2. Joint Design of Organizations and Advanced Technology

by *Louis E. Davis*[*]

Abstract

This paper addresses the central themes of the Venice International Conference, namely:

a. the mutual interdependence of technology and social organization;
b. the causal factors in organizational environments, which are complex, chaotic and global, affecting the mutual interdependence;
c. the systems of joint causation that so crucially determine the paradigms of both technologies and societies used in design;
d. the processes of joint design themselves.

These themes will be developed from viewpoints of both operations as the basis for organizational design decision making and the satisfaction of multiple objectives of living organizations. The most important of the multiple objectives are: (1) effective performance to meet global competition, (2) high quality of working life, (3) the effective application of advanced (high) technologies, (4) social systems that generate and support high commitment, learning and adaptability of its members, and (5) flexible structures that suit complex and chaotic global environments. Reviewed will be some history of the attempts to address these themes over the past 40 years, the successes and failures achieved and the dilemmas that still exist for both the science and practice of joint design.

1. Brief history

At present all advanced industrial societies, worldwide, are in states of disarray as relates to treatment of their work forces, substantial unemployment, introduction and transition to high technology. Fundamental to all of these are investment in the economy and its people, i.e., infrastructure, and the design of organizations and their jobs so as to fit together people and technology to provide the most effective outcomes for society, its organizations and their members. The process of developing the

[*] † Professor emeritus Anderson Graduate School of Management - University of California Los Angeles.

Studi organizzativi - Special Issue 2020- Issn 0391-8769, Issn-e 1972-4969

DOI: 10.3280/SO2020-001-S1004

optimal fit among economic, technological, societal and human factors is known as joint design.

A brief history of developments of organizational design practices and their application help us to understand present successes and failures and the dilemmas confronting organizational design. Interdisciplinary organizational design attempts, which began about 1950, revealed a number of serious conceptual and practice gaps in both technical system design and social system (organizational design).

Technical systems design as it existed since the beginning of the 20th Century was based on an ideology and a set of social values that predictably yielded inadequate design results.

Unfortunately, a substantial part of both of these is still present. Among these are the values closely held by technical systems designers (culture of technology) and still largely accepted by advanced Western societies:

- *primacy of technology*. To gain the promised benefits of technology all other requirements and interacting systems are held to be subservient to it. The requirements of technical systems are held to be paramount to any others. Application based on this value leads both to "closed-system design" and to inadequate social structures known as "machine theory" based organization;
- *technological fix value*. Not surprisingly the above is closely associated with the technological fix value, namely there is a technological solution to any societal or organizational problem. All that is needed is to develop the best technological solution;
- *technology design is value free*. Technology is seen to derive directly from an underlying physical (including information) science without mediation of societal values. Thus by attending exclusively to the physical requirements the "best" technological system will be designed. This is reinforced by the engineers' and other technologists' own set of social values. These professionals are acculturated and trained to be the "perfect servants" of society or their employers. Studies of the culture of engineers show that they are so socialized that their central concern is with "how", the "why" and "what" to be designed is rarely if ever questioned and neither are the consequences of their technical choices. In such a culture, technical system efficiency easily overshadows long-term effectiveness.

To satisfy the crucial future goal of optimal joint design of technical-economic and social systems, the primary focus should be on those who have the power (authority) to decide the "why" and the "what is to be designed". It is, therefore, the existing social values, and how these can be

changed, of managers and other organizational power holders that are key to how technology- economics will be combined, (joint design) with social systems to design organizations. Further, the choice of social values determines how technology itself will be used. Will technical systems be designed to perform only needed transformations? Will they be designed also to control members of the organization as before? Will they provide the means for learning, adaptability, high quality of working life and high commitment? All the latter are now seen to be essential for future survival of firms or enterprises. It is the power holders who sanction and support design and implementation. Changes in the design practices of engineers and technologists follow changes in sanction. A caveat should be indicated, coming from long experience. Even with appropriate sanction and support, engineers and technologists, although quick learners, have inadequate preparation regarding social system variables needed to carry out joint design. However, a needed design process now exists that overcomes this inadequacy to do joint design, and is reviewed later.

Two additional values strongly affecting technical system design outcomes are Experteeism and Technical system Idealization. These are almost entirely within the compass of the technical designers.

The first, *Experteeism*, can be seen as an acculturated value of engineers and technologists or as "As an expert, I have the final decision authority and if challenged at all, only by other experts". From the viewpoint of joint design, this is an enormous impediment in a design process whose goal is the best fit between two disparate and independent systems. An additional shortcoming of engineers takes technology design to be the same as technical- systems design leading to a failure to understand that many technical systems, including their machinery and information components, can be derived from a single technology. It is this failure that inhibits development and consideration of different options that will be so crucial in the future. Choices in joint design of technical and social systems cannot be made without prior development of suitable alternatives. Further, technical systems themselves cannot be designed until the designer specifies how the systems, including its machinery, tools, controls and information, will be operated by members of the organization. To complete technical system design, the "expert" decides on his or her own how the system should be operated, referred to by Boguslow (1966) as designing of utopias. This is usually done sub-rosa, some would say sub-consciously. Most often the technical "experts'" decisions are based on assumptions derived from outdated social values and inadequate knowledge of social systems. In effect such technical systems and their artifacts, whether designed or

purchased, carry with them the risk of social system requirements frequently antagonistic or incompatible with the values and practices of the recipient organization. This is particularly so when technical systems and/or their machinery, controls and information are purchased off-the-shelf. Usually unrecognized by purchasers is that technical system designers are in part "social engineers". The joint design process, discussed later, provides an effective means for the design of technical systems as well as social systems.

The second, *Technical System Idealization*, may be seen as *hybris*, based as it is on the belief that systems will function as designed. It may also be seen as defying "Murphy's Law". In contrast Sociotechnical Systems (STS) eschews assumptions about systems performing as designed and instead deals with the realities, including malfunctions, of ongoing operation. A specifically fundamental concept of STS is that the social system is the adaptive part of the joint system. Among the fundamental attributes designed into the social system are the authorities and capabilities for taking charge of the operation to overcome disruptions and emergencies assuring that goals are met. This concept is known as the equi-finality characteristic of living systems. The STS joint design process engages in technical system analysis to identify existing or prospective disruptions in operation. This data provides the basis for designing an organization structure and its roles that places the means of control (overcoming stoppages and interruptions) in the hands of members of the social system.

Social system design was, until the early '60s, subsumed under technical system design (Davis, Canter and Hoffman, 1955) or, most frequently, it was a modified duplication of existing organizations. With the breakthrough introduction of joint design in the '70s came the recognition of the resulting inadequacy of social system practices and of the critical influence on design of the values and power of executives (sanctioners). Here again as in technical system design, the acceptable models of organization held by executives are based on retaining power via behavior control. These models determine the kind of charter (sanction) given to designers. Not surprising those charged with social system design, as HR or training managers, have proposed rather timid, but safe, innovations that do not seriously disturb existing behavior control structures.

A case in point is the use of Quality Circles based on voluntary problem solving groups. Although appearing to be quite radical, Quality Circles quickly became the darling of American managers for two reasons. First, they do seek to capture shop floor learning and experience and second they do not disturb the existing behavior control structure. The obverse side

however, is that Quality Circles soon become ritualistic requiring large amounts of supervisor's and manager's attention and company resources. Even so, after a first gush of improvement proposals, they do not live up to their early promise of developing innovative solutions to operating problems. Partly this is because (1) the circles are "parallel" organizational units (not part of the regular organization and thus not having any power) and (2) they are not permitted to engage with "problems" that are embedded in the social system – most frequently the power reserving structure. Until recently, the emphasis in social system design has been on improving the efficiency of relations and interactions of its members. The issues of reserving power and of behavior control became more sharply etched when in 1975 (Davis, 1982) the participative (representational) joint organization design was introduced in the design of two greenfield plants. By the '80s (Zuboff, 1988), the above issues also became central to the design of computer-based technical systems in manufacturing and services. Whether in public or private organizations, the social values and power of executives are the crucial factors that determine the paradigms that will be followed in the joint design process. Of course the utilization of the paradigms depends on the knowledge and competence of designers. There have been and still are conceptual and practice gaps in Social System design.

Too many social scientists, managers and personnel or human relations specialists, who are concerned with the social systems side of organizations, are committed to values and practices that both limit their ability to interact with technical experts and to develop new organizational models. Major among these is the extremely limiting *non-systems conceptualization of the organization as consisting of individuals* beset by rules and hostile working conditions performing tasks under tight control of insensitive supervisors with little or no future. This is tempered by the recognition, now 60 years old, of the sub-rosa or informal organization in which real people and groups circumvent or subvert unsuitable organization structures and establish influential sub-rosa relationships and norms. Contrast the quite unrealistic non-systemic conceptualization with the sociotechnical systems derived concept of the organization as a system of four simultaneously existing entities interacting with a complex environment and responding to a set of stakeholders each imposing objectives to be satisfied.

The four entities are:

1. the organization as a *Transformation Agency*;
2. the organization as an *Economic Entity*;

3. the organization as a *Small Society*;
4. the organization as a *Collection of Individuals*.

The *Transformation Agency* concept embodies the originating purpose of the organization that of providing a product or service. It is conceived to consist of a technical system of process, equipment, tools and data, and an interacting social system of roles and relationships for operating, maintaining and regulating the technical system.

The *Economic Entity* concept views the organization as utilizing and transforming resources and as having to account for them. It reflects the decision language of western enterprises and agencies.

As a *Small Society*, the organization is conceived to be a collectivity of people performing activities-work, to produce a product or service. Once gathered together the collectivity develops ways of achieving its goals of governing, maintaining and adapting itself as well as distributing status and rewards to its members.

The organization as a *Collection of Individuals* focuses on members as individuals who bring with them their values, aspirations, expectations, and needs which they seek to satisfy through membership in the organization. It is the satisfaction of the needs and expectations that link individuals to the organizations. The opportunities to satisfy members' needs and expectations is at the core of building high commitment to the organization's goals.

The complexity of design and the skills of the designers are revealed by considering *the joint optimization of each of the requirements of the four simultaneously interacting entities*. Social scientists have to be prepared to develop an understanding of the basics of technical systems to the extent which gives them a common platform for interaction with technical designers as professional equals. Further, they have to deeply understand the concepts of systems: general, social and living, the psychology of individuals and groups, of work physiology and of employee relations (Davis and Sullivan, 1980)[5]. Unfortunately not very many social science based staff are so prepared nor do they invest in acquiring this large body of knowledge and skills.

What is found around the design table at present are social system representatives, if participating at all, adhering exclusively to behavioral models of organization (rejecting environmental-structural models). An atmosphere is created which accepts "let's take care of workers after the technical systems are designed". Technical systems designers view personnel staff as single-issue oriented, namely the people or personnel issue. They are also viewed as accepting Technical Systems as givens and

then seeking a best fit to them of the Social Systems with the hoped for goal of a better quality of working life for employees. The organizationally the non-systemic worldview of personnel-social scientists also permits them to accept parallel organization solutions, i.e., arrangements or structures outside the mainstream of the operating organization.

Such structures avoid the necessity to deal with power, authority and social values. Unfortunately, parallel structures do not survive for long.

The era of sophisticated technology, including continuous processing and computer integrated manufacturing, now underway, requires *a total rethinking of the concepts of organizations as presently structured*. This is one of the themes of this conference. To be recognized by both technical and social systems designers are two related fundamental changes brought about by the use of high technology.

The first is the *redefinition of work, from work as service or product making to work as systems intervention*.

The second is the increased dependence of managers on shop floor employees for successful operation (Davis, 1971). Alternatively stated, there is an increased survival vulnerability of the organization stemming from inappropriate Social System designs.

The redefinition of work makes supervision based on behavior control useless, at best ineffectively ritualistic, and at worst harmful to organizational performance. Consequently organizations using high technology not only require jointly optimized technical and social systems but their social systems must also have those features and attributes that support the development of high commitment (Walton, 1985) of its members to the goals of the organization.

2. The present status of joint systems design

Given the liabilities and shortcomings reviewed, what has been the progress in joint design of organizations? With the urgent need to develop suitable organizations to meet the options and choices generated by the rapid development of sophisticated technology how much and what is the quality of the accomplishments?

Additionally there are still very limited capabilities available to engage in joint design or even share a common set of concerns in exploring the interdependence of and joint design of social and technical systems. Despite the gloomy picture reviewed so far, there are significant pioneering

developments underway which provide encouragement for what could be accomplished.

Although the Tavistock Institute Center for Human Relations, London, laid down the conceptual bases for Sociotechnical Systems through their pioneering work in the ’50s and the ’60s, it was not until the decade of the ’70s that joint design was to begin. Early in the ’70s, a number of opportunities arose when very forward looking managements faced building new plants to introduce sophisticated technology. An indication of this is seen in a statement made by the Chairman of the Board of Directors of a large American paper manufacturing company to his managers at a meeting to decide how to approach the introduction of the new advanced technology. He said in effect: «We are preparing to spend hundreds of millions of dollars to bring a new technology on stream and at the same time I see that we are quite prepared to continue using our existing systems of organization which we agree are not performing well now under simpler conditions. Can we afford to accept an organization design that now is poorly suited and perhaps entirely unsuited to the new requirements for our people brought by the sophisticated technology on which our future depends?».

These early design opportunities in the U.S., Canada and Western Europe saw the groundwork laid far the scientific and professional response capabilities now increasingly available to face the growing complexities of rapidly evolving high technology.

Significant contributions have been:

1. The *creation of a process for joint design of technical and social systems*. First, the new process of joint design calls for creating a temporary organization design structure devoted to sanctioning, supporting, designing and implementing the completed, recommended organizational structure and roles. At the highest level, a Policy Committee is established concerned with corporate policies that may need to be created, modified or undone and with the Mission of the enterprise or agency. At the senior management level a Steering Committee is established consisting of those senior managers whose areas of responsibility will be affected by the new design (or redesign). This group provides sanction, protection, resources and guidance to the Design Team(s) which actually carries out the process of design. In many instances the Policy Committee and its activities are included in those of the Steering Committee. The third element is the Design Team which at the outset consists of representatives of all the technical, operational, and social science experts needed to perform joint design.

In participative design, both employee representatives and union officials are also members. As the design itself progresses some technical experts may drop off and be replaced by managers and employee representatives concerned with implementation. The Design Team establishes its own internal working rules and frequently utilizes some team building exercises to develop openness and capability to resolve conflicts. Its activities may be visualized as an open arena of conflict where important needs, each clamoring for recognition, require resolution (not compromise) to optimize their joint outcomes. Utilizing a recommended set of design decision rules, that support joint design, and the design guidelines 3 referred to below, the Design Team beginning with the Mission statement develops an Organization Philosophy that serves as a charter for design and a constitution for later operation.

2. Second, a concrete realistic methodology for joint design acceptable to engineers, operating managers, and social scientists is now available. The methodology, its design decision rules and its support structure are described in Davis (1981). The creation of *participative joint design methodology*. Here employee representatives, union officials, technical and social science experts, and operational managers are all members of the joint Design Team. The purview of such a Design Team comes to include the requirements of that socio-political system, the Union.
3. To make the design process less ad hoc, while still focused on the unique requirements of each organization, design guidelines were developed from the learning of each new design experience. The result is the availability of a *set of systemic sociotechnical systems based organizational design guidelines* (see reference 3, paragraphs 2.1.16-2.1.19 and reference 8).
4. The work of participative design teams employing joint design methodology has produced some significant *contributions for new forms of organization* including those for high-technology settings. Most noteworthy among the innovations are:
   - redefinition of work at all operating levels of an organization and creation of new enlarged and comprehensive *work roles*;
   - concrete definition of *work teams* as self-regulating organizational units including: (1) the means for selecting their boundaries, (2) effective size (5-22 members), (3) authorities and responsibilities and (4) self regulation, self development and institutional governance roles;

- new form of *wage payment* to suit redefinition of work, team structure and responsibilities, and career needs, i.e., payment by knowledge and skills;
- *team structures for all levels of the organization* from manager teams at the top to operations teams at the bottom;
- *participative methods of governance and maintenance* of the society of the plant with roles-played by representatives of every team;
- restructuring of each *individual member's role* in response to the requirements of each of the four organizational entities, i.e., the creation of enlarged, integrated, comprehensive roles for each team member;
- methodology for *design of technical control systems* particularly in continuous process operations and methods of technical training for employees directed at control of the technical process.

Success and failure reports are in continuous demand by managers. They want to know whether or not sociotechnical systems based organization designs "work". They are particularly interested in successes, tending to discount these and in failures tending to dwell on these not only to avoid pitfalls but also as a vindication for not engaging in such leading-edge developments. Realistically there are no firm answers since each design is quite unique and both the designs and the process of design are still in their developmental phases. However two kinds of successes can be reported, namely how widely used is the joint design process and is its use growing, and secondly, what are the performance records of such organizations.

In the '70s it was possible to track each application of the joint design process. This was done by research institutes in Canada, England, Italy, Sweden and the United States. In the U.S. by the early '80s, because of the rapidly growing number of applications it is no longer possible to collect other than casual information. In the U.S. and Canada there are substantial numbers of greenfield designs being undertaken using comprehensive joint design methods.

It is also the case that in fair number of redesigns the applications are neither as in-depth nor as comprehensive as would be called for by the full-fledged joint design process. Some observers of developments in North America have said that this is a period of extensive organizational experimentation with new models being tested and many instances of application of sociotechnical systems models and concepts. In Western Europe, rapid growth of application is also taking place with more emphasis on redesign or restructuring.

Greenfield plants that are based on joint design become in a relatively short time the best performers in their companies. *Redesigned plants* become outstanding performers using all the usual "bottom line" measures plus others focused on commitment and quality of working life. Greenfield startups achieve such high levels sooner than predicted by past company experience as incorporated into learning curves and other indicators. Some of these plants go on to become the best performers in their industries or for their products.

An American greenfield joint designed automated manufacturing plant making metal containers, in national price and quality competition with all other makers, became the highest quality producer in the country as measured by the customer acknowledged to have the highest quality standards in the industry for the product. This status was achieved much earlier than predicted by the company's historical learning curve despite starting with a workforce that was new to the technology and the product.

A Canadian chemical plant, now a mature greenfield joint design, makes an internationally price competitive commodity product using a hazardous process. A few years ago it became the best performer worldwide as to costs and quality. Some of its international competitors are in third world countries where labor's hourly wage is approximately one hundredth of that in the Canadian plant. This is another illustration of the changed managerial decision making required in high technology plants. Success is a consequence of maximizing the performance outcomes of the resources needed to produce the product or service rather than minimizing the costs of inputs.

Organizational design failures coming from poor performance results or substantial discontinuation of the design are not often reported, although researchers wish they were. An analysis of formal and informal cases and reports indicates that failures can largely be attributed to three general sets of causes. These are:

a) untutored and/or unskilled design or redesign,
b) gaps in managerial and/or union support, and
c) control or overcontrol by management of the design process and/or specific organizational features.

a) Untutored and/or unskilled self-design or self-redesign most frequently is a major self-inflicted source of difficulties. To understand why unskilled self-design is used would require an exploration, quite beyond the scope of this paper, of the economic, political and psycho-social dynamics of the organization. However, characteristic of most unskilled self-design undertakings is copying from other organizations all or many features of

existing innovative organizational structures. Copying treats the organization as far too simple an institution, given the competing needs to be accommodated indicated by the concept of the four organizational entities previously reviewed. Copying disregards the organization as a complex system where any one feature or practice is effective because of the support it receives from the system of which it is a part. The consequences are the presence of inappropriate structure, roles, organizational support features, and frequently without the underpinning of a supportive culture. When operating difficulties then arise, the fault is seen to be the new form of organization.

b) The most frequently heard assessment is that "it" does not work with no identification of what is the "it" that does not work. Gaps in managerial and/or union support include (1) the tragile reliance on a single leader, (2) the lack of support for the design or change process, (3) the failure to prepare local managers and union leaders, (4) setting unrealistic expectations of outcomes without consideration of startup or developmental requirements, and (5) the failure to support the large amounts of training needed by managers, supervisors and employees, as well as local union representatives. In such instances there are some or all of the following outcomes: (1) short life for the new design when the single leader (champion) leaves, (2) feelings of being misled stemming from unsatisfied unrealistic expectations, (3) lack of support, if not obstruction from middle and lower levels of management, (4) union and management blaming each other having plunged into situations for which they were not prepared or (5) supervisors and employees untrained for their new roles.

c) Control or overcontrol by management of the design process results in truncated design, very frequently in support of reserving power for managers. In this instance employee commitment and acceptance of responsibilities, so necessary to both effective use of high technology and to participative, adaptive organizations, do not develop. Overcontrol frequently arises during the more mature phase of a new or redesigned organization. Here, organizational features and/or control systems have evolved which are congruent with participation and self-regulation. These appear to threaten management's perceived control of the organization and of its members. Zuboff (1988) describes in detail instances in which sophisticated computer control systems assisting operators to control process were later modified to controlling operations and controlling operators. At less technically sophisticated levels there is the case of a pioneering firm that supported the design of a greenfield plant in 1975 whose structure then was the most radical in the U.S. It is a design that had

no middle or lower management levels and where work team members share the performance of the tasks normally done by these managers and supervisors. As a consequence, the work of the teams and their members included managing the business of the teams and participating in the governance of the plant. Planning, review and problem solving team meetings take place as a regular part of each week's work, and more often for some team members. Incidentally, by the end of the second year, the plant became the best performer in the company. The operations vice-president visited each of the company's plants monthly to see and be seen. In the third year, he expressed dissatisfaction with what he observed during his visits to the plant and requested that people stop attending meetings and get back to "work" so that the plant could achieve even higher levels of performance. Fortunately, before implementation of his request, he was made to see that "work" now included managing each team as a mini-business. Further, that participation was a central factor in the high commitment and innovations of team members and these were important contributors to the outstanding success of the plant.

3. Future organization structures and quality of working life

Organizational design developments already underway indicate that in the near future organizations, particularly those using more sophisticated technology, are very likely to have the following structural and social system features. Some of these are already present.

Structural organizational features that are being generated in response to the requirements of advanced technology and turbulent environments:

1. *flat organizations* – few hierarchical levels with mostly the lower middle levels omitted;
2. *few or no supervisors*, replaced where needed by technical coordinators and team facilitators;
3. comparatively *few employees* and these have security of employment;
4. *self-regulating, self-maintaining teams* as the basic units of the organization;
5. *multi-skilled employees* including craftsmen;
6. *no formal position or job descriptions at the operating levels*;
7. *primary wage payment by knowledge and skills* based on certification;
8. *open, extensive communication*;
9. *information systems* that provide data to teams for problem solving, decision making and self-control.

Structural social systems features in support of high organizational adaptability, high quality of working life and high commitment:

1. *individual participation* in team and plant governance, improvement, and operational decision making;
2. *expanded roles and skills* of individuals beyond operational tasks;
3. *career ladders* for all members at all levels;
4. high levels of *training/education* in process, plant operation, economics and improvement, and team self-management;
5. high levels of *response capability* of teams and individuals to unplanned disturbances;
6. high *adaptive capabilities and support for change*;
7. teams managed and evaluated by *results achieved or goals attained*.

4. Agenda for the future: realizing options and choices

So far this paper has largely concentrated on an exploration of the impediments and constraints to the joint design of organizations utilizing the growing variety of options that are available. The tragedy at present is that so many managers and union officials do not see any other choices or understand the rich variety of options that are becoming available. This self-imposed, closely circumscribed world-view inhibits the development of organizational designs far more suitable to present and future technological, economic and social needs.

One of the dilemmas existing at present concerns why managers and union officials accept organizational designs (social systems) that are poorly suited, if not largely unsuited, to the requirements of sophisticated technology and/or of contemporary society and its members. It is unheard of that outdated or ineffective technical systems would be accepted. The narrow world-view, fear of the unknown, concern about holding and use of power, and outmoded social values of managers and union officials provide the only rational explanation. Additionally the acculturation and training of engineers, physical scientists and social scientists plus the narrow confines in which they work professionally adds to the missed opportunities.

The *agenda for the future* has to address each of these groups of actors.

A. For *managers and union leaders* what is required is enlarging their world-view. Different strategies will be needed in each country depending, in each instance, on what are the most effective processes of diffusion and opinion making. Central to joint design is the establishment *of* enabling conditions in a company or agency that stimulate and support the

development of new forms of organization. This may be thought of as *institutionalizing joint design.* In business and industrial organizations most of the enabling conditions are generated and maintained only by the highest levels of management and unions. Among these are agreement on and diffusion of organization's mission and a statement of social values that will guide how the mission will be achieved. Popularly this statement has come to be known as the *Organization Philosophy.*

Flowing from this is creation of company policy requiring that all technical systems changes be developed through the joint design process and to all extent possible, participative joint design. The same applies equally to social system changes. To support fulfillment of the policy, the *managerial reward system* should be modified to include the recognition and reward of managers who undertake joint design and then manage high-participation organizations.

An additional policy is needed that supports *investment in training and retraining of managers and employees* to acquire the social system skills and practices needed to operate and maintain a participative team-based organization.

For individuals, *additional technical training* may be needed to expand their operating systems skills. Lastly is the adoption of practices and relationships between top and middle level managers that serve as models for the cooperative team behaviors called for at the working level. Such also needs to take place between middle and lower levels of management.

B. A second set of short-term needs concerns the *professional self-enhancement of social science and technological staff* who at various times will be involved in joint design. There are important roles that can be played by the scientists, professionals and managers present at this Conference. For *social scientists* the long term strategy is to fundamentally modify the content of their education. The short term strategy is to enhance their capabilities to contribute to joint design and to penetrate and cross the boundaries that encapsulate them in their professional work. A number of developments exist that can be utilized. This is no more than the requirement for becoming updated professionally. As in so much else, in organizational careers, this requirement needs to be elucidated, supported and rewarded by higher levels of management. Social scientists have to acquire an understanding of how technical systems design takes place. Especially they must develop reasonable knowledge of the transformation processes, controls, operating variables, and disturbances of the technical systems in their organizations.

The depth of this knowledge should be such that social scientists can be credible in raising issues with the technical systems designers during the joint design process.

Technical systems designers have to acquire sufficient knowledge to realize that what is to be designed is a sociotechnical system. As such they need to learn enough to understand both the behaviors demanded by the technical systems, and the interactions between technical systems requirements and control insufficiencies, and the people operating the systems who are ultimately responsible for their outcomes. Lastly they need a modicum of insights to help identify the likely impact of technical system choices on the functioning of a social system and its members. Again here, the objective is to prepare technical designers to effectively participate in creating the various technical systems options needed in the joint design process of optimization. An illustration of what is not intended are the so called "user friendly" computer systems- designed by computer system experts. The notion of "user friendly" computer systems is anathema to joint system designers. Minimally, the issue is who defines what is friendly, and under what conditions, etc. More critically such technical (computer) systems have not been put to the test of joint optimization with the various social system needs identified in each of four entities or manifestations of an organization. The "user friendly" approach perpetuates the old paradigm of separate, but net equal, technical and social systems with primacy given to the technical system.

Given the particular circumstance and the requirement to implement the joint design policy, the following programs should be developed:

- for the *company's Technical experts* who design process, equipment and computer systems, seminars were provided that developed awareness of the requirements of participative operating organizations, created familiarity with fundamentals of sociotechnical systems and organizational design guidelines;
- for the *company's Personnel and related specialists* seminars were provided that developed deeper understandings of the functioning social systems in their different manifestations, the fundamentals of sociotechnical systems, the joint design process, organizational design guidelines, and the change processes essential to successful implementation. Similarly, this preparation is intended to be provided to all incoming Personnel specialists;
- for *Vendors and other external designers of equipment and systems* the requirement was established that they be provided with brief tightly focused seminars similar to those given to internal technical experts.

The seminars are provided on the vendors' sites for their key technical design staffs. Incidentally some of the sites were overseas.

Conclusions

The design of work organizations involves a process of embedding a technical (transformation) system into a social system given the specific environment and multitude of objectives the particular organization is to satisfy. The primary goal of the embedding is the joint optimization of the two systems. The difficulties, impediments, and dilemmas, and the two cultures (Snow, 1963)[9] have been reviewed as has the prospect for true joint optimization. To date there have been few such true designs. Further development of a design process for joint optimization is an urgent necessity. The present inability to design work organizations suitable to Western post-industrial societies, centrally affects most aspects of social life from schooling through utilization of technology to labor policy and economic future. It is of small utility to contemplate the options and choices made available by advancing technology fora better life at work unless there is joint design. The present incapacity to design suitable organizations can just as readily lead to control of individuals and groups through technical systems as to a high quality of working life.

It would be remiss to consider this to be a purely professional issue, although the paper largely concentrated on this aspect. Needed is the leadership of managers, union and government officials, scientists and professionals to help create understandings, goals, policies and regulations that encourage the design of new suitable forms of organization. Further they should aid in the diffusion and educational use of the learning derived from the operation of these new forms of organization. Given the breakthroughs achieved under severely limiting conditions, there is some room for optimism, perhaps not as great as there was when the search began 40 years ago. Lastly, basic for the future of Western societies is revision of the content of professional education. Changes are needed in the curricula at both undergraduate and post-graduate levels. At undergraduate level the role of technology, and not only science, needs to be introduced through courses and field experience. Understanding how technology is developed and applied will take us back to and focus on societal values. This is particularly necessary for engineers and managers. At post-graduate level opportunities for deeper exploration of social values and technology

design – joint design – are required in the face of the profound societal issues of the day.

References

Boguslaw R. (1966). *The New Utopians: A Study of Systems Design and Social Change*. Upper Saddle River (NJ): Prentice Hall.

Cherns A. (1987). "Principles of Sociotechnical Design Revisited", *Human Relations*, 40: 153-162.

Davis L.E. (1971). "The Corning Crisis for Production Management: Technology and Organization". *International Journal of Production Research*, 9 (1): 65-82.

Davis L.E. (1982). Organization Design. In: Salvendy G. (ed.). *Industrial Engineering Handbook*. New York: John Wiley.

Davis L.E., Canter R.R., Hoffman J. (1955). "Current Job Design Criteria". *Journal of Industrial Engineering*, 16: 1-7.

Davis L.E., Sullivan S. (1980). "A Labour-Management Contract and Quality of Working Life". *Journal of Occupational Behavior*, 1: 29-41.

Snow C.P. (1963). *The Two Cultures*. London: Cambridge University Press.

Walton R. (1985). "From Control to Commitment in the Workplace", *Harvard Business Review*, April.

Zuboff S. (1988). *In the Age of the Smart Machine*. New York: Basic Books.