguard: the programme is founded on discourse-oriented democratic theory. Democratic dialogue which encompasses large networks of people forms the vanguard of the approach and determines the direction of local development.

6. infrastructure: the programme uses multi-level strategies which connect local developments to the various elements in the larger infrastructure of Swedisch society. Its points of anchorage in laws, agreements and bi- en tripartite structures and it linkage with the broader social and political structure, make the LOM programme 'reform oriented' rather than 'organization development oriented' (Gustavsen, 1989)."

Van Beinum (1990a), p. 16-17

As previously pointed out, the rational, tripartite stimulation programmes in Scandinavia are highly important in realizing an infrastructure for a democratic dialogue. In Norway, this is the

HABUT programme, which stands for 'The Basic Agreement's Enterprise Development Measures'. In Sweden, it is the LOM programme, established by the Swedish Work Environment Fund, and which means 'Leadership, Organization and Co-determination'. Of both programmes, LOM is the most extensive in terms of its content and size. Its most important characteristics are summarized in box 10.

The LOM programme acts as an umbrella under which separate, regional network programmes are performed. According to Gustavsen (1989) there are more than 100 firms and institutions taking part in this programme which was instituted in 1985.

3.4.2 Ulbo de Sitter's Integral Organizational Renewal (IOR)

From the end of the seventies, the Dutch variant of STSD became increasingly broadened and in the late eighties developed into the approach of 'Integral Organizational Renewal' (IOR). According to De Sitter (1989a), an integral approach is a structure approach by definition. By 'structure' he means that part of a process which in relatively invariant in time (nature of the operations, norms). The core of an integral approach is "that on the basis of a strategic orientation external function demands are determined. (...) Problems in the business management are evaluated in the light of the function demands ..." (De Sitter, 1989a, p. 36). He refers to settling those problems that can be solved independently of one another as 'improvement' (partial change in structure), and to settling interdependent problems as 'renewal' (integral change in structure). In De Sitter's view, renewal basically means the reordering of process functions with respect to order flows. De Sitter (1989a) typifies IOR as a fundamental shift from the old functional production concept to the new flow-oriented production concept.

In the early eighties, new opportunities arose for the application of STSD, because the quality of work was no longer viewed as a social luxury, but as an essential foundation for a flexible production organization. De Sitter observes these developments, and places the production and work organization in a socio-economic perspective (De Sitter, 1980). He was the first to connect themes as the quality of working life, efficiency and effectiveness, as well as social binding and cooperation in a model. Following up on that he pleads for 'new factories and offices' based on modern STSD (De Sitter, 1981a). In these publications he stands up for more policy-based integration of the areas of attention of the quality of work (with stress and alienation as problems), the quality of the organization (with flexibility and controllability as bottlenecks), and the quality of the internal industrial relations (with employee turnover, absenteeism and labour conflicts as central issues). He points out that the issue of industrial democracy has traditionally been fragmented in the above-mentioned problem areas which are separate studied by psychologists, sociologists, economists and organization scientists. This has resulted in the well-known 'engineering, personnel and union-management approach', having as respective orientations *isolated* improvement of the quality of the organization, work and industrial relations (cf. table 5).

Table 5. Three types of partial analysis in the study of participation

type of approach	democratic 'idea'	object of reform	object of analysis	expected function	quality level
the engineering approach	participation in managerial functions	primary process regulation, boundary control between work units	production control structure	organizational performance	quality of organization
the personnel approach	integration of productive and regulative task functions	autonomy and discretion	task structure	work motivation	quality of work
the union-management approach	representation of collective interests	regulation of working conditions and the distribution of rewards	structures of collective representation, rules and procedures	stability of cooperation, effective conflict regulation	quality of labour relations

De Sitter (1981b), p. 6

De Sitter very well recognized the functional relevance of participation in decision-making as a vehicle for industrial democracy in order to have a synergetic effect on the above-mentioned problem areas. For an operational definition of participation, see box 11.

Box 11. Indicators of participation

"a. the number of regulative functions performed;

b. the levels of regulation implied in a work role:
  - internal regulation;
  - external regulation;

c. effectiveness or influence:
  - task complexity;
  - substitutability;

d. symmetrical interdependence".

De Sitter (1981b), p. 8-12

Integral design is at the core of the IOR approach. A basic problem is the ability to control the production system as a whole; the objective of STSD is to improve this ability by means of changes in structure. The Balance Model discussed earlier acts as the core of IOR in terms of content; interference and control capacity are its central concepts.
The core of IOV research consists of making an inventory of market demands and performance

criteria (cf. Bolwijn *et al.*, 1986; Bolwijn, 1988; Bolwijn & Kumpe, 1989; Kumpe & Bolwijn, 1990), and, in its extension, the identification, analysis and introduction of structural parameters which together must reduce the chance of disturbance and sensitivity taking place (cf. box 12).

Box 12. Structural parameters for sociotechnical analysis and design

1. Functional (de)concentration: Grouping and coupling performance functions with respect to order flows (transformations). There are two extremes: all order types are potentially coupled to all sub-systems (concentration), or each order type is produced in its own corresponding sub-system (deconcentration in parallel flows).
2. Performance differentiation: Separating the preparation, supporting and manufacturing functions into specialised sub-systems.
3. Performance specialisation: Splitting up a performance function into a number of performance sub-functions and allocating them in separate sub-systems.
4. Separation of performance and control functions: Allocating a performance and corresponding control function to different elements or sub-systems.
5. Control specialisation: Allocating the control of functional aspects to separated aspect-systems (quality, maintenance, logistics, personnel, etc.).
6. Control differentiation: Splitting feedback loops into separate control levels (strategic, structural and operational).
7. Division of control functions in the feedback loop: Allocating 'sensing', 'judging' and 'action selection' functions to separate elements or sub-systems.

Adapted from: De Sitter (1989b), p. 234
De Sitter *et al.* (1990), p. 12

Performance and control are the basic functions here. Initially, De Sitter distinguished between two basic aspect-systems: the Production Structure (P) as grouping and coupling of executive functions (performance), and the Control Structure (C) as grouping and coupling of regulative functions (control). Later, these were expanded by the Information Structure (I) as technical elaboration of P and C. A whole series of design principles were formulated in the eighties (cf. box 13).

Giving shape to the production structure through parallelization and segmentation drew special attention. This is really concerned with a method to fundamentally change the organization of the technical processes, which is an explicit objective of the sociotechnical paradigm. The IOR approach pays a great deal of attention to the parallelization of order flows. For an elaborate study on the possibilities of Product Flow Analysis (Burbidge, 1975) as a technique for parallelization, see Hoevenaars (1991).

Box 13. A selection of design principles from the IOR approach

	Design strategy	Structure	Level	Parameter
a.	Parallelisation	P	macro	1
b.	Segmentation	P	meso	2+3
c.	Unity of time, place and action	B	micro	4 t/m 7
d.	Bottom-up allocation of feedback loops	B	micro, meso	4
e.	Uncoupling of feedback loops in time	B	meso	6
f.	Building in feedback loops in each task	B	micro	1 t/m 7

Adapted from: De Sitter (1989b), p. 237-249
De Sitter *et al.* (1990), p. 13-19

In addition, the formation of the control structure has also been elaborated upon in detail (cf. Landré, 1990; Van Amelsvoort, 1989/1991). Also, the exploration of the information aspect is given attention (cf. Van Eijnatten & Loeffen, 1990).
The IOR approach moreover distinguishes explicit design sequence rules (De Sitter *et al.*, 1986; De Sitter, 1989b; De Sitter *et al.*, 1990). Thus, the production structure should be given shape preceding the control structure and the design of process technology, and the design of control circles should be in the order of allocation, selection and coupling.

Apart from the content of the (re)design, the process of change also receives full attention. IOR suggests a renewal trajectory of two to four years (Den Hertog & Dankbaar, 1989; De Sitter *et al.*, 1990) including a strategic exploration, on-the-job-training and training for self-design, as well as project phasing and management. The IOR approach is internationally called the Dutch variant of (Post) Modern STSD.

3.4.3 Post-Modern STSD and the 'Fourth Phase Milestone' contest

The period of Post-Modern STSD has only just began. By now it is far too early to ask for a definite winner of the 'Fourth Phase Milestone' contest. Whether or not the Democratic Dialogue as described in paragraph 3.4.1 actually encompasses a subsequent qualitative leap forward in the development of STSD, or is just a further broadering, development and expansion of Participative Design, cannot, in the early nineties, be determined with certainty. According to Fred Emery (1990, personal communication) a real fourth phase would be characterized by the development of "organizational forms for the management of self-managing work groups". The Dutch approach to 'Integral Organizational Renewal' (IOR), described in paragraph 3.4.2, would in such a case be more eligible for the designation of 'fourth phase milestone'.

Chapter Four

Epistemological and Methodological Foundations of the STSD-Paradigm

In the previous chapter some highlights of the STSD paradigm were presented. Four distinctive development trajectories were described by means of anecdotes, and there was a first exposition of concepts and methods. Due to the basic historical account followed, a closer examination of methodology was not possible. This chapter will further elaborate on the scientific foundations of STSD:

- In paragraph 4.1 the main scientific-philosophical points of departure and the nature of STSD explanatory diagrams will be presented;
- In paragraph 4.2 the methodology of directive correlations, which is central to STSD, will be discussed;
- In paragraph 4.3 the development of systems concepts will be analyzed, and its influence on STSD modelling;
- In paragraph 4.4 STSD methods will be looked upon. The discussion is concentrating on the evolution of models for analysis and design;
- In paragraph 4.5 STSD practice will be described starting from the controversy on design content versus process.

4.1 Scientific-Philosophical Points of Departure and the Nature of STSD Explanatory Diagrams

Although very implicit in the publications of the pioneering phase, the scientific-philosophical foundations of the STSD paradigm were anything but absent.
Above all it was Fred Emery who at first actually did articulate on this. Already in his thesis he had reached on the major empistemological and methodological questions that concerns social scientists (Emery, 1946). In line with American pragmatism, in Tavistock Document 527 (Emery, 1959) he employed these ideas to create a firm and solid basis for the evolving STSD paradigm, using contextualism as a root metaphor:

"My position was realism vs nominalism and materialism vs idealism; in one word, contextualism. That position is very clear in my publications before Doc 527. In Doc 527 the opposition to nominalism is apparent in the stress that is placed on systems theory; the opposition to idealism in the critique on the Human Relations school. The latter point is strongly reinforced in Part III of Doc. 527- 'psychological requirements'. Here, short-shrift was given to individualistic psychology and the answers sought in the reciprocal relations between persons and the objectively structured task environment. Implicitly rejecting Lewin's subjective 'life space' and explicitly using the conceptual framework introduced in *Social Structure and Personality*, 1954. Methodologically I was well and truely convinced, by 1946, of Lewin's arguments in his paper on *'Aristotlean and Galilean modes of thought'* (1935). Phil Herbst in those days was well into Formism (Pepper's term) and peripheral to our thinking".

Emery 1990), p. 7
personal communication

Later, Herbst also contributed to the scientific grounding of STSD. He fully considered and published the consequences of developments in science philosophy for his own discipline (cf. Herbst 1970/1974/1976). According to Herbst (1976) the philosopher Spencer-Brown made an important discovery with his 'primary distinction', whose consequences for the formulation of theories should not be underestimated. Whereas classical epistemological schools such as Platonism, (Neo-) Positivism and (Neo-) Kantianism all depart from axioms in the form of dichotomies (cf. 'phenomena constructs', 'external-internal', 'objective-subjective'), Spencer-Brown establishes a triad set of elements (cf. 'internal-boundary-external'). This trichotomy is proclaimed an 'unexamined given' of each conceptual system, on the basis of which Herbst (1976) derives the following axiom:

'The primary conceptual unit is given as a triad of distinguishable undefined components, which are definable in terms of one another.'

From this axiom he subsequently derives a theorem:

"It is not possible for a single entity or a pair of entities to exist by itself or to be definable."

Herbst (1976), p. 90

In a next step he checked to see if the systems concepts could be derived from the definitoric entities. This appeared to be possible by using an operational interpretation. It is not difficult to grasp the relevance of a similar contribution to a developing systems theory in general, and to STSD in particular.

Ackoff and Emery published a revealing study in 1972 on scientific-philosophical and methodological principles bearing the title 'On purposeful systems'. It took Ackoff more than 30 years to finish the manuscript! In this book, which is an absolute must for methodologists, actually the insights that in the fifties and sixties proved to be usable metaphors from biology and cybernetics are rewritten and developed further to be applied to the STSD approach. According to Emery (personal correspondence, 1990) this book "enabled me to clear up some conceptual problems with the level of purposeful systems but it neither arose from mainstream STSD work nor fack into it. Our methodology in STSD had been firmly based on Sommerhoff's directive correlation since 1963" (p.

10). Nevertheless, this publication offered a lot of conceptual digging up, which is of major importance for the development of the paradigm. 42 meticulously formulated definitions aptly illustrate the evolution of structural principles into functional systems concepts, followed by another ten statements elaborating seven classes of functional systems (cf. table 6).

Table 6. Seven classes of functional systems. Ackoff & Emery (1972), p. 29.

		FUNCTIONS OF OUTCOMES		
		A. UNI-UNI One function in all environments	B. UNI-MULTI One function in any one environment. Different functions in some different environments	C. MULTI-MULTI Different functions in same and different environments
STRUCTURE OF ACTIONS	1. UNI-UNI One structure in all environments	1A. PASSIVE FUNCTIONAL (meters)	1B. PASSIVE MULTIFUNCTIONAL (waste emitters)	
	2. UNI-MULTI One structure in any one environment, different structures in some different environments	2A. REACTIVE FUNCTIONAL (servomechanisms)	2B. REACTIVE MULTIFUNCITONAL (industrial robots)	
	3. MULTI-MULTI Different structures in same and different environments	3A. ACTIVE FUNCTIONAL GOAL-SEEKING (single program automata)	3B. ACTIVE MULTIFUNCTIONAL MULTI-GOAL-SEEKING (multiprogram automata)	3C. ACTIVE MULTI-FUNCTIONAL AND ENVIRONMENTALLY INDEPENDENT PURPOSEFUL (people)

As table 6 shows, from now on there is a solid systems basis for distinguishing man from machine. In an inimitable way the vital concept of the 'adaptive, purposeful system' is derived, one of the building stones of the STS approach. The development from closed into open system concepts also influences the nature of the explanatory diagrams used according to Ackoff & Emery (1972). These authors place the traditional positivist principle of causality, whereby the cause is both necessary and sufficient for a certain consequence (deterministic relation), right opposite a new explanatory diagram in which a cause, albeit necessary, is not considered sufficient (producer/product relation).

Following Peirce's (1898) 'logic of relations', in which there is made a clear difference between *'class membership'* (subsuming the individual particular to a class of such particulars; containment) and *'class inclusion'* (inclusion by definition; inclusion of one class in another), Emery later came to distinguish four basic rules that govern the process of defining observables by classification:

U-1 *similarity (familiarity) relation*: classifying universals as nominalistic collections of particulars;

U-2 *proximity (in time and space) relation*: classifying by relative frequency, or tendency (frequency

of interaction or co-occurance);
U-3 *cause-effect (producer - product) relation;*
U-4 *relation of part-part within a whole (e.g. siblings);*

Emery (1990), p. 7

Early STSD was classifying particulars in terms of cause and effect (U-3 relation) whereas contemporary STSD also is classifying particulars in terms of its function (U-4 relation).

According to Emery (1989) the basic form of logical inference STSD is using, is neither deduction nor induction but *abduction* (retroduction). This form of inference yields in Peirce's terms 'reasonable ex post-facto hypotheses'. Emery typified it as 'a logic of discovery':

"In the laboratory sciences we might know and be able to control 80-90 percent of the variance. The small indeterminate element can then be systematically explored by varying our experimental controls even if, as in the isolation of salvarsan, 606 variations are needed.
In field experiments with sociotechnical systems in a non-isolable environment we would be lucky to know and be able to control 20 percent of the variance. A radically different situation. It is a situation that does not permit a strategy of systematically exhausting possibilities because a) there are too many permutations and combinations, b) we do not know enough to establish the controls for such systematic variation and c) we want to know what the system does in its characteristic environment, not what it does in laboratory.
We have to follow scientific strategies appropriate to our special circumstances. Thus we need to judge our theories by their fruitfulness in directing our inferential processes of retroduction. That is we need sketch maps that convey the prominent features of the territory we are trying to traverse. We check those maps by following up on the hypotheses they suggest. It is the only way we can go. Deductive and inductive inferences will always be very secondary for us and the only forseeable future is a fistful of grubby sketch maps. Call them theories of the middle-range (Merton) or local theories it does not matter. It adds up to the fact that any science of developing systems is limited to local logics - a grand logic would necessarily deny the qualitative changes that alone warrant our attention as scientists."

Emery (1990), p. 10/11
personal communication

The use of an open-system approach also affects the way in which theories are formulated, as Melcher (1975) aptly illustrates:

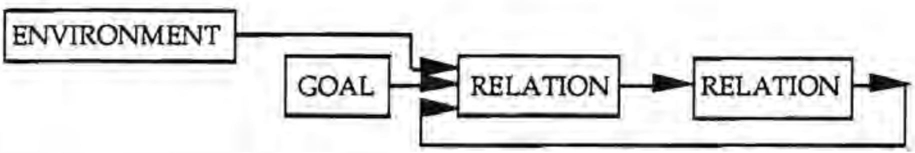
"Normally, model building involves defining independent and dependent variables. One of the minimum logical tests of the model is whether the variables are conceptualized and measurable in independent terms. Otherwise, any relationships are tautological. The thrust of research studies is to determine the degree of influence the independent variables exert over the dependent variables.

The strategy of building a systems model, on the other hand, is sharply different. The thrust is to define variables in relationship terms. (...) The adequacy of the definitions is tested in terms of the degree to which useful relationships can be described. Since the entire thrust is on relationships, it is considered essential to build the model in these terms."

Melcher (1975), p. 7

It not a simple task to find a schematic representation of such a new fundamental diagram in the literature. After much effort only one example could be discovered, i.e. Fry's variant of a system 'regulated by feedback' (cf. Figure 3).

Figure 3. Fry's (1975) variant of a system 'regulated by feedback': a schematic representation of the basic explanatory diagram of STSD, p. 57



Fry (1975) explains this diagram as follows:

"A goal drive causes a 'determining' relationship to influence a 'determined' relationship. At the same time, the determining relationship is also being influenced by other factors while it simultaneously influences the multiple factors working on it".

Fry (1975), p. 57

This kind of constructions are highly complex, but allow for both static and dynamic analyses.

4.2 The Problem of the 'Openness' of Systems and Von Bertalanffy's Conceptual Leap

As said before, of crucial importance in STSD methodology is the notion of the 'open system' (Von Bertalanffy, 1950). This construct is defined by a set of four types of relations (cf. figure 2 in paragraph 3.3.2): L11-system functions; L22-autonomous, independent environment functions; L21-input functions and L12-output functions. Emery is proclaiming a dualistic relation between system (i.e. organism) and environment:

"As a general proposition we are saying that the organism cannot be characterized without characterizing its environment, and that the environment cannot be characterized without characterizing the kinds of organisms for whom it is an environment.
We will go one step further, following Shaw & Turvey (1981), and argue that this symmetrical compatibility implies that the laws governing one must have some invariant relationship with

the laws governing the other, i.e. L11 s L22, where s symbolizes symmetry. This can be termed the Postulate of Duality or the Postulate of Reciprocal Contexts."

Emery (1989, p. 9

Emery is stating (1989, p. 10) that when the temporal dimension is added to the basic earlier mentioned four types of relations: "this expanded set corresponds to the form of the directive correlation postulated by Sommerhoff (1950/1969) to characterize the biological concept of adaptive behavior". According to Emery: "this same set effectively defines the root metaphor of Contextualism (Pepper, 1942)".

In the early fifties, indeed Emery did help in the breaking of new ground by developing a methodology of directive correlation. Because of the centrality of this epistemological pioneering work, we quote Emery's argument at full length here:

"There was a further epistemological problem inherent in the position I had taken. This was the problem of the 'openness' of systems (what Pepper, following Peirce, terms dispersiveness vs integratedness). I was made aware of this by Bertalanffy's 1950 article in Science. I brought it to the attention of the Tavvy when I was there on the Bolsover experiment 1951-2. The solution of this problem was in the 'Progress in conceptualization' papers, 1963, and made public in the summer of 64. This was the conceptual leap from Bertalanffy's:

L11 (L12, L21)..?,

to L11 (L12, L21) L22.

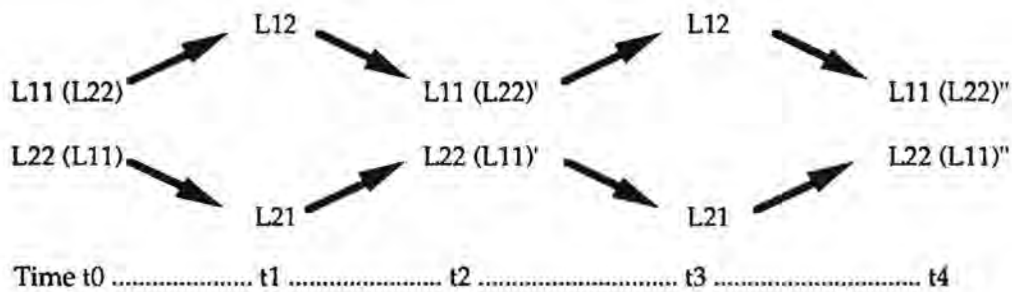
That is a leap that most so-called systems theorists have still not been able to make. A leap they cannot make because it is academically unacceptable to deny Kantianism and accept that the L22 can be known for what it is. However, it is only thus one can get from Formism, Organicism or crude forms of inter-actionism to the genuine contextualist position of trans-actionalism; acknowledging that L11 and L22 are complementary, mutually determining. Neither can be adequately characterized without characterizing the other. A system and, particularly, the system principle, cannot be characterized without characterizing what is environment for it. Conversely, an environment cannot be characterized without specifying what sort of systems it is an environment for. (Which gives some idea of how far the concept of environment is from physics textbooks).

Staying with Bertalanffy's immature concept of an open system had several serious consequences. Within that framework our only knowledge of the L22 comes from the interaction L21. L12 is confined to efforts to adapt to what that L21 discloses of L22. The purposes of L11 can then be no more than internal equilibrium that defines systems survival. This same model forces us to define the relation of L11 - L22 by inference from the observed interactions i.e. L12, L21. This level of interaction is no advance on Newton and the planets. The definition of open system that we advanced explains the interactions in terms of the relation of L11 and L22. In this model we can rigorously define 'active adaptation'. Because the L22 exists for L11 then L12's can be purposefully selected to induce L21's that L11 can turn to its adaptive advantage. All of this was spelt out in Doc 527 before it was formalized in 1963. In that same document it was repeatedly spelt out that when we speak of organizational missions, objectives or 'primary tasks' we are only using linguistic shorthand to refer

refer to special forms of interdependence between the L11 and its L22. I do not know how often I have reasserted this but it has fallen on deaf ears because those who should have been listening think that the L22 is what the CEO, or his personal constultant, think is 'the world out there'.

As the debate has spread to the physical sciences, due to ecological concerns, I have realized that the model we have used since the late fifties had to be elaborated. A case of dotting the i's and crossing the t's for those for whom this was not their native language. To adequately represent their mutual determination we should use the following symbolization: L11 (L22') - L22 (L11'). Such mutual determination can only be a result of a process of co-evolution. Our perceptual and affective systems have evolved so that we are, as a species adapted to living in the environment the world provides. We have shaped that world with a view to it supporting the purposes we consistently pursue. (OK we did not respect the time scales for adequate 'feedback'!).

To accomodate the notion of active adaptation/purposefulness (Emery, 1967) the paradigm has to have an intrinsic temporal dimension:



With this step the relation of the basic conceptual paradigm and the methodology of directive correlation is explicit. Note that if we consider the L11 chain in isolation we can speak only of producer-product relations. Only the totality of the joint action provides the necessary and sufficient conditions.

This step also makes it clear that we are already into ontology as we are talkking about facts of development. Not surprising, as it only when you assume an unknowable L22 that you have a free-floating epistemology.

Inability to make this conceptual leap to recognizing a knowable L22 has prevented system theorists from recognizing how advanced Sommerhoff's methodology of directive correlation is compared with Ashby, Prigogine and ilk. The latter use as much mathematical formalism as Sommerhoff but have been highly popularized, and prescribed as university texts. Sommerhoff, however, demanded that the L22 be given equal status with the L11 and that the asymmetry of the concept of adaptation be replaced by the logically symmetrical concept of directive correlation. The concept of directive correlation made no presuppositions about whether the relation of L11 - L22 was being determined by L12 or L21; that was a matter for empirical determination in each case. As Sommerhoff spelt out this concept of directive correlation it provided a rigorous methodological framework for contextualism. Something that R.A. Fisher's *Design of Experiments* fell far short of doing. Something that has still not been equalled."

Emery (1990), p. 7-9
personal communication

From its start, Classical STSD methodology has been firmly based on Sommerhoff's directive correlation.

4.3 The Development of Systems Concepts and its Influence on STSD Modelling

From the very beginning STSD modelling has been strongly infuenced by systems thinking:
- As is illustrated in table 1, paragraph 3.1.2, during the Pioneering Phase the Tavistock researchers adopted a whole array of systems concepts from biology, logic and cybernetics. In those early years the STSD pioneers hardly have had any aspiration to develop their own coherent, STSD-specific theory of concepts (personal communication with Van Beinum, 1989). They became mere fascinated by systems concepts as they emerged from other disciplines and enthusiastically tried them out in actual practice.
- As described in paragraph 3.1.3, it is not before the end of the fifties that the first systematic attempts have been made to develop what is called here the Classical STSD theory of concepts (cf. table 2). In the sixties this conceptual framework further has been refined to the system of analysis and design principles as we know it today (cf. table 3 and 4, paragraph 3.1.4).
- Up till the present time it is not generally known that during the phase of Classical STSD concept development has been redefined in the light of evolved systems thinking.

In this paragraph two contributions to the modernization of (Classical) STSD concepts are presented: De Sitter's 'Balance Model' for routine work systems, and Purser and Pasmore's 'Organizing for Learning' approach for non-routine work settings.

As an extension to the epistemological work of Luhmann (1968a/b) and Elias (1970), and taking into account the results of the Habermas/Luhmann (1971) debate, De Sitter, in cooperation with other business sociologists, produced a new theoretical foundation for Classical STSD from Eindhoven University of Technology, The Netherlands, in the mid-seventies (cf. De Sitter, 1974a/b; Van der Zwaan & Vermeulen, 1974; Van der Zwaan *et al.*, 1974; Smets & Van der Zwaan, 1975; De Sitter & Heij, 1975), which was adjusted in the early nineties regarding some minor points.
First, De Sitter broadly describes STSD as the study and explanation of the manner in which technical instrumentation and the division of work determine [system behaviour, capacity and functions] in their mutual connection and in relation to given (but changing) environmental conditions, as well as the application of this knowledge in (re)designing production systems (De Sitter, 1974a, p. 76). Fifteen years later he replaces the part between brackets in the previous sentence by "the possibilities for the production of internal and external functions" (De Sitter, 1989, p. 232). For a graphic representation of the core variables from this complex definition and their relationships, see figure 4.

OBJECT OF STUDY AND (RE)DESIGN

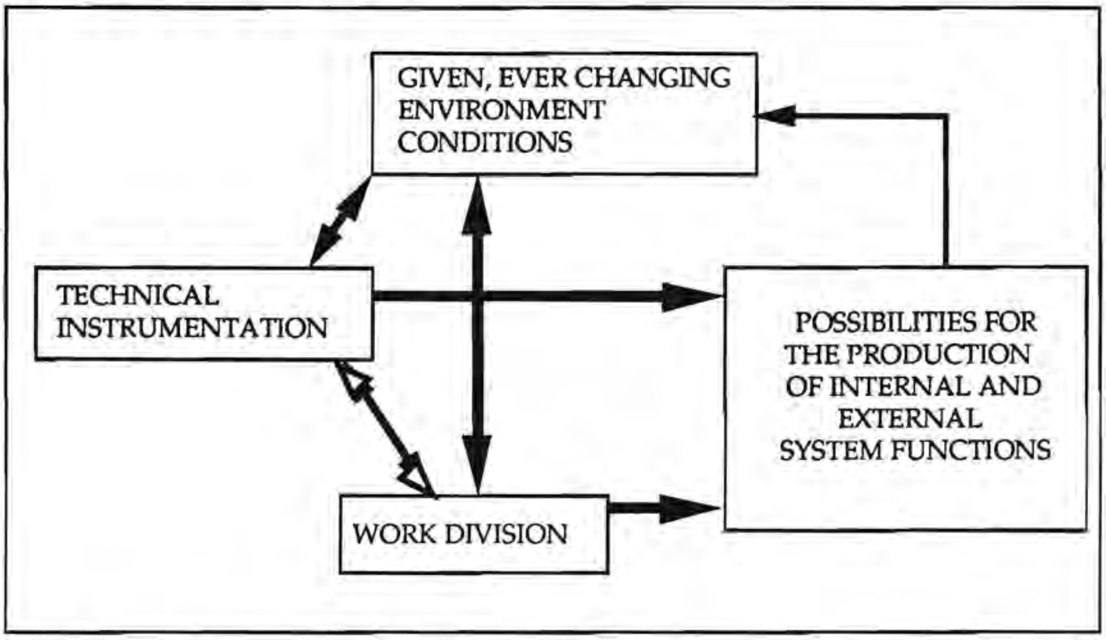


Figure 4. STSD, a graphic representation
Legend: ⟷ *interdependence*
⟶ *determining relationship*

Adapted from: Van Eijnatten (1985), p. 55

Technical instrumentation is defined here as the technical equipment of people and means (in terms of capacity). *Work division* is defined as the grouping, allocation and coupling of executive and regulative functions. This is concerned with the separation of executive and regulative tasks on the one hand, and the splitting or division of executive and regulative tasks in sub-operations and subregulations respectively. De Sitter (1980/1981a) speaks of "the architecture of production control" and distinguishes four basic types of work division which he does not specify in more detail (p. 44/p. 119).

In the above description of STSD, De Sitter stresses that in particular, it is the nature of the *interdependence* between technical instrumentation and work division which influences the behaviour of the system, in terms of internal (directed towards purchase, preparation, manufacturing and sales) and external system functions (directed towards various 'markets'). Basically, De Sitter develops a process theory of change, which he designates with the term 'Model of Balance', in which the dynamics of cyclic interdependencies (both cause and result, compare the principle of the servo-controlled mechanism) is put central.

An explicit point of attention of the Model of Balance is the structure of the selective labour process. The quantitative aspect of the labour process is the volume of goods and services exchanged, the qualitative aspect is the continuity and development of work relationships (De Sitter, 1989a). The labour process is viewed as an intersection of various institutional and private exchange processes; needs and values are considered as being *changeable* social processes cultivated by society and brought into the work situation by individuals and groups. According to De Sitter,

giving meaning is a function which is inherent in selective social processes which is closely connected to the regulation of the labour process: "What structural conditions must my labour process comply with in general, in order for me to solve changeable numbers and types of problems in time and participate in the process of giving meaning?" (De Sitter, 1978, p. 9).
Without regulative components in work, alienation occurs; but on the other hand, regulations provide involvement in work. Stress occurs when someone has problems and is unable to solve them.
Using this model, which basically is applicable to all kinds of social systems, thus including firms, one is able to describe the dynamic process in a simple and economical manner, in which open system and environment follow from each other's change in a constant manner again and again, in different ways. As such, the model is a system-theoretical alternative to Emery's directive correlation methodology. In his elaboration, De Sitter concentrates primarily upon interaction conditions, upon conditions for structure. The operational problems in production control are the explicit point of departure.
Once again: De Sitter makes a conceptual contribution here which breaks new ground. In 1973, he had already published a well-defined and coherent system concept framework, including the 'empty cartridge' concept of *'aspect-system'* unknown to Tavistock (cf. De Sitter, 1973). In the same article, a strongly condensed effort can also be found to fill the 'mould' of systems approach in terms of its content, by means of what is referred to as "a scheme of interaction strategy" (p. 138). De Sitter directs his theory towards social interaction in which he integrates segments of value, regulative and power theory. He calls the product "a theory of qualitative system dynamics" (p. 113). After 1973 this scheme was converted into a more verbal model (De Sitter, 1978). Central in the Balance Model is the so-called 'interference' phenomenon, an effect which occurs in a situation where one process operation is disturbed or even totally obstructed by another. De Sitter describes interference as follows:

> "(...) the chance that two or more interaction processes meet each other in the labour process, and as a result of their normative and/or material incompatibility, cause a disturbance which tends to affect the interaction possibilities which come into being through the labour process".
>
> De Sitter (1978), p. 15

The core of the new process model for Classical STSD is either preventing or curing interference and its diffusion in the system. This can be effected by means of regulation. Regulation can be broadly defined as keeping in balance processes fine-tuned to *different* functions in a system. The Balance Model uses the feedback loop as a basic model of the labour process. In the feedback loop, it is preferable not to separate and divide implementation (realizing connections) and regulation (selecting connections), but rather to integrate them (principle of minimal labour division).
The Balance Model, as well Classical STSD, departs from the so-called 'latitude premise', an assumption regarding control scope which is founded on the cybernetic 'Law of Requisite Variety' used as an axiom (Ashby, 1956a). This law roughly states that the external variability of the environment (turbulence) as input can be only compensated for or cancelled by a proportional

internal variability of the open system (*un*programmed production control/latitude). De Sitter (1978) defines the variability of the input as control need, and the potential open systems variability as control possibilities. The balance between control need and control possibilities is defined as the quality of work.

A key concept in the Balance Model is 'control capacity'. According to De Sitter (1978), this concept does "not refer to authority but to control *possibilities* resulting from the objective nature of the labour process" (pp. 20/21). In 1980 he briefly defined control capacity as the problem-solving of disturbance reduction capability: "In actual practice the control capacity present manifests itself in the disturbance sensitivity of the process, thus in the extent to which a disturbance is reproduced without the possibility of reducing it through regulative action" (p. 69). According to Van Eijnatten (1985, p. 402) (internal) control capacity as a concept refers to a structure condition of the labour system in which it is possible to choose from alternative activities in order to achieve the production norms in different situations and under changing circumstances. A similar choice from possible situation leads to actual regulation (fulfilling a function). De Sitter states that latitude provides control capacity in order to reduce interference.

As pointed out earlier, in an objective sense there exists an adequate quality of work when the control capacity is relatively high and fine-tuned to the existing control need (the complexity of the exchange relationship in terms of work orders, process specifications, time and work pressure). Karasek (1979) defines this combination as "the active work with social and technical learning opportunities". This American researcher made use of two sample surveys - the Quality of Employment Survey (USA, 1979, N=1016); and the Living Conditions Survey (Sweden, 1968/1974, N=2281) - to check the impact of work pressure (the amount of work, variance, and precision of assignments) and 'control capacity' (knowledge, skills, available technical resources and consultation possibilities) on absenteeism and dissatisfaction with work. He found that in the condition of combined high work pressure together with various control possibilities the scores regarding both dependent variables were *lowest*. De Sitter predicts - and this has been confirmed in a large number of cases in practice (cf. De Sitter, 1981a; AWV/NIA, 1990) - that the production result in this situation would also be optimal. Karasek (1990) demonstrated that there exists a negative relationship between 'job control' and health risk in a sample survey of 25% of all office staff in Sweden (4481 men and 3623 women).

Measuring instruments for control capacity (and latitude) have been developed in the course of time by De Sitter & Heij (1975), Egmond & Thissen (1975), Van Eijnatten (1985), Pot et al. (1989a/b) and De Sitter (1989c).

Conceptually based on Miller & Rice (1967) and methodologically departing from a non-equilibrium-oriented, dynamical model of open systems (Laszlo, 1987/1990; May & Groder, 1989; Nicolas & Prigogine, 1977) in which change is an integral aspect of organizational life, Purser & Pasmore (1991) re-interpreted Classical STSD analysis and design concepts to be of use in non-routine knowledge work settings. They came to define a couple of new STSD concepts (cf. table 7).

Table 7. STSD concept development for non-routine knowledge work settings.
Adapted from: Purser & Pasmore (1991)

STSD concepts for routine work settings (manufacturing process)	STSD concepts for non-routine work settings (knowledge work process)
- joint optimization	- dynamic synchronization
- redundancy of functions	- redundancy of rhythms
- multi-skilling	- multi-phasing
- semi-autonomous work group	- multi-disciplinary, highly differentiated technical group
- controlling variances at their source	- removing barriers to learning during developmental phases in knowledge work
- quality of working life	- quality of thinking life

- According to Purser & Pasmore (1991), dynamic synchronization: "is an ever active, renormalizing movement in which nonoptimal permutations are dampened and phasic mismatches in knowledge development conversion cycle are brought into harmony" (p. 11/12). Dynamic synchronization is based on a new theoretical framework, i.e. the 'catastrophe'/'order through chaos' theory (Prigogine, 1976; Jantsch, 1980; Briggs & Peat, 1984). According to De Greene (1990) catastrophe models and chaos theory already have been applied successfully in physics (Grebogi *et al.*, 1987), chemistry (Prigogine & Stengers, 1984), meteorology (Lorenz, 1963) and ecology (May, 1976). Devaney (1987) states that chaotic systems (i.e. which show turbulence) are unpredictable, indecomposable and recurrent. In this view self-organizing systems adapt to turbulent environmental conditions by admitting increasingly complex inputs. As complexity has reached a critical level, the system reorganizes itself into smaller parts through a process of 'willful bifurcation' (Abraham, 1988; Montuori, 1991).
- Another related concept, described by Purser & Pasmore (1991), is the process of 'rhythmical organizing of temporally dynamic structures' (Warner, 1988), which is attuned to phase-specific cyclically varying equilibrium levels in non-routine systems. Instead of redundancy of functions, in sociotechnically redesigned knowledge work situations there should be 'redundancy of rhythms'.
- According to Pava (1983) multi-skilling is not a viable option in non-rutine work systems, because of the high training level of knowledge work professionals. Instead of multi-skilling, Purser & Pasmore (1991) suggest 'multi-phasing' which "has a variety-increasing effect as contradictions and divergent perspectives are surfaced, coupled, and managed in deliberations" (p. 15).
- Instead of semi-autonomous work groups Purser & Pasmore (1991) suggest 'multi phased groups': "highly differentiated technical groups to plan and solve problems in parallel with each other" (p. 15), in a highly participative manner.

- The STSD concept of variance control does not apply in non-routine systems (Taylor, 1989; Purser & Pasmore, 1990) because process deviations are not easily detectable or traceable. Instead of controlling variances at their source, STSD in non-routine systems should aimed at removing barriers for learning during developmental phases in knowledge work.
- Because the whole knowledge work process is occuring in peoples' minds, Purser & Pasmore (1991) suggest to adjust the notion of 'quality of working life' to 'quality of thinking life'.

Thus the Classical STSD theory of concepts has become very much differentiated in the course of time.

4.4 STSD Methods and the Evolution of Models for Analysis and Design

This is also true for the development of methods. Table 8 represents an outline of the complete range of STSD methodologies distilled from the literature. Van Strien's so-called 'regulative model cycle' (1975/1978/1986) was used as criterion for division here.

- The pioneering work is characterized by the application of 'action research'. No specialized methods for analysis and design have been used.
- The development of more formal methods of analyses began at the start of the 'Industrial Democracy' project in Norway. Around 1964 Engelstad applied the so-called 'traditional variance analysis' technique for the first time in the Hunsfos paper mill. Two years later this technique was repeated by the Tavistock institute in the Stanlow oil refinery of Shell UK (cf. Foster, 1967; Emery *et al.*, 1967; Hill, 1971). In the literature this method is known as the '9 step method', although - as table 8 shows - the number of sub-steps varies for each author. The method, which was initially developed to be applied in the processing industry, was later - very much to the dissatisfaction of Emery & Trist (1978) - also used for the analysis of other (discrete production) situations and for mapping out administrative processes. According to Taylor (1989) the 'technical systems analysis methodology' was seldom or no longer applied in England after 1970, with the exception of Hedberg & Mumford (1975) and Mumford & Henshall (1979). The 'variance analysis' was much more widespread in other European countries and the United States to map out various manufacturing processes in the production sector (cf. Cummings & Srivastva, 1977; Pasmore *et al.*, 1982; Taylor & Asadorian, 1985), in insurance companies (Taylor, 1977; Allegro & De Vries, 1979), in the health care sector (Macy & Jones, 1976; Friss & Taylor, 1981; Boekholdt, 1981; Glor & Barko, 1982), in the service sector (Taylor, 1978; Pava, 1983), in the development of MIS-systems (Bostrom & Heinen, 1977) and in R&D (Taylor *et al.*, 1986). Although Emery had already solved the problem of non-linear processes in 1974 by means of his 'participative redesign and search method' (cf. table 7), and although Van Beinum had successfully applied this method at the technical department of Shell laboratory in Amsterdam, additional variants for non-linear processes were developed in the United States around 1980 (cf. Pasmore *et al.*, 1978; Pava, 1983). Technical systems analysis, which places much emphasis on process, product and their functions in a wider whole, has thus made a large-

scale and crucial contribution to the diffusion and recognition of Classical STSD as an alternative to Scientific Management.

Table 8. Outline of the development of STSD method.

*** Whole cycle: problem definition, diagnosis, plan, intervention, evaluation:**

-strategy for industrial change: '10 step method'
(Norwegian Industrial Democracy Project) Thorsrud, 1966; Emery & Thorsrud, 1976
-strategy for implementation: '8 step method'
(all organizations) Cummings, 1976/1978; Cummings & Srivastva, 1977
-change model: '9 step method'
(redesign situations) Pasmore, 1988
-IOR model: '17 step method'
(all organizations) De Sitter *et al.*, 1990; Van Eijnatten *et al.*, 1991

*** Problem definition and diagnosis: 'technical system analysis'**

-traditional variance analysis: '10 step method'
(linear conversion processes) Engelstad, 1970
-analytical model A: '6 and 9 step method' *)
(linear conversion processes - continuous process)
Foster, 1967; Hill, 1971; Emery & Trist, 1978; Pasmore, 1988
-analytical model B: '7 step method' *)
(non-manufacturing systems - office/service processes)
Foster, 1967; Hill, 1971; Emery & Trist, 1978
- deliberation analysis: '5 step method'
(non-linear technical systems) Pava, 1983
-sociotask approach: '17 propositions'
(non-linear systems) Pasmore *et al*, 1978

*** Diagnosis, plan for redesign and evaluation:**

-ETHICS method: '7 step method'
(computer system design) Mumford & Weir, 1979

*** Process of change:**

-participative design
(all organizations) Emery & Emery, 1974; Emery, 1974/1976
-participative design workshop
(all organizations) Emery & Thorsrud, 1976; Thorsrud, 1977
-search conference
(all organizations) Emery & Emery, 1974; Emery, 1982/1987
- the change process in innovative work designs
(all organizations) Kolodny & Stjernberg, 1986
-organizational change as a societal multi level strategy
(all organizations and their industrial relations settings) Van Beinum, 1986
-large scale change process in broadly based societal context with democratic dialogue as vanguard
(all organizations) Gustavsen, 1985/1988

*) also in Cummings (1976); Cummings & Srivastva (1977); Emery, Foster & Woollard (1976/1978).

- The development of sociotechnical methods certainly did indeed go further than just the phase of problem definition and diagnosis. The plan for (re)design and implementation were laid down in 'step diagrams' (cf. table 8). An illustration of the first 10-step method can be found in paragraph 3.2.3 (box 4), which represents the basic approach in Norway (Emery & Thorsrud, 1976).

Later, this method was refined further for the entire (re)design cycle (cf. table 8: Cummings, 1976/1978; Cummings & Srivastva, 1977; Pasmore, 1988). The ETHICS method (Mumford & Weir, 1979) deserves separate mention. This method was the first of its kind to support explicitly the design of information systems.

- At last, the process of change also received more and more attention (cf. table 8). Participative design workshops, search conferences and the change process itself have been elaborated in methodical terms (cf. Emery & Emery, 1974; Emery 1974/1976; Emery, 1982/1987; Emery & Thorsrud, 1976; Thorsrud, 1977; Kolodny & Stjernberg, 1986; Van Beinum, 1986; Gustavsen, 1985/1988).

In an attempt to briefly summarize the method of Classical STSD, Taylor (1989) developed a 'master procedure', which is represented in figure 5. The separate place assigned to the analysis and design techniques can be clearly recognized here.

Some special attention is paid to the IOR model, developed in the Netherlands, to support Integral Organizational Renewal (De Sitter *et al.*, 1990; Van Eijnatten *et al.*, 1991). This Post-Modern STSD method further elaborates the issue of (re)design implementation logic. A multi-level model for more integral organizational (re)design is proposed, containing a mixture of (re)design ends, (re)design means and (re)design processes (cf. figure 6). Central in the model is the so called '(re)-design interface' in which means, ends and processes are tied together to lead up to the factual (re)-design intervention. The model specifies three main entries to this (re)design interface: environmental, knowledgal and methodological.

. The *environmental entry* is producing market requirements and functional claims to guide design ends for the (re) design intervention. These claims are normative in character;
. The *knowledgal entry* specifies theories, practices and conceptual organizational paradigms to deliver design means for the (re)design intervention. These content-theories are supportive in character;
. The *methodological entry* consists of action planning procedures and participative methods/ techniques for (re)designing, in order to support the process of (re)design intervention.

Modern Dutch STSD method - here it is stressed again - is a mixture of content and process: it contains both rules and procedures based on structural paradigms sprung from several key disciplines (including management science, industrial engineering and accountancy), and (re)design strategies based on participative methods and techniques within a regulative action cycle framework.

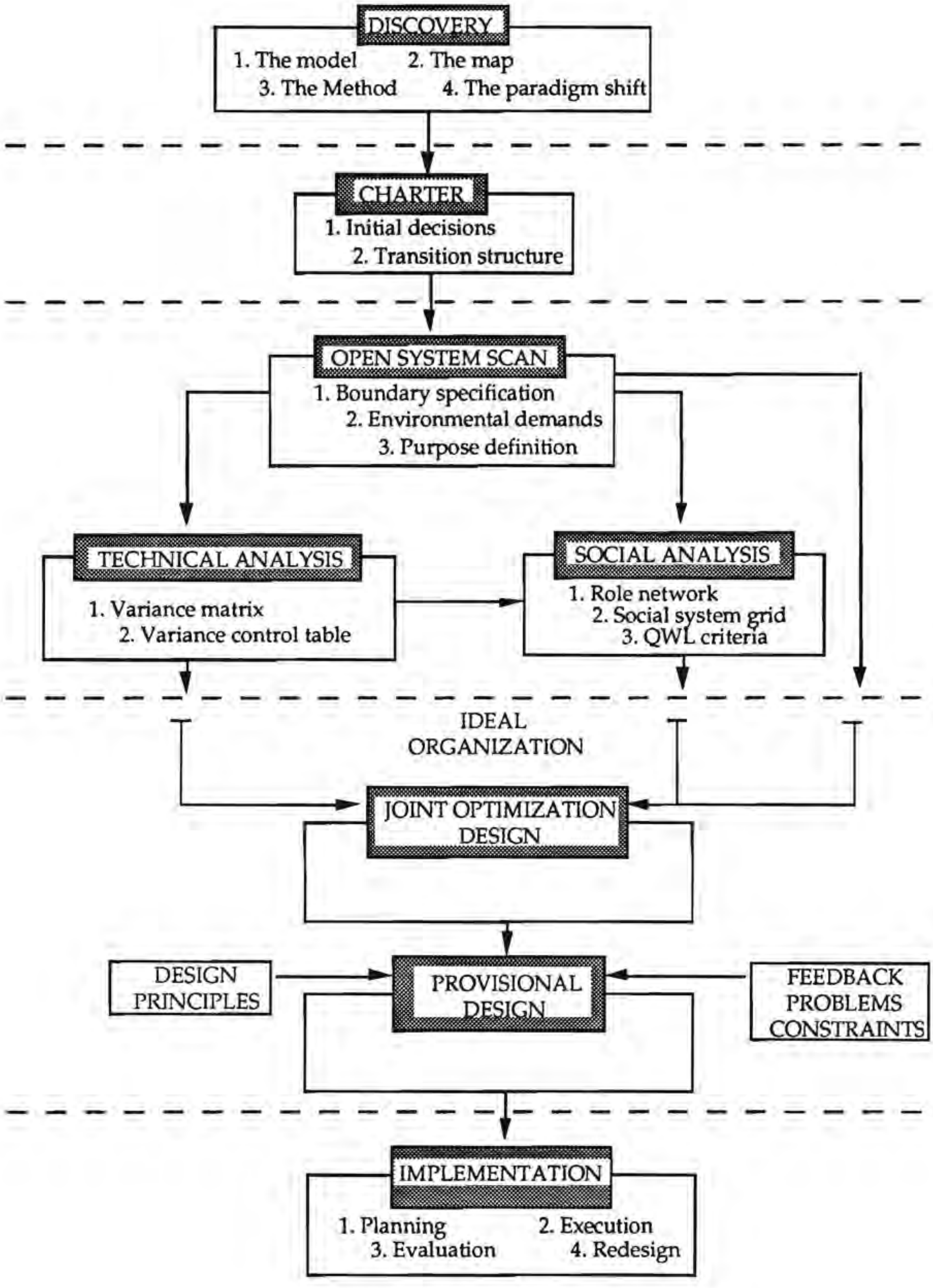


Figure 5. A schematic representation of the Classical STSD method. Taylor (1989), p. 28.

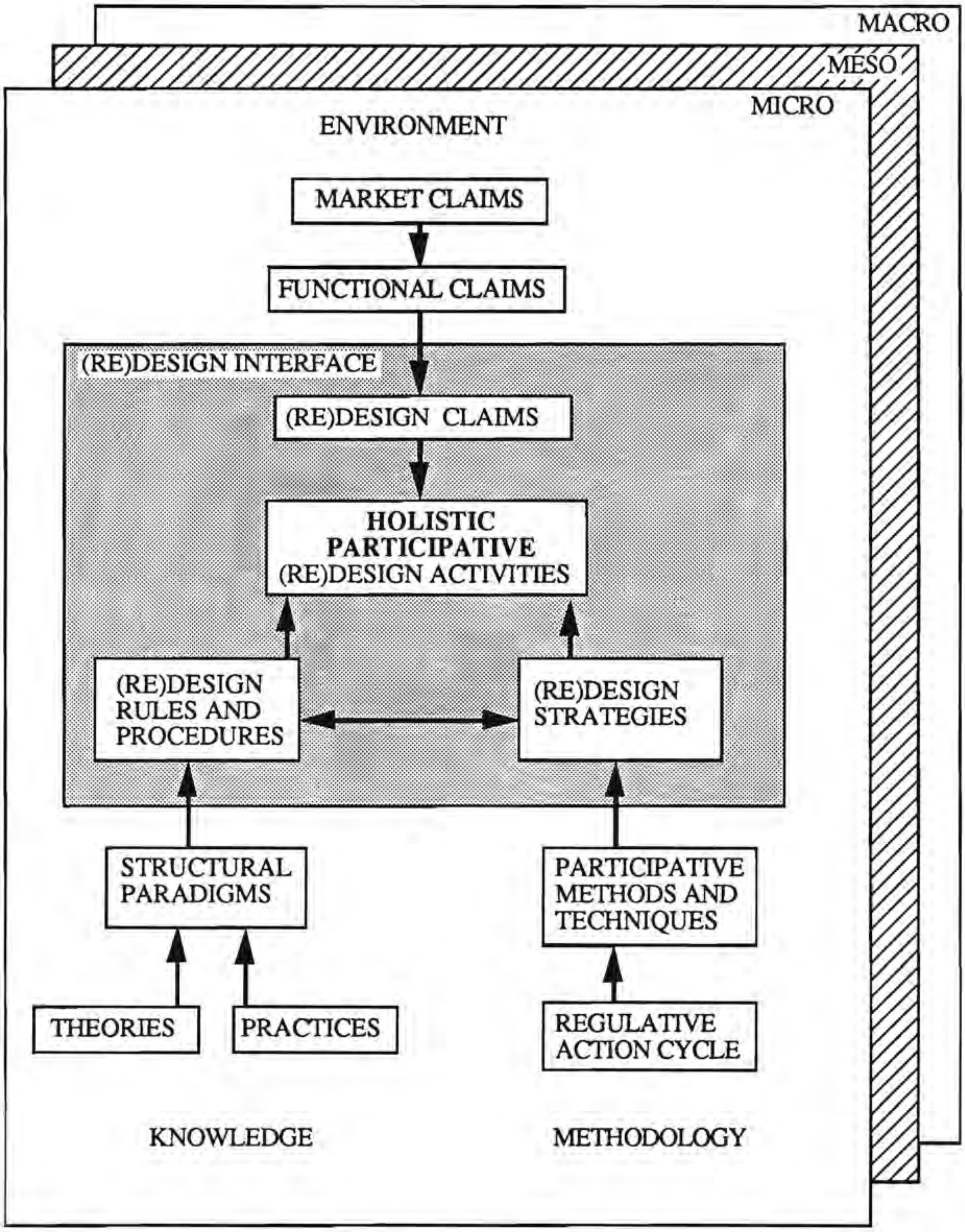


Figure 6. An analytical model for more integral organizational redesign.
After: Van Eijnatten, Rutte & Hoevenaars (1988).

What is 'really new' in contemporary Dutch STSD method is the re-introduction of a proper balance of up to date structural system paradigm with participative process paradigm, explicitly

stressing both content and process on the same advanced level. The resulting holistic participative (re)design activities are guided by the normative multiple environmental claims, which have been analyzed and given a concrete form to.
The model stresses the multi-level quality of organization (re)design: the interface problem must be simultaneously dealed with at macro, meso and micro level, in order to count for the actual complexity of the (re)design intervention.

This Post-Modern STSD-method follows the five methodological steps of Van Strien's regulative cycle. Each of those steps will be divided into smaller portions in such a way, that the method contains a total of 17 steps (cf. figure 7). The new method not only emphasizes the micro level, but also incorporates the meso and macro level to guarantee an integrative approach. It also is explicitly participative in character: a (re)design team of organizational members is trained to do the self-design.

A) Identification of the Problem

1) Global Strategical Analysis

The first step contains a global strategical analysis of the system at hand on a macro level. In this stage it is important that the system boundaries are widely chosen, preferably on the level of what Kotler (1988) has called 'strategic business unit' (p. 39). Basically a strategic business unit is a single business or collection of related businesses that can be planned separately and, in principle, can stand alone from the rest of the company. It has its own competitors which it is trying to equal or surpass. For the selected strategic business unit a global analysis has to be done with respect to environmental demands, and the consequences of these for the (re)design of the system. It is important in this step to actually start specifying the environmental demands in terms of market claims with respect to controllability, flexibility and quality of work. In the succeeding phases of the regulative cycle these functional claims serve as design objectives.

2) Global System Analysis

The second step is a global system analysis of the business unit on a meso or departmental level, starting with a pure description and ending with an estimation of the current achievement in already specified design objectives. The purpose of the description is to provide insiders as well as outsiders with a global picture of the system containing matters as layout, organizational structure, main inputs, transformations and outputs. An estimation of the current achievement in design objectives can be made by analyzing if and how much the system conforms to the requirements of the design objectives as specified in the previous step.

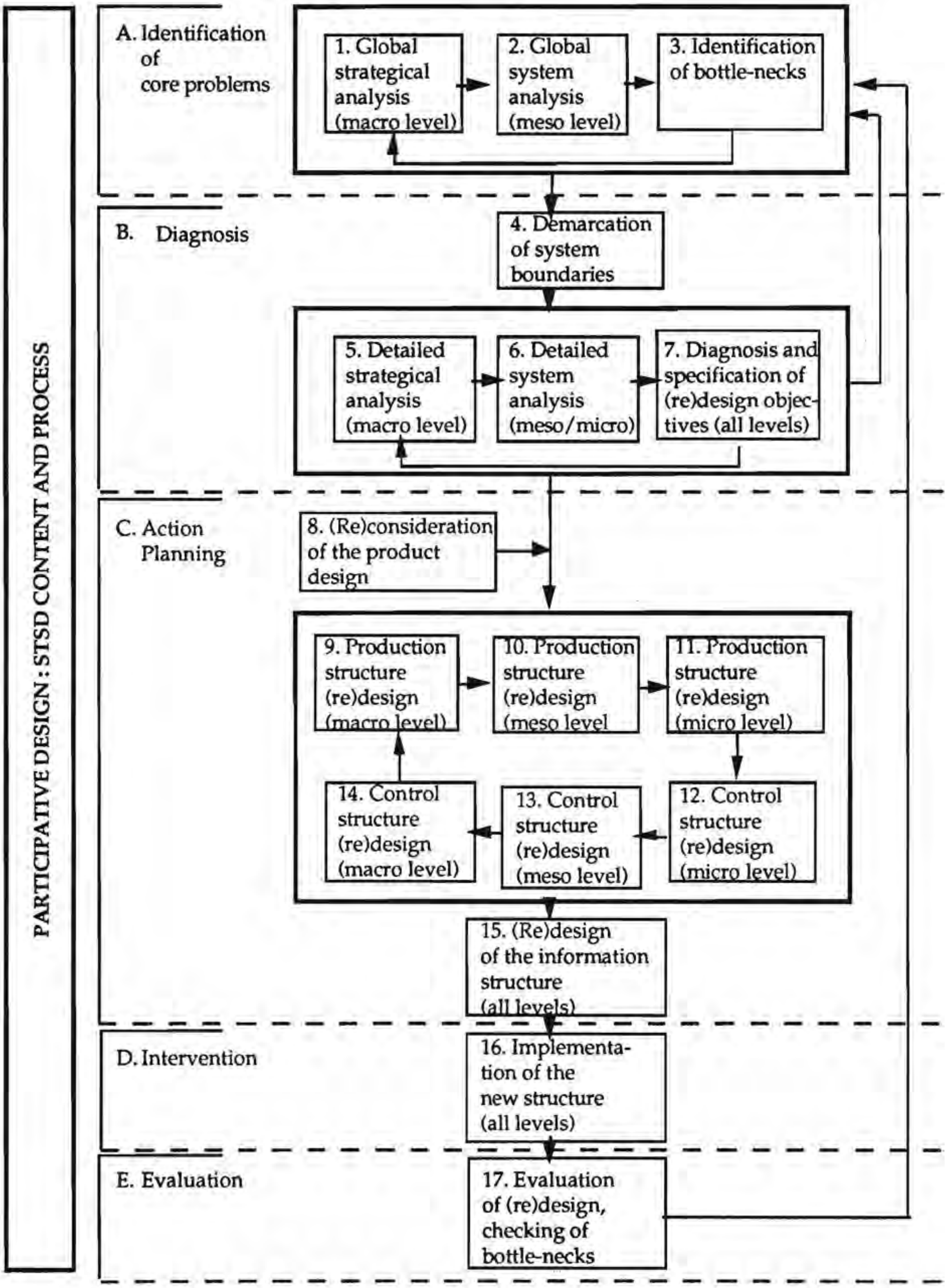


Figure 7. A method for Post-Modern STSD

Van Eijnatten, Hoevenaars & Rutte (1991), p. 10.

3) Identification of Bottle-Necks

Contrasting the design objectives of step 1 with the current state of affairs in step 2, results in an inventory of bottle-necks. Herewith phase A of the regulative cycle is completed, i.e. the problems are identified.

B) Diagnosis

4) Narrowing the System's Boundaries

To start the diagnostic phase, the system's boundaries are definitely demarcated. Accurately demarcating the boundaries is an important step. A too wide boundary results in unnecessary extra work. A too narrow boundary results in incorrect design choices. The boundaries should be chosen thus, that the (re)design can provide a solution for all bottle-necks. Often this will imply that the originally chosen system has to be (re)designed entirely.

5) Detailed Strategical Analysis

Step 1 is repeated in detail for the demarcated system. The parts of the organization which were possibly deleted from the original system, are now considered to be additional parts of the environment. Environmental demands and the design objectives belonging to them are to be recorded as detailed and as specific as possible.

6) Detailed System Analysis

Now step 2 is repeated in detail for the demarcated system. A complete inventory has to be made of material and information inputs, transformations and outputs. It has to be established how materials and informations flow through the organization. All decision tasks have to be specified within the context of regulation loops. An inventory has to be made of all norms and of all supportive tasks. With the help of all these data it has to be established who performs what tasks. Finally a detailed description has to be made of layout, organizational structure and units, and product design.

7) Diagnosis and Specification of (Re)Design Objectives

The data collected in step 6 are used to determine the exact causes of the bottle-necks specified in step 3. At this point the semi-autonomous (re)design team has very detailed knowledge of the environmental demands (step 5) and of the causes of current problems. These insights in the system can be used to detail the (re)design objectives even further. With this full description of the (re)design objectives the diagnostic phase is completed.

C) Action Planning

8) Reconsideration of the Product Design

A good and efficiently constructed product is of vital importance. In this step it is tried to reduce the number of parts and components of the product and to minimize the number of manufacturing steps, or to prepare for easier making (design for production).

9-11) Planning the (Re)Design of the Production Structure

The (re)design of the production structure has to be done on all levels, planned in a *top-down* order. To start the planning of the action process, firstly the macro level has to be (re)designed (step 9). Next the production structure on the meso level is prepared for (re)construction (step 10). Finally the micro level production organization is (re)structured (step 11). In general the (re)design team will parallellize on the macro level, segmentize on the meso level and build in operational flexibility on the micro level.

12-14) Planning the (Re)Design of the Decision and Control Structure

The (re)design of the decision and control structure is also done on all levels, but in reversed order (bottom-up)! Starting on the micro level (step 12), the planning of the (re)design is continued on the meso level (step 13). The (re)design of the decision and control structure is completed on the macro level (step 14). In general the (re)design team will allocate respective decision power as close to the point where the problems originate.

15) Planning the (Re)Design of the Information Structure

The (re)design of the information structure should not be started before the planning of the new production and control structure satisfactorily have been finished. How this can be done, is still the subject of study (Van Eijnatten & Loeffen, 1990). With this step the action planning phase is completed.

D) Intervention

16) Implementing the Plans

This step has many facets. From a sociotechnical point of view this step contains the actual building up of the planned production and decision i.e. control structures and information systems, in close cooperation with users and specialists.

E) Evaluation

17) Checking of Bottle-Necks

After implementing the new system, an evaluation has to take place in terms of the (re)design objectives. If discrepancies are found, adjustments have to be made by starting a new regulative cycle.
A training program to master modern STSD concepts, rules and procedures supports the (re) design team in the same way as used to be done in the participative design tradition. Training of process and content matter is seen as an essential condition for effective self-(re)design and organizational learning (De Sitter *et al.*, 1990).

The proposed method for Post-Modern STSD primarily has been developed as a practical tool, which can be used in (re)design projects. As said before, it is an intricate part of the Dutch STSD package, which also contains elaborated structural systems concepts, (re)design principles advocating more integration of aspects, and procedures supporting participative self- (re)design process.

At first sight the proposed method looks very much the same as it famous predecessors like the admired and abused 'nine step method' (Foster, 1967; Emery & Trist, 1978). But at a closer look there are some striking differences.

- The proposed method for Post-Modern STSD clearly has an iterative character (see figure 7). This is true for the cycle as a whole, as for the constituting phases. Therefore, in practice each project can have an unique intrigate pattern of specific iterations of 'successive' steps and phases. In each stage already available techniques and instruments can be used and may improve the efficiency of the distinguished steps. We list some of them briefly for illustration purposes. System Analysis (SA) can support the problem identification and diagnostic phase. A Dutch steady state system model (In 't Veld, 1978; Van Eijnatten, 1987b) governs the descriptive and evaluative process on all the levels of aggregation (macro, meso, micro). Socio-Technical Process Analysis (STPA) and Socio-Technical Task Analysis (STTA) can be used for task analysis at the micro level during diagnosis and evaluation (Van Eijnatten, 1985/1986). Recently alternative Dutch task analysis instrumentation has been become available (Pot et al., 1989a/b). Stream Analysis (Porras, 1987) may be of great help in identifying core problems during the diagnostic phase as well as in planning the (re)design actions and tracking the interventions in the action planning and intervention phase. Very useful in the action planning stage is TIED analysis (Schumacher, 1975/1979/1983; Van Amelsvoort, 1987). This (re)design technique governs segmentation of production flows, while controlling for machine interaction, process interaction and interferences. A similar technique to plan the parallelization of factory/manufacturing flows is Group Technology (Burbidge, 1975/1979; Agurén & Egren, 1980). Production Flow Analysis (Burbidge, 1975; De Witte, 1980) can be used to recognize routes of production flows in the planning phase. The Semi-Parallel Streams (SPS) design technique (Hoevenaars, 1991) is a recently developed IOV tool for parallelization of the production structure. We want to stress here the importance of technical (re)design of the production process. Therefore technical analysis once again has become vital in Post-Modern STSD. Of course, also the whole array of OD techniques are good supporters of the diagnostic, action planning and intervention stages in a regulative design-oriented cycle, ranging from process consultation (Harvey & Brown, 1988) to user participation and quality circle *techniques* (Juran, 1978; Dewar, 1980) such as Pareto Analysis, Ishikawa's 'fishbone' and Brainstorming. Also Soft Systems Methodology (Checkland, 1979a/b/1990a/b) can be used by all parties to organize and manage the process in each stage of the regulative cycle.

- The proposed method for Post-Modern STSD basically promotes *controllable* organizations ànd *democratic* work structures as the same time. Although for traditional sociotechnologists there is something of a paradox in that statement, Dutch STSD is trying to find a proper balance between variety *increasing* measures like segmentation of flows constituting 'whole tasks' ànd variety *decreasing* measures like inputs selection by means of parallelization of process flow. The argument is discussed in more detail in De Sitter *et al.* (1990).
- The proposed method for Post-Modern STSD is basically supporting a multi-level approach. The parallelization of flows is advocated on the next higher level than segmentation is carried out. Also a strategical analysis of the system at a macro level is actually stimulated to discover the environmental demands of the very near future. In this context of course there is acknowledgement of the Search Conference (Emery, M., 1989) as a network approach for creating desirable futures under turbulent field conditions. In Holland a STSD (re)design tradition is gaining ground in which technological, social and organizational innovation are going hand in hand. A series of more integral organizational renewal projects is being carried out along the theoretical and method(olog)ical lines of The Approach to Flexible Productive Systems (AFPS).
- The proposed method for Post-Modern STSD is not necessarily linear in nature. The 'successive' steps do not insistently represent a prescribed time order. They also can be used as a checklist to manage aspects interconnections. The order of steps first of all are indicative of available degrees of freedom for change. For instance, a change in production structure necessarily will urge forward changes in control and information structure, while a change in information structure is not expected to affect the production and control structure at all (see figure 7). The steps stress *dependencies* in the (re)design process.
- The proposed method for Post-Modern STSD is of course highly political in nature. Although it must be stimulated that the different parties are using it as a connecting and integrative device, insufficient control of that process easily can result in coalition formation. Also there will be some sort of paradoxical self-selection process going on among firms with respect to adoption. Because the method basically supports a democratic approach, organizations which want adopting it already feel sympathy or have invested in the type of change which Post-Modern STSD intents to accomplish.

4.5 STSD Practice and the Controversy on Design Content versus Process

In the course of its development STSD paradigm has placed seesawing importance on design content versus process:

- During the period of Classical STSD much emphasis has been put on content design principles. STSD practice was dominated by an expert approach;
- During the period of Modern STSD the accents have been placed primarely on the process of change. STSD practice was guided by a participative approach.

The main reason for this change in design strategy was the disappointing diffusion of the new work structures in the sixties. Although the shift in approach is all but absolute in consecutive projects, it significantly has stagnated the additional development of design concepts. Only in Holland the further designing of content principles flourished in the seventies (cf. paragraph 4.3), but without much apprehensibility from the international forum.

In the seventies and eighties both STSD content and process design approaches simultaneously were practised many times, in rather distinct geographic areas (e.g. countries/continents), but *seldom* in a well-balanced combination. STSD modelling itself prevented such endeavours for many years. In the mid eighties the first 'mixed content/process models' became available to facilitate an integrative approach. Figure 8 shows Kolodny & Stjernberg's (1986) 'change process in innovative work designs' model.

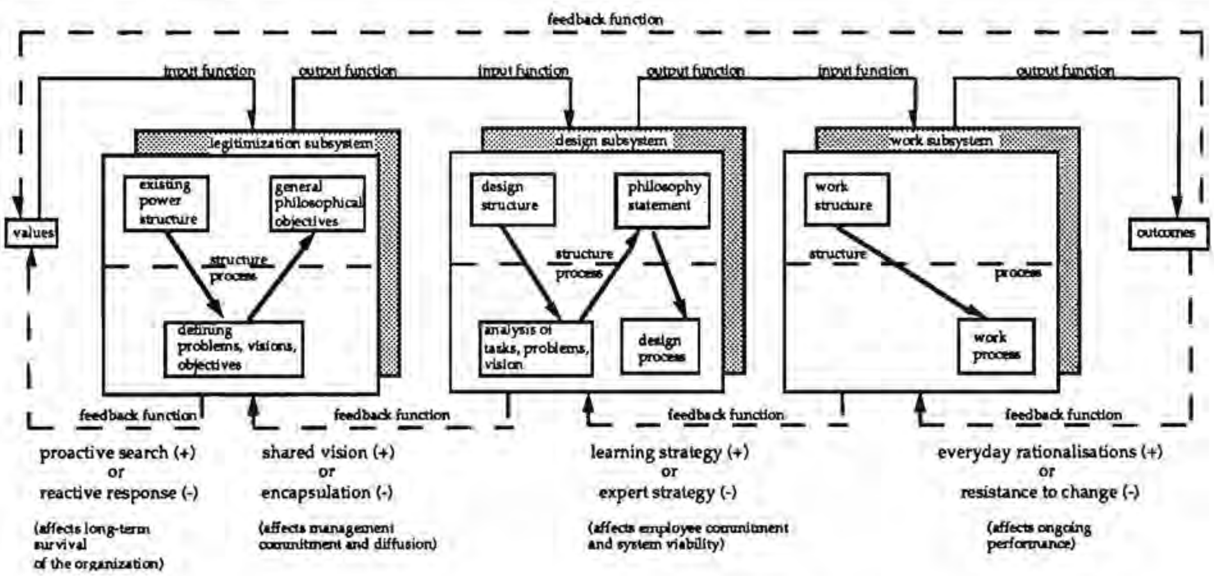


Figure 8. A mixed design content/process model for contemporary STSD

after: Kolodny & Stjernberg (1986), p. 287

Chapter Five

An Impression of STSD Projects as Reported in the Literature

(still to be expanded - it is also possible to skip this whole chapter)

In this chapter STSD practice is documented. An inventory of projects is presented, which have been distilled from available literature. Following such a search strategy, it was by no means possible to be exhaustive in any respect; the compiled projects only represent the top of an iceberg. It is my intention to give just an impression of the actual practising of Socio-Technical Systems Design. Again a phase-based approach is followed, taking into account both the temporal and the geographic spreading of the STSD paradigm.

5.1 Phase One Projects

As is already mentioned in paragraph 3.1.1, phase one projects predominantly have been confined to the United Kingdom. Tavistock researchers did some observational work in several underground coal-mining settings and documented the observed work experiments very accurately (cf. Trist & Bamforth, 1951; Shepherd, 1951; Wilson & Trist, 1951; Emery, 1952; Rice, 1953/1958/1963; Trist, 1953/1956/1957; Higgin, 1957/1958; Murray 1957 a through g; Pollock, 1957/1958; Herbst, 1958; Trist *et al.*, 1963). During this Pioneering Phase innovative work organizations in different mines have been studied (Haighmoor/Elsecar, South Yorkshire; Bolsover, East Midlands/North-West Durham). The field experiments in the textile industry in Ahmedabad, India, have been initiated spontaneously by the *workersthemselves*, after a visit and lecture by Rice.

5.2 Phase Two Projects

During the Classical STSD period many hundreds of sociotechnical projects were carried out, both in so-called 'greenfield' sites (new factories and offices) and in redesign situations. A schematic representation of studies published during this period can be found in Table 9. Some forty-five studies originating from thirteen countries have been selected from the literature, on the basis of completeness of the categories used (starting year, company name, type of company, department, city/district, country and reference). All studies were carried out before 1980. An excellent survey of over 120 work system design 'experiments' - mostly from Europe, Australia and North America - has been published by Taylor (1977a/b). The majority of these projects can be labelled as Classical STSD (re-)design cases.
We conclude that Classical Socio-Technical Systems Design is extremely widespread, both in terms of geography and in terms of company type. It should be emphasized here that this is just a small pick from the various projects launched during the period of Classical STSD.

Table 9. An impression of sociotechnical projects carried out during the Classical STSD period until 1980.

Year	Company	Type of Company	Department	City, district	Country	Authors
1962	Philips	Television factory	Assembly	Eindhoven	Netherlands	Van Beek (1964)
1962	PCGD	Post giro	Current account	The Hague	Netherlands	Van Beinum (1963)
1964	Hunsfos	Paper mill	Chemical pulp	Vennesla, Kristiansand	Norway	Emery & Thorsrud (1969/1976); Engelstad (1972)
1964	Christiana Spigerverk	Steel industry	Wire drawing	Oslo	Norway	Marek *et al.* (1964); Emery & Thorsrud (1976)
1964	Alcan Aluminium	Aluminium factory	Sheltered experiment	Arvida, Kingston, Ontario	Canada	Archer (1975)
1964	Coras Iompair Eireann	Transport company	Bus service	Dublin	Ireland	Van Beinum (1966)
1965	Alcan Aluminium	Aluminium factory	Reduction division	Arvida, Kingston, Ontario	Canada	Gagnon & Blutot (1969); Chevalier (1972)
1965	Nobø	Domestic appliances	Electrical panel heaters	Trondheim	Norway	Thorsrud (1970); Emery & Thorsrud (1976)
1965	Philips	Audio/Video	Assembly	Eindhoven	Netherlands	Does de Willebois (1968)
1965	PCGD	Post giro	Punch centres	Leeuwarden/Tilburg	Netherlands	Van Beinum, Van Gils & Verhagen (1968)
1966	Northern Electric		Advanced devices	Montreal, Ottawa	Canada	Gabarro & Lorsch (1968)
1967		Shipping	Merchant ships		Norway	Roggema (1968); Herbst (1971)
1967	Shell	Oil refinery	Microwax plant	Stanlow, Cheshire	England	Burden (1972/1975); Emery *et al.* (1967)
1967	Norsk Hydro	Processing industry	New Fertilizer plant	Heröya, Porsgrunn	Norway	Bregard *et al.* (1968); Gulowsen (1974)
1968	General Foods	Dry dog food factory	Nieuw plantdesign	Topeka, Kansas	USA	Ketchum (1975); Walton (1972/1977)
1968	Corning Glass Works		R&D department	Medfield, Mass.	USA	Beer & Huse (1972)
1968	Shell	Oil refinery	Highly automated plant	Teesport	England	Hill (1971)
1969	KNTU	Textile industry	Spinning mill Bamshoeve	Twente	Netherlands	Allegro (1971)
1969	Philips	Television factory	Assembly	Eindhoven	Netherlands	Den Hertog & Kerkhof (1973)
1969	Saab Scania	Carrossery factory	Grinding bodies	Trollhättan	Sweden	Karllson (1979); Logue (1981)
1970	Orrefos Glass Works		Polishing		Sweden	Agurén & Edgren (1980)
1970	Fokker	Aircraft factory		Dordrecht	Netherlands	In 't Veld (1984)
1971	Saab Scania	Engine factory	Saab 99 motor-ass.	Södertälje	Sweden	Norstedt & Agurén (1973); Agurén & Egren (1980)
1971	British Oxygen	Welding equipment Heating equipment		Bletchley	England	Burbidge (1979)
1972	Secours IARD	Insurance		Paris	France	Pionet (1979)
1972	Ollivetti	Components factory		Ivrea	Italy	Butera (1975)
1972	Sherwin-Williams	Paint factory	Automotive coating plant	Richmont, Kentucky	USA	Poza & Markus (1980)
1972	Bang en Olufsen	Audio-Video	Pick-up assembly	Stuer	Denmark	Larsen (1979)
1973	General Motors	Automobile factory	Assembly division	Tarrytown, New York	USA	Walfish (1977); Rundell (1978)
1973	General Motors	Automobile factory	Fisher Body plant	Grand Rapids, Mich.	USA	Robison (1977)
1973	General Motors	Automobile factory	Entire concern	Detroit, Michigan	USA	Miller (1978); Landen (1977/1978)
1973	Volvo	Automobile factory	Car assembly	Kalmar	Sweden	Agurén *et al.* (1976/1984)
1974	Philips	Machine factory	Tool department	Eindhoven	Netherlands	Alink & Wester (1978)
1974	ESAB	Welding equipment	Semi-automatics shop	Låxa	Sweden	Agurén & Edgren (1980)
1974	Fläkt AB	Ventilation equipment	Production	Ljungarum	Sweden	Agurén & Edgren (1980)
1975	SEMA	Pension fund	Executive services	Paris	France	Lefebvre & Rolloy (1976); Legros (1976)
1975	Philips	Machine factory	Mechanical workshops	Eindhoven	Netherlands	Hertog & Wester (1979)
1975	Shell	Chemical plant	Polypropylene plant	Sarnia, Ontario	Canada	Davis & Sullivan (1980); Halpern (1984)
1975	Centraal Beheer	Insurance company	"Life" department	Apeldoorn	Netherlands	Allegro & De Vries (1979); Glas (1980)
1976	Rolls Royce	Automobile factory	Engineering works	Derby	England	Mumford & Henshall (1979)
1976	Tannoy	Audio	Accounting	Coatbridge	Shotland	Weir (1980)
1977	Trebor Sharps	Audio	Loud speaker departm.	Woodford	England	Birchall *et al.* (1978)
1977	SEB-Pyrenées	Domestic appliances	Computer department	Lourdes	France	Grenier (1979)
1978	Siemens	Pneumatic control equipment		Karlsruhe	BRD	Schlitzberger (1978)
1979	Sulzer	Turbine paddles		Winterthur	Switserland	Warnecke & Lederer (1979)

5.3 Phase Three Projects

As is already mentioned in paragraph 3.3.3, Modern STSD has not been as widespread (yet) as its classical predecessor. Projects mainly are restricted to the North European countries, Australia and India.

5.4 Phase Four Projects

For the present, projects in the 'Democratic Dialogue'-tradition can only be found in Norway and Sweden (cf. Engelstad, 1990).
For the time being, projects concerning 'Integral Organizational Renewal' are limited to the Netherlands (cf. Den Hertog *et al.*, 1991).

Chapter Six

A Critical Evaluation of the STSD Paradigm

In this chapter the STSD paradigm is critically analyzed and evaluated, using the historical context and carefully evading the widespread pre-judgements and knowledge gaps, caused by the use of secondary sources. Reviewing STSD methodology, constructive criticism is put forward with respect to the epistemological basis, the open systems approach, basic STSD concepts and analysis/ design methods. Also a concise critique of STSD practice is provided.

To rightly and fairly evaluate some 40 years of STSD theory and practice is no sinecure. But it is just an easy job in comparison with the almost divine mission to do equal justice to the many authors from all over the world who contributed to the field of STSD with a wide range of ideas and elaborations. No critique can meet all these requirements at the same time. So, our contribution ought to be modest in every respect.

This is not to say that this critical evaluation does not make a stand. It does, while at the same time avoiding too much conservatism or chauvinism.

6.1 Constructive Criticism versus Widespread Pre-Judgements and Knowledge Gaps

As is mentioned in chapter 2 and 3, on the basis of the literature four developments can be distinguished: the Pioneering Phase of Tavistock, Classical STSD, Modern STSD and Post-Modern STSD. An important characteristic of these trajectories is that in terms of time they partly overlap. They are also illustrative of the discontinuous development of STSD in different countries and continents. Each development trajectory more or less concerns specific concepts, individual methodologies and views. Constructive criticism should take into account the peculiarities of these distinctive phases. Our criticism of the STSD paradigm in many respects *contradicts* what has been written before. According to Van Eijnatten *et al.*, 1991, in the literature there seems to be only slow progress in system-theoretical, methodological and conceptual debates concerning what is generally known as core STSD. Probably one or more of the following circumstances are accountable for this:

. STSD key publications have been highly dispersed in heterogeneous volumes and in exotic international journals, while a number of conceptual papers never reached these media at all. Prolonged difficulties in obtaining such documents have urged authors to copy older or non-original sources, resulting in inaccurate or incomplete discussions of the subject matters;

. STSD literature is hardly organized with respect to the paradigmatic generations. Each author implicitly represents his/her country with its own idiosyncratic time schedule of STSD phases and specific mixture of conceptual developments. STSD lacks an universal approach;

. STSD paradigm is mainly a strategy. Originally it has been developed as a method, not as a theory. STSD method can produce a whole array of concrete, highly situation-specific, end results which are not always reported as STSD-inspired endeavours.

. STSD has been strongly based on (a narrow version of) the open-systems concept. Early design principles lacked appropriate conceptual profoundness. As said before, part of the problem inevitably had to do with the severe immaturity of systems thinking in the fifties and sixties. It is not before the seventies start, that more basic solutions are put forward. Paradoxically these new insights have not been picked up in STSD literature. In the same period of time STSD paradigm shifted gradually from an expert approach to participative process. Because of this, further development of more specific and accurate structural design concepts faded and moved more and more into the background.

Because of these circumstances, potential supporters of the STSD paradigm find it hard to acquire untainted phase-specific knowledge. But also experienced practitioners often will be bogged in polemic discussions about STSD's scientific status and methodology. Because of the fact primary sources are not easy available, and systematic handbooks or specialized sociotechnical journals are lacking, STSD knowledge is rather fragmented. Consequently many knowledge gaps exist among practitioners. The literature is full of 'small mistakes' which add up to a highly inappropriate body of knowledge.
Take for instance the critical analysis by Kelly (1978). He 'discovered' some differences in emphasis in the search for theoretical explanations for the semi-autonomous work group phenomenon. According to Kelly both Trist and Rice gave the group work a socio-cultural basis by stressing the social organization of production and the local and industrial culture. Kelly wrote that Emery & Thorsrud (1964/1969), also supported by Davis (1957/1962), later turned away from this explicit viewpoint in favour of a more individually oriented task design within a group context. But he was wrong, because he was not acquainted with the splitting of the Tavistock into the HRC and CASR, or the reasons for the split (personal communication with Emery, 1990). Kelly's 'distortion' in Human Relations up till now went uncorrected.
Another instance is the centrality of some STSD publications. Although Herbst's (1962) *Autonomous group functioning* provided an attempt to ground STSD paradigm in a deductive way, according to Emery (1990, personal correspondence) it was unhelpful and misleading. Rice's (1963) *Enterprise and its environment* was not the spearhead of Tavvy's work on STSD, as Kelly (1978) suggested, but only a sort of 'hang-fire' after the split. As Emery wrote me, the same is true for Miller & Rice's (1967) *Systems of organization*. Being a mere 'copy' of the Tavistock work on STSD, Katz & Kahn's (1967) *The social psychology of organizations* was by no means an original contribution. It contained no new information, but indeed it very much helped the introduction of Classical STSD in the United States.

In attempting to 'de-mythologize' STSD and simultaneously putting it into the broader cultural context of social architecture, Van Beinum (personal communication, 1989) pays attention to central points of confusion, summarized in the following three statements:

- "Sociotechnical systems design is used as a tautology: all work organizations have the characteristics of some sociotechnical system, both those that function well and those that are inefficient. It is thus a tautology and therefore it makes no sense to state that work systems should be designed as sociotechnical systems;
- The sociotechnical concept is used as a 'straw man', i.e. it is a metaphorical way of speaking. Sociotechnical systems thinking is the core of a conceptual strategy. It is a method whose aim is to map out the interdependencies between a social and a technical system; Tavistock never presented it as a theory. By elevating the sociotechnical method to a theory, and subsequently labelling it a bad theory, one follows the disastrous route of non-argumentation with Don Quichotte-like characteristics. In addition, one also discourages the use of a perfectly suitable method;
- Sociotechnical systems design is used in such a way that it is given the meaning of 'misplaced concreteness'. STSD is applied correctly when the sociotechnical systems characteristics of work organizations are mapped out by means of STSD, that is to say as a descriptive and analytical model that can be used for design purposes in a much broader and different context. However, if the logic of sociotechnical analysis is identified with the logic dealing with organizational change, and as a result if it is used to understand and handle processes of organizational change and learning, one becomes the victim of the 'deception of inappropriate concreteness'. This causes the most critical form of confusion, whereby two different realities are mixed up. The process of cultural change - which is the core of the radical conversion from the old to the new organizational paradigm, which is based on the design principle of 'redundancy of functions', can neither be merely understood, nor just be led by the sociotechnical systems way of thinking. This will inevitably lead to a form of 'social engineering', which implies that we reduce the subject to object. Despite our good intentions we then throw away the baby with the bath water."

Van Beinum (1989)
personal communication

The above misconceptions are described as simple ideal types. In reality they occur in numerous combinations, varieties and gradations. The sociotechnical way of thinking has developed in the course of time into a subtle approach which extends far beyond the original method. Nevertheless it does happen that the way of thinking described in the misconceptions are inherent in the advanced design approach as assumptions (which are not visible at first sight) (Van Beinum, 1990).

6.2 An Annotated Review of STSD Methodology

(general introduction still to be written)

6.2.1 Epistemological and Methodological Basis of the STSD Paradigm

It seems that after 40 years the interest of the international academic world in STSD as a paradigm has vanished. But on a more local level the sociotechnical inspiration is still very much alive. Although most problems concerning methodology and systems theory have been solved in the last two decades, international diffusion is hampered by the fact that a majority of studies is stated in the own national language.

Although the visibility in the international literature is minimal, the contribution of Dutch researchers to the methodological renewal of STSD has been quite significant, as we shall illustrate:

. With respect to system-theoretical aspects, there have been two major developments. First, at the time that Ackoff & Emery (1972) published 'On purposeful systems', De Sitter (1973) presented an up to date system-theoretical paradigm of social interaction, in which there is a systematical thorough definition of systems concepts. Second, In 't Veld (1978) developed an elaborated analytical model of a system in steady state with equifinality, which also have made it possible to systematically differentiate between succeeding systems levels in an ordered way. Both contributions can be characterized as 'empty cartridge' approaches, constituting some neutral system-theoretical framework on which the Classical STSD view can be more firmly based.

. With respect to methodological aspects there has been one significant Dutch contribution. In an attempt to support the process of giving full scientific status to the action model, Van Strien (1975) proposed the 'regulative cycle of diagnostic and consultative thinking'. This cycle contains five phases: identification of the problem, diagnosis, action planning, intervention and evaluation. The unique aspect here is not the action cycle as such, but the epistemological and methodological treatment of action research as an equal alternative to the traditional scientific method (Van Strien, 1986). Central in it is the 'theory of practice'. According to Van Strien (1975) "the view of science as a system of statements is making place for a view of science as a set of conceptual and methodological tools in approaching reality" (p. 601). Modern STSD-interventions can be methodologically treated as theories of practice.

. With respect to design aspects, in Holland in the last decade Post-Modern STSD paradigm widened towards a management science approach, covering more relevant systems aspects (production, control, information), including different levels of aggregation (micro, meso and macro level in the organization and its relevant environment) and at the same time combining design content (integration of tasks in self-controlled organizational units) and process (training for self-design, participation, organizational learning).

6.2.2 Degree of Elaboration in Terms of an (Open) Systems approach

A Dutch contribution to the development of STSD which helped in the breaking of new ground was provided by Ulbo de Sitter. He was the first to formulate objections against the original paradigmatic elaboration of Classical STSD both in terms of content and methodology. The most important items of his fundamental criticism are briefly summarized in box 14.

Box 14. A summary of the most relevant objections against the original foundations of Classical STSD

" - the inadequacy of static structure concepts used;
- the logical contradiction of sociological value and psychological need postulates proclaimed into axioms, which exclude one another;
- the impossibility of the use of models which are partial in their cores at different aggregation levels, and as an extension, the impossibility to arrive at an integral approach;
- the logical insolubility of a, once assumed to be unambiguous, relation between the form of behaviour and its function;
- the impossibility to trace so-called 'operational disturbances' caused by processes obstructing each other, within a static, partial model."

Adapted from: De Sitter (1974a), p. 70-72
Source: Van Eijnatten (1985), p. 53

De Sitter's objections are concerned with, among other things, the outdated system-theoretical foundation of the paradigm and with its partial and static elaboration as socio-scientific approach in the aspect area of the quality of work. Van der Zwaan (1970/1971/1973) also points to the lack and insufficient specificity of the definitions used. These should, in his view, be determined by the exchange axiom of social systems. In view of the minimum availability of numerous 'Tavvi' documents in which Fred Emery in particular has performed much significant conceptual digging, one may wonder whether all this criticism is justified. It is my conclusion that, even after having read these development papers and considering the directive correlations methodology, the above-mentioned points of criticism do actually cut ice. Let me elaborate two central points for illustration purposes. From the Netherlands comes the reproach that (the American variant of) Classical STSD has used a partial problem definition, stressing too much the human conditions:

"The (...) point of criticism concerns the theoretical elaboration on the open system characteristic of production systems in traditional STSD. This principle implies that a production system cannot be autonomous in its choice with respect to technology, industrial relations, social values, products and services because it is at all sides tied to time-dependent and changing, technological, political, cultural, economic and environmental conditions that govern the relationships between a system and its environment. It seems that traditional sociotechnical systems design has departed from this point of view by stressing the primary importance of the human conditions which production systems should meet: the 'Quality of Working Life'. It is this bias that has given a dominant branch in sociotechnical systems design the image of a specialism in the area of QWL and Industrial Democracy. As such, it had to base its identity in fulfilling a critical function, by contending that the quality of work is important and should no longer be kept in disregard.

This rather unconditional stress on QWL cannot be reconciled with a truly 'open' theory of systems. The theoretical problem is *not* to formulate a plea for a reshuffling of priorities, but to acquire insight into the manner in which structures impede or foster the balance between a differentiated set of functions to be performed. This implies that from a sociotechnical point of view, functional requirements with respect to customers, the physical environment, the labour market, suppliers of capital, workers etc., should be regarded as functionally equivalent. Sociotechnical systems design should be as good in shortening delivery times and in designing effective information systems as in improving jobs. An open systems model presupposes a comprehensive or *integral* rather than *partial* problem definition. As a partial theory with respect to a partial set of functions, sociotechnical systems design would simply join the range of already too numerous managerial specialisations such as informatics, production technology, logistics, auditing, maintenance, marketing, quality control and so on."

De Sitter, Den Hertog & Van Eijnatten (1990), p. 5-6

Also the systems basis of STSD has not been adapted to new insights on time:

"The (...) point of criticism concerns the definition of a sociotechnical system as a combination of social and technical 'systems' viewed as sub-systems [Emery, 1959; Trist, 1981].
As an applied science, STSD holds the view that the approach to organizational (re)design must be an integral one: social as well as technical aspects are involved and insight into their mutual interdependence is the designer's key to strike a balance between the two.
In (social) systems theory, a system structure is defined in terms of relationships between subsystems and aspect-systems and their couplings to the system's external structure. A sub-system is defined as the *complete* set of all functional relationships between a *subset* of system elements, and an aspect-system is defined as a *sub*set of functional relationships between the *complete* set of system elements.
Thus, conceived as a sub-system, the social (sub-)system would contain all human elements (and their attributes such as attitudes, values and norms), and the technical (sub-)system would represent mostly human artifacts such as chairs, tables, telephones, (...), machines, buildings, and so on. Clearly, the relationships between elements grouped in such a manner are nominal.
The conventional sociotechnical definition of the social and technical 'systems' as *sub*-systems contradicts the notion of a production system as an integral functional system. The relations which constitute a real production system are functional relationships in which matter, energy and time are involved. The separation of social and technical system-elements into *sub*-systems transform these functional relationships into nominal ones. In consequence, the concepts destroy the very object of analysis and impede rather than foster a comprehensive understanding of organizational dynamics.
The twin concept of the social and technical system can also be used in a functional instead of nominal sense. In this case, its meaning changes drastically. No longer the nominal difference between subsets of 'social' and 'technical' *elements* is used as the basic distinction, but the functional difference between 'social' or 'technical' *relationships* between the same set of elements are used as the

fundamental criterion. In terms of systems theory, social and technical systems would thus be conceived as *aspect-systems*. In principle, this redefinition would open the opportunity to view organizational dynamics as a set of interactive relationships between functionally differentiated processes within and between sub- and aspect-systems. In social systems theory, however, in *each* functional relationship cognitive, as well as normative and technical dimensions would of course be implied. This is so, because in order to 'close' an interaction cycle - whatever its function - three sets of correlated norms must be implied: cognitive (semantic) norms (in order to map a state of affairs), pragmatic norms (in order to attach value to cognitions), and technical norms (in order to make a choice of action based on insight into 'if ... then' relationships). Aspect-systems, as they come into being in the form of subsets of interactions engaged in the production of a specific input-output function, do not differ in this respect, as they always contitute a configuration of social (semantic and pragmatic) as well as technical (syntactical) functions.

In other words, the choice for an integral approach implies that the focus should be on studying *the manner in which a system's structure determines its capacity to select, develop, coordinate, reconcile and balance a multitude of input-output functions with respect to a multitude of interaction partners within and between systems in each of which cognitive as well as evaluative and technical dimensions are implied.*"

De Sitter, Den Hertog & Van Eijnatten (1990), p. 6-7

6.2.3 A Further Examination of Basic Concepts and Theory Formation

In the literature STSD most often is associated with the early Tavistock pioneering work. Several authors have been criticizing the initial conceptualisations which indeed suffer from the growing pains of systems thinking in the fifties and sixties.

The conceptual roots of traditional STSD paradigm lay in biology, cybernetics and neurophysiology (Litterer, 1963; Herbst, 1974; Lilienfeld, 1978). Although epoch-making insights like the open-system conception, steady state and equifinality (Von Bertalanffy, 1950), the law of Requisite Variety (Ashby, 1958) and learning in random networks (Beurle, 1962) have had considerable impact on STSD scholars, an adequate translation and incorporation of these new concepts in *early* STSD models is problematic. In his commentary to the historical review by Trist (1981) Hackman (1981) has pointed to the elusive character of STSD's basic notions. According to Van der Zwaan (1975) in general definition of concepts is poor. Also, the system-theoretical model hasn't been worked out properly. For instance, the vital concept of 'steady state' is not much elaborated. A main point of theoretical critique is that traditional STSD has not reached a satisfying level of maturity. Conceptual clarity as well as coherence is criticized especially. Unfortunately, there is some absurdity, even logical inconsistency in specifying coupled but independently based social and technical systems which have to be jointly optimized (Emery, 1959/1963). The brilliant idea of integral design, which lay behind this, initially could not be sufficiently worked out theoretically because the 'aspect-system' as a logical construct was not known at the time.

Sociotechnical design principles mainly have been borrowed from 'natural occurring field experiments'. Although Cherns (1976/1987) did try twice to summarize those principles, the resulting

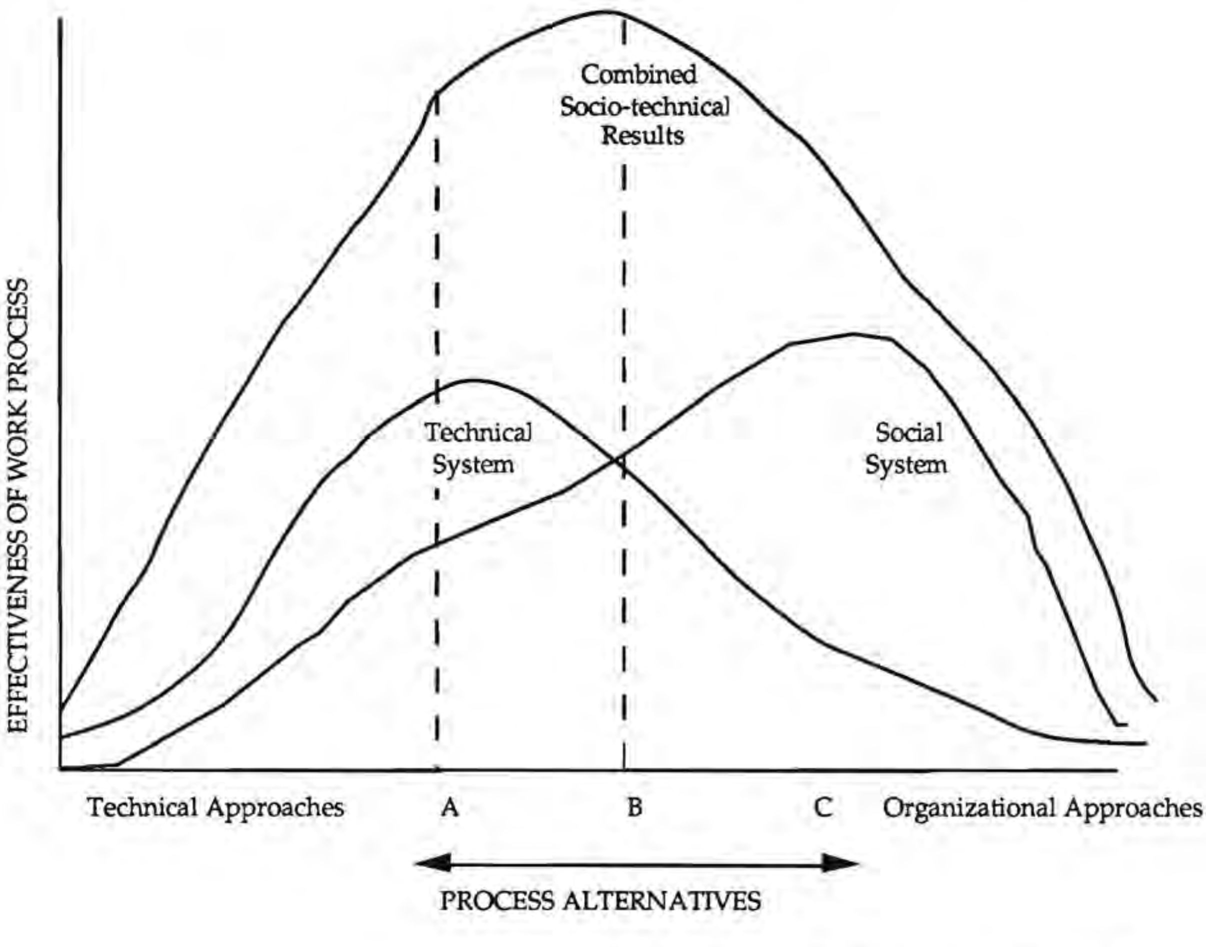
theory never has become a very coherent one. According to Kuipers and Rutte (1987) the principles haven't been clearly attributed to different kinds of organizational structure (production, control, preparation), while design application order has been totally neglected.
Also the scope of traditional STSD theory has been judged as too narrow. In addition, conventional STSD is not as integral as it claims to be. According to Van der Zwaan (1975) traditional STSD has occupied itself almost exclusively with psychological needs, resulting in unacceptable reductionism with respect to the social aspect of the system. In addition, there is the controversy over technology and organizational structure. According to Van Dijck (1981) this concerns a tautology, because the system-theoretically founded technology concept of traditional STSD includes some organizational-structural characteristics.
In terms of concepts there are more points of criticism, for example Van der Zwaan's (1975) reproach regarding the fact that Classical STSD had refrained from giving a precise definition of central concepts. An analysis of norms, values and structure of the social system is also lacking. Finally (perhaps the reason for the first two statements), the available knowledge is too fragmented. In his view a good handbook on Classical STSD has never been published.
After a delay of more than 10 years, STSD spread to the United States, There, the sociotechnical approach was renamed 'Quality of Working Life'. In the seventies, this approach was used in a large number of (North) American companies (cf. Davis & Cherns, 1975; Taylor, 1990).
This problem with the poor availability of STSD's basic papers and the specific characteristics of the blue and white collar consultancy environments abroad, urged American researchers to rework/re-publish Classical STSD concepts for their own convenience (cf. Taylor, 1975/1989; Susman, 1976/1983/1987; Cummings & Srivastva 1976/1977; Pasmore & Sherwood, 1978; Davis & Taylor, 1979; Pava, 1979/1983/1985; Taylor & Asadorian, 1985; Pasmore, 1988). Unintentionally their ambitions sometimes evolved into some conceptual ambiguity, prompting Pasmore *et al.* (1982) to state STSD has become eclectic.
Take for instance the fundamental Classical STSD design principle of 'joint optimization' (Trist *et al.*, 1963; Emery, 1963). Shani & Elliott (1988) quoted their own lecture in 1985 in which they point to the variety of definitions American scholars developed with regard to this concept:

"Elliott, Shani and Hanna (1985) (...) note that 'best-match' (Pava, 1983), 'best-fit' (Susman, 1975), and 'optimal alignment' (Golomb, 1981) are all used to describe (...) that an organization will function optimally if the social and technological subsystems are designed to fit the demands of each other and the environment. A closer examination of the constructs used, further revealed the influence of a variety of disciplines such that it somewhat alters this essence of the STSD theory and its focus."

Shani & Elliott (1988), p. 54

Taylor & Asadorian (1985) defined 'joint optimization' most accurately, using the same terminology as Emery (1963) and Emery & Thorsrud (1976) did, while visualizing the principle as a 'goodness of fit'-approach regarding process alternatives (cf. figure 9). Obviously, at that time they were unaware of the Dutch novelty of the basic STSD aspect-systems of production and control structure (cf. paragraph 3.4.2). Communication and language barriers apparently prevented the unhindered flow of new ideas, resulting anno 1985 in a dated American Classical STSD approach.

Figure 9. The concept of Joint Optimization.
Results are best when the technical system and social system are jointly optimized.



Taylor & Asadorian (1985), p. 14
source: Chrisholm (1988), p. 46

"The 'best match' approach toward 'joint optimization' of the social and technical system in traditional STSD contradicts both the concepts of an open and integral system.

The openness of the system refers to its external structure. The focus is here on the problem of adaptive and innovative control and balanced coordination of a multitude of separate external functions (better: input-output transactions or transformations), where each function contains social as well as technical dimensions.

The integral character of the system refers to its internal structure. The focus here is on the problem of adaptive and innovative control and balanced coordination of the relationship between external functions and a multitude of functionally differentiated internal functions, where, again, each function contains social as well as normative and technical dimensions. In the 'best match' approach, however - apart from being unclear how the supposed social and technical system should be conceived - the problem of compatibility is treated as a matter of counting pluses and minuses attached to alternative *partial* designs of separate social and technical aspect-systems. You cannot design a whole starting with the parts, but you can design (integral) parts starting from a vision of the whole."

De Sitter, Den Hertog, & Van Eijnatten (1990), p. 7

Box 15: The most relevant differences in terms of content between the mainstream approach and the Dutch variant of STSD

SOME CONCEPTUAL DIFFERENCES		
	TRADITIONAL STSD	DUTCH STSD
definition of system components (aspect-systems)	social system (S) technical system (T)	production structure (P) control structure (C) information structure (I)
main (re)design objective(s)	quality of work (partial improvements)	flexibility (integral controllability renewal) quality of work
(re)design scope/ aggregation level of intervention	work groups micro	total organisation micro-meso
basic concepts	open system responsible autonomy self-regulation	integral design controllability interference control capacity
main (re)design principles	minimum critical specification redundancy of functions requisite variety incompletion human values	parallelisation of P segmentation of P unity of time, location and action (C) uncoupled control cycles whenever possible (C) control capacity built in every task
main (re)design strategies	reaching the 'best match' between technology and organisation (ideal of joint optimization) by using: - search conference - 9-step method (variance control) - participant design	reduction of complexity by obtaining a balance between required variation and available opportunities for process variation, both brought back to acceptable minimum levels, advocating informed self-design: - including all aspects - at all levels - with all parties
form of work organization (self-regulating units)	semi-autonomous work group discretionary coalitions	whole-task group semi-autonomous work group operational group result-responsible unit business unit

De Sitter et al. (1990), p. 27

Evaluating the (American) STSD paradigm, Pava (1986) is sighing the sociotechnical systems design approach is decaying. The concepts that were considered revolutionary at one time, have become 'old-fashioned'. But evidently also he is unaware of the modernization of systems concepts and of the inauguration of a (Post-) Modern STSD phase. Box 15 illustrates how far apart traditional STSD concepts are from contemporary ones. The sociotechnical message still remained the same, but the theory of concepts changed dramatically over the course of time.

6.2.4 Some Closer Look at the Diversity of Socio-Technical Analysis and Design Methods

Considering the different steps in the methodological 'regulative cycle', the separation of the analytical and design models in Classical STSD is problematic. This point focuses on the improper use of the Variance Control Matrix for redesign purposes. As De Sitter *et al.* (1990) underline, an analysis of disturbance sources coupled to disturbance controllers is only useful to explain the operation of the *existing* architecture of the production system, but is absolutely unsuitable for giving shape to a *renewed* structure, since it is organized in a totally different manner:

"Conceptually nested within the wrongly assumed 'technical subsystem', traditional STSD relies almost exclusively on variance control as both an analysis *and* design technique (Emery & Thorsrud, 1989; Pava, 1983; Pasmore, 1988). Because there is no clear distinction/procedural separation between the analytical and action models (Van der Zwaan, 1970), variance analysis activities carried out in the diagnostic phase are easily contaminated with variance control activities in the (re)design phase, making it very unlikely or even impossible to actually change the interaction of the system, with the environment. We would like to stress that, in our opinion, the Variance Control Matrix [Engelstad, 1970; Hill, 1971] as used in STSD projects, can *only* be used as an inventory of prevailing types of variance or disturbance *in a current architecture* in order to analyse how system members try to cope with such variance and with what results. The next step should be to explain recurring variance by relating it to the specific 'architectural' characteristics of the prevailing structure. Redesign, however, *cannot* be based on current variance displayed in the matrix, but only on insight into the quantity and quality of variance in a *future* architecture of structure and the expected emergent opportunities to improve variance control.
The designers' goal should be to design an architecture of structure sustaining and reinforcing the development of interactive relationships which support and reinforce each other with respect to all functional requirements such as flexibility, delivery time, throughput time, product quality, innovative capacity, pollution control, quality of work and industrial relations.
Modern STSD can only open new perspectives by fulfilling a truly comprehensive function with respect to the question of how sets of differentiated and purposive functions can be grouped and coupled into an organizational structure in such a manner that they mutually sustain and reinforce each other."

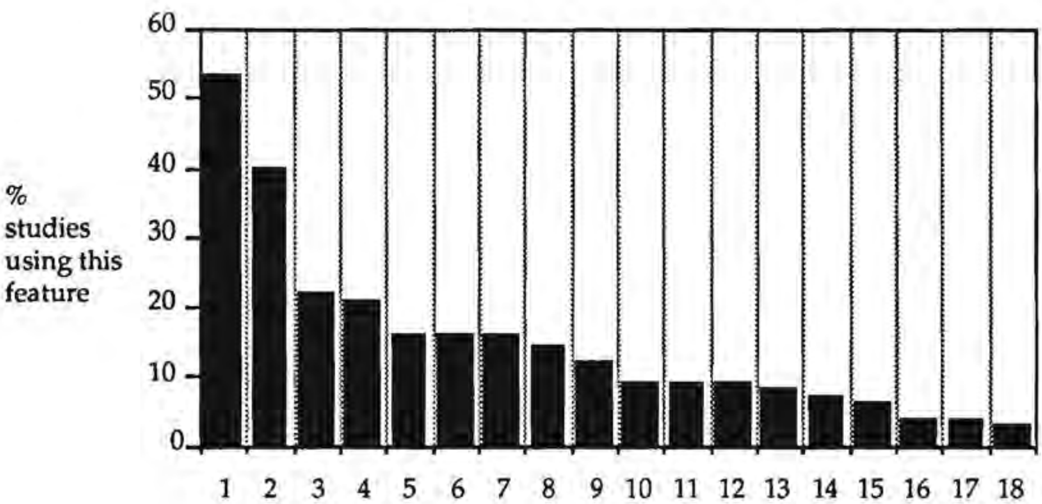
De Sitter, Den Hertog, & Van Eijnatten (1990), p. 7

6.3 A Concise Critique of STSD Practice

Now, what exactly are the results of the 'normal research' period of STSD? In order to answer this question we had another look at the literature, particularly the voluminous review of Pasmore *et al.* (1982), which encompasses some 134 sociotechnical experiments until 1980, including the projects evaluated earlier by Friedlander & Brown (1974), Srivastva *et al.* (1975), Taylor (1977), and Walton (1979). The results are summarized in Figure 10.

- Although the design criteria listed in Figure 10 are usually applied in specific combinations, it clearly illustrates that the formation of semi-autonomous groups and the induction of employees to new tasks are most popular in the 134 projects examined. An important point of criticism is therefore that despite the ideal of 'organizational choice' it is remarkable how often the 'one best way' solution of the semi-autonomous group is turned to in actual practice. Pava (1983) is one of the few exceptions here. In particular the automatism with which this happened time and again sparked off a great deal of criticism, from both the inside (cf. Kelly, 1978) and the outside (cf. Hackman, 1981). The sociotechnical type of organization is thus given the character of a 'trick', a 'deus ex machina', an 'off-the-shelf' solution (Pava, 1986).

Figure 10. The use of 18 sociotechnical (re)design criteria in 134 reported projects. Pasmore et al. (1982), pp. 1192/1193 (This figure has been integrally borrowed from Pasmore, 1988, p. 104.)



1 Autonomous Groups (53%)
2 Technical Skill Development (40%)
3 Action Group (22%)
4 Change Reward System (21%)
5 Self-inspection of Quality (16%)
6 Technological Change (16%)
7 Non-rating Teams (16%)
8 Facilitative Leadership (14%)
9 Operators Perform Maintenance (12%)
10 Minimal Critical Specification (9%)
11 Performance Feedback (9%)
12 Interface with Customers (9%)
13 Self-Supply (8%)
14 Information Sharing (7%)
15 Group Selection of Peers (6%)
16 Status Equalization (4%)
17 Pay for Knowledge (4%)
18 Peer Review (3%)

- Another aspect coming to the fore in Pasmore's *et al.* (1982) study is that almost exclusively successful projects are reported in the literature, making mention only of those output indicators which had shown improvements. However, more than half of the studies that mention improvements regarding all output indicators evaluated (productivity, costs, absenteeism, employee turnover, attitudes, safety, and quality) introduced the semi-autonomous group as form of organization.
- In this connection Wall *et al.* (1986) observe that few of the research designs applied allow for causal deductions and that the research designs cover too limited a time span. A longitudinal study performed by the authors mentioned above themselves showed that at the micro level the formation of autonomous work groups in a greenfield situation has a very specific effect on the behaviour and attitudes of colleagues. Although intrinsic satisfaction increases, intrinsic work motivation, performance and attitudes do not show a noticeable increase! The advantages were said to concentrate one-sidedly on organizational level. Kelly (1978) more or less shares this view when he states that the principle of 'joint optimization' at Tavistock led to more intensified labour more than once. Rather than adapting the technical system, the social system was changed one-sidedly, which eventually resulted in a heavier work load and higher work pace. In their review of 30 years STSD Pasmore *et al.* (1982) also draw the conclusion that on balance only little was contributed to technological innovation. As Figure 10 shows, only 21 out of the 134 studies examined made mention of changes in the technical system. Thus, machine design and process layout were apparently considered - in spite of all good intentions - unchangeable much more often than was to be assumed on the basis of the socio-technical design philosophy. The Volvo Kalmar plant is probably one of the few really favourable exceptions here.
- Moreover, according to Kelly (1978) a large number of sociotechnical projects involve an increase in financial remuneration. In his view observed improvements might be attributed especially to this. The study by Pasmore *et al.* (1982) provides some insight into the actual use of wage increases, at least insofar as this aspect was reported. Looking at Figure 10 we see that Kelly's observation should be somewhat put in perspective: in only 22% of the successful studies the remuneration system altered.
- Finally, we would like to point to the methodology used in the projects, which was of course much criticised. According to Cummings *et al.* (1977) socio-technical studies generally score badly in regard to internal and external validity. The necessity to operate in field situations with the associated restrictions is undoubtedly to blame for this. However, this point of criticism too should be put into a broader perspective. Already in the early sixties 'hard' field experiments were carried out in the Netherlands, complete with experimental and control groups, as well as pre- and post-measurements (cf. Van Beinum, 1963; Van Beinum *et al.*, 1968). Nevertheless, quasi-experimental designs (Campbell & Stanley, 1966; Cook & Campbell, 1976) could be applied more often. Although this is sometimes in contrast with the objective of organizational change, Cummings *et al.* (1977) provide some suggestions to improve on the research itself:

1. "Assess whether and to what extent the treatment took effect;

2. Use multiple measures where possible;
3. Use unobtrusive measures where possible;
4. Seek to avoid changes in instrumentation;
5. Where the selection of experimental and control groups on a random basis is not possible, the use of a control group - even an unmatched or non-equivalent control group - represents a considerable improvement in design;
6. Avoid bias in the choice of groups, and especially avoid the selection of experimental or control groups because they manifest some characteristic to an unusual degree;
7. Use statistical tests in order to eliminate the threat from instability;
8. Collect time series data;
9. Protect the experiment;
10. Record all occurrences and circumstances that might reasonably be expected to pose a threat to internal and external validity, or would otherwise qualify the findings."

Cummings *et al.* (1977), p. 703-706

However, since sociotechnical research is operating at the crossroads of different parties of interests, as pointed out above, the question remains whether scientific interest of thoroughness and well-considered choice - as put forward in points 2 through 8 - always and completely corresponds with the various practical business interests.

Chapter Seven

The Future of the Socio-Technical Systems Design Paradigm

(this chapter will be extended with reference to the Round Table Conference on the future of STSD in San Francisco, September 1991)

The sociotechnical approach is now more than 40 years old. In the four decades of its existence, the paradigm has developed from a coincidental re-discovery of a flexible form of work organization in a British coal mine, into an integral alternative to Taylorism dating from the beginning of the Industrial Revolution. The open system and self-regulation are its key concepts. In the course of its existence, the sociotechnical approach has been rejuvenated and renewed time and time again:

- In the pioneering phase of Tavistock, the mine studies were globally founded in theoretical terms with a hybrid system of concepts, derived from the rapidly emerging revolutionary system thinking.
- In the period of Classical STSD these conceptualizations were expanded, adjusted in more detail in terms of content, made logically consistent, and founded in method(olog)ical terms.
- During the period of Modern STSD, models and methods were brought into line with developments in systems 'do-it-yourself' method.
- In the period of Post-Modern STSD, emphasis was increasingly placed on the formation of inter-organizational networks and integral production renewal.

However, despite these external metamorphoses, the ultimate objective of STSD never got lost: the integration of aspects was and still is of paramount importance. This integration thinking will continue to be prevalent in the future. In this context, Van Beinum (1990b) predicts a shift from sociotechnical to socio-ecological design. The organization *plus* its environment will be both object and objective of change. In Sweden, the LOM programme (cf. section 3.4) is a forerunner of such an approach. Also De Sitter (1990, personal communication) speaks of a similar development. He points to the ecological environment as a relevant new function demand for the integral design of production organizations.
Meanwhile, the complexity and unpredictability of the environment takes 'vortical' forms; the new Swedish Volvo plant of Uddevalla experiments with full parallelization of the production process of the Volvo 740 (Janse, 1989), in which autonomous workplace teams assemble a *complete* passenger car (learning time one year and a half, cycle time more than two hours, construction kit consisting of more than 1500 components and subassemblies); in the United States one is more and more willing to pass into a more integral and participative STSD approach; and from Japan comes the futuristic idea of 'Holonic Production Systems', i.e. decentralized adaptive assembly systems built up from autonomous cells, involving 'Human Integrated Manufacturing' (HIM), a concept in

which man takes part in one or more holons, brings in the creativity and makes decisions, while the equipment provides the adaptive implementation (Sol, 1990). These and other developments will largely co-determine what new appearance STSD will evolve into in the nineties. But it's only the form that will change, not its function!

The Socio-Technical Systems Design (STSD) Paradigm: A Full Bibliography of English-Language Literature

DR. FRANS M. VAN EIJNATTEN

Chapter 8
An Anthology of STSD

In chapter 8 there is some choice to include only the references used in the book (variant A: 30 pages), or a full bibliography of STSD (variant B: 90 pages). In this manuscript the full bibliography of English-language STSD literature is printed for illustration purposes. As a consequence, all other-language references, used in the book, are kept out.

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The Socio-Technical Systems Design (STSD) Paradigm: A Full Bibliography of English-Language Literature

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This bibliography does contain a full english-language reference list of the Socio-Technical Systems Design (STSD) Paradigm. It has been produced by carefully cross-checking each reference as it resembles in the literature. Scholars from all over the world helped in extending this new release.
STSD bibliographies of other-language literature references are in preparation.

This bibliography also will become available on disk (Apple Macintosh System - Hypercard Literature).

This bibliography was also made possible through a contribution of the research stimulation programme TAO (Technology, Work and Organization), industrial sector.
Please send any corrections or new references to the subjoined address. With your help this bibliography can grow further into a main STSD reference base.

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