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Social Science Transformed: The Socio-Technical Perspective

William A. Pasmore[1]

The recently-published second volume of the Tavistock Anthology on *The Social Engagement of Social Science* focuses on socio-technical systems theory and practice. This paper reviews that volume, examining its classic contributions in the light of modern perspective and challenges.

KEY WORDS: socio-technical systems; work organization.

THE BEGINNINGS

The second volume of the Tavistock anthology, *The Social Engagement of Social Science: The Socio-Technical Perspective* provides readers with a long-awaited compilation of the seminal early works which shaped the paradigm of thinking and practice we continue to apply today. In reading this volume, I was struck by how incredibly valid the ideas and observations of the pioneers remain in our modern context, and hence how relevant this volume is to our current research and practice. While no review can substitute for the original, it is my hope that this glance through the second volume will provide an additional perspective on the impact of these papers on social science, and an invitation for those interested to return to this volume for a renewal of their intellectual and emotional spirit. As applied scientists, investigating what Fred Emery called, "the important practical affairs of man," the Tavistock researchers helped us to understand that our work must be driven by a combination of ideas and values in the face of strong and constant opposition to change. The stories these papers tell is one of scientific advancement, to be sure; but it is one of human advancement as well. The legacy of the Tavistock pioneers is both a rich

[1]Requests for reprints should be addressed to William A. Pasmore, The Weatherhead School of Management, Case Western Reserve University, Cleveland, Ohio 44106.

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theoretical paradigm and a shift in societal beliefs concerning the meaning of work, organizations, and life.

In their overview to the Volume, Trist and Murray note that the socio-technical perspective developed by the group led by Trist was an original one for Tavistock at the time. Following Lewin's influence, as well as the object–relations approach to psychology and systems theory, Trist's group adopted the perspective that behavior could be influenced by the context in which it was observed. The socio-technical perspective was a natural outgrowth of this line of thinking; technology, especially in instances of manufacturing and mining, was easily observed to be one of the strongest elements of the context affecting behaviors at work. Breakthroughs in the understanding of the effects of different socio-technical systems arrangements resulted from studies at the Glacier Metals Company and in the British coal mining industry, leading to the now familiar principles put forth by Emery. Later, consideration of the important influence of context on behavior was extended beyond the workplace to include first interorganizational relationships (in the classic piece by Emery and Trist on the causal texture of organizational environments), and then to communities, and finally to society as a whole. Interdependencies among these contextual levels led to the conclusion that increasing turbulence in societal and interorganizational relationships demanded more flexible organizational forms, which would of necessity be highly participative and require a substantial democratization of organizational life.

In his own introduction to the Volume, Trist details the events that led to the involvement of Tavistock researchers in the British coal mines; Ken Bamforth, a fellow at the Institute, had observed an innovative mine in operation in South Yorkshire. The general manager of the mine had proposed a new "shortwall" concept of mining, which the local union and workforce developed into a workable system. In contrast to the more common (and more traditional) "longwall" method in which each miner performed a single or limited number of tasks, in the "shortwall" method, mining was accomplished by multiskilled miners working together closely in teams. Differences in productivity, safety, absenteeism, and morale were clearly evident between the shortwall and longwall methods; while the Tavistock research team did not create the organization design that produced these dramatic differences, they did demonstrate how such differences could be explained.

Key insights in this regard included the following. First, that the work system should be conceived as a set of activities making up a functioning whole, rather than a collection of individual jobs. Second, that the work *group* should be considered more central than individual jobholders. Third, that internal regulation of the work system was preferable to external regulation of individuals by supervisors. Fourth, that the underlying design philosophy should be based on a redundancy of functions rather than on a redundancy of parts (multiskilling vs. single-skilling). Fifth, that the discretionary component of work was as important to the success of the system as the prescribed component. Sixth, that the individual be viewed as complementary to the machine rather than as an extension of it; and seventh, that the design of work should be variety increasing rather than variety decreasing, meaning that individual and organizational learning is essential to allow organizational adaptation to change.

Much later, Emery would add to these insights that at the level of the individual job in a socio-technical system, there should be for each person an optimal level of variety, learning opportunities, some scope for setting decisions that affect the outcomes of work, organizational support, a job worthy of societal recognition, and the potential for a desirable future.

One of the fascinating elements of the studies in the mines was the attention paid by the researchers to instances of psychological trauma. In a contribution by Trist and Bamforth, the stress of isolated independence in the semi-mechanized longwall method of mining is explored. The technology used in the longwall method of mining isolated workers from each other on the same shift, as well as from those who prepared their coal face for them on other shifts. The problems created on the other shifts (which we have come to know as "variances" in socio-technical system jargon) could make life exceptionally difficult and extremely dangerous for those involved in removing coal from the coal face. With no viable means to influence workers on other shifts, and no reasonable alternatives for employment, miners were forced to work under harsh and dangerous conditions, with little hope for long-term survival, let alone a better future. To compensate for their vulnerability, miners developed and utilized elaborate defense mechanisms, including bribery, scapegoating, and absenteeism, which allowed some relief from their psychologically harrowing plight.

In an article by Trist, Higgin, Murray, and Pollock which is extracted from the seminal socio-technical source book, *Organizational Choice: The Loss, Rediscovery and Transformation of a Work Tradition*, shortwall and longwall mining methods are compared in detail. The design of the shortwall system created interdependent, multiskilled teams of workers which not only boosted productivity, but also dealt with many of the psychological threats posed by the longwall method of mining. It is interesting to note that the article also calls attention to issues that are very much a part of our concern today: for example, changes in the roles of supervision and in pay systems that must be achieved to support new ways of working.

Despite the obvious advantages of the shortwall method of mining, there was little interest on the part of the Divisional Coal Board in diffusing the approach to other mines. Mining technology was evolving rapidly, and offered management another alternative for boosting productivity, while the shortwall method relied on a system of teamwork and self-regulation which made control-oriented bureaucratic managers uncomfortable. Due to the lack of widespread interest, Trist described the period following the coal mining studies as "the latency decade" of the socio-technical systems approach.

Work continued on in India, as described by Rice in a contribution taken from his book, *Productivity and Social Organization*. Rice became involved in the Indian weaving industry as a consultant, working with managers of the Calico Mills in Ahmedabad. An experimental loom shed was proposed by Rice and the mill management, involving multiskilled teams who would hold the responsibility for the entire operation and maintenance of a bank of looms. Workers immediately accepted the proposal, and ironed out the details of team formation and individual roles and responsibilities literally overnight. As in the case of the coal mines, the socio-technically designed work system was far more successful than the traditional one-person, one-job setup. In addition to validating the conclusions drawn from the mining studies, the Indian weaving studies added the following insights to the developing theory of socio-technical work systems. First, the relationships among interdependent workers have important effects on productivity; second, that groups become internally cohesive, but that members who don't "fit in" need to be given opportunities to move to other groups; and third, that differences in pay and status within a group make self-regulation by group members more difficult.

A paper written by Eric Miller recounts his visit to Calico Mills 17 years after the experiments by Rice were begun. Miller found the effects of the experiment to be robust in the experimental loom shed, which still operated in accordance with the design developed by Rice and detailed by workers, despite some changes in the products and market. Yet in other parts of the mill, where the concept of working in teams had been tried, there was evidence of regression to a traditional system of work. Miller explains that the latter groups were not given sufficient support in the form of spare help and training to allow them to deal with the difficulties they encountered. Moreover, boundary conditions were not managed effectively, so that demands for increases in quality and the turnover of group members were not dealt with successfully. Miller concludes that a reversion to a more rigid structure can be taken as a symptom that the group as a social system has exceeded its capacity to accommodate external change. As the group's ability to self-regulate is exceeded, supervision steps into provide support, but often, as in the case of the Calico Mills, ends up destroying the resilience of the group by fostering dependence on directive external leadership.

THEORY DEVELOPMENT

While Trist, Rice and others were pioneering Tavistock's work in the field, Fred Emery was leading efforts to conceptualize theories that could explain what the group was discovering. In a series of six climacteric papers in the Volume which are must reading for every student of the approach, Emery conveys the essence of socio-technical systems theory. The first paper, "Characteristic of Socio-Technical Systems"conveys important principles of socio-technical work design, hewn largely from the coal mining studies and weaving experiments in the group's formative years. Drawing heavily on open systems theory, Emery explores the nature of technical systems, social systems, and the work relationship structures that bring the two systems together. Emery defines the dimensions of the technical system to include: the nature of the material being worked upon (e.g., physical properties of coal); the level of mechanization or automation; unit operations (steps that result in a physical transformation of the product); the degree of centrality of certain operations compared to others; required maintenance operations; supply operations; the spatial layout of the operation and the spread of the process over time; the immediate physical work setting; and the nature of interdependence among tasks. Each of these dimensions has the potential to affect the nature of roles and role relationships, and hence the level of productivity and quality of work life of the work system as a whole.

The dimensions of the social system, while less precisely defined than the dimensions of the technical system, were said to include: tasks and task interdependencies that constitute occupational roles; the grouping of roles into teams around tasks; the nature of coordination and control; the effectiveness of boundary management; the degree of delegation of responsibility; and the degree of reliance on the expertise of workers in making complex judgments and decisions.

Emery argues that because organizations employ whole persons, it is important to pay attention to human needs beyond those required for the regular performance of tasks dictated by the technology. His psychological requirements for individuals include: some control over the material and processes of the task; that the task itself be structured to induce forces on the individual toward aiding its completion; that the task have some variety and opportunity for learning; and that the task be continuously interesting and meaningful. Emery's paradigm is in violent conflict with the master/servant relationship that characterizes many workplaces. Instead, Emery considers the creation of a more symmetrical relationship vitally important, a relationship in which management recognizes that no work can be accomplished without workers, and therefore values their contributions to decision making. Some managers have mistaken this concern for the influence of workers in decision making to be a veiled form of advocacy for socialism. In fact, Emery is a staunch supporter of democracy whose primary concern is with the effectiveness of work systems. The truth is that the logic of the work system, as developed by Emery, would work equally well within either a democratic or socialistic governance system, provided that neither was run in a hierarchical, bureaucratic fashion.

In his article on socio-technical systems for greenfield sites, Emery points out that changing the paradigm of management/employee relationships has been extremely difficult; he likens his experience to fighting through a World War I defense system, in which trench after trench of resistance is encountered. Greenfield sites, however, provide the advantage of a fresh start, where experience has not yet resulted in various forms of institutionalized protection against change.

In the same article, Emery makes the distinction between semi-autonomous groups and self-managing groups. The former are granted authority for decision making, but may lack the necessary infrastructure, such as an effective information system, that enables true self-management. Still quite often today, we witness the creation of semi-autonomous groups rather than self-managing groups, as companies rush to create "self-directed work teams" without fully understanding what support is required.

In "The Assembly Line: Its Logic and Our Future," Emery helps us to understand that the continued extreme fractionation of work, best represented by the assembly line, can and often does exceed that level of fractionation which produces optimal results. Taking a systems perspective, Emery clarifies that the fractionation of work creates an inability to control the system as a whole, rather than greater control, as assumed by designers of the system. Because the system seldom operates perfectly, even small problems can create large systemic impacts. In highly fractionated work systems, the single worker is powerless to correct the situation. Each person is "tied to the job" or machine, and cannot change the technical system to compensate for the disturbance. Instead, using the Volvo Kalmar example, Emery proposes that, "the basic unit for design of socio-technical systems must itself be a socio-technical unit and have the characteristics of an open system." By this, he means a small (8–10 person) self-managing group of workers who among the members of the group, possess the skills and authority to control the operation of their technology. In his own words, "If reasonably sized groups have accepted a set of production targets and have the resources to pursue them at reasonable reward to themselves, they will better achieve those targets than they would if each person was under external supervisory control." At a larger system level, the success of each group would depend on the linkages among the groups, and the logic of control (in this case, self-control) behind those linkages. The three principles of design emerging from this analysis are profound: First, that the best design for a productive system is one in which each part of the system embodies the goals of the overall system; second, that the parts should be self-managing to the point that they can cope with problems by rearranging their own use of resources; and third, that members that make up the parts of the system be multiskilled in ways that allow them to cope with anticipated needs to rearrange themselves around problems or opportunities that might arise.

Of the three design principles, the second has proven to be the most pivotal in distinguishing the socio-technical systems paradigm from other approaches to work. In his paper, "The Second Design Principle: Participation and the Democratization of Work," Emery distinguishes between organization designs that address the problem of adapting to problems or change through either the redundancy of parts (each part/person is replaceable; when one fails, the other takes over) or through the redundancy of functions (a.k.a., the second design principle). "At any one time some of the functions of any part will be redundant to the role it is playing at the time; as and when a part fails in the function it is performing, other parts can assume the function; so long as a part retains any of its functional capabilities (i.e., functional relative to system requirements) it is of some value to the system." More simply put, people are multiskilled rather than singly-skilled, so they can help one another out when problems arise.

But far more than simply allowing people to be more timely in their response to problems, Emery points out how only the second design principle permits adaptation to change, and hence fosters the democratization of work through adaptive planning, using highly participative methodologies such as the search conference. In organizations designed on a redundancy of parts, the limitations of individual jobs makes adaptation through learning difficult. The knowledge possessed by members of the system is ignored, as experts are asked to design various systems for others. However, experts often make mistakes, and fail to consider the importance of human ideals in their planning. In his most passionate writing, Emery explains how organizations based on the second design principle of redundant functions allow people to pursue ideals of beauty, homonomy, mutual help and nurturance, instead of pursuing self-serving, power-hungry, individual aggrandizement.

In "Socio-Technical Foundations for a New Social Order," Emery discusses the emerging new paradigm of work, one based on self-managing groups with meaningful involvement in decision making. Focusing on educational transformation and drawing heavily on Trevor Williams' analysis, Emery concludes that the movement toward self-management will become encapsulated in a relatively few organizations and segments of society unless the educational system itself is transformed to provide learners with greater control over their experience of learning. The educational system, designed as it was to produce redundant parts of bureaucratic organizations, must begin to produce people capable of self-guided learning and developing redundant functions.

In an excerpt from *Toward a New Philosophy of Management*, Paul Hill and Emery discuss the learnings gained from the pioneering work of Shell (U.K.) in workplace design. The statement of objectives and philosophy written to guide these experiments has held up well over time, and could be used almost verbatim by organizations undertaking a socio-technical redesign project today. Even more useful, however, is the discussion by Hill and Emery of the thinking behind the principles, and the difficulties managers experienced in accepting the statement initially.

Together, the papers in the "Emery" section of the Volume are well worth the price of admission. I can recall, in sharing an early manuscript of mine with Trist, his admonition that I "should read more Emery." The papers included in the second volume (and of course, the source documents from which they are derived) are clearly what he meant. I benefitted greatly from his advice, and pass along his admonition to contemporary scholars interested in understanding the socio-technical systems paradigm.

In a paper that has never received the attention it deserves, David Herbst discusses organizational alternatives to hierarchies. Herbst was ahead of his time; in an era of virtual organizations, network, alliances, and circular management, we have all become more comfortable with the idea that "organizing" does not necessarily require a fixed and stable hierarchy, or even a hierarchy at all. Herbst introduces us to a variety of alternative, non-hierarchical organizational arrangements, including the composite autonomous work group, matrix, and networks. What is crucial, in Herbst's view, is that the organization have the capacity to be multistructured; that is, that people are able to rearrange themselves at will depending upon the demands of the situation.

The next paper by Herbst on "Designing with Minimal Critical Specifications," reminds us that we should not seek protection in our designs, since learning and adaptation imply that the design must change. Important supporting conditions for creating a self-maintaining system, such as including tasks that require personal competence in order to foster the acceptance of responsibility, are discussed. Herbst also introduces the reader to evolutionary system design, which involves changes in the design of the system as it passes through stages of growth and maturation.

In two classic papers from the UCLA node of the Tavistock network, Lou Davis reviews the theory of job design and why production management must change in a post-industrial society, while Albert Cherns lays out a succinct list of principles for socio-technical systems design. The principles of compatibility, variance control at their source, multifunctionalism, boundary location, information flow, support congruence, design and human values and incompletion are used, if not chanted, by all who are involved in socio-technical design.

Rounding out this section of the Volume are two papers by Trist, one reviewing socio-technical ideas at the end of the '70s and another on QWL and the '80s. Each is an excellent introduction to the basic concepts underlying the socio-technical systems paradigm. Additionally, the paper on QWL and the '80s considers the distribution of forms of organizational democracy in a number of countries. This comparison is illuminating, in that systems in use in some countries, like Norway, Holland, and Australia, may be leading edge examples of where other countries are headed. A third paper by Trist, "A Socio-Technical Critique of Scientific Management" which is placed later in the Volume is also rich in introductory material, and includes some of Trist's thoughts concerning the impact of information processing technologies, which he calls the "second industrial revolution," of organizational design. As the title implies, Trist sees information technology as the last nail in the coffin of scientific management: " . . .the second industrial revolution is rapidly rendering obsolete and maladaptive many of the values, organizational structures and work practices brought about by the first. In fact, something like the opposite seems to be required."

Gareth Morgan's article, "Organizational Choice and the New Technology," updates the consideration of joint optimization in light of the microprocessor revolution. Specifically, Morgan is concerned that the new technology may be used in old ways; that is, to achieve greater bureaucratic control rather than to increase human and organizational capacities. Increasingly, as information-processing and electronic communication technology is applied, organized relations between people are being replaced by relations within and between computer programs; the identity of the organization is more and more a function of its information-processing structure. The enormous potential of the new technology enables organizations to be holographic, meaning that parts of the system may now possess enough information about the rest of the organization, customer needs, regulations and so forth to be independently self-organizing. Control need not be top-down when the information exists to make intelligent decisions at lower levels. In fact, if top-down control is maintained when such information is available, the organization will fail to capitalize on the potential of its parts to learn and help the organization adapt to change by increasing its requisite variety.

Lisl Klein laments the unfortunate splitting of concerns about work systems into "socio" and "technical" components. Using the psychological meaning of "splitting," which is to simplify a complex problem by dividing into two parts, one of which is all good and the other all bad, Klein observes that social scientists and engineers have tended to avoid collaboration in the design of work systems. Now it seems, neither group can say much that is positive about the other; and the poor state of their relationship is producing disjointed efforts to design effective work systems. To rectify the situation will take more than good will; Klein contends that collaborative efforts must become institutionalized through policies, procedures, methods, and infrastructures that require collaboration to occur.

In yet another classic paper, Miller addresses the internal differentiation of complex production systems through technology, territory, and time. As systems become larger and more complex, one or more of these three dimensions may determine the organizing logic for the system. Each potentially creates a boundary within the system, which both enables responsible self-management by buffering a unit from its dependence on other units and simultaneously creates problems of managing interdependencies across such subunit boundaries. When complex systems become internally differentiated, management of some kind is required to assure coordination and integration of activities. Each basis for differentiation (technology, territory, time) creates a unique set of management challenges, which are detailed by Miller. Inappropriate differentiation, that does not coincide with the inherent nature of tasks and flow of work, necessitates more management than would otherwise be required.

The papers in the Volume that trace theoretical developments in the sociotechnical paradigm span three decades, from 1959 to 1989. Clearly, thinking has continued to evolve, which may be somewhat of a surprise to those who view the paradigm as older and more established than newer paradigms in the social sciences. From the beginning, the Tavistock group sought to test their thinking in the field, following Kurt Lewin's dictums for action research. Each new challenge or unexpected result in the field prompted a return to the intellectual drawing boards upon which the theoretical foundation for the socio-technical approach was being crafted. The next section of the Volume reviews a few of the more important projects undertaken by field researchers following the early studies in Britain, India, and Norway.

BACK TO THE FIELD

The first project to be reviewed is the unusual work of Herbst in the design of the Norwegian ship, M/S *Balao*. Using socio-technical principles, Herbst helped to create a ship that was different in almost every way from the traditional model. In doing so, five characteristics related to work organization were of particular significance: (1) total crew involvement in organizational change; (2) organizational change as a learning process; (3) participative work planning; (4) development of a learning community; and (5) open and joint territory. The result was shipboard organization which continuously evolved over time, and in which each crew member, from captain to junior crew, could in one situation be a teacher and in others a learner. Rigid vertical, horizontal, and territorial boundaries disappeared, to allow each crew member to become multiskilled and contribute to the successful operation of the ship to the fullest extent of their capabilities.

Susman and Trist review their project with the Rushton Mining Company, essentially an American duplication of the original Tavistock work in Britain. In this case, a labor–management steering committee developed the terms and conditions under which experimentation would be carried out. One of the terms of the agreement was that all members of the experimental (socio-technical) crew would receive the top rate of pay; this later resulted in difficulties, as issues of equity arose with other non-experimental crews, and experimental crew members felt there was no incentive for extra effort or learning new skills. Despite careful attention to documenting the economic advantages of the experimental unit, equity issues led to a vote of no support for further experimentation by the union membership, after which the program was discontinued. Susman and Trist's discussion of the pay and political issues that can interfere with otherwise successful change makes for interesting reading. They conclude that, "The envy, anger and rivalry generated between the autonomous sections and the rest of the mine soon overshadowed the search for a better way to work and a better future." Because of the problems encountered at Rushton and in several other locations, I have long held serious misgivings about "pilot experiments" in redesign. Often, there is enough skepticism and fear of risk taking among senior labor or management officials to allow no other course of action; but if pilots must be undertaken, they must be approached with great caution and careful attention to the dynamics described so vividly by Susman and Trist.

Care must also be taken in the introduction of self-directed work teams, as indicated in the next piece by Trist and Charles Dwyer. After visiting seven locations where semi-autonomous groups had been introduced and then largely "faded out" in a large manufacturing company, Trist and Dwyer observed that only one project remained active. All the projects which faded out were introduced in existing locations in a piecemeal fashion; the one remaining project was a greenfield site, which was begun on socio-technical systems principles. Employees at some of the other locations reported that, "All of a sudden we were a work group," reflecting the hasty imposition of team structures that were not well understood or supported by management. In still other locations, supervisory or union resistance to self-direction was overt and highly detrimental. Trist and Dwyer point to the laissez-faire posture of corporate management as the limiting variable in the diffusion and maintenance of viable experiments in work design. "There was no systematic organizational support, no preparedness for system wide implications, no working through to an overall concept to which plant management as a whole could become committed." It is both amazing and tragic that such lessons continue to be learned over and over again in efforts at organizational change.

The succeeding piece by Bill Westley and Trist reviews the pros and cons of work undertaken with the Canadian Federal Public Service, and the next by Emery and Einar Thorsrud looks backs at the Norskhydro fertilizer plant which set the standard for much more work to follow in Norway. Both are valuable in that they share learnings from experience, while the latter piece is especially interesting in revealing the approach used in one of the early greenfield experiments undertaken by the Tavistock group. In the age before the need for broader participation throughout the redesign process was recognized, Emery and Thorsrud used an action committee, or what we would call today a design team to conduct the planning for the new unit. The plant was successful, and the authors were able to measure marked improvements in employee attitudes toward their jobs. Still, as in other cases, success was no guarantee of diffusion throughout the parent corporation because of labor and management resistance.

An article of a different nature is contributed by Trevor Williams, who discusses the effect of visual display technology on worker disablement and work organization. His intriguing observation is that, "organizations which introduce new technology while retaining conventional bureaucratic work designs will experience greater occupational injury among workers than organizations in which work design provides employees with more variety and scope to control their own task performance." After reviewing the literature and examining comparative studies, Williams concludes that work design and injury are directly linked, but also that critically examining and changing the design of work organization was the *least* chosen alternative to dealing with injury problems. Organizations turned much more frequently to ergonomic redesign, technical fixes, training for workers, and rest breaks, none of which were effective in eliminating the injury problem, but which were less likely to challenge the bureaucratic status quo.

Lou Davis and Stu Sullivan offer some stimulating thoughts about a new type of labor–management contract involving the quality of working life, based on the evolution of the well-known Shell Sarina chemical plant in Canada. The contract provided for true union partnership in both the design of the plant and in operational decision making. The contract that was written to support experimentation was intended to provide maximum flexibility to allow for future change while enhancing labor–management relationships and ensuring the just and equitable treatment of all members of the organization. Despite the plant's performance at nearly 200% of its rated capacity, a visit by Davis 11 years after the original contract was negotiated revealed that the work system was, as he put it, in a state of "arrested development." In the intervening period, learnings that could have been used to update and improve the design of the system were overlooked; hence, much the same system (along with some of its flaws) continued to persist: "The organization remains in a state of arrested development as reflected in the inactivity of the standing committees, in the substantial amount of unilateral decision making and in the relatively rare meetings of the work teams to solve problems, plan, and deal with their self-regulation and the governance of the plant." Davis and Sullivan attribute this state of affairs to the failure of senior management to acquire and transmit the necessary understanding of the underlying conceptual paradigms on which the plant's organization is structured, and to a lack of sensitivity to the effects of transferring new managers into the plant without preparing them to understand or support the system in use.

TOWARD THE FUTURE

Field efforts like the one described by Davis and Sullivan have been guided by a "nine-step model" for socio-technical analysis developed by Emery, described in a paper included in the next section of the Volume. The steps include: (1) initial scanning; (2) identification of unit operations; (3) identification of key process variances and their interrelationships; (4) analysis of the social system; (5) people's perceptions of their roles; (6) analysis of the maintenance system; (7) analysis of supply and user systems; (8) analysis of the work environment and any proposed development plans; and (9) proposals for change.

Although still in use in North America, the nine-step model has been superseded in Australia by participative design, described in yet another paper by Fred and Merrelyn Emery. Based on principles and practices developed for search conferences, participative design processes place the responsibility for analysis and design of the system on members of the system, with only conceptual guidance on the second design principle and psychological criteria for meaningful work being provided by external consultants. Many of the analyses described in the nine-step model are left to work groups to perform (if they are performed at all) once the macrostructure of the organization has been determined. Search conferences are gaining ground in North America, principally through the efforts of the Emerys and Marvin Wesibord; we can expect to see further integration of search conference and socio-technical systems analysis methodologies, as well as more widespread adoption of participative design, as organizations seek to speed up the redesign process and embrace more democratic values.

North America has been slower to embrace democracy at work than some other countries, notably West Germany and Norway, where national legislation supports workers' participation in decision making. Emery discusses the feasibility of legislating quality of work life. He points out that even if effective legislation is drafted, it must be supported by adequate policing and committed prosecution of offenders.

Hugh Murray contributes a piece on designing simulations for training engineers to consider socio-technical systems principles in designing industrial systems. Noting that actual field applications cannot provide sufficient training to a large number of students, Murray sets out parameters for designing realistic simulations, using action research methods that involve students in the design of their own learning. Murray also notes that in the ideal, training would occur in a multidisciplinary context, beneficial to both engineers and students of psychology, sociology, and management. How many times have we heard this call in higher education, and how few times have we responded?

On another topic, Trist discusses the choices available for sanctioning experimentation in work systems redesign in a large corporation. Using examples from Philips Electrical Industries, General Foods, Shell, Corning Glass, and Sony, Trist points out that a central mandate for change from the top (as in the case of Philips) is not sufficient to produce systemic change. But then, neither has been the strategy of cumulative innovation from the bottom up, as was the path in General Foods. Innovative subsidiaries, like those in Shell, also face strong countervailing pressures, such as the transfer of key people, and larger economic forces. Local experimentation, as in Corning, shows some promise; basically, it's every unit for itself, without the need to gain consensus from other units or to receive top management permission for innovation. Yet, the lack of top management support in such cases can become a fatal flaw. In Sony, the effort is also a grass roots one, taking the form of quality circles and networks that teach workers how to do industrial engineering and quality control themselves. Trist offers no perfect solution or model of large system change; but he does call for organizational learning that begins with individual job designs that support learning and the participative involvement of workers in change.

The next contribution by Cal Pava is taken from his book, *Managing New Office Technology*. The book was badly titled, in that the essence of Pava's contribution is to help us consider the application of socio-technical systems thinking in all kinds of nonroutine work. Information systems play a minor and supporting role in the analysis and design of systems following Pava's attention to deliberations (times when people think together about a topic of importance) and discretionary coalitions (groupings of people who seek each other out to think about things together). Pava's book has served as a bible to those who struggle with redesigning work that is always changing. Trist's reflections on Pava's contributions make interesting reading, as they display the obvious affection the mentor had for his student.

The final piece in the Volume is a very brief introduction to the search conference by David Morley and Trist. The purpose of the search conference is: "to gain new understanding, to generate new options and, through these, to create the possibility of more cohesive relationships among many who have hitherto not been able to cooperate through apparent incompatibility." For those interested in reading more about the historical evolution of the search conference, we are promised a rewarding account in the third volume of the Tavistock series, which is currently being put together by Eric's wife Beulah with the help of Fred Emery.

WHAT WAS AND WHAT WILL BE

Many of the papers in the Volume are now classics, historic in their contributions to the development of a paradigm which had a greater impact on "the practical affairs of man" than almost any other in the social sciences. But how do these ideas fit our society today? Which shall we embrace, which should we leave behind, and what must we invent anew?

Ideas that Endure

Clearly, socio-technical systems theory remains as valid today as it was in the 1950s. We continue to live in a world greatly affected by technology; so much so, that we have taken the choices made for us by technical systems designers almost for granted. Today, as in the past, the socio-technical paradigm calls on us to question the design assumptions underlying technical systems; to ask, "Is this the best way to design and utilize technology for people and society?" And in our organizations, to question whether we have assessed the degree of joint optimization of social and technical systems in light of a demanding external environment. Other aspects of the theory that endure include: (1) that context affects behavior, so that behavior cannot be understood without appreciation for its setting; (2) that increasing complexity makes top-down control increasingly difficult if not impossible, demanding a more democratic form of organization; (3) that teams are a viable basic building block for organizational design in many instances, and that well designed and fully trained teams are capable of responsible self-direction; (4) that a design based on redundancy of functions is generally superior to one based on a redundancy of parts; (5) that adaptation to change requires learning, which in turn requires flexibility in roles and job descriptions; (6) that change at the level of the core work system requires changes in supporting systems as well; (7) that boundary management is critical to sustained high performance; (8) that organizing does not necessarily depend upon hierarchical arrangements being in place; and (9) that organizations must develop evolutionary competence, which permits design arrangements to change as the system matures.

Near the end of his life, Trist was disappointed with the rate of diffusion of socio-technical systems thinking. After nearly 50 years of work, he recognized that the paradigm of scientific management conceived by Taylor, linked with the control-oriented systems of bureaucratic management was still the dominant form. Democratic methods of management were still encountering stiff resistance, and even some islands of successful demonstration projects had shown signs of regression in the face of a raging sea of traditional authoritarianism. But whatever history may say about the paradigm he helped to create, it is clear that his basic challenge is still relevant: humanism and effectiveness can and must be thought of as linked together in the design of work and work systems. Whether the war he fought will ever be won is open to question; but many continue to fight the good battles that began with the skirmishes in the coal mines of Great Britain.

Also valid today are the assumptions about people underlying Emery's second design principle and the criteria for creating meaningful work. People at work should be viewed as resources. When given appropriate skills, meaningful work, appropriate rewards and a system for managing interdependencies among themselves, responsible self-direction is a predictable and now widely-demonstrated outcome. Furthermore, well designed systems based on Emery's socio-technical principles have consistently demonstrated superior performance over systems based on maximum technical efficiency, tight control and the bureaucratic assumption that people are irresponsible and uneducable, and thereby incapable of sharing concerns for the welfare of the enterprise.

The open systems perspective is more important than ever, as we recognize the interdependencies that exist among organizations in different sectors of our economy and in different parts of the world. The methodology of the search conference in particular is becoming more widely recognized and applied as needs to integrate the concerns of diverse and sometimes conflictual stakeholders have become more apparent in a wide range of settings and types of organizations.

Attention to unit operations and the interdependencies in whole technical processes has been reinforced recently by those involved in reengineering. Although reengineering does not utilize the technical analysis methods associated with the socio-technical systems paradigm, the conclusions reached by the two methods are nearly identical, in terms of the technical design of work processes. The multifunctional, empowered team responsible for a whole process is becoming the design outcome of choice, where multiskilling is feasible and the size of the group needed to manage the process is not too large.

Finally, the approach to work adopted by Tavistock was based on Lewin's action research, coupled with a strong theoretical base constructed from many disciplines. More traditional, tightly controlled research methods or more purely theoretical approaches may have produced significant learnings as well; but there can be no argument about the richness of thought and the applicability of methods conceived by the Tavistock pioneers using action research methods. I see no reason to doubt that action research, in the hands of thoughtful masters like Emery and Trist, will produce additional breakthroughs in years to come.

What Should be Rethought or Left Behind?

Socio-technical systems theory is basically sound, although it has shortcomings that will be mentioned in the next section. In terms of practice, however, there are notable gaps in the methods associated with the application of the theory. First, despite the attention to systems theory and the organization's environment, sociotechnical innovations have tended to become isolated. Diffusion even within a division of a large company has often been slow and problematic. As mentioned in several of the papers in the Volume, efforts rapidly become entangled in the politics of the situation. Union or top management resistance is often cited as a problem; so are economic conditions, turnover among key personnel, rapid changes in technology, or jealousy on the part of other groups or units. Socio-technical intervention has not succeeded in obtaining the support for universal application that other techniques, most notably total quality and reengineering, have enjoyed. More than these other approaches, socio-technical systems theory is based on notions of democratic decision making and self-direction which threaten traditional power arrangements. Once begun, the process of socio-technical change is less reversible, and its specific design outcomes more difficult to predict. Total quality and reengineering are more "power friendly" in that they have more circumscribed methods for controlling both the process and the changes that result. Socio-technical interventions are often perceived by managers as "riskier" than the others despite the well documented track record of successful outcomes recorded in this Volume and elsewhere. Socio-technical advocates must choose between the anti-authoritarian value stance that is consistent with self-direction, or more widespread acceptance by those in power. Historically, a few innovative managers have been willing to step up to the challenge of enacting the values of the socio-technical school in their organizations. For some, the price has been high; overlooked for promotion, or branded as "soft-hearted" or "too far out" by their peers, theirs has been a lonely and difficult experience. Others have capitalized on the results they have achieved to vault into higher positions of authority, where they could encourage their peers to abandon tradition in favor of effectiveness. But overall, many more managers have chosen to opt for other, "safer" interventions, if they chose to intervene at all. The danger, in the end, is that socio-technical systems interventions may become widely regarded as too complex, difficult or politically dangerous to pursue when other methods appear to be more simple and less risky. Isolated successes, against a larger backdrop of skepticism or even hostility, are unlikely to remain viable over time.

Socio-technical systems interventions that have followed the nine-step model have also been too lengthy and costly. While new approaches to intervention are being invented that speed up the process of analysis and implementation by combining elements of the nine-step model with search conference methods or even participative design, it is clear that some depth of analysis and understanding is being lost. Methods that allow more speed, greater ownership, and more complete understanding of design options are needed.

Methods of social analysis have never been fully adequate, despite the rich contributions of Bion, Lewin, Sapir, and others to the genesis of the theory. Various methods have been tried, including GAIL, role network analysis, evaluating individual job characteristics, and surveys of attitudes or opinions. None have captured the complexity of the multiple dimensions of behavior and their associated influences in even the most simple of systems. While some behaviors seem almost predictable (people will be motivated by rewards and feedback) others are still a mystery (preferences for some co-workers over others) and are therefore not considered during design. Yet the nuances of social dynamics can cause good designs to fail or bad ones to succeed; and so we must do more than trust to fate that the social system will evolve naturally as it should. Here perhaps is a frontier beckoning the scientist who wishes to continue in the socio-technical tradition but still perform work that advances the state of the art.

What Must We Still Invent?

Socio-technical systems theory has failed to capture the dynamic nature of organizations and their external environments. In much of the early writing, attention is paid to Ashby's concept of requisite variety, and to the need to create roles that permit learning and instill variety increasing behavior. Yet, with the exception of the writing of Herbst, one is still left with the feeling that attention is centered on the conversion of organizations from traditional systems of bureaucratic control to systems of democratic self-direction. Clearly, many organizations are still trying to take this first step; but others have taken it, and face environments that demand that the next step be taken. Here, the socio-technical school must pay more attention to the requirement for organizations to learn, and to processes that will allow them to do so. As organizations face an increasingly unpredictable and even chaotic world, they must become more flexible, and the process of learning and redesign more constant rather than widely punctuated over time as it is today. Some directions here are provided in the works of Peter Senge, Margaret Wheatley, and in my own recent writings.

We must also build on Pava's contributions to advance our thinking about nonroutine work to refine the methods we use to redesign organizations in which it occurs. We can begin here by revisiting what we know about the process of human thinking, both in isolation and in groups, which is covered in a vast literature ranging from Plato to Dewey, Descartes to Polanyi, Machiavelli to Lewin. Then, we can pay greater attention to thinking at the group level, as illustrated in the work of Janus, and finally the organizational level, as explored by Argyris and in an intriguing new series of volumes on social creativity underway by Ron Purser and Alfonso Montuori. After all of this, we may begin anew with the process of inventing new forms of organizations for learning and thinking, following the same steps as the original Tavistock pioneers. The second industrial revolution, based on the microprocessor, may already be giving way to a third. The third revolution will be driven by a combination of artificial intelligence and telecommunications technology, linking networks of thinking people together in nonhierarchical forms of organization the coal miners in postwar England could hardly have imagined. Nonroutine work will become ever more the norm, in a world where things like borders and boundaries and physical limits that have always appeared stable will dissolve or become less meaningful. Socio-technical thinking must keep up with the innovations in technology and society, or become associated with routine work and stable organizations that may soon no longer exist.

In addition, the socio-technical school must broaden its horizons beyond short term success to future viability. Socio-technical theory and design should be flexible enough to incorporate concerns about sustainable development, ecological balance, health, population, human rights, and human development. Certainly, Trist and his colleagues were constantly expanding the scope of their horizons throughout their careers, moving from single groups or organizations to entire communities. The invention of the search conference was itself a response to the recognized need to include the external context of the firm in the active process of thoughtful, co-determined design. The challenge is upon us to continue in the direction that has been set, to invent new theories and new methods that will enable action and research to proceed on these most pressing global agendas.

A FINAL THOUGHT

As a younger professor interested in the socio-technical systems paradigm, I found myself in London with a few days to spare during a research project in Europe. I couldn't resist the temptation to drop by the Tavistock Institute, just to see the place and meet a few of the staff. I went seeking intellectual enlightenment; I wanted to walk in and find Tavistock unchanged, to hear the wisdom of Emery, Trist, Thorsrud, and Herbst still being spoken in the hallways, to find the original notes from the coal mining studies, to be swept up in the continued search for applied social justice that Tavistock had always stood for in my mind. Instead, I found a different Tavistock; there were a few remnants of the old, but much more concern for the new. There was the busyness of people getting on with projects and writing papers, many having little to do with the socio-technical systems perspective. There was much interest in what was going on in the States, which I shared, but that was not really what I had been there to discuss.

As I left, I felt somewhat unfulfilled, but at the same time recognized that my expectations had been unrealistic and inappropriate. The Tavistock I was searching for had ceased to exist; a new, and perhaps more appropriate Tavistock had emerged to fit the needs of the current staff and times. As I walked back to the train station, I recalled a few lines from a poem included in Weick's book on the social psychology of organizing and recently read at Jacqueline Kennedy Onassis' funeral, *Ithaka* by C. P. Cavafy:

> Ithaka gave you the marvelous journey.
> Without her you wouldn't have set out.
> She has nothing left to give you now.
> And if you find her poor, Ithaka won't have fooled you.
> Wise as you will have become, so full of experience,
> you'll have understood by then what these Ithakas mean.

Fortunately, Trist and Murray have allowed the travelers among us another chance to relive the journey of the Tavistock pioneers to the Ithaka I had hoped to find. Volume II of *The Social Engagement of Social Science* is Homer's *Odyssey* for socio-technical systems theorists and practitioners, and the trip is well worth taking, one more time.

BIOGRAPHICAL NOTE

WILLIAM A. PASMORE is Professor of Organizational Behavior in the Weatherhead School of Management at Case Western Reserve University, Cleveland, Ohio. Dr. Pasmore's research examines several topics, including the sociotechnical systems design of organizations, participation in organization change, organizational learning during research and development activities, and global social change. He has published his work in a variety of books and journals. His most recent book is *Creating Strategic Change* (1994, New York, Wiley & Sons). Dr. Pasmore received his BS in Industrial Management and Aeronautical Engineering as well as his PhD in Administrative Sciences from Purdue University. He has also taught at Stanford University, INSEAD (France), and the University of Leuven (Belgium).