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# **DEVELOPMENTS IN THE SOCIO-TECHNICAL SYSTEMS DESIGN (STSD)**

**Frans M. van Eijnatten**

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For a full treatment of the history of the Socio-Technical Systems Design (STSD) paradigm,  
please consult the following publication:  
Eijnatten, F.M. van (1993). *The Paradigm that changed the Workplace*. Assen, the Netherlands: Van  
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## **Developments in the Socio-Technical Systems Design (STSD)**

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# Developments in the socio-technical systems design

Frans M. van Eijnatten

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## 1. Introduction

Since its inception in the fifties, the socio-technical design paradigm of organisations has never left the scene of socio-scientific and management literature. Socio-Technical Systems Design (STSD) plays an important role in giving shape to factories, offices and government institutions that follow modern patterns. Socio-technical systems design is an applied science that aims to improve the functioning of both the worker and organisation through adaptation or fundamental redesign of contents and organisation of technology and human labour tasks. Many authors, not least psychologists, contributed to the development of this broad approach in the past four decades oriented to both management and staff.

In socio-technical systems design, social and technical aspects are considered and fine-tuned to one another with respect to their mutuality. Nowadays, such an orientation is referred to by the term 'integral'. To give a historic overview that does some justice to the total range of ideas and elaborations in this area, would take us far beyond the available space and intentions of this handbook. We have therefore opted for a selection of essentials. For a more extensive introduction to the socio-technical systems design as an integral design method, we refer the reader to Van Eijnatten (1993).

In this chapter we give a broad outline of the history of socio-technical systems design. Instead of striving for completeness, we choose to typify the phases distinguished anecdotally. In addition, we characterise the episodes by giving short descriptions, and we sketch the dissemination of socio-technical systems design for time and location. We will only concentrate on countries where a substantial development of the paradigm has taken place. Special attention is paid to the Dutch representatives and relevant developments.

## 2. Socio-Technical Systems Design as Scientific Paradigm

Before we explain the actual development of Socio-Technical Systems Design (STSD) using a division based on phases to be looked at later, we will first give a general delineation of methodological points of departure and aspects regarding content.

### 2.1 Methodological Starting-Points

For a long time, STSD in its strive for integration - with the structure of the organization as its object of study and integral (re)design its objective - was a scientific outsider. Such a holistic, design-oriented science was not very suitable for the academic disciplines found at the universities. STSD was not only new as a design theory in terms of its contents, but it also implied a clearly different paradigm in terms of methodology. To gain a notion of the actual meaning of STSD, scientists and staff officials had to take a different attitude in various respects. First, they had to learn to think about new schemes, and besides that to do their work differently.

This new line of thought implied a move from the 'machine' approach to the 'system' approach (Eyzenga, 1975). The main features of the machine approach are: stressing reduction (converting wholes into parts; disaggregation); stressing analytical thinking (explaining the behaviour of wholes from the sum of the behaviour of the parts); and stressing mechanistic thinking (concerning the unicausal cause/result relationships). Here, the object of the study is viewed as a machine. The main features of the systems approach include stressing expansion (the parts are included in ever-expanding wholes; aggregation); stressing synthetic thinking (explaining behaviour from the role of the parts in the larger whole); and stressing teleological thinking (determining and changing objectives, adaptation; cause is essential though not sufficient for a certain result). The object of the study is looked upon here as an 'open system' which interacts with its environment.

The other way of working meant moving away from the use of a predictive model cycle towards a regulatory cycle on the one hand, and a different stance of the researcher on the other; from distant to being of influence. The empirical or predictive cycle (De Groot, 1980) accentuates the testing of hypotheses 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), tests (verifying/falsifying), evaluation. The regulatory or design cycle (Van Strien, 1986) underlines actual designing and, by that, developing a theory for practice carrying out the following actions: problem definition, diagnosis, plan, action, evaluation. The role of the researcher is no longer distantly observant, but more involved and in fact influential. The relevant technique is called 'action research'.

## 2.2 Aspects regarding Content

The contents of the socio-technical approach can be characterised as a reaction to the unilateral stress placed in previous paradigms (Scientific Management; Bureaucracy; Human Relations; see elsewhere in this handbook) on the technical or the social aspects of the organisation. In the new viewpoint, both factors are moulded together as components of the same 'socio-technical whole'.

In an attempt to illustrate STSD briefly and concisely, Van Beinum (1990a) lists nine features of substance of what he calls 'the new organisational paradigm', and defines them with the features of the 'old paradigm': the Tayloristic bureaucracy. He makes the following comparisons (p.3):

- Redundancy of functions versus redundancy of parts. Rather than maximizing the labour division, STSD suggests a minimal work division. Everybody has to be capable of carrying out different tasks, which leads to the enhanced usability of personnel.
- Internal versus external coordination and control. Self-regulation rather than step-wise supervision is considered of paramount importance in the socio-technical paradigm. An emphasis is placed on small organisation units with internal coordination and semi-autonomous control.
- Democracy versus autocracy. STSD designers strive for direct participation of workers in decision-making. Democracy in the workplace is the foundation of this approach.
- Joint optimization versus fragmentation. STSD prefers an integral to a partial approach, which implies optimisation of various aspects rather than maximizing one's own field-specific aspect.
- Man as a resource versus a commodity. The socio-technical paradigm considers the worker to be complementary to the machine, and not as its useful extension. People are the most valuable asset an organization has and they should be invested in.
- Minimum critical versus total specification. STSD designers make sure they do not design an organisation down to the last detail. The idea is that designers need only figure out the contours; the rest is filled in by the users according to their own insights and needs. To an important extent the current situation is conditional to the actual organisation of work.
- Maximum task breakdown versus optimal task grouping (narrow versus broad skills). The socio-technical paradigm strives for complex tasks in a simple organisation instead of simple jobs in a complex organisation. This means that workers must have various kinds of skills.
- Individual versus group. In STSD, the smallest organisational unit is the group, not the individual. In this way it is possible for individuals to take the organisation of work into their own hands.
- Alienation versus involvement and commitment. Job erosion leads to alienation. Socio-technically redesigned labour systems are characterised by 'whole tasks'. It is meaningful work, thus promoting personnel commitment.

## 2.3 Towards a Division based on Phases

STSD is a series of major and minor discoveries, projects, conceptualisations and developments of methodologies. On top of this, the literature about it is very splintered. Nevertheless, an attempt has been made to record the history of the socio-technical organisation paradigm. Thus, Merrelyn Emery (1989) distinguishes several important turning-points:

- As a first important fact - no more than a starter - she mentions Lewin's leadership experiments just before the Second World War (cf. Lippit & White, 1939). These laboratory studies pointed to three basic types for organisational structures: the autocracy (bureaucracy), the democracy, and the 'laissez-faire' type (variant without structure).
- The first actual turning-point of STSD is the set of 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'), and applied it on a limited scale.

- The second actual turning-point of STSD is the Norwegian 'Industrial Democracy Project' (cf. Emery, F. & Thorsrud, 1964). Here, employers, employees and the government jointly carried out research into and improved the democratic content of industrial sectors for the first time.
- The third actual turning-point of STSD covers the development of the so-called 'Participative Design' methodology in Australia (cf. Emery, F. & Emery, M., 1974). As a result, workers themselves carried out the whole trajectory of socio-technical analysis and redesign by means of 'participative design workshops' and 'search conferences'.
- Van Beinum (1990a) points out a fourth actual turning-point in the development of STSD: 'large-scale and broadly based organisational change process with democratic dialogue as the leading element on the conceptual as well as on the operational level' (cf. Gustavsen, 1985), as has been brought into practice on a national scale in Sweden. Eventually, the Dutch approach to Integral Organisation Renewal (De Sitter et al., 1990) may become a competitor. This approach not only combines a structure and process option, but looks for the happy medium between the expert and participative approach.

The four turning-points form sequential steps in a democratisation process of the workplace.

Grounded in a bibliometrical analysis of the literature (cf. Van Eijnatten, 1990a/b), we have sought to split the historical line of STSD up into phases (cf. Van Eijnatten, 1993). We distinguish three development trajectories:

- Phase I (1949 - 1959+): the period of the Socio-Technical Pioneering Work.

- Phase II (1959 - 1971+): the period of Classical STSD.

- Phase III (1971 - xxxx): the period of Modern STSD.

The latter phase can be subdivided further into the following:

- Type A (1971 - xxxx): Participative Design.

- Type B (1973 - xxxx): Integral Organizational Renewal.

- Type C (1979 - xxxx): Democratic Dialogue.

- Type D (1971 - xxxx): North-American Consultancy.

Figure 1 gives a representation of the phases thus defined, combined with the turning-points previously mentioned. What immediately strikes us, is that the trajectories cover each other to a certain extent in time. One could almost talk of parallel flows sometimes. Two main reasons can be given for this. First, the inventors/developers of the paradigm regroup to discuss new ideas from time to time, while the implementors/consultants continue to follow the course taken for a limited period. Secondly, the development of STSD does not coincide in the different countries and continents: one country is already in the next phase while the other has yet to start the previous one. It also happens (in the United States for example) that the entire development only begins to pick up after a couple of years.

### FIGURE 1 ABOUT HERE

Now Classical STSD and Modern STSD approaches of all kinds can be found in different locations all over the globe, each equally professional. Unfortunately, this does nothing to help people new to this field, who have difficulties discussing matters with colleagues because of the differences. Concrete end-dates cannot be given to the various stages as it is unclear whether they will cease to exist.

### 3. Highlights in the Development of STSD

To typify the development of STSD, each phase will be described below by means of anecdotes. We will discuss the discovery of the Semi-Autonomous Work Group (Phase I), the Industrial Democratisation Project (Phase II) and Participative Design, and Democratic Dialogue and Integral Organizational Renewal (Phase III), respectively.

### 3.1 The Tavistock Episode

STSD found its beginnings in the postwar British coal mines. The early fifties brought about a new form of work organisation that we now look upon as 'self-managing groups'. The British coal industry that has always had its ups and downs suffered frequent labour conflicts. It was nationalised and further mechanised after the Second World War. As a field of work, it was not that easy for social scientists to penetrate. However, Ken Bamforth, a new researcher of the Tavistock Institute of Human Relations in London, got into the field unlike others. The advantage of being an ex-miner was that he could visit the Elsecar mine in South Yorkshire without too much trouble. One of his stops led to a discovery: he noticed an aberrant form of work organization in a new coal seam, called 'the Haighmoor'. The 'longwall' mechanisation method normally used, just would not work, because of a short coal front. The local mine management allowed him to carry out descriptive research with Eric Trist, because of his former employment. Things became a bit harder, however, when they wanted to publish their findings. After some commotion, the mine management eventually agreed to a strongly censored version of their work. In their article, now widely renowned, which was carefully included in an elaborate description of the mechanized coal-mining process unravelled in small subtasks, Trist and Bamforth (1951) present, in guarded terms, a unique underground alternative work organisation built up of so-called 'composite work groups'. These were small, relatively autonomous work groups consisting of eight miners, who were responsible as a group for a full cycle in the coal-mining process. This 'new' form of work organisation had similarities to the manual situation that had existed up to the introduction of mechanization. What appeared in Haighmoor was that there were other, even better, ways of modelling the way work was carried out at the same mine. This was diametrically opposed to the prevailing practice of 'one best way of organising that fused Weber's description of bureaucracy with Frederic Taylor's concept of scientific management' (Trist, 1981, p. 9). It was a grand success that led to the introduction of a new scientific paradigm: Socio-Technical Systems Design. As Trist later recalled in his correspondence with Emery, the beginnings of the socio-technical paradigm were not exactly plain sailing. In fact, the pioneering phase came about erratically.

Real tests with autonomous groups were carried out in the Bolsover mines in the East Midlands coal field. When Fred Emery stayed at this mine, during his sabbatical leave from Australia in 1952, he found autonomous groups in seven locations. However, here too, the National Coal Board was terrified of what might happen and cancelled a proposal for further diffusion. From January 1955 until March 1958, Trist c.s. did a series of graphic 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 ardently states how groups consisting of 40 to 50 miners worked here while exchanging their various tasks and drew up the shift schedules themselves. They had defined an adapted 'fair' rewarding system among one another. Compared to identical circumstances with a traditional work organization, however, the output here was 25% higher, the costs were lower, and absenteeism was cut in half! A flood of reports was published about this Bolsover case. A collected survey of these mine studies can be found in Trist et al. (1963).

Analogous to this, two field experiments were undertaken in the textile industry (the Jubilee and Calico Mills in Ahmedabad, India; cf. Rice, 1958) from the Tavistock base. Both in an automated and non-automated weaving mill a system of semi-autonomous groups was introduced, and with lasting success in the latter (Miller, 1975).

Trist (1977) says that in the fifties autonomous groups could be found in both the London harbour and British retail trade, but that attempts to study them all failed. Another early socio-technical reorganization is known from Scandinavia. In Sweden autonomous groups were introduced in the Stockholm telephone exchange (cf. Westerlund, 1952).

The pioneering phase of STSD is characterized by notional vagueness. The lack of both time and resources at 'The Tavistock' made systematic concept development impossible. The workers from the very beginning were encouraged in their observations by the emergence of systems thinking, that initially was derived from biology, but later stemmed from cybernetics too. They



eagerly took on the new concepts and tried them out in actual practice. -The well known 'Gestalt' notion, renamed the 'holistic system' (Angyal, 1941), allows for a closer inspection of the coal mining situation in its entirety, i.e. both social and technical aspects and their mutual connection.

-By means of the 'open system' concept (Von Bertalanffy, 1950), the environment is considered. Thus, the unpredictable work situation in mines, hostile to workers, can become explicitly involved in study. The researchers make the concept of 'self-regulation' the footing of the semi-autonomous group (Sommerhoff, 1950). Self-regulation of all steps in the coal mining process is most effective in an unpredictable environment, and 'requisite variety' (Ashby, 1956) - that is to say, all-round miners in the semi-autonomous group - is needed. Trist and Bamforth recorded this fact in the Elsecar mine in South Yorkshire: small semi-autonomous work groups made up of eight miners, all receiving equal reward, who took on a complete production cycle in the coal mining process as a group. The continuing labour division, typical of early twentieth century mechanisation of the industry, was rigorously done away with. Actual practice provided all the necessary ingredients for a new theory of organisation. However, the exact conceptual elaboration only took place from the early sixties on.

### 3.2 Classical STSD in Europe

The further development of STSD was foreshadowed by Fred Emery's arrival at Tavistock in 1958, while director Wilson left. Trist eventually managed to find financial support for socio-technical concept development, so that Emery, aided by Herbst and Miller, could start on the difficult task of tying up the many loose ends from the pioneering phase. The transition from the pioneering phase to that of Classical STSD is demarcated by three documents (Tavistock 526-528: cf. Miller, 1959; Emery, 1959; Herbst, 1959). Following Emery (1959) the starting of the idea of the open systems in the production organisation results in the evolution of a 'socio-technical system'. Both social and technical components are part of a socio-technical system, i.e. people and machines. The technical component is taken to be the 'internal environment' of the organisation. In his review Trist (1981) says that the technical and social systems are independent of one another: the former follows the laws of natural sciences, and the latter those of social sciences. However, the two do not operate independently of each other. They rely on each other to fulfil the production function. We are dealing with a connection of heterogeneities. The economic aspect is not a separate third system in Emery's view (1959) as previously suggested by Rice (1958), but may be seen as a means to measure the effectiveness of the socio-technical whole.

In the years that followed, Emery also went to work on the formalisation and methodological foundation of STSD as an open systems approach (cf. Emery, 1967). Jordan's message (1963) that man is supplementary to, and not an extension of machines, was motivation enough to further explore the design precept of 'joint optimisation'. The social and technical systems were no longer to be maximized as independent bodies, but to be optimised at the same time instead. The point was to reach the 'best match' between technical instrumentation and social work organization. In 1963 Emery wrote of 'the ideal of joint optimisation of coupled, but independently based, social and technical systems'. In the early sixties, Emery did pioneering work in the field of science theory and methodology too. He further developed Von Bertalanffy's (1950) 'open systems' concept, for example, so that a definition of the process of 'active adaptation' was simplified, 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' offered by Emery lies at the heart of the socio-technical paradigm, and encompassed in brief the symbiotic relationship between an open system and its environment. The way in which the two are a result of one another while determining one another, was and still is difficult for many people to comprehend, and it was Emery who often pointed this out.

The epistemological and methodological documents mentioned above, though hard to get to, were the key to the foundation of STSD as a scientific paradigm, because they laid the facts bare. We shall not go into this subject in detail any further here, except for one theme. The well-known

environment typology can be viewed as a direct consequence of the establishment of STSD. From 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) generated an environment typology that takes 'causal texture' as its base. The term point to the 'degree of organisation' of the environment, in which systems originally non-related become interwoven to an increasing extent. The division consists of four classes of increasing complexity and unpredictability: 1 placid, randomized environment; 2 placid, clustered environment; 3 disturbed-reactive environment; 4 turbulent field. With this typology, the next logical step in socio-technical conceptualisation, one can better understand the increase in (changeable) demands affecting the organisation, which are heading for the organisation from increasingly rapidly changing markets. Successful interaction between the organisation and the increasingly complex environment greatly influences the chances of survival. The above typology was expanded by the hyper-turbulent 'vortex' variant by Babüroglu (1988): 5. vortical environment.

The Norwegian 'Industrial Democracy' (ID) programme, that ran from 1962 to 1969, was a historic part of the Classical STSD period. The mine studies in the United Kingdom made it difficult to do action research there. However, in the early sixties opportunities arose for larger-scale experiments in Norway. A joint committee was formed between employer and employee organisations at the beginning of 1962 to take a closer look at matters of industrial democracy. The government decided to become part of this committee at a later stage. At first, research in this area was subcontracted to the Trondheim Institute for Industrial Social Research (IFIM), which in turn called in the Tavistock Institute. Eric Trist was the original contact, but Fred Emery from 'The Tavistock' with Einar Thorsrud of the Norwegian Work Research Institutes (WRI) in Oslo were the ones who embodied and led the ID project (cf. Thorsrud & Emery, 1964). The most important feature from 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 especially dealt with sequential field experiments in which alternative forms of work organisation (primarily centred on semi-autonomous work groups) were set up and tested. Next, the effects on employee participation for each layer within an organisation were investigated.

The companies allowed to participate in these projects were carefully chosen by the experts of the 'Joint Committee'. The most important sectors in Norway were represented being the metal, paper and chemical industries. The choice was based on an elementary diffusion theory (Emery et al., 1958, see also section 3.3). We will now give a brief description of the four main projects:

-The first project started in 1964 in Christiania Spigerverk, a wire draw plant in Oslo (cf. Marek et al., 1964). Group work was introduced by the investigators with little difficulty, but the reward system instantly posed all kinds of problems. The whole process of change was not supervised properly in this project. Local unionists and management did not really empathise with the project, so it was cancelled when the research team left the factory having been there more than a year.

-The second project took place in February 1965 after prudent familiarisation and sustained sessions with unions and management at the chemical pulp department of the Hunsfos paper mill located in Vennesla, Kristiansand (cf. Engelstad et al., 1969). Here, they managed to get a firmer hold on the change process: the introduction and formation of 'extended groups' was accompanied step-by-step by project and work groups composed of employees' spokespeople, and lower and upper management. However, the project really got under way when the research team withdrew into the background and the (upper) management committed itself in more pronouncedly. In 1966 the new work organisation thrived and the effects of group work and multi-skilled personnel were finally proved. However, early in 1967 the project ran aground because of a crisis in the paper industry and the associated priority changes in management. In the seventies the Hunsfos employees took over the project for themselves and gave it a new lease of life (cf. Elden, 1979).

-The Industrial Democratisation programme met with greater hold-ups. After an initial refusal by the management to join the programme because of politically sensitive issues within the company, the third ID project

started after all - more than two years after the first application - in December 1965 at NOBØ household appliances/metalware in the Hommelvik division near Trondheim (cf. Thorsrud, 1972). Here too, an experiment with semi-autonomous groups took place, carefully set in the organisation, specifically for a new production line for electric radiator heaters. This project became the spearhead of the ID programme, which attracted many interested parties from Norway and Sweden. Later, when a new factory had to be put into use in connection with higher production, the employees succeeded in maintaining the new organisation.

-The fourth ID project was launched in 1967 - at the request of the firm itself - in the chemical concern Norsk Hydro, more specifically in the rearrangement of the old and design of a new fertilizer factory in Heröya, Porsgrun (cf. Bregard et al., 1968). This project, which also involved Louis Davis, was one of the many variants to the introduction of a group structure supported by a training programme and a reward system adapted to group work. It was a resounding success: the two factories showed a good performance well into the seventies with this socio-technical work organisation.

The four demonstration projects described above were the basis for considerable study (cf. Emery & Thorsrud, 1969/1976; Engelstad, 1972; Gustavsen & Hunnius, 1981). They were meant to explain the functionality in practice of the new socio-technical organisation principles, but unfortunately these examples initially had little following. Though the experiments were successful (cf. Gustavsen & Hunnius, 1981), they were largely limited to the department or the factory where they had started. In turn, the 'experimental gardens' were separated from the rest of the organisation and thus it started to resist such a change. This phenomenon was referred to by Merrelyn Emery (1989) as 'paradoxical inhibition'. Although various diffusion programmes were set up, the programme came to a halt in Norway around 1970.

The situation for the neighbouring country Sweden, however, was the opposite. A cooperation project carried by employers and unions similar to that in Norway was set up. Soon employers wanted to start their own programme in more than 500 companies (cf. Jenkins, 1975) as a result of slow progress. They also promoted a socio-technical 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 having developed a whole range of pioneering new forms of work organisation, Kalmar being the most well known (cf. Agurén et al., 1976/1984). For a more extensive overview of the Volvo projects, see Auer & Riegler (1990).

From 1965 on the Industrial Democracy programme was redone in the United Kingdom. The Norwegian example was 'copied', as best they could, at Avon Rubber, Shell and RTZ (personal communication of Emery, 1990). However, one important element was lacking: a steering committee that was composed of employers and employees. 'The Shell Philosophy programme was an innovation but not a change in trajectory. It was developed because we could not get a sanctioning body of the union and employer leaders in the UK, as we had in Norway' (Emery, 1990).

The Norwegian ID programme and its variants are characteristic of the Classical STSD period, in which the expert approach prospered. While moulding and elaborating upon the ID programme in Norway, a major emphasis was placed on a systematic explicitation of the project approach - among other things, because of its demonstration character. This led to important 'breakthroughs' in the field of method and concept development. In the ID project approach, the whole process of change was defined and monitored in phases and steps. The starting point was a thorough socio-technical analysis of the in situ business situation. The notions 'variance' and 'variance control' (cf. Engelstad, 1970; Hill, 1971) were essential here. Based on Herbst's (1959) concept of 'disturbance control', the principle of 'signalling occurring disturbances and their control by the employees themselves as close to the source as possible' was operationalised through projects. The implementation of this principle came about through use of the so-called 'variance control matrix': a table with both specific disturbance sources and (factual) disturbance controls. This procedure became the first formal socio-technical method. The so-called 'traditional variance analysis' technique was first used at the Hunsfos paper mill. The steps are as follows:

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 and control table.
9. Suggest technical changes.
10. Suggest social system changes.

Engelstad et al., 1969

The technique was then used at the Stanlow oil refinery of Shell-UK (cf. Foster, 1967; Emery et al., 1967; Hill, 1971) working from Tavistock. Emery and Thorsrud developed a series of job redesign principles to be used for the actual experiments with Industrial Democratisation based on the work of Louis Davis from the United States (cf. Emery & Thorsrud, 1964, pp. 103-105). These so-called structural propositions for joint optimisation acted as criteria for the assessment of the existing and newly created work situations. Afterwards, they were repeated in the literature often in various publications (e.g. Emery & Thorsrud, 1975/1976).

### 3.2.1 Classical STSD Development in the Netherlands

From the very beginning, the Netherlands has held an important place in the history of STSD. Dutch researchers have been involved in the development and application of the paradigm from the outset.

From 1957 to 1959, Hans van Beinum was the first in the Netherlands to carry out a kind of socio-technical field experiment. This was done at the Department of Transfers of the then Post Cheque and Giro Services (PCGD) in the Hague (Van Beinum, 1963a). At the main Current Account department, which employed 1,700 personnel, he examined the effects of the introduction of 'stable table groups', of another method of management ('business discussions'), and of delegating power. He found no differences in productivity between experimental and control groups. However, Van Beinum did conclude that the experimental groups clearly expressed a more positive judgement of their working situation after the introduction of the organisational changes (Van Beinum, 1963b, p. 112). In the sixties, Van Beinum did several other projects, both from Tavistock (Van Beinum, 1968) and in the Netherlands (Van Beinum et al., 1968/1970). In connection with this, we have to mention Van der Vlist, who - just like Van Beinum - did Tavistock research in Dublin. He subsequently carried out a socio-technically influenced dissertation research, under the guidance of Mulder and following Van Gils' tracks, to study the group performance of ships' crews in Dutch offshore fishing (Van der Vlist, 1970). Following this, the effects of naval fishing were examined by Herman Kuipers (1969) through simulation, and reported in a dissertation (Kuipers, 1980).

Allegro started a socio-technical project subsidised by the Social Economic Council (SER) in 1969 at the cotton spinning mill Bamshoeve in Enschede (Allegro, 1973a/b). This analysis is a textbook example of a classical socio-technical analysis, with much emphasis being placed on the variance control matrix.

In the late seventies, Allegro & De Vries (1979a/b) did a socio-technically-inspired experiment at Centraal Beheer insurance company in Apeldoorn. The immediate cause was the development and introduction of the 'Effective Life Insurance Information System' (ELVIS) initiated from technology. The project consisted of the re-introduction of work consultation in 25 groups at the life insurance department and experimentation with a contract (client)-oriented approach. A test with three contract control groups was a success. In contrast with the Bamshoeve, more emphasis was placed on the training of group supervisors in a different type of guidance and leadership. The researchers spoke of an integration of a task-structural and group-dynamic approach, and of structure and culture.

Parallel with the above projects, pioneering work was done in the sixties and seventies at Philips in the area of Work Structuring (see elsewhere in this handbook).

Walravens (1977) carried out a series of field experiments with what he

calls 'Industrial Democracy'. These projects were concerned with work consultation and task structuring at the Worsted and Ironing Spinning Mill Swagemakers-Bogaerts in Tilburg, and at the packaging company Thomassen & Drijver-Verblifa in Oss. The total organisation including all its policy levels and its relevant environment was the express object of research. The projects show a clear resemblance with the Norwegian ID projects described in section 3.2. Walravens (1977, p.247) opted for:

'(...) a development and institutionalisation of bottom-up participation, where all levels are continuously involved in the changes, in order to guarantee success and continuity. Characteristic (...) is the attention given to the relationships of the enterprise with the organisations or parts of organisations that are relevant to its functioning, such as works councils, unions, employers' organisations, (...) and the government'.

Walravens actually carried out two projects and concluded that the success and permanence of the organisational change depended on the extent to which employees were personally responsible. At the same time, however, he remarked that there was little enthusiasm in Dutch companies in 1977 to experiment with enlarging participation. The study contributed to the insight that the exclusive application of a micro-approach concerning humanisation of work is too limited to achieve structural improvements in the area of Industrial Democratisation.

Looking back on the projects portrayed in this section so far, we must conclude that various applications of Classical STSD can be recognised in the Netherlands. Remarkably, the same shortcomings of this 'expert-driven' approach have come to the fore, namely little acceptance, disappointing diffusion and the hedging in of projects.

### 3.3 Modern STSD in Different Continents

The results from the Classical STSD period were a let-down. A time of introspection followed which led to extensive thought on the strategy to be developed. This took place in various places in Europe, North America and Australia without much tuning between the groups. Thus, separate approaches came into existence that have many common features upon closer inspection. An emphasis on the diffusion process rather than on the changes of content themselves is a main characteristic of the Modern STSD period. In this context, one speaks of a 'figure-ground reversal' (cf. Herbst, 1976; Emery, M. & Emery, F., 1978; Emery, M., 1986) as a contrast to the previous phase. The 'figures' refer to our factual structures (the factories, offices, institutions), the 'ground' to our lifestyles and values. The object of change is reversed, so a change in attitude is the focus: learning to participate.

Elden (1979a) outlined the features of Modern STSD in sequence:

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 are usually redesign team members.
2. Employees receive some training in work design 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).
8. There is a supportive network of co-operative relations between design teams from different organizations who learn from each other's experience (they are not entirely dependent on experts for the necessary learning).

#### 3.3.1 Modern STSD Development in Australia

Fred Emery who had spent over ten years in Europe, went back to Australia

in 1969. Once there the petitions came pouring in for projects analogous to those he had worked on in the United Kingdom and Norway. He found himself having to allow companies to set up and realise their own design projects. The 'vertical project group' (top-down cross-section of the hierarchy) tried out at Hunsfos was the basis for the so-called 'vertical slice approach' that Emery later formed. The approach meant having to improve 'Industrial Democracy' for the entire organisation by means of 'self-managing design groups'. The groups were made up of employees, supervisors and managers who ranked differently in the organisation, but who expected to work together as equals.

The ID diffusion process in Norway has been a failure that Emery was not ready to repeat. He attributed the poor results mainly to the expert approach advocated by the researchers. The projects had never managed to gain a proper footing within the companies, because there was a lack of involvement. The expert approach was no longer a viable option in view of the changed spirit of the times (the students' rows in Paris had only recently taken place).

Emery gradually realised from the perspective of STSD research that an entirely new democratic value system lay hidden beneath the semi-autonomous work group in the UK and the principles for task redesign developed in Norway. Emery and Thorsrud (1969, p. 105) started by saying 'a limited number of general psychological requirements', but Emery (1977, p. 68) later goes on to say 'a set of workable and relevant values (...), things (...) valued in work regardless of sex, nationality or race'. He outlines these values as follows:

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.

Emery (1977), p.68

Trist (1976) also talks of new values that enable us to cope with the increasing complexity of the environment, mentioning things like self-actualization, self-expression, and 'capacity for joy'.

In 1971 Emery produced a technique called the 'deep slice' method of Participant Design. This method allows employees, (middle) management and union representatives to work on task and organisation design together when the project starts. The idea behind this was to get rid of any opposition to change. The South Australian Meat Corporation SAMCOR (Yearling Hall), the Royal Australian Air Force, and Imperial Chemical Industries ICI were the experimental breeding grounds for this technique. Even before the famous fourteen-page 'little golden book' was published (cf. Emery, F. & Emery, M., 1974/1975) the method had been transferred to India (cf. Nilakant & Rao, 1976), the Netherlands, and Norway. By 1972 things started to look up in Norway as diffusion was given a new boost. This was the result of companies assuming control of the development themselves following the departure of the researchers.

'Participative Design' (PD) is described by Merrelyn Emery as 'an environment for conceptual and experiential learning about democratic learning organisations' (cf. Emery, M., 1989, p. 114). During the seventies, two such environments were further worked out: the Participative Design Workshop (Emery & Emery, 1975) and the Search Conference (Emery & Emery, 1978).

The Participative Design Workshop (PDW) is a gathering that lasts between one-and-a-half and three days. Four to ten members are chosen from all layers of the organisation ('deep slice') and come together as equals in a total design group to map, assess and redesign the working situation with the counsel of a so-called facilitator. The fundamental substance of the 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 earlier 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 that underpins the workings of the total design team, is reflected in part II of the book. The different jobs of staff are assessed using the six psychological job requirements, and the process flow is analyzed. Also, training requirements are obtained from a so-called multi-skilling table, which helps evaluate skills per person for every (group) task. The aim of the PD workshop is to accomplish structural organisational change by those involved. The complete framework is 'anti-expert-oriented', and works on the hypothesis that 'the most adequate and effective designs come from those whose jobs are under review' (Emery & Emery, 1975). Content is not the focus here, but the participative process where the members of the organisation devise their own evolutionary learning process. The Search Conference (SC) is a non-hierarchical meeting for policy preparation, based on the principle of 'redundancy of functions', involving a maximum of 35 persons who cooperate in isolation for two to three days. It is their task to work out plans for the future as a group of equals. The socio-technical search conference makes use of the indirect or 'Broad Front' approach, and is aimed at the joint development of 'desirable and probable future scenarios'. Especial care is paid to the opportunities and limitations provided by the environment, without neglecting the history of the company. 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 decide their own future. The distinct goals are: deciding policy, planning and learning in a non-dominant democratic structure. According to Merrelyn Emery (1993) both PD tools have their own function. SC is primarily a participative planning methodology, while PDW is the actual organisation redesign instrument.

An explicit diffusion strategy underlies Participative Design. The point of departure for this strategy was the diffusion model constructed by Emery et al. (1958) for an agricultural renewal programme in South-East Australia. Qvale (1976) made a brief abstract of the findings 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. 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

To explain the (Norwegian) democracy experiments, Philip Herbst (1976) further developed this diffusion theory. The network concept is central to Herbst's theory. According to him (1976, p. 33), a network group should be portrayed as the reverse of an autonomous group. It is a transient organisation of similar thinkers in separate locations, who periodically meet for consultation. Such a meeting is sometimes referred to in the literature as a 'flocking session' (cf. Davis & Cherns, 1975). Flocking is a phenomenon that involves different people with collective interests coming together for a few days to intensely confer, without arranging for another meeting. According to Herbst (1976), flocking by members of a network is exactly what keeps them together, and it supports a network's objective, namely maintaining 'long-term directive correlations'. The process chiefly involves stimulating one another to reach a common, though not (fully) specified objective. The primary function is the collective learning process.

Emery, M. & Emery, F. (1978) ground their Participative Design paradigm on an open-system model, which they believe to be pertinent to the diffusion process. The 'system' has the members of a PD workshop, search conference or network of companies, while the 'environment' includes 'the extended social field of directive correlations' (Emery & Trist, 1981), together forming changed society in its totality.

They call the input function 'learning' and the output function 'planning'. In general, both Merrelyn and Fred Emery state that the level of the

environment complexity decides the form assumed by the learning and planning functions in practice. In a competitive 'type III' environment ('disturbed, reactive', compare section 2.1) the learning function assumes the form of 'problem solving', and the planning function that of 'optimizing, utilising technical and economic standards only'. In a turbulent 'type IV' environment (rapid, unpredictable changes, disturbed ecological chains) learning occurs through 'puzzling' (Angyal, 1965), and planning through the active and adaptive formation of 'desirable future scenarios' (Emery, 1977).

Puzzling is a kind of learning - in the literature it is also looked upon as 'double loop learning' (cf. Argyris, 1976) - in which individuals try to trace the more vital basic questions in a non-hierarchical, friendly atmosphere. They try to find trends in an excess of data, filtering 'the leading part' (Emery, 1967). Planning subsequently occurs by plotting, evaluating and adapting a strategy in sequence, which consists of jointly formulated 'desirable future scenarios'. Thorsrud (1972) feels this type of policy-making is a form of active, adaptive planning, which is essentially a continuous learning process. The real drive behind PD is the pleasure experienced during this learning process. Instead of assuming an expectant attitude, people are willing to get to work. In the PD workshop, they work as a group by themselves to adapt the working situation (in their own company); in the search conference, participants develop future scenarios.

As a kind of Modern STSD, PD is still not as prevalent as its classical antecedent. Presumably this is because of the anti-expert character of the new approach, which sets consultancy agencies on a sidetrack. In the seventies, PD workshop projects were mainly confined to Scandinavia, India, Great Britain and the Netherlands. Moreover, only a few of these projects have been recorded in the literature. In North-America and Canada, the application of Participative Design has only recently started to carefully emerge (see section 3.3.3).

### 3.3.2 Modern STSD Developments in Scandinavia

In Scandinavia STSD went off at a slightly different tangent after 1970. 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). In essence, it is a response to the Participative Design approach emphasising 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. To promote DD, the authors mentioned above defined the circumstances under which a democratic dialogue may come about. A democratic dialogue should especially be formed at organised network meetings. Therefore, conferences functioning like springboards are central to this. The DD network philosophy should be set against a background of years of experience with democratisation in the working situation. More specifically, it is a reaction to the moderate outcome of PD. In Scandinavia, PD was only brought into practice at (some) large companies during the seventies. In small and medium-sized companies it never really caught on. This was attributed, among other things, to the lack of adequate joint networks. People are trying to change this by means of DD, both in Norway and in Sweden.

In Norway, a national basis emerged for the development of local networks in 1982, when employers and employees jointly agreed to strengthen network-oriented activities both professionally and financially. Based on the regional experiences gained in this context, the so-called Development Organization (DO) approach matured steadily (Engelstad, 1990). This is a more indirect approach to PD, aimed at creating a suitable platform for bilateral exchange - also for SMEs - and enhancing the quality of the mutual dialogue. The DO approach rests on five pillars: the strategy forum; company-wide conferences; supra-departmental project groups; basic groups within departments; socio-technical changes in the daily work organisation. The first two pillars demand further explanation. The strategy forum is not so much a steering group in the traditional sense, but rather a semi-open conditioning body of the network that also allows external experts in at the body's request. The strategy forum conceives general aims, brings together (groups from) the participating centres in the organisation



network, stimulates productive dialogues, and supports contacts with the whole 'broad field' of activities.

As for the conferences, it can be said that originally these were largely built up in the same manner as those in the PD tradition. However, they became more fixed bit-by-bit. From the experiences gained with branch projects, the Dialogue Conference (DC) method was developed. It is a type of PD workshop or search conference for network development. It works on the assumption that the quality of the dialogue is a major medium for the change process. The DC method can be separated into three successive stages entry into the branch network; business development projects; augmentation of the (supporting) network. In phase one, the demonstration conference is held, the strategy forum is chosen and regional promotion conferences are formed. In phase two, a 'whole-company' conference is arranged, and a supporting expert is let in to the company part-time as a 'scholarship holder', paid and supported by the national programme. In phase three, a 'network development' conference is begun to enlarge the number of firms taking part and supporting institutions. The strategy forum acts as an initiator and coordinator in all these activities. The content of the conferences is mostly the concern of the groups participating. However, the order of the sessions and constitution of the groups are carefully planned beforehand.

As pointed out previously, the national, tripartite stimulation programmes in Scandinavia are highly important in realising an infrastructure for a democratic dialogue. In Norway, this is the HABUT programme, which translates into 'The Basic Agreement's Enterprise Development Measures'. In Sweden, it is the LOM programme, initiated by the Swedish Work Environment Fund. Here, the acronym stands for 'Leadership, Organization and Co-determination'. LOM is the most comprehensive of the two programmes in its content and size. Gustavsen (1989) reports there are more than 100 firms and institutions taking part in this programme begun in 1985. For a broad evaluation of the LOM programme see Naschold (1992/1993). The results of DD are without doubt imposing. However, whether the Democratic Dialogue described above will actually encompass a subsequent qualitative leap forward in the development of STSD, or is just a further broadening, development and expansion of Participative Design, cannot be convincingly concluded at this time. Fred Emery (1990, personal communication) reports that a real fourth phase would feature the development of 'organizational forms for the management of self-managing work groups'. The Dutch approach to 'Integral Organisational Renewal' (IOR) would then be more eligible for the designation of 'fourth phase turning-point' (see also section 3.3.4).

### 3.3.3 STSD Developments in the United States and Canada

STSD only really managed to gain a firm footing in North America after the return of Louis Davis in 1967. He had been to Tavistock and from there had been participating in the Norwegian 'Industrial Democracy' experiments. Katz and Kahn had just published their 'Social Psychology of Organizations' at the time (1966). Davis had convinced Eric Trist to temporarily give up his position at Tavistock for a seat at an American university. Later this proved to be his last time in Europe. Davis and Trist established themselves at the University of California in Los Angeles (UCLA), where they developed a complete STSD programme together. UCLA became the breeding grounds for a whole generation of American socio-technologists. UCLA's graduates spread out across various other North American universities (e.g. Pennsylvania State, Case Western Reserve, Texas Tech, Harvard, Loyola, and Toronto), or worked as advisors in companies and institutions (e.g. Alcan, Proctor & Gamble, General Motors, General Foods, Digital, U.S. Army, Labour Canada, cf. Taylor & Felten, 1993).

An important feature of the North American STSD approach is that under the influence of Trist right up to his death in 1993, it remained a faithful copy of the original classical Tavistock approach as described in section 3.2 (cf. Taylor & Felten, 1993). The socio-technical approach, which was renamed 'Quality of Working life' in the United States, was used in many American companies as an application of participative redesign in the seventies (cf. Davis & Cherns, 1975; Taylor, 1990). Lately, it seems that Participative Design is gaining more advocates in the United States because of Merrelyn Emery. Modern STSD in North America is therefore clearly becoming more pluralistic.

### 3.3.4 STSD Developments in the Netherlands

A conceptual addition to the development of STSD that broke new ground was provided by Ulbo de Sitter. He was the first to oppose the original paradigmatic elaboration of Classical STSD, both concerning content and methodology. Among other things, De Sitter's opposition centres upon the obsolete system-theoretical foundation of the paradigm and with its partial and static elaboration as a socio-scientific approach in the aspect area of the quality of work. Also, Ad van der Zwaan (1973) points to the lack and insufficient specificity of the definitions used. In view of the inadequate accessibility of many conceptual 'Tavvi' documents in which Fred Emery in particular did much significant conceptual digging, one may wonder whether all this criticism is warranted. In our judgment, even after having read these development papers and considering the directive correlation methodology, these points of criticism do actually have some value. In brief, the most relevant theoretical and methodological objections, presented by Van der Zwaan (1975) to the international forum, are as follows: insufficiently precise definition of basic concepts, inadequate attention for the system/environment relationship, the incorrect system-theoretical distinction between a social and technical subsystem, too great a reduction of the social system into a mainly psychological entity, and the inadequate separation of the analytical and the design models. The latter point focuses on the improper use of the Variance Control Matrix (cf. section 3.2.) for redesign purposes. As De Sitter et al. (1990) underline, an analysis of disturbance sources coupled to disturbance controllers is only provides information on the operation of the existing architecture of the production system. It is completely inappropriate for the moulding of a renewed structure, since it is organised dissimilarly.

The above objections prompted the development of a fresh theoretical base. For the purposes of analysis and redesign STSD is broadly described as the study and explanation of the way in which technical instrumentation and the division of work determine [system behaviour, capacity and functions] in their mutual connection and in relation to given environmental conditions, and also the application of this knowledge in (re)designing production systems (De Sitter, 1974a, p. 76). In 1989, he switches the part between square brackets in the previous sentence by 'the possibilities for the production of internal and external functions' (De Sitter, 1989b, p. 232). For a graphic representation of the central factors from this intricate explanation and their relationships, see figure 2.

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### FIGURE 2 ABOUT HERE

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Technical instrumentation is defined here as the technical accoutrements of people and abilities concerning potential. Work division is taken to be the grouping, allocation and coupling of executive and regulative functions. This concerns the segregation of executive and regulative tasks on the one hand, and the disjoining or dividing of executive and regulative tasks in sub-operations and subregulations respectively on the other. In this characterisation of STSD, it is repeated that the nature of the interdependence in particular between technical instrumentation and work division biases the behaviour of the system. This occurs through internal (directed towards purchase, preparation, manufacturing and sales) and external system functions (directed towards various 'markets'). In essence, De Sitter develops a process theory of change, which he labels 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) are central. The structure of the selective labour process is explicitly looked at in the Model of Balance. The quantitative aspect of the labour process is the quantity of goods and services exchanged, the qualitative aspect is the permanence and growth of work relationships. The labour process is seen as a crossroads for various institutional and private exchange processes; needs and values are considered changeable

social processes fostered by society and introduced into the work situation by individuals and groups. Signification is a function that is inherent in selective social processes and is closely connected to the regulation of the labour process: 'What structural conditions do my labour processes have to comply with in general, so that I can solve numbers and kinds of problems that change in time and participate while giving meaning?' (De Sitter, 1978, p. 9). Where there is a lack of regulative elements in work alienation occurs, but regulations provide involvement in work. Stress occurs when someone faces difficulties and cannot get rid of them. The Balance Model, which in principal is applicable to all kinds of social systems, including companies, can describe the dynamic process simply and economically, in which open system and environment continuously follow from the alteration in the other, in ever-changing ways. From this perspective the design is a different system-theoretical option to Emery's directive correlation methodology. In his elaboration, De Sitter predominately focuses upon interaction conditions, i.e. upon conditions of structure. The operational problems in production control are the explicit starting-points in this.

In 1973, a well defined and coherent system concept framework was published, including the 'empty cartridge' concept of 'aspect-system' that Tavistock did not know about (cf. De Sitter, 1973). In the same article, one finds much work is poured into an attempt to fit the 'mould' of the systems approach as to its content, by means of 'a scheme of interaction strategy' (p. 138). After 1973 this scheme was changed into a more verbal model. What lies at the heart of the Balance Model is the so-called 'interference' phenomenon. This happens in a situation where one process operation is disturbed or possibly obstructed entirely by another. One notion of interference is:

'(...) 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 possibilities for interaction which come into being through the labour process'. (De Sitter, 1978, p. 15)

The crux of the new process model for Classical STSD is to prevent or cure interference and to stop it spreading in the system. This can be achieved through regulation. Regulation can be broadly defined as the maintaining of balance in processes fine-tuned to different functions in a system. The Balance Model utilizes the feedback loop as a basic model of the labour process. It is better not to separate and divide use (realising connections) and regulation (selecting connections) in the feedback loop, but rather to combine them (principle of minimum division of labour). The Balance Model, like Classical STSD, departs from the so-called 'latitude premise'. The premise is an assumption regarding the scope of control founded on the axiomatic cybernetic 'Law of Requisite Variety' (Ashby, 1956). The law generally implies that the external variability of the environment (turbulence) as information can be only compensated for or cancelled by a proportional internal variability of the open system (unprogrammed production control/latitude). De Sitter (1978) interprets the variability of the information as the need for control, and the potential open systems variability as opportunities for control. The balance between the need and opportunities for control is interpreted as the quality of work.

A fundamental notion in the Balance Model is control capacity. De Sitter (1978) reports that this notion does 'not refer to authority but to control opportunities resulting from the objective nature of the labour process' (pp. 20/21). In 1980 he succinctly described control capacity as the problem-solving or disturbance reduction capacity: 'In actual practice the control capacity present manifests itself in the process' sensitivity to disturbance, and thus the degree to which a disturbance ripples onwards without the possibility to reduce it through regulative action' (p. 69). In the last few decades, measuring instruments for control capacity (and latitude) have been made by De Sitter & Heij (1975), Egmond & Thissen (1975), Van Eijnatten (1985), Pot et al. (1989a/b) and De Sitter (1989c). Towards the end of the seventies, the Dutch approach to STSD was expanded considerably to eventually become the method of 'Integral Organizational Renewal' (IOR). In the early eighties, new opportunities arose for STSD, because the quality of work was no longer viewed as social extravagance,

but as a vital base for a flexible production organisation. Themes like the quality of working life, efficiency and effectiveness, as well as social cohesiveness and cooperation are set within a model for the first time. In line with this there is a call for 'new factories and offices' based on modern STSD (De Sitter, 1981a). The way is made clear for more policy-based integration of the following areas of attention: the quality of work (with stress and alienation as problems), the quality of the organisation (with flexibility and controllability as bottlenecks), and the quality of the internal industrial relations (with employee turnover, absenteeism and labour conflicts as central issues). The issue of industrial democracy has traditionally been spread across the preceding problem areas, which have been individually studied by psychologists, sociologists, economists and organisation scientists. The essential thing is the interaction between these aspects, while the focus is the dynamic whole. In a cyclical movement the quality of work, organisation and industrial relations should mutually reinforce each other (upwards spiral) instead of weakening each other (downwards spiral), as often happens. Getting away from the downward spiral of the division of labour in the production organisation, however, is the first condition for this. De Sitter (1980) feels the above qualities are each other's counterparts in the proper production structure and that they 'maintain each other as a pattern of characteristics' (p.25). The functional importance of participation in decision-making is acknowledged as a medium for industrial democracy, to have a synergetic effect on these problem areas. Thus, Modern STSD became a reality in the Netherlands as well.

Integral design is the central element in the IOR approach. The fundamental issue is the flexibility of the complete production system. The aim of STSD for now is to enhance the controllability and the quality of work through alterations in structure. An integral approach is a structural approach by definition, where 'structure' means being part of a process that does not change a lot over a period (nature of the operations, norms). The gist 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). Getting rid of bottlenecks that can be solved independently of each other is called improvement (partial structural alteration), while settling interdependent problems is called 'renewal' (integral structural alteration). In essence, renewal means reordering process functions with respect to order flows. De Sitter (1989a) characterizes IOR as a clean break from the old functional production concept to the new flow-oriented production concept. The Balance Model we already looked at, acts as the centre of IOR concerning content; interference and control capacity are its central concepts. The IOR approach entails making an inventory of market demands and performance criteria (Bolwijn, 1988). In addition, one needs to identify, analyze and set structural parameters, which collectively reduce the chance of and sensitivity to disturbance of the production system:

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 specialization: dividing 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 specialization: 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

Performance and control are the primary functions here. At first, two primary aspect-systems were discerned: the Production Structure (P) as a grouping and coupling of executive functions, and the Control Structure (C) as a grouping and coupling of regulative functions. Subsequently, the Information Structure (I) was included as a technical elaboration of P and C. Many design principles were formulated in the eighties (cf. table 1).

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### TABLE 1 ABOUT HERE

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What drew special attention was the shaping of the production structure through parallelisation and segmentation. One can really speak of a method to fundamentally change the organisation of the technical processes, which is an explicit objective of the socio-technical paradigm. The IOR approach has done much to realise the parallelisation of order flows. For an elaborate study on the opportunities provided by Product Flow Analysis (Burbidge, 1975) as a technique for parallelisation, see Hoevenaars (1991). Besides this, the formation of the control structure has also been worked out in detail (Landré, 1990; Van Amelsvoort, 1989/1992). Also, the exploration of the information aspect has been given attention (Van Eijnatten & Loeffen, 1990).

The IOR approach also discerns distinct design sequence rules (De Sitter et al., 1986; De Sitter, 1994). Therefore, the production structure has to precede the control structure and the design of process technology in its formation, and the design of control circles should follow allocation, selection and coupling in that order. Besides the content of the (re)design, the mechanism with which change comes about also receives full attention. A renewal trajectory of two to four years is proposed (Den Hertog & Dankbaar, 1989), including a strategic exploration, on-the-job-training and training for self-design, as well as project phasing and management. De Sitter (1993) states that 'within the boundaries of what is feasible a socio-technical agent of change strives for: a) commitment; b) a well-balanced design according to his/her own professional conviction and judgment; c) self design by knowledge of transfer' (p.176). This approach attempts to be a fusion between the expert and the participative approaches. To make things clearer, the terms from IOR are compared with those of a more traditional STSD in table 2.

In 1981, the Dutch Institute for the Promotion of the Quality of Work and Organisation (NKWO) was established. The aim of this foundation is to train business executives of all levels in socio-technical principles, so that they can take control of the redesign in their own company (compare the approach of Participative Design in section 3.3.1).

Various teams are working on the development of (parts of) the IOR approach in the Netherlands.

- Until 1988, the research team 'Quality of Work and Organisation' (KWO) at the University of Nijmegen worked on a follow-up to the Socio-Technical Task Analysis (STTA): the conceptualisation and application of the Flexible Labour Systems Approach (BFA) (cf. Van Eijnatten, 1987; Koopman-Iwema, 1986). A practical approach was involved that would give shape to the task structure at the micro-level (building in steering capacity, control capacity and latitude in labour tasks). It was based on a design philosophy, in which social perspectives in mutual interaction with business administration and other aspects are discussed. It concentrated on a bottom-up approach and on the function demand quality of work.

- From 1985 on NIPG/TNO in Leiden in cooperation with NIA Amsterdam and IVA Tilburg have been working on the development of the WEBA methodology (cf. Project Group WEBA, 1989; Pot et al., 1989). This methodology is used by the Dutch Labour Inspectorate as an instrument to test application of the Law on Working Conditions (Labour Inspectorate, section on welfare, 1991).

Table 2. Pertinent contrasts in content between the mainstream approach and the Dutch variant of STSD (De Sitter et al., 1990, p.27)

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## TABLE 2 ABOUT HERE

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- The STSD Group at Eindhoven University of Technology worked on the conceptualisation and application of the Flexible Company Approach (BFB) until 1986 (cf. De Sitter et al., 1986). It concerned a design paradigm involving the top-down redesign of the production structure and the bottom-up redesign of the control structure. This approach encompasses all levels and aspects, but emphasises the macro and meso-levels, using controllability in particular as a function demand, and specifically stresses the logistic aspect.
- From 1988 on research teams at Eindhoven University of Technology have been working on the methodological development of IOR (cf. Van Eijnatten & Hoevenaars, 1989), the integration of BFA and BFB into the Flexible Organizations Approach (BFO) (cf. Van Eijnatten et al., 1988/1990), and on the documentation of its content (Kuipers & Van Amelsfoort, 1990; Van Eijnatten 1990a/b; Van Eijnatten et al., 1992; Van Eijnatten, 1993a/b, 1994a/b).
- Since its foundation NKWO/Koers has been working on the use and practical application of IOR and the development and implementation of a socio-technical training programme for business executives (cf. the journal 'Richtingwijzer' and Ligteringen, 1989). Now there are various other STSD-oriented consultancies besides Koers (e.g. ST-groep, Oss; Rubicon, Vessem; Intrieri, Boxel) that lend support to companies in the actual implementation of IOR by means of projects, courses and publications related to working practice (cf. the journal 'Panta Rhei', and Van Amelsvoort & Scholten, 1993; Nober & Verschuur, 1994).
- Those most actively involved in the development and extension of socio-technical thought through research and education are the universities of Eindhoven, Groningen, Leiden, Rotterdam, Nijmegen and Maastricht. Several dissertations have been published in recent years (Boonstra, 1991; Hoevenaars, 1992; Van Amelsvoort, 1992; Heming, 1992; Roberts, 1993; Benders, 1993; Ten Have, 1993; Deetman, 1994; Fruytier, 1994; Haak, 1994). In 1994 the Dutch Foundation for STSD (SSTN) was established (Van Eijnatten (ed.), 1994). All Dutch professors involved in the field of STSD are members of the foundation.
- The Technology, Work and Organization (TAO) research network prompted research involving IOR in the period 1988 to 1994. The Maastricht Economic Research institute on Innovation and Technology (MERIT) coordinated these activities through links with international networks (cf. Den Hertog, 1988a/b; Den Hertog & Schröder, 1989).

### 4 STSD at the End of the Twentieth Century

The socio-technical approach has been evolving for over four decades now. In this time the paradigm has developed from a chance re-discovery of an adaptable kind of work organisation in a British coal mine, to an integral option to Taylorism dating from the beginning of the Industrial Revolution. The open system and self-regulation are its chief ideas. Throughout its evolution, the socio-technical approach has continued to revitalise and revive itself.

- In the pioneering phase of Tavistock, the mine studies were built on theoretical terms on the whole, with a mixture of notions originating from the speedily arising revolutionary system thinking.
- These notions were further extended in the Classical STSD period, and also adjusted for content in more detail, made logically consistent, and founded in method(ological) terms.
- During Modern STSD, models and methods were attuned to advancements in systems theory and the paradigm was enriched by an elegant and necessary 'do-it-yourself' method. The emphasis was increasingly being placed on the formation of inter-organisational networks and integral production renewal. Yet, disregarding all the surface changes, the ultimate aim of STSD has always been kept in mind: the integration of aspects was and still is of capital import. Integrative thinking will go on to be popular in the period to come. In this context, Van Beinum (1990b) speculates on a shift from socio-technical to socio-ecological design. The organisation plus its environment will both be object and objective of change. In Sweden, the LOM programme is almost a forerunner of this kind of approach. With the onset on the nineties, and particularly within the car industry

that was facing a crisis, discussions again arose about the pros and cons of STSD. These particularly concerned other approaches based on the Tayloristic model, like the Toyota Production System. In the western world this extremely successful method of production has been dubbed Lean Production. The discussions on effectivity have been set in a different light now that the Volvo management has decided to close the brand new factory in Uddevalla, where experiments were being carried out with complete parallelisation of the final assembly process of the Volvo 740 (cf. Janse, 1989). For the moment, it seems that the Tayloristic concept will only hold in sectors that produce relatively large batches of products. Outside these sectors there is a gradual transfer to the new flow-oriented production concept. In advocating integral organisation renewal, modern STSD gained unexpected support from an American approach that is rapidly growing in importance: Business Process Reengineering. Also, in the United States people are showing increased interest in a more integral and participative STSD approach. Japan has come up with the innovative concept of 'Holonc Production Systems', i.e. decentralised adaptive assembly systems with autonomous cells, involving 'Human Integrated Manufacturing' (HIM). What this entails is that the worker takes part in one or more holons, supplies the creativity and makes decisions, while the equipment supplies the accommodating instrumentation (Sol, 1990). In the Netherlands, the STSD organisation renewal model has been applied to the process of product creation (Simonse & Van Eijnatten, 1993; De Sitter, 1994).

These and other developments will play an important role in shaping the new face of STSD into the next century. Its main focus will remain the same whatever shape STSD takes on.

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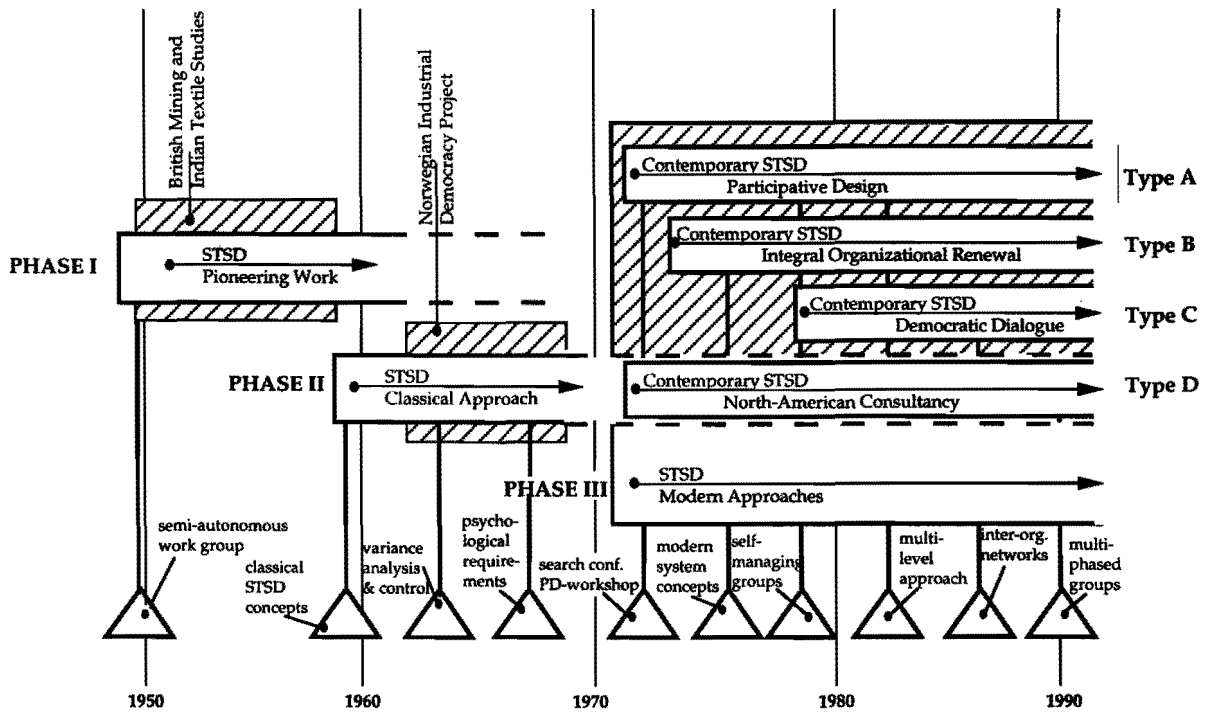


FIG 1. The phases and turning-points in the evolution of STSD (Van Eijnatten, 1993a)

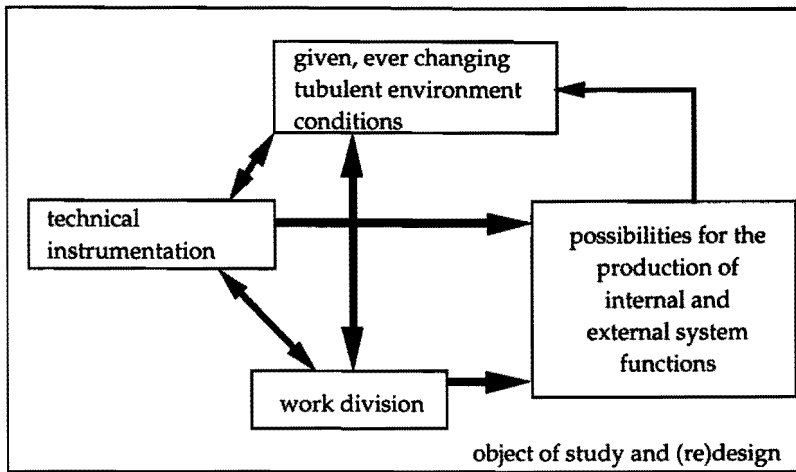


FIG 2. STSD, a graphic representation (Van Eijnatten, 1993; adapted from: Van Eijnatten, 1985, p. 55)

<-> interdependence

--> determining relationship



<i>Design strategy</i>	<i>Structure</i>	<i>Level</i>	<i>Parameter</i>
a. Parallelization	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

TABLE 1. A selection of design principles from the IOR approach (Adapted from: De Sitter, 1989b, p. 237-249)

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, controllability quality of work (integral renewal)
(re)design scope / aggregation level of intervention	work groups micro	total organization 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	parallelization 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 organization (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

TABLE 2. Pertinent contrasts in content between the mainstream approach and the Dutch variant of STSD (De Sitter et al., 1990, p.27)