Designing socio-technical systems for 'greenfield' sites

FRED EMERY

The Australian National University

SUMMARY

In opposition to the traditional organizational paradigm of the master–servant relation there has emerged the paradigm of co-operative, symmetrically dependent relations.

In practice it has proven difficult to reorganize existing establishments about the new paradigm: mutual trust has typically been too eroded by the past master–servant relation and both sides are reluctant to emerge from their trenches. This has not fortunately been a problem in designing and establishing new 'greenfield' sites.

However, the movement into capital intensive and automated technologies has created new problems for those seeking the advantages of the new organizational paradigm even in greenfield sites. The simple and effective self-regulatory properties of face-to-face work groups are inadequate to the tasks of co-ordination and control when the group is spread over shifts or geographically dispersed. The only answer lies in a radical increase in operator education into both the nature of the productive processes they are controlling and the management science tools they can use to control and coordinate their contributions.

In the arguments that are going on about the democratization of work I think we can see people talking past each other because they have fundamentally different models or paradigms of what work is all about. These paradigms are consistent within themselves but quite irreconcilable with each other. If you are looking at work through one paradigm you cannot see what is seen through the other.

At the heart of the traditional paradigm of work is the master–servant relation. Logically this is a relation of asymmetrical dependence: the servant is dependent on the master for his job. As far as the master is concerned the servant is a redundant, replaceable part. From this the notions of managerial prerogatives and the right to hire-and-fire flow naturally.

Over the past 15 to 20 years a new paradigm has emerged. It is a relation of symmetrical dependence, a relation of cooperation within work. It expresses a refusal to accept the role of servant in a master–servant relation. It accepts, however, that workers are often able to do their work better with good management and that management can do nothing without workers.

The conflict between these paradigms comes to a focus on the role of the foreman. In the old paradigm the foreman/first-line supervisor is the essential link between managerial decision-making and shop floor activity but is not himself part of management. Neither, of course, is he accepted as a worker. He is in the unenviable role of being the meat in the sandwich.

In the new model of work there is no place for the role of foreman. Such a role is quite antithetical to the notion of there being cooperation on the job. It

implies that the workers are not being trusted to keep up their end of a relation of symmetrical dependence.

The role of the foreman is so central to the traditional authoritarian system that the first question to ask of any proposed scheme for democratization of work is, what does it do to the foreman's role? If it leaves that role intact then the scheme is fraudulent, at best mere icing on the cake. Most representative schemes are of this nature. Whilst the elected representatives are off at their Council meetings the foreman continues to rule the roost. Similarly, most of the job enrichment, job enlargement schemes put forward by Herzberg, Scott-Myers and Ford leave the foreman's role quite untouched. For those who see the world of work through the traditional paradigm these schemes have an attraction. They can accept that happier workers could be more docile, maybe even produce more. They can accept that dull, meaningless and repetitive work activities make for unhappy workers and hence that there is some value in re-writing the individual job specifications to put more meaning in the task and provide more variety. What they simply cannot accept is that people would better perform even these improved jobs, and better co-ordinate them, if the foreman was not standing over them. Their implicit assumption about 'the psychology of the worker' is obvious from the argument that is usually thrown in to clinch the case—'if the foreman was not there a natural leader would emerge and probably be even harder on them'.

When people have had years to build a work culture on a different and opposing paradigm it is painfully difficult to change the situation by mere scientific argument. One is inclined in fact to the pessimistic view that the great physicist Max Born expressed in looking back over the turbulent history of quantum physics:

> 'A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it'. (quoted Kuhn, 1962, p. 150).

We have experienced many difficulties in introducing the new paradigm into established work places. It has been like trying to fight one's way into a World War I defence system. The first line of trenches are occupied by the trade union officials and can be negotiated aforehand. Behind this is a second line of trenches that arise from the formulation of on-the-job customs and procedures. This second line of trenches is held by the rank and file of workers. These defences are specific to the work place and protect the individual worker from abuse even when his trade union officials desert him or are powerless to intervene. Working men have no alternative to developing this second line of defences: the law of the land or the powers of the unions usually does not reach far enough into the work place to prevent abuse of managerial prerogatives. However, these defences can readily blind workers to changes that serve their interests. The defences have usually emerged for good reasons that are now buried in the past, the occasions and the authors forgotten. That they emerged for some good reason is the reason for them being sacrosanct and the reason for them being extremely difficult to negotiate. In fact, any attempt to negotiate them is seen,

ipso facto, as proof of evil managerial intentions. Sophisticated socio-technical analysis that proves the existence of joint benefits to workers and management helps, but not much in these circumstances.

'Greenfield sites' offer a good chance for a socio-technical analysis to make a contribution because in such cases a second line of defence has not emerged and most matters can be negotiated beforehand with trade union officials (and laid down for the new management). The workers and management can start from the beginning in conditions that allow for co-operation or open confrontation.

If socio-technical analysis is to play its part then

> (a) it must be involved in the planning process before technical plan-
> ning has pre-empted too many options with regard to who is to be em-
> ployed, how and how organized. This is contrary to common practice
> where the technical designers are guided only by such simple-minded
> criteria as minimal manning.
> (b) It must be concerned with creating those interfaces between the
> technical and the social system that allow for the fulfilment of the
> human requirements of a job and an organization of people around the
> work which is maximally self-governing.

The first requirement can be met only by the relevant decision-makers becoming more conscious of their social responsibility. Social scientists, or engineers-cum-social scientists have the responsibility for identifying what has to be taken into account in order to design effective socio-technical systems; systems that are rewarding to all that take part in them.

In *Some Characteristics of Socio-technical Systems* I tried to spell out what we knew about these desidarata. A lot of discussion has taken place since that was written in 1959 (Emery, 1978). The need for 'greenfield site' design has become more critical as more and more organizations find that they are incapable of undoing the exploitative and defensive systems built into their existing plants.

There is, furthermore, the chance that by demonstrating what can be done at a new plant, the management and workers in the old plants will be inspired to follow suit.

In designing a social system to efficiently operate a modern capital intensive plant the key problem is that of creating *self-managing groups* to man the interface with the technical system.

The term 'self-managing group' deserves comment as it highlights why I should want to talk about their management problems. Through the nineteen fifties and sixties it was common to refer to democratized work groups as 'semi-autonomous groups'. Only in the seventies was it felt that the idea was more clearly conveyed by the concept of self-managing groups. I do not think that that shift in terminology was accidental or arbitrary. The first studies of democratized work groups were in traditional work settings e.g. coal mining faces, textiles and metal fabrication. In each of these cases the most serious problem was that of how much autonomy they could have which would be consonant with company production plans, maintenance procedures, safety rules and personnel practices. Co-operation within the groups was no real problem as most people could easily master the tasks done by others and hence be able to help out or relieve as the

need arose. Control over each others contribution to the group task was also little of a problem. The work places were intimate enough to enable each to see what the others were doing, or not doing: all of the tasks were well enough understood to enable others to judge whether the workmanship was up to standard and the constant face-to-face interaction made it reasonably easy to generate group pressure on someone who was not pulling his weight. This last comment should not be taken to imply that these groups pressure everyone to keep up with the best and fastest workers in the group. (In my experience the bull-gang atmosphere has only emerged when a group's reward was based on a simple index of quantity produced.) Typically these groups are far more conscious of, and responsive to variations in skill, intelligence, age etc., including daily variations due to health, than any foreman could be expected to be, no matter how well versed he is in human relations theory. People in relatively stable groups, even up to a platoon size group, seem to be remarkably adept at keeping books on favours given and debts due, and yet not at all impatient about balancing the books.

Thus, it was that, in these kinds of work settings, we had simply to work out beforehand what was going to be the group territory, what were adequate performance levels and rewards and what limits to group autonomy had to be observed. That done, it could be left to the group to learn how they would manage themselves. In the case of our first Norwegian experiment—in the wire-drawing department of the Oslo Iron and Steel Works—I do recall very serious discussions about whether the groups should first be taught the art of group self-management. The previous mode of individual working had, as our interviews has shown, completely inhibited any sense of group identity, mutual respect or co-operativeness. We decided that this would be a bit too insulting to the self-respect of the workers. After both shifts had been working for several weeks it was obvious that we need not have worried.

This emphasis on degrees of autonomy started to shift with our very first case of a continuously operating process plant—the chemical pulp department of the Hunsfos Pulp and Paper Coy, 1964. Although we did not appreciate it at the time we were probably fortunate that there was a further complication. At the heart of the production of chemical pulp was a batch method of digesting the wood chips. Each batch took approximately sixteen hours in the cooker and there was no way of knowing how successfully the process was going until it emerged from the cooker. Thus each batch was started on one shift and finished on another (even two shifts later). Responsibility could not be located within a shift group; it had somehow to be located with the ensemble of four shifts that provided the continuous manning. The conditions of an open workshop and face-to-face interaction were not present (see Miller, 1959). There also seemed to be restrictions upon the degree of multi-skilling; a person from another section of the department could be trained-up to take an assistant's role in a particular section but the prospect of one person being thoroughly versed in more than one section seemed to be well in the future. Last, even within a shift the operators were so widely scattered that there was little chance of them overseeing each other.

Under these conditions found at Hunsfos it became clear that autonomy was critically dependent upon the cross-shift group evolving forms of effective self-

management. Intuition and commonsense could not suffice when the people whose tasks were interdependent were in no position to see what each was doing, when the effectiveness of group pressures were grossly attenuated and when it was very difficult to judge who had contributed what to any result.

Subsequently it became clear that, if work was to be democratized for interdependent workers who are widely separated by their skills or by space and time, then the critical problem was not that of deciding on the degree of autonomy that should be allowed but of devising information systems that enable effective self-management. To allow any degree of autonomy in the absence of an effective information system would be simply to induce anarchy, a *laissez-faire* situation where each of the interdependent parts went their own way. In describing this matter I have used the notion of an 'information system' as a piece of shorthand to refer to an information system that is about agreed objectives and review of performances. An information system that simply reported on what each interdependent part had performed would degenerate into an unhelpful exercise in one-upmanship and scapegoating.

My basic proposition, in this paper, is that under these conditions semi-autonomous groups have problems with controlling and co-ordinating their efforts that are much greater than would be required if they were bureaucratically organized. Similarly with the setting of their objectives.

Let us look first at how control and co-ordination are achieved in the bureaucratic section. The fundamental premise of bureaucratic organization is that each individual is allotted a personal task that they must perform, and usually an allotted work place and working hours. The more these matters are laid down in rules, regulations and job specifications the easier it is to pinpoint movements out of control. In the absence of such fine controls supervision usually requires stronger rewards and penalties. Control is then simply a matter of the supervisor overseeing the individuals in his section to make sure that they are at their allotted work places, during the specified working hours and performing their allotted tasks. Co-ordination is simplified because in overseeing for purposes of control the supervisor has, or thinks he has, knowledge of which workers are behind with their task, which ahead, and what shuffling of people between jobs needs to be done to catch up on backlog. If no one is ahead with their work the supervisor may decide that some work is less urgent and may be allowed to lag; alternatively he may call upon reserves held by his superior. Such reserve forces are commonplace as the individual workers in this system are motivated to pretend that they are fully occupied with their allotted task, even when they are not, and to cry 'overload' when with a bit of extra effort they could cope. The reserves are not always designated as such. They usually accrue through an incremental process of over-manning. When the work being done by one person regularly piles up to what the supervisor takes to be one and a half man-shift loads a whole person is sought to split the work. It will be noted that the problems of co-ordination tend to be solved by evasion; 'delegating' them up the chain of command, rather than by trying to get a better grip of the actual work situation.

The setting of objectives is also much easier for the supervisor or superintendent in a bureaucracy. It is enough if the supervisor knows the order of importance that his direct superintendent places on the different tasks to be performed by his section. It is of no concern of his if his superintendent has got it wrong

from the organization's viewpoint. In matters to which his superintendent is indifferent the supervisor is free to order them according to his personal preferences and feelings. Even if he gets this wrong he can escape blame by pointing to the lack of explicit orders from above.

At a theoretical level we can note that control in a bureaucracy is made easier by a familiarity with the myriad of rules, regulations and job specifications; and by familiarity with the dodges the workers are likely to employ. Co-ordination is made easier by familiarity with what the boss wants and a personal style of management that gets the job done i.e. is effective. The supervisor will not seek efficiency in the use of his resources if that is likely to lead to some being taken away or weaken his case for additional resources. The setting of objectives is a similar mixture of familiarity and personal preference (the dimension of Probability of Choice) and of effectiveness (the dimension of Probable Effectiveness). The dimension of organizational choice that is absent is that of Relative Value or Intention. In its absence the question of efficiency can be of only academic interest.

We need to note as well that any attempt to run a bureaucracy by 'management by objectives' is fundamentally flawed by the fact that the objectives of a supervisor for his section are not the objectives of any one of his subordinates, their objectives are limited to their own allotted sub-task. The same lack of identity holds between a superintendent and the supervisors reporting to him.

So far I have discussed a bureaucratic section as if it was working at the one place and time, and whose work was not beyond the ability of the supervisor to supervise. What special difficulties are posed for a bureaucratic organization when the section task is performed on different shifts, in separate work places or when the task involves several specialist skills in the work force? The bureaucratic form of organization copes with this problem with the greatest of ease, although with a further loss of efficiency—it simply throws up another level of traditional supervisory roles.

As most organizations in real life are of this complex type it is not difficult to see why the overwhelming majority of schemes to introduce management by objectives and integrated information systems fail to get off the ground.

Let us turn now to the difficulties self-managing groups face in controlling and co-ordinating their activities and in setting their objectives.

Some of the difficulties are obvious. Control is more difficult because no one is so free of other duties that they can, at practically any time of their choosing, make an inspection round, and no individual has formal authority over any of the others. Co-ordination is difficult for much the same reason: no one can spend much of their time seeing how work is going with the other sub-groups and no one can command help from others, they can only request help. Nor can they so readily request the next line of command for extra resources. The supervisor has usually been told, 'this is the job for your section and these are the resources you will have at your command': it is not his fault if there turns out to be a mismatch, although he will probably justify his request on the grounds that things have changed rather than suggest that his superiors made a misjudgement or that he is incompetent. A self-managing group, on the other hand, will have started with a negotiated agreement about the resources they needed to perform their task. They will need hard evidence in order to renegotiate the agreement.

To add to these difficulties no one in an extended or multiply skilled group will know at any one time who is doing what, and where. Hence it can be difficult to know who best to seek immediate help from or who needs help. This is far more confusing than in a bureaucratically organized section. In such a section one can count on each person being engaged with the sub-task spelt out in their job specification at the work station allotted to him.

It is not all negative. Members of a self-managing group are in a position to subject each other to a fairly continuous and close scrutiny, even when they are split into sub-groups through which they rotate. This can be a direct scrutiny when they are helping the other by sharing the same sub-task or just assisting with a less skilled part of the task. It can be indirect evaluation *if* they understand the technical interdependencies within the total group task. Thus there is a considerable potential for exercising intra-group controls in a realistic and sensitive manner. They are not likely to be mislead by the face a worker would show to a supervisor. Furthermore the relation between members of such a group is a relation between 'us' and hence requests for assistance are going to be very much more powerful than requests made in a 'them-and-us' context.

These potentialities are not going to be realized in an extended group, let alone sustained, unless the difficulties discussed above are overcome.

The fact-to-face semi-autonomous group can take its own ongoing activity as a common reference for its constituent members. Seeing what is going on around them they can decide what they should be doing next, or be seen by others to be defaulting. In a bureaucratic section, extended or face-to-face they have only to look over their shoulders to see the common reference, the supervisor. For the extended self-managing group their relations have to be mediated by reference to the group task as it is reflected in symbols that are free of temporal and spatial limitations, and free of professional jargon.

Thus it is that self-managing groups require an *integrated information system*. It is not something imposed to enable someone in higher authority to keep track of them and the resources they use but a requirement that is intrinsic to their self-management. In the Hunsfos example, mentioned earlier, this was reflected in the demand for a central information centre, continuously updated throughout each shift and across shifts by the operators themselves, to keep track of what was in the 'pipeline' and measure progress against targets. All parameters that could be significant for any part of the group task were recorded, not just those that, in the past, some supervisor or superintendent had a fad about. By the same token standing rules and regulations for plant operation were gradually replaced by standard operating procedures that evolved with accumulating empirical evidence. I do not know how far the latter continued to evolve but eight years after moving toward this form of organization I was able to observe that the central information centre was still the hub of operator activity and still growing in its comprehensiveness.

In discussing the need for an integrated information system that will allow group members to know what is happening in other parts of their system I have been guilty of putting the cart before the horse, for ease of exposition.

No integrated information system is of use unless there is:

    (a) a need to know,

  (b) an ability to understand what is conveyed,
  (c) an ability to learn from what is understood.

The need to know will be felt by group members only if they accept responsibility for the achievement of group objectives. Many things, such as potential reward and trust of management, will affect the acceptance of responsibility. One thing is sure, however, and that is that a group will not accept responsibility, or will quickly regret accepting responsibility, for an open-ended commitment. Setting group goals as moving from output level A to output level A+10 per cent is one such open-ended commitment. It does not delimit the responsibilities of the group to the organization because it does not specify the inputs that are allowable or necessary.

Appropriate objectives must so specify inputs and outputs that a group can demand to be judged on 'value added' (or saved).

In bureaucratically organized systems hardly any supervisors or superintendents have any notion of the value added by their area of command. In a system of self-managing groups it is mandatory, and hence it is necessary to conscientiously apply the tools of the management sciences. To seek to continue to manage by the seat of one's pants is to court disaster in their industrial relations.

It will be obvious that input–output analysis at this level throughout an organization is going to provide an unusually high level of organizational self-consciousness, but only at the expense of considerable instrumentation and logging, and the discomfort of considerable re-organization of those many support services that seem to defy objective evaluation.

Generation of this sort of information is of little use if it is understood by only a few in the group. Under those circumstances knowledge becomes power. By implication this takes us beyond training for doing a specified job to education in what is involved in the total group task. Insofar as the task reaches from material inputs to a product we are referring to polytechnical education. In bringing on line a new fertilizer plant in Norway in 1967 we thought it revolutionary to provide a theoretical course of 200 hours for operators. To do the same thing in a highly capital intensive mining and milling operation in 1978 we have had to specify 500 hours plus of formal classroom education for operators.

Effective use of this knowledge and information cannot be taken for granted, nor can one place responsibility for combining these too much with experts outside the group. It becomes necessary for the group to have the means and the skill to monitor what it does with at least the proficiency that in past decades was shown by quality control engineers and production planners. Fortunately the growth in computer assisted analysers has made this possible.

Where these three conditions are met a viable integrated information system is possible. Not only does this ensure that the operators are alert to what is going on in the process they are operating and hence able to quickly take appropriate corrective action; it also provides the means for continuously learning how better to do what they are about. This latter is, in my experience, the critical criterion. If, at any point in the life of a plant, the learning curve

plateaus, then there is reason to believe that the management of the self-managing groups has gone bad.

This brings me to my last point. How does one manage an organization where the interface with the technical system is primarily controlled by self-managing groups of operatives? Not only has foreman gone but also the whole layer of T and M men, production planners, quality controllers etc. that Frederick Taylor so fervently espoused. Even the role of departmental and shift superintendents is cast in doubt.

It seems to me that the primary tool of management is the negotiated agreement on group objectives. I have already alluded to the destructive nature of agreements that simply define outputs. Clearly the agreement must cover the 'minimum critical specifications' (to use Herbst's fecund phrase) for economic transformation of the inputs to the product, within legal limits imposed for such things as human safety and health. This should not be difficult for management who, after all, have skilled resources at their command, or on call. Since the negotiations are about the operation of a technical system that has some unifying character this should be a much easier problem than carving a group task up into individual work stations and man/shift units (on spurious estimates of 'norms', e.g. Baldamus, 1961). It needs only to be added that the negotiations are about a *socio*-technical system and hence amongst the minimum critical specifications to be negotiated are the selection of group members, their training and their access to other skilled personnel.

The point I have wished to make in this paper is that the move toward self-management in complex organizations is going to mean more conscious management, not more of the *laissez-faire*, seat of the pants management, which is the bread and butter of the bureaucracies.

REFERENCES

Baldamus, W. (1961). *Efficiency and Effort*, Tavistock Publications. London.
Emery, F. E. (1978). 'Some characteristics of socio-technical systems'. In: *The Emergence of a New Paradigm of Work*, Centre for Continuing Education, Australian National University, Canberra.
Emery, F. E. and Thorsrud, E. (1976). *Democracy at Work,* Martinus Nijhoff, Leiden.
Kuhn, T. S. (1962). *The Structure of Scientific Revolutions*, Phoenix Books, Chicago.
Miller, E. J. (1959), 'Technology, territory and time', *Human Relations,* **12**, 243–272.

Author's address:
Dr Fred Emery, Centre for Continuing Education, The Australian National University, Box 4, P.O., Canberra, Australia 2600.