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Design and Change in Ship Organization[1]

Socio-Technical and Psychodynamic Variables in Ship Organization Design

The problems encountered in designing ship organizations differ in a number of respects from those met with in developing new forms of organization in factories. In designing a factory organization, we can generally start off with the specification of an established or a new technology and generate possible types of work organization in terms of the requirement of achieving joint optimization of the total socio-technical system.

In ship design, on the other hand, the critical decisions that have immediate implications for the social and work organization on board are concerned with the choice that exists with respect to the allocation of tasks requiring human intervention which can be located either on board or ashore. These, in turn, create alternatives in terms of manning by a continuous crew or a temporary crew, or by means of shore-based personnel. Since there exists in this case a wide range of possible technological alternatives, we can, instead of taking a specific technological system and working out the requirements for a supporting social system, consider the possibility of working the other way round. That is, we can attempt to specify initially the essential requirements for a social organization on board and then work backward to discover the critical supporting technological conditions that would need to be satisfied with respect to ship design.

The Conventional Sequence of Socio-Technical Design

The basic design variable is the allocation of tasks on board and ashore. The basic tasks include navigation and engine control, engine and instrument maintenance, ship maintenance, ship-shore communication, loading and unloading and catering.

[1] A reproduction of chapters 3–6 in *Socio-Technical Design: Strategies in Multidisciplinary Research.* London: Tavistock Publications, 1974. First published in *Tidsskrift for Samfunnsforskning* 10:371–400, 1969.

In principle, each of these task sectors can be wholly or partly shore based. If tasks are split up so that one part is carried out on board and the other part ashore, then the significant decision variable is the location of task components that involve

- decisions requiring a high level of skill and judgment;
- work and decisions at technician level;
- unskilled and semiskilled labor.

Decisions made at this point are crucial since they have direct implications for

- the extent to which the total task allocated to the ship provides conditions for autonomy and self-regulation;
- the communication requirements between ship and shore (this is not a purely technical problem since a great deal of relevant information on the ship cannot easily be recorded, transferred and adequately responded to ashore);
- the possible work-role and social structure; and, given this,
- the possible career structure;
- educational and training requirements.

The possible manning requirements are continuous crew on board, supporting transient crew and land based manning.

The unit for socio-technical analysis will need to be the total set of tasks required for effective ship operation, wherever they happen to be located. It would appear to be feasible to look at the design for manning chiefly from the point of view of optimizing the social system and then look at the supporting conditions required in terms of tasks or task components which should be allocated to a continuous crew on board.

Given the manning requirements on board, the next decision variable is the departmental structure established which further restricts the possible work organization and career structure. The final decision variable is the shift structure and shift-allocation pattern. The socio-technical design problem can thus be broken up into a sequence of decisions (Figure 1).

If we look at what can be done in terms of immediate organizational changes that are required on board in consequence of the changes in technology that have been introduced over time—the decreased size of crew and the increasing difficulties of recruitment—then it is clear that the change process will have to go in the reverse direction of the design sequence. Thus, in experimental programs concerned with the integration of deck and machine crew, changes in shift structure have been used to facilitate changes in interdepartment relationships (A. Trist, 1968). Changes of this type cannot, however, go beyond a certain point insofar as major decisions are already built into the ship design and into the existing work-role, career and status structure.

As long as technological change was relatively slow, it was possible to find ways of adjusting the social organization to a given technological system. The

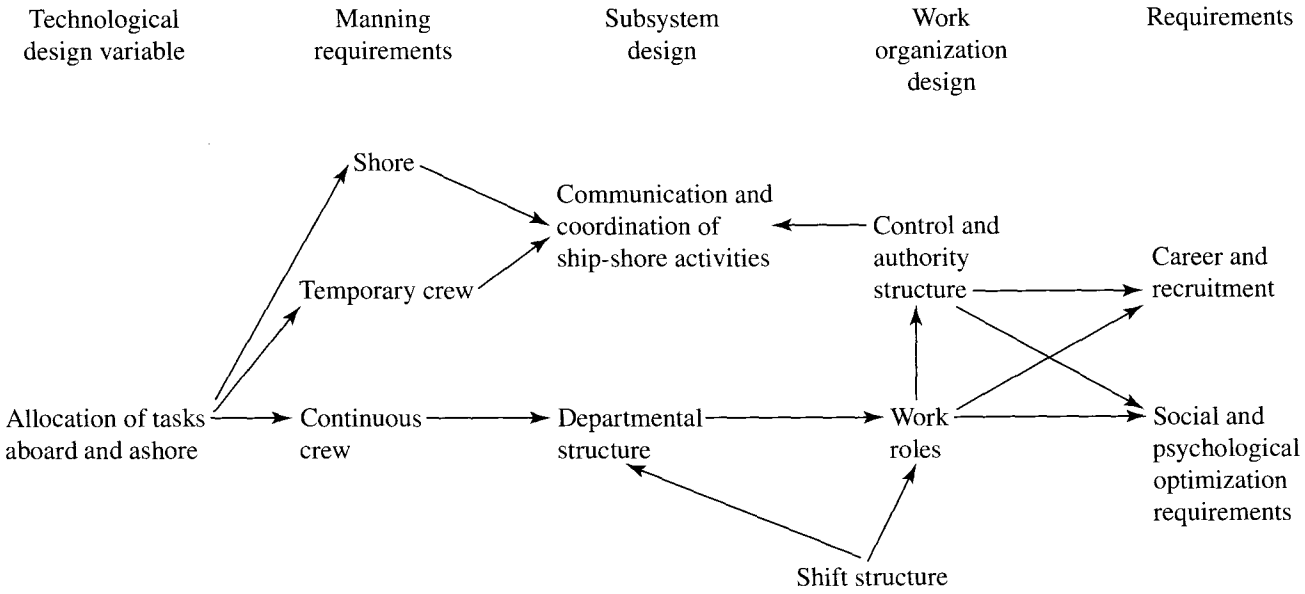

Figure 1. Socio-technical design sequence.

main contribution of socio-technical analysis at this stage lay in showing that, even within the restrictions imposed by a given technological design, a choice of alternative types of work organization existed. It was therefore possible to work toward joint optimization of the techno-economic and the social systems. But this type of static socio-technological analysis is no longer adequate to cope with the current problems of the shipping industry. The present rate of technological change is such that, before a new form of organization on board can be established (together with new training and recruitment schemes, new career structures and pay systems), further technological changes will already have disrupted the conditions for the maintenance of the new social organization. This appears to be a major contributing cause of the emergence of turbulent and potentially uncontrollable environments (Emery and Trist, 1965/ Vol. III).

It is no longer sufficient to utilize the possibility of organizational choice unless the possibility of technological choice is utilized at the same time. Changes in technology have to be directively correlated with changes in social organization over the same period. Policy decisions with respect to changes in social organization over initially the next three to five years have in this case to be coordinated with the choice of new ship designs so that the type of technology and design chosen for new ships that will come into operation is, as far as possible, consistent with, and supports, the direction of social, educational and organizational development. This possibility did not exist earlier when, as a rule, only a single techno-economically feasible solution to a problem was available. At present, the limitations lie not so much in the possibility of generating alternative types of technological design as in the possibility of being able to specify, within the limits of techno-economic feasibility, the essential social and psychological conditions that have to be satisfied by the technological design we wish to implement.

As a first step it is necessary to consider the characteristics of the existing culture and organization on board merchant vessels. Whatever new organization develops has to grow out of the existing one. Field studies were carried out on a number of Norwegian ships: a car bulk carrier on the Europe-East Coast of America Line, a cargo vessel on the Europe-West Coast of Africa route and a factory fishing vessel in the North Sea (Thorsrud et al., 1967).[2] While the purpose of the initial field studies was to collect data on existing technology and organization, a later field study was concerned with identifying potential directions of organizational change and development. Just as autonomous work groups were originally discovered in the course of field work in coal mines in northern England, where in a number of places they had been

[2]So far, only relatively few social scientific studies of seafaring have been carried out. Of particular relevance are Aubert and Arner (1959), Arner and Hersson (1964) and Barth (1966).

designed and implemented by the workers themselves (quite independently of the theoretical socio-technical analysis which had indicated some years previously that this type of organization would be optimal in the light of existing task requirements), so it appeared possible that, at least on some ships, crew members might already have become sufficiently concerned to explore for themselves potential directions of organizational development.

Psychodynamic and Social-System Characteristics of the Existing Organization on Merchant Ships

Excessive Fragmentation

Over a period of time the size of crew has decreased and it is likely to decrease further. Given the conventional departmental and role divisions, the hierarchical structure and the shift structure:

- A large number of crew members become isolated.
- The possibilities of collegial interaction in both work and nonwork activities are minimized.
- Even if the total territory of the ship is large, it becomes split up into private, work and nonwork territories, thus minimizing the effective living space for nearly all crew members (Roos, 1968).

Hierarchical Structure

The existing basic values and traditions of ship culture are intimately related to the existing status hierarchy. The present structure emerged under conditions that are not dissimilar to those found in factories ashore with, however, the following differences:

- All crew members may have to meet physical survival crises.
- The accepted way to the top is from the bottom of the hierarchy.
- The basic assumptions are those of a military organization.

The last point is of some importance since perhaps a key issue is whether to retain the military organization model or to look for an altogether different type of organizational model. On the other hand, if it is judged that a military organization model should be retained, then it will be relevant to consider in some detail innovations and new forms of naval and military organization that have developed during the past generation.

If the need to maintain unskilled and low-skilled crew members on board as part of a continuous crew disappear, it would become possible to restructure

both the content and the responsibility of officers' roles. In this case, possible alternatives to the hierarchical status structure could be considered.

Exchangeable Component Structure

This model is one that makes it possible for any man in any position to be replaced, ideally without altering the effectiveness of the total organization. The basic assumption is that all the relevant work and interpersonal relationship requirements can be built into each role. Over and above this, specific psychological attributes are built into each role. Thus men at the bottom of the hierarchy tend to be given the attribute of being irresponsible and incompetent and the captain's role has almost godlike superhuman attributes.

Unless crew members at the bottom of the hierarchy are perceived to lack—or actually lack—competence and willingness to accept responsibility, the justification for the existing authority structure largely disappears. However, if we simply designed a new organization in which the bottom level was made up of, say, junior officers, then almost inevitably attributions of irresponsibility and incompetence would be transferred to the junior officer group.

Consideration of the existing organizational structure shows that there are a number of reasons why the development of personal, collegial and friendship relations is difficult and why such relations are, on the whole, both exceptional and unstable:

- The existing work organization design does not require the development of personal relationships and these, where they do occur, are more likely to introdùce a variance into the organizational system, which has to be dealt with, than to contribute to its effectiveness.
- The high level of labor turnover unpredictably disrupts relationships that are formed, although some pair relationships may survive.
- A two-class structure develops, with proletarian and "gentleman"-type values, respectively. This allows greater freedom of interaction within each group. There are, however, problems in that potential membership of each group is reduced by decreasing crew size and that intermediate and specialist crew members cannot easily be integrated in either group.
- Given the conditions required for maintaining the conventional status structure, it is difficult to switch over to a different type of social system during the leisure-time period.
- There is considerable evidence that the development of collegial and friendship relations is perceived to be inconsistent with the maintenance of a conventional authority and status structure. Since this is regarded as a central problem, it needs to be examined in more detail.

Distance-Regulating Mechanisms

There are a number of social-psychological processes that contribute to distance maintenance on board (Figure 2). The most frequent reason given for distance maintenance is that familiar relations lead, if not to contempt, then at least to loss of respect.

It is, of course, characteristic of an authoritarian structure that respect is the attribute of a role and not of the person who occupies the role. At the same time, it is possible that

1. The work role of some officers does not provide them with a feeling of competence. This may be the case for deck officers insofar as they can no longer utilize their navigational skills.
2. Some officers may be given responsibility for operations for which, owing to technological and administrative changes, they have insufficient training.
3. Officers are not able to demonstrate the competence that they do possess. At the same time,
   a. It is precisely the distance-maintaining mechanism that makes it difficult for officers to demonstrate competence and at the same time makes it possible for the superior to protect himself from a judgment of incompetence by subordinates.
   b. The higher the status position, the more the role content is looked at as a kind of mystique by subordinates, in which case distance maintenance is consistent with the needs of both superiors and subordinates.
   c. The tendency over time to transfer high-level decisions to head office, coupled with decreased crew size, has reduced the effective authority of officers both upward and downward. The actual competence requirements for high-level roles will in this case be reduced.
4. As the size of the crew decreases, each crew member experiences himself as being individually more visible to other crew members. He can now less easily distance himself by disappearing as a member of a group and he is also more likely to be physically isolated. As a result, the feeling of loneliness increases. The interview material[3] (Roggema, 1968) suggests that officers seek to cope with the problem of loneliness by keeping

[3]The interview material was obtained by Roggema and the final recommendations are based on joint discussion in the course of the field study referred to above. Roggema's more recent field studies concerning long-term change projects in ship organization are reported in Roggema (1971) and Roggema and Thorsrud (1974). An independent study carried out by the Westfal-Larsen Shipping Co. indicates that better results are obtained by having a fairly large group of trainees on board one ship rather than by having smaller groups on a number of different ships.

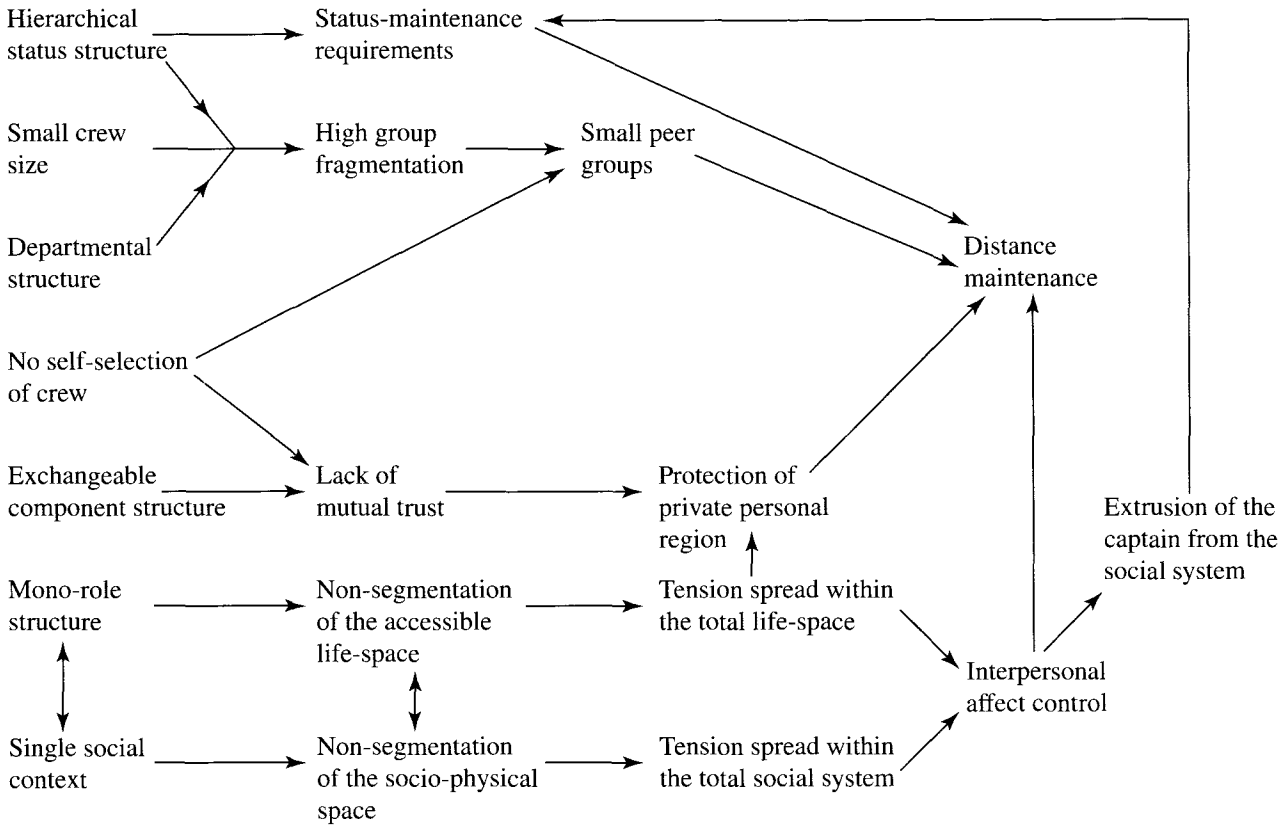

Figure 2. Organizational conditions that contribute to distance maintenance.

themselves busy all day long; and it would appear that the desire of crew members to work as much overtime as possible is not simply economically motivated. Thus, again, the possibility of social interaction during nonwork time is decreased.

We may note here that closer relationships between crew members are not necessarily inconsistent with the maintenance of a status hierarchy. However, this presupposes:

- a joint value orientation of men and officers rather than the existing separate men and officer cultures, together with specialists who belong nowhere;
- commitment to a clearly defined joint goal or mission to which each crew member can effectively contribute;
- respect relationships based on demonstrable and clearly perceived competence.

These conditions are to quite a large extent consistent with the operation of fishing vessels, but they are not easily applicable to merchant vessels.

So far, we have looked at the distance-maintaining mechanisms that derive from the formal organizational structure. A somewhat deeper level of this issue is indicated by comments such as:

> I cannot say why, but it is better for the atmosphere to keep a little distance. (officer)

> It's a stress to be in such a small community. One has to defend one's private life. (officer)

> It's a psychic stress. You work together, you eat together, you see the same faces all the time. Even in leisure time. You even see the same faces when you watch a film. (officer)

A number of interrelated aspects are touched upon here. To use Lewinian terminology, the life-space on board ship is not internally segmented. This means that tension, when it arises, floods the total life-space; and there is nowhere to get away from it, since there is no outside region. The central problem then becomes that of affect control in conditions in which the obvious mechanisms for affect control that exist on land are not available. On land, it is possible to play different roles in different social contexts so that, whenever tension builds up in one social context, one can transfer to another. There is always a temporary shutting-off mechanism available. On board, the role-shifting mechanism cannot operate as there exists a single social context and within this each crew member is fixed in a single role, e.g., captain, bosun or cook.

On land, it is possible to release positive or negative affect insofar as it is

generally possible to break off a relationship or escape from a social context. On board ship, positive and negative affect expressions spread and reverberate within the closed unsegmented social space. The spreading effect is unpredictable insofar as the crew is made up of persons who do not know one another. In view of the independent tendency of psychological tensions to build up over time, the triggering of affect expressions can relatively easily lead to explosive and destructive reactions.

The problem here is twofold: (1) At the interpersonal level the crew has the characteristics of an aggregate rather than of a structured community. (2) Interpersonal love-hate relationships which do not form part of the formally sanctioned structure cannot be closed off or played out within a private space by the participants; and there is no immediate escape possible. The participants cannot easily separate themselves again, nor can they jointly remove themselves from the response of the total social system.

The necessity for interpersonal affect control under these conditions appears to be a major cause of the distance-maintaining mechanisms which, while independent of the status hierarchy, are at the same time consistent with the maintenance of it.

The psychological consequences include the following: (1) Interpersonal affect control and distance maintenance tend to lead to an impersonalization of interpersonal relationships. The experience of others as just faces, to the extent that this occurs, also implies a corresponding relationship to oneself. (2) Similarly, the experience of a non-segmented social space implies a corresponding absence of segmentation and bounded regions within oneself. Under these conditions the individual cannot respond to problems within one of several roles and within one of several social contexts; rather, in these conditions the way he meets and responds to problems affects his total personality.

There are three possible ways of compensating for the reduction of personal affect relationships:

1. At a superficial level, the telling and retelling of yarns permits the vicarious enjoyment or reliving of memories concerned with affect-laden interpersonal events in the nonprivate sphere of the individual's life, allowing them to become the public property of the community. By this means, a crew member can also define for himself and others a personal identity apart from his role identity.
2. Telling yarns and stories about oneself can also be a way of protecting one's personal life-region.
3. Retreating into the personal life-region is a third type of compensatory behavior.

Concern for one's family ashore and protection of the personal life-region appear in the interview material as two major themes that are interrelated. To a

man on land his home is his private territory. He can retreat into it and shut the door. It contains what he treasures. He allows access to it only to his friends. It has a semi-sacred character. It is a focal and central region of his life-space.

The personal private region has similar properties; to allow it to become public property would be to lose it; to protect it means to have a private space into which one can retire, but primarily to experience in fantasy, or relive in memory, positive affect relationships.

Long separation from home may give grounds for quite realistic fears and concerns about those whom one loves, in which case the availability of at least one person to whom one can talk freely will be of considerable help.

More problematical is the tendency for the content of the personal private region to become idealized over time. While this makes it possible to enhance the positive affect that can be experienced in fantasy, it will at the same time almost inevitably also produce internal doubts and uncertainties, and increase the unreality of the content of the private region. Under these conditions one may have an almost compulsive and indiscriminate need for communication to provide reality support for an idealized fantasy that is already threatened by one's own uncertainty and doubts. The risks in this case are that one's private life becomes public property and that the response received is likely to increase one's doubts and uncertainty, with the result that the idealized fantasy now becomes the reverse. Whereas before it provided a surplus of enjoyment and happiness, now it appears full of fear and negative feelings and a depressive phase sets in. An alternative risk-lowering strategy is to reduce communication with others, thus creating the need for distance maintenance.

The major significance of the private personal region for most crew members is that it provides a bridge back to shore. To the extent that this region becomes idealized, what typically occurs is that, on return to land or home, discordance between fantasy and reality leads to increasing discontent and to a reverse idealization of life on board ship and thus to an oscillation pattern which may also be repeated during shorter shore visits. The sailor is thus caught in a condition of double ambivalence. When at home he has a fantasy of life at sea which may not match reality, and when at sea he has a fantasy of being at home or in port. Eventually he may give up the one or the other.

We know very little about the consequences if the personal region that binds a crew member to shore is given up. A transitional pattern in this direction is expressed in the following response to shore visits:

> The first things you see are the docks, ugliness and dirt, filthy factories—terrible. It's the same everywhere. One often feels inclined to stay on board. You have to get through a sort of barrier before you see something of the normal world. (sailor)

In a novel on life at sea Geelmuyden says on this point:

> If a seaman has a horror of ports and longs to be at sea, then he is a proper seaman, then his chance to get away, if he would like to, is much less. He has thrown away his last bridge and become part of the ship.

We need to refer briefly to another method of regulating interpersonal relationship. At lower-status levels, we find some references to the concept of "shipmate," and at higher levels to the concept of "style." Both form part of the implicit culture of the shipboard community. It would be worth while to find out to what extent there is consensus regarding these role definitions and to what extent they are still significant and actualized. We note here only that both refer to impersonal role requirements with respect to proper ways to behave, in the one case for persons with peer-group status and in the other for those with officer status, and that their function is to extend the formalization of interpersonal relationships consistent with the requirements of the existing role and status organizations. For the purpose of considering possible changes in the formal organization, an understanding of the present core values of shipboard culture will be needed.

So far in our discussion of distance-regulating mechanisms we have examined, first, those deriving from the authority structure and, second, those relating to the problem of interpersonal affect relationships. The latter are linked to (1) a mono-role system; (2) nonsegmentation of the socio-physical space on board; and (3) the aggregate properties of the crew. Both (1) and (3) are directly modifiable by means of socio-technical design; (2) is only indirectly modifiable since it is based on a situationally induced nonsegmentation of the self.

A still deeper level of the problem of distance maintenance finds very clear expression in the following interview extract:

> I am afraid to look at the captain as a person. Seeing the captain in this way would mean an attack on his authority. (officer)

Close contact between captain and officers would, according to another comment, show "that he is only a human being." If in at least one aspect of his role, the captain is not a human being, what is he? References to him by the men as "God" and "the father" clearly indicate what his perceived role is but why is it of such importance, especially to the officers, to maintain this extra-human role attribution? After all, not even a present-day king or president requires these attributes.

We noted earlier that the shipboard community has the characteristic of nonsegmented social space in the sense that it provides a single social context that

one cannot leave and within which inter-personal tension cannot normally be contained locally but will easily spread and build up. If the captain becomes personally involved in this, he is not in a much better position to achieve control than is any other crew member. In order to be able to control, he has to be located, in a sense, outside the human community and not be part of it, except that on board ship it is not physically possible to create an outside region.

The characteristics attributed to God are that He is omnipotent and all-seeing. What is relevant is that the attribution of omnipotence is based on His not (normally) entering into direct human relationships and not exerting direct control, for in this case His power would be finite and limited and thus not much greater than that of an ordinary human being; and the attribution of being all-seeing is based on his not being seen.

The captain is the person in whom all power and authority on the ship ultimately reside. By minimizing his personal interaction he becomes a focus of concern and creates the condition whereby an image of himself becomes internalized in the crew members. Insofar as an image has been internalized it acquires characteristics of internal control and, at least in this sense, the captain becomes all-seeing. At the same time, direct communication, where this is required, will proceed not on a person-to-person basis but via the internalized image, and in this case may not require more than a hint or a gesture.

It will be of considerable importance to crew members that the ultimate source of authority be completely trustworthy, benevolent, just and, if need be, willing to offer himself for their safety.

Again, since the captain is the source of all authority and officers have their power only by delegation, it becomes of importance to officers that, if not the actual, then at least the perceived power of the captain be as great as possible; for as his power decreases so also does their share of it. In this case distance maintenance between captain and officers is also required to maximize perceived power.

To the extent that the captain is perceived to have godlike attributes, other crew members acquire correlated roles so that at this level all crew members can become actual or potential participants in a cosmic drama. According to the ancient and medieval myths, the cosmic drama scarcely ever involves the human community but is played out in the upper regions. Therefore, if it is actualized anywhere in some form, it will be in the officers' mess—that is, among those who to some extent share the captain's authority and power—and not in the men's mess—that is, among those who are content to remain ordinary human beings.

At the same time, to the extent that the captain is perceived to be omnipotent and to carry the responsibility for ship and crew, the men at the bottom of the hierarchy will perceive themselves to be nonresponsible and to have little actual

or potential competence. This is quite consistent with the fact that officers scarcely ever refer to the need for the men to be efficient or competent over and above the level of following instructions, but consider the men's primary role to be that of having respect for officers, not for themselves as persons but as representatives of the captain.

Every social system implies a world view. This may be less immediately realized in the case of factory organizations but becomes significant in the case of social systems in which people both work and spend their lives.

The principles on which a social system is based do not become invalid if they are technically inefficient. If techno-economic criteria become a major aim to which people are prepared to subordinate themselves, then this is part of a world view. However, if the social system becomes inconsistent with task requirements and also the world view on which it is based becomes eroded—that is, people are no longer interested in, or able to play, the implicit roles—then the social system no longer possesses survival possibilities.

The conventional organization combines the hierarchical status structure with an exchangeable component system which can operate like a machine. If the former becomes weakened, then the latter becomes dominant. This is quite consistent with the trend toward ship rationalization. The effect of this, which is already becoming clear, is the opposite of what is found in factories on shore. In factories, the prevalent result is a reduced involvement in work. On board ship, the typical result is a compulsive overinvolvement in work which is frequently referred to:

> You are like a machine that belongs to the ship; you like the work, but it's work and nothing else. You cannot get rid of it. (sailor)

> You don't have a problem as long as you work, you don't notice a thing. (officer)

> It's all right as long as you work. (officer)

In such cases, leisure time has a negative connotation and even shore visits can appear empty.

Here we encounter the problem of alienation in its fundamental form. Both the self and the environment appear to be empty and there seems to be nothing with which to fill the void, except work. To cope with the psychological problem at this level demands a good deal of maturity. Normally, one should avoid creating conditions where this type of problem is situationally induced and experienced as deprivation. The design for a new type of socio-technical system will need to start at this level.

Socio-Technical Design of Ship Organization

Organizational Requirements

Every socio-technical system has to satisfy several requirements. The number of requirements for an effective ship organization will be larger than that for a factory organization since we have to create a social system in which people have both to work and to live. The problem is not to create a new social organization for a new technology, but an organization that can cope with a steadily changing technology. At the same time, conditions have to be provided for the development of a micro-community which can function in a situation of isolation. The minimal conditions for effective task performance have to exist from the start. The requirements have to be both feasible individually and mutually consistent and, if possible, mutually supportive. The set of requirements would appear to include the following. The organization should

1. be adaptable to technological change;
2. facilitate the effective use of leisure time;
3. provide conditions for both autonomous and group-based activities;
4. be consistent with an exchangeable component structure; that is, it should not be too difficult to replace leavers and to integrate new crew members;
5. be either an overlapping role structure or a multiple role structure;
6. if possible, link mutual respect relations to perceived and demonstrable competence;
7. if possible, be consistent with, and provide conditions for, the development of collegial and friendship relations;
8. minimize the build-up of psychological tensions;
9. provide effective control over interpersonal tensions;
10. provide greater stability of crew membership.

Work roles should (1) provide a basis for technical or professional competence; (2) facilitate both transition to and recruitment from shore with a minimum of retraining; and (3) be consistent with career advancement requirements. The task and task elements allocated to the ship should (1) be consistent with the requirements of the social system; (2) consist as far as possible of complete task regions; and (3) provide to some extent conditions for operating toward a joint aim for the total crew.

There are indications that at least some of the requirements form a cluster. Few data are available on the interrelations of relevant variables. The interview material provides only some general pointers.

Tension Symptoms on Board

The analysis referred to earlier showed that a fundamental requirement of any new type of ship organization is that it must not be less effective than the existing type in coping with personal and inter-personal tensions.

Results obtained from alcohol studies are revealing in this connection. At the time of the ship studies 38 percent of patients in institutions for alcoholics in Norway were ex-sailors. Of the Norwegian population as a whole, it is estimated that approximately 20 percent are ex-sailors. Since of these 20 percent quite a high proportion will have spent only a short time at sea, the actual degree of risk for the sea-faring population is likely to be even greater.

Within the population of sailors the risk of alcoholism tends to be limited to a well-defined group. Brun-Gulbrandsen and Irgens-Jensen (1964) carried out a study of 3,440 young sailors, aged 20 to 21, in which they employed a composite "handicap index." The index was based on interview and objective-type data and included the following variables: (1) abnormal home environment; (2) low education; and (3) high neurotic score. It was found that sailors who come from a normal home environment and have a high level of education and a low neurotic score have practically no alcohol problem, and that there is a steady and pronounced increase in alcohol abuse with ascending position on the handicap index. At the same time, alcohol abuse is found to increase markedly with increasing length of time at sea. Furthermore, there is a higher rise over time, in both incidence and degree of alcohol abuse, among sailors of a lower educational level (and this group will also be likely to contain those who have no further interest in education). Thus, there are no indications here that long periods at sea have a therapeutic effect; quite the contrary.

Interdependence Structure of Organizational Requirements

As a starting-point for the design of a socio-technical system for ships we shall take it as a given that

Over the next 10 years there will be relatively frequent changes in ship design, ship operation and fleet operation in the direction of greater automation and more efficient data-handling and data-transmission techniques, which will provide the basis for an integrated technical-system design.

Whatever organization is established must be consistent with this condition. Technical redesigns and changes take relatively little time, whereas the development of an appropriate new work and social organization takes a relatively long time. Since, therefore, by the time a new organization is developed it is almost certain that fundamentally new technical changes will have occurred, it

is clear that the organization established must, from the start, be such that it is adaptable to, and able to cope with, relatively frequent changes in technology at a possibly quite sophisticated level of automation.

In the light of the consequences of the above for a social and work organization, what we are looking for is

1. the derivation of a set of organizational conditions that have to be satisfied;
2. an examination of the consistency of the conditions which will indicate whether the required organizational properties will be mutually supportive;
3. a general specification of the resultant type of organizational structure, which could later be specified in more detail with the introduction of additional requirements.

Given a steadily changing technology in the direction of greater automation, change-adjusting properties need to be built into the organization. The size of crew will decrease, and this in itself will make it difficult to maintain the traditional hierarchical status structure in which authority and work execution are separated. Instead, work execution and authority will coincide to a greater extent for the crew members on duty at a given time. In order to permit adjustment to technological changes only a minimum of structure should be built into the organization because the organizational structure will be constantly disrupted. Instead, adjustment capacities will have to exist to a greater extent in the crew members. This implies that crew members will require a fairly high level of education and an orientation toward further education. This would suggest developments in the direction of a small crew all of whose members have a professional or technical work role—that is, basically an all-officer crew.

The expected consequences of these suggested lines of development are (1) reduction of status-induced fragmentation and isolation and (2) greater educational and cultural homogeneity of the crew. Both should facilitate a capacity for more effective individual and joint utilization of leisure time and should contribute to improved management of personal tension. At the same time, the data on alcohol abuse indicate that, at least under conditions on board, a higher educational level—and possibly also commitment to further education in either a teaching or a learning role—will contribute to better management of personal tension.

Whatever can be done in the way of improving the management of personal tension would lead to a reduction of labor turnover and therefore to a greater stability of the crew; and thus conditions would exist that would encourage the self-selection of group members.

At the same time, given crew members all of whom have professional or technical competence, provided the technological structure is such that their actual and potential skills can be effectively utilized, and provided further that

the correlated conditions for the improved management of personal tension are in operation, the conditions exist for an organization based on the autonomous responsible behavior of individual crew members. In this case, the external hierarchical control structure would no longer need to be the dominant authority and control system. It could possibly be allowed to fade into the background and be activated only under emergency conditions. However, the type of organization required to cope with emergency conditions has still to be considered.

There is one possibly relevant finding from the coalmining studies (Trist et al., 1963/Vol. II; Herbst, 1962). The autonomous groups studied were not created by individuals who came together, but in most cases by pairs who came together from a larger unit. A detailed analysis of the group process (Herbst, 1962) showed that subsequently, depending on task requirements, pair units joined together, split or exchanged members. Consequently, under conditions of stress, the group did not regress to an aggregate but regressed only partially, the complex structure temporarily breaking down into smaller subgroup units. Trist and his colleagues, in studying a 24-hour cycle unit, found that the development of subgroups that rotated members across shifts played a significant role in avoiding shift fragmentation, which would have destroyed the self-regulating properties of the system.

Figure 3 shows the argument so far in diagrammatic form. It will be seen that the organizational requirements listed earlier are not independent but are all related to one another; they appear to a considerable degree to be mutually supportive, which is essential for a feasible organizational system.

The implication obtained at this stage from the total set of requirements is that an appropriate type of organization for ships would be similar, to some extent, to that found in some arctic camps. The basic crew would consist of officers. The range of task competence would need to include mechanical and electronic engineering, navigation, communication, computer programming and data analysis. Even on a fully automated vessel the crew should not be allowed to decrease its size below a minimum of eight to ten persons, so that at least a pair would be available for each shift. Each officer, in addition to having specialist competence within his task region, would need to acquire some degree of skill and competence in one or more other task regions. This would mean that an officer would be in a command or an assistant position, depending on the nature of the task. Also, if some nontechnical tasks were allowed to rotate, it would be possible to further increase the number of role relationships of crew members. The relationship between officers should in this case be basically of a collegial type. They should be able to engage in joint problem solving where necessary, with the captain playing a senior role. The primary task role of the captain would need to lie in the field of ship-shore relationships, that is, in the management of boundary relationships between the ship and various parts of the larger system of which it constitutes a part.

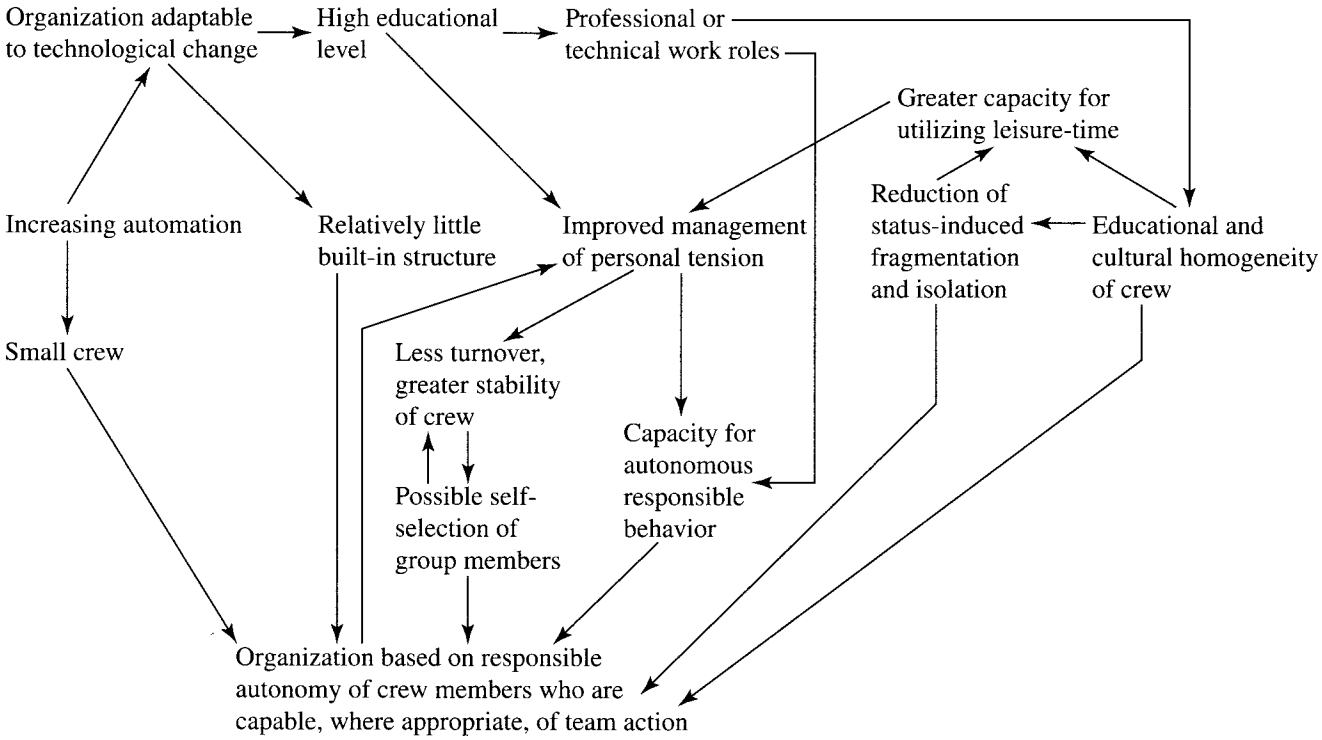

Figure 3. Tentative interrelationship of design conditions and requirements.

If a sufficient degree of crew stability could be achieved, then, within defined safety limits, it would be possible to allow the crew to evolve their own work organization and to decide on shift structure, allocation, rotation patterns etc. This would allow each ship to some extent to develop an idiosyncratic culture and would give crew members a better chance of finding the type of ship that suited them best. Another possibility would be to allow a more idiosyncratic culture to grow around the utilization of leisure time. This would be particularly aided by the self-selection of crew membership.

From the point of view of technological design, the implication is that relevant decision-making and problem-solving tasks be located on board. This means that a computer installation would be put aboard and a possible link provided to a central computer installation at headquarters. A major aim of automation and ship design should in this case be to eliminate task components requiring no or low-level skills on board.

The total design is, then, one in which the permanent crew has the position of an elite and the length of time spent aboard is related to the level of skill. Trainees would initially spend only shorter periods aboard as part of their training program. They would thus have a transitional period before they committed themselves to joining a more permanent crew. This would make it easier for them to reintegrate in the community ashore if they wished to do so.

The ship design should be based on the principle of creating clearly demarcated areas: work area, nonwork leisure territory and private territory. The leisure territory might include part of the deck area and should be designed to permit a wide range of possible uses. The territorial design should provide at least the possibility of creating distinct behavior settings.

In terms of recruitment and of maintaining relative highly skilled personnel aboard, the conditions that have to be satisfied are that

1. the technological design permits the location on board of a sufficient range of challenging tasks involving high-level skills;
2. from a technological point of view the ship constitutes a relatively autonomous unit;
3. the permanent crew aboard acquires the characteristics of an elite.

These conditions are interdependent insofar as it will be difficult to recruit and maintain relatively highly skilled men on board if the ship is depleted of high-level tasks, if total task control and task management are not possible, if task roles do not provide sufficient autonomy and if the perceived status of crew members is low. It should not be overlooked that hiring and induction procedures and shore-leave facilities will need to be consistent with the status level required of personnel.

Referring again to Figure 3, it will be noted that the organization considered so far pivots, and is critically dependent, on the extent to which more effective management of personal tension is achieved. If there is failure in this respect

the system might, in fact, not be viable. On the basis of the analysis earlier in this paper, which showed that a monorole structure, together with a single social content and a nonsegmented socio-physical space, creates not only a considerable amount of tension but also considerable problems of tension management, the additional suggestions have been concerned with the possible development of a multirole structure and distinct and separate behavior settings and with the provision of sufficient freedom to permit tension adjustment by means of changes in allocation, work rotation and organization structure.

Finally, it is necessary to consider a design which is practically the mirror image of the one considered so far. Given the already existing capacity for controlling vehicles in space, it will become feasible to build ships that can be steered from land based installations. This would imply that professional skill would be shore based. A transient repair and overhaul crew would need to join the ship and, at most, a routine watchkeeping and maintenance crew would remain on board. What would be required in addition is a set of strategically placed air stations, both on land and at sea, from which a professional stand-by crew could be flown out in a short time in case of emergency. Such a service would probably need to be organized on a national or international basis. The social-psychological problems for such a crew would be considerable given the lack of significant content in their tasks and the long periods of isolation.

From the point of view of long-term planning, the best policy would appear to be to provide all crew members with educational opportunities and with facilities for employing professional and technical skills so that, if technological development should go in this direction, they could be readily transferred to shore establishments or to specialized emergency crews. Whatever way is chosen, a clarification of future career policy is essential to solve recruitment and organization problems over the coming years.

Organizational Learning and Organizational Change in Merchant Ships

Matrix Organization

The preceding analysis of the existing social and work organization on merchant ships has shown that emergent technological requirements and social organizational requirements point in the direction of a future organization on board that will consist of a small team of officers, all of whom will have a technical or professional task role. Each officer will need to be able to perform several tasks. This is not simply in order to provide greater work variety but because, with increasing automation, the performance of some tasks will be

only occasionally required. At the same time, more composite and overlapping task roles will provide the conditions for smaller teams to cooperate on specific tasks. This will imply a development away from a hierarchical status structure to a matrix organization within which different team subgroupings can come into operation to carry out specific tasks or planning roles.

A matrix organization is one that does not have any single division of functions, such as deck and machine, but permits the formation of these and other subgroups according to the nature of the task to be performed. The matrix organization does not contain built-in status differences; it is based on the assumption that each officer has a specialist role, together with a range of task competence which partly overlaps the competence of other officers. Any officer may thus, depending on the nature of the task to be done, take on a leadership role or act as a member of a specific task group.

To the extent that crew size decreases and the need for technical competence increases, it will become important that the organization remain viable even if one or more officers are absent owing to recruitment difficulties or sickness. A matrix organization based on composite roles will make possible a flexible redeployment of officers. At the same time, a decrease of built-in occupational and status differentials will make it easier for the organization to adjust to technical changes.

It appears unlikely that a direct change from the existing organization to the new type of organization outlined can take place. What is required is not simply a new technical learning program for the existing staff of officers and for younger crew members, but a process of learning how to operate a new type of organization on board. The learning program must therefore be based on a total crew and may require a planning horizon of five to eight years.

The main immediate problem, in this case, is to find possible transitional types of organization aimed at modifying the existing organization in the direction of a matrix-type organization. The transitional organization should be consistent with the operational requirements of both existing vessels and automated vessels—automation will permit ships to be operated from a single control center on board.

The organizational diagrams presented here (Tables 1 and 2) are intended not as actual proposals for a new type of organization but as illustrations of the various possible ways in which further training of the existing staff of officers could provide a bridge toward the development of a matrix organization. The illustrative examples are based on a core of six officers. At this stage, all officers would require technical school or technical college training.

The second type of matrix organization, suggested by David Moreby (personal communication) is one in which all officers can carry out bridge and engine control, watchkeeping and also maintenance (Table 2).

TABLE 1 Transitional Type of Matrix Organization

A Captain		
B Navigation Cargo handling Deck maintenance Clerical work	C Navigation Radio communication Clerical work	D Navigation Computer use Data handling Instrument maintenance Clerical work
E Mechanical engineering Mechanical maintenance Engine stores Clerical work	F Mechanical engineering Electrical maintenance	G Mechanical engineering Electronic maintenance

Navigational group	BCD
Cargo group	BDE
Administrative group	ABDE
Communications	CD
Data handling and Records	BCDE
Engine operational group	EFG
Mechanical maintenance group	EFGB
Electrical maintenance group	FGD
Electronic maintenance group	GDC

TABLE 2 Fully Multiskilled Matrix Organization

A Captain		
B *Cargo* Navigation Engineering	C *Navigation* Electronic maintenance Engineering	D *Radio communication* Navigation Cargo Electronic Maintenance Engineering
E *Mechanical engineering* Electrical engineering Navigation	F *Electrical engineering* Mechanical engineering Navigation	G *Electronic engineering* Mechanical engineering Navigation

A major difference between the traditional organization and the matrix organization in its transitional form is that the traditional single division of functions between deck and machine becomes now only one of a number of possible subgroupings. At this stage the deck and machine subgroups overlap and at the next stage of technological development the distinction in its present form may no longer be relevant.

Instead of the present subordinate crew there would need to be a number of officer cadets. The initial aim of training would be to make every cadet capable of taking over at least one of the basic officer roles. The training scheme for cadets would need to be coordinated with a training scheme for officers that would both increase their level of competence and give them the opportunity to act as teachers. At the next stage, the officer trainee scheme would have the function of providing a second generation of officers who could operate a more complete matrix organization. Officer cadets would need at this stage to be trained in at least two adjoining roles such as CD, FG, DF, leading to an organization with a smaller number of more composite roles based on combinations of

X	Y	Z
Administration	Navigation	Machine
Maintenance	Computer use	Electronic
Cargo handling	Data handling	Electrical
	Communications	

The organization design outlined is essentially of the developmental type (Herbst, 1974). The initial problem is that of creating the conditions for a self-sustaining and continuous learning process, both at the individual and at the organizational level. Sustaining a developmental process requires, however, that the necessary external supporting conditions be continuously evaluated and appropriately modified. To give an analogy: if a child's development is to be maintained, both the teaching he receives (content and method) and the relationships he has with his teachers and other relevant persons in his environment have to change over time in an appropriate way.

The immediate problem is how to initiate and provide the conditions required for the development on board of an organization that has the capacity for continuous learning.

Preliminary findings from a field study (carried out by the author and Jaques Roggema) indicate a possible starting point. The findings relate to a number of partly unanticipated consequences of a recently introduced trainee scheme. During the first year of this scheme, elementary training is provided both on deck and in the engine room. During the second year (or the first year in the case of technical school graduates), further training is provided for qualifica-

tion either as able-bodied seaman or as mechanic. The study revealed that officers who had previously felt that the men showed no interest and had no sense of responsibility were impressed by the boys' interest and eagerness to learn and considered that they had achieved remarkable results in a few months time. One of the engine officers, reviewing the experience, began to see that the earlier difficulties were not all attributable to the men:

> I now start treating people in another way. For example, one of our greasers made a bad start; so we more or less cold-shouldered him. I did, too. But I decided to give him more and more difficult work. I gave him jobs which were just a bit above his level. He changed completely. He has become interested. He does a fine job now. It all depends on leadership but we never had the opportunity to learn anything about it. (officer)

The training scheme in this case led to a relationship between officers and men that was different in quality; it had the characteristics of a personal teacher-pupil relationship in which the officers involved reexperienced their own tasks as something of value that could be passed on to their juniors, while at the same time the men had greater autonomy and felt increased satisfaction with their tasks.

The officers were able to learn a better leadership role. It should be noted that teaching, although not in its present form, was in earlier days an accepted part of the officer role so that officers who were willing to act as teachers in a sense rediscovered a valuable component of their traditional role. Like many teachers before them, they found that they had to do quite a bit of studying and thinking themselves in order to keep a jump ahead of their pupils. Unlike classroom teaching, which rarely presents the need for reality testing, in the teaching situation on board the trainees could—and did—ask for immediate checking of what they had learned against actual operations on board and were thus in a situation where they could test the knowledge of their teachers.

Officers who had acted as teachers, and also some who had not, became more aware that a good deal of the training they had received at maritime schools was obsolescent, that their own knowledge of the functioning of equipment and instruments, while sufficient for daily operations, was incomplete and that they had no understanding of the new types of ship technology that were being introduced. Many of these officers expressed a wish to participate in more specialized and advanced training courses or felt the need for more basic technical knowledge.

The findings at this stage indicate the following:

1. A training scheme in which officers become involved in teaching may provide the initial condition required for a change in the basic culture of ship organization. Such a scheme is found to decrease the distance be-

tween officers and men in a task-related context and in a form that is experienced as appropriate by both officers and men.

2. A good way to extend one's knowledge of a subject is to teach it. The involvement of officers in teaching, and especially in the design of courses and the adaptation of teaching material, creates the conditions that can lead them to become interested in evaluating and extending their own knowledge. It is essential in this case that those officers who have become involved in teaching, and at the next stage also other officers on board, are given the opportunity for further appropriate training. At the same time, other ordinary crew members should be encouraged, and given the opportunity, to participate in parts of the total trainee program.
3. The emphasis should not be on the elementary training of young sailors but on the provision of conditions for the development of a teaching-learning culture based on the total crew on board.

It will be clear that the trainee scheme in its present form, while it is valuable as far as it goes, is neither designed nor sufficient to create fundamental changes in organizational structure. One of its functions at this stage might be to provide a means of selecting ship crews that are able and willing to participate in an experimental total-crew training scheme. An experimental scheme of this type would be specifically appropriate for ships that are likely to be replaced by more highly automated vessels. It would, in this case, be possible either to transfer a total crew or to provide a pool of potential recruits to take over new ships. This could be expected to reduce both the time and the difficulties involved in bringing new vessels into efficient operation.

A possibly equally important consideration is that there is at present a widespread concern, especially among officers, about future career prospects. There is likely to be an increasing tendency for officers with good technical training to seek jobs ashore, leaving on board those who have nowhere else to go either because they lack technical training or because they are too old to be able to start a new career. The active involvement of officers and men, both in training and in the development of new forms of organization required on automated ships, could contribute considerably to the reduction and possibly the reversal of this trend.

Emerging Characteristics of Socio-Technical Organizations: A Summary

Directions of Change in Organizational Design

1. From adapting organizations to technological requirements to adapting technology to human and organizational requirements.

2. From designing organizations with a single, prescribed, rigid structure to designing organizations
   a. capable of learning and of relatively continuous change in organizational structure and
   b. with a capacity for operating different types of organizational structure, depending on task requirements.
3. From organizational designs based on one-man/one-job to designs based on enlarged and partly overlapping jobs.
4. From designs whereby responsibility for organizational units is allocated to one person or group (thus generating a hierarchical structure) to designs whereby responsibility is allocated to nonhierarchical self-organizing groups.
5. From organizations using electronic data-processing techniques as work directors to organizations utilizing computer equipment as consultants to provide relevant information for self-organization and to assist in problem solving by operating groups.
6. Specific forms of organized design have to be evaluated in terms of
   a. technological requirements,
   b. environmental requirements,
   c. work role and career implications,
   d. educational requirements,
   e. psychodynamic and mental health implications and
   f. social-ecological implications.

   Each of these leads to different types of implication for organizational design, which optimally should be consistent with one another. At present a static organizational design is not possible since each of the above categories is subject to change. What needs to be aimed at is, therefore, a direct correlation of all the characteristics—technological, social, environmental, educational—that affect organizational design requirements.
7. The emerging science of socio-technical organization will need to be nondisciplinary. It cannot be contained within any one discipline, nor can existing problems be "solved" independently by existing disciplines. What one is looking for are criteria for policy decisions with respect to optimal directions of change.

Development of New Strategies of Change

1. From policy-making based on the formulation of pre-specified plans to policy-making as a learning process within organizations.

2. From the separation of research and doing, to the building of research capacities into organizations; it is no longer feasible for the research role to remain a prerogative of a privileged profession.
3. From the use of professionals as experts and implicit policy-makers to the utilization of professionals in collaborative research projects.
4. A transition in educational techniques from predominantly programmed teaching to predominantly project and research-oriented teaching.

SOCIAL MONITORING

The development of capacities for the rapid recognition and evaluation of emerging and evolving social, psychological and technological trends.

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