Ship management systems developments

1. Introduction

Ship management can be defined as the complex array of decisions required to assure effective operation and performance of a ship as a unit, as part of a fleet of ships, or as part of a transportation system.

While many aspects of ship management such as ship navigation, ship condition control (trim, stability, etc.), crewing, inventory control, maintenance, repair, ordering, accounting, and others are generally performed on the basis of historical or traditional approaches, there are many developments which may make these methods and procedures of ship management obsolete. This applies equally to ship operational as well as performance management. Ship technology, like methods of operation, has changed radically in recent years. The increasing cost of bunkers as a function of operating costs is leading to technological changes in ship design, propulsion, communication, and arrangement. Communications, information handling, data-processing, control, cargo handling and storage and other relevant technologies are now changing so rapidly that many shipboard systems become obsolete long before the expiration of their economic life.

A related issue is the impact on ship management of changes in the physical form of cargoes, integration of transport modes and services, as well as novel methods of operation of ships such as a combined containership/bulk carrier. The (increasing) participation of large corporations, multinational or transnational companies, and national governments in ship ownership and operation also influences ship management.

Jurisdiction over coastal waters has been greatly extended, and active traffic control, other control systems, and regulations influencing ship operations are continually being introduced. The enforcement of tougher environmental regulations affects the methods of ship ballasting, ballast and solid/liquid waste disposal, and other operating procedures. During recent years, the number of non-ship and non-transport users of the oceans of the world has increased greatly. Offshore resources development, fishing, and other activities actively compete with shipping not only in coastal waters but also for deep ocean space. As a result, shipping is becoming constrained. Serious consideration is now being given, for example, to the introduction of controlled ship-traffic lanes extending far into the oceans.

The increasing number of ships under flags of convenience, developing nations, or similar flags has had a major impact on the control of ship operations procedures, the qualifications of shipboard staff, and the condition and maintenance of ships. As a result, there has been a growth of interest in more international regulation of ship design features, operating procedures, manning skills, and ship automation. Lack of available skilled manpower, and the development of long-term maintenance warrantee agreements with shipyards, has resulted in a decrease of shipboard repair and increased attention to more effective performance monitoring and diagnosis. Probably the largest impact on ship management has been the integration of shipping as one mode in multi-modal total integrated transport systems. This is true even when different modes (such as shipping) are not under the same ownership or operational control as the other modes of the system.

The capital intensity of transportation in general, and shipping in particular, and the lack of control of fixed as well as major variable costs such as fuel, have gradually forced operators to aim at achieving more efficient utilization of their vessels within an integrated system. Similarly, with customers often unwilling to contract for the individual modal services in preference to door-to-door contracting, ship schedules, the physical form of cargo handling, ship arrival/departure conditions, the sequence of port calls, the speed of transit, onboard cargo maintenance, and many other ship management functions are often no longer under the sole control of ship management. This also implies that ships are increasingly encouraged to adopt or adapt to effective interface technology.

Finally, the technological revolution in information-handling, communications, and in general management systems imposes a requirement for consistency in ship management in line with the needs of fleet, company, or systems management.

Ship management, therefore, requires a much higher degree of sophistication due to the changes in

—ship technology
—organization of shipping companies
—role and function of ships
—integration of transport systems
—ship maintenance
—congestion in ship traffic lanes
—freedom of shipping and trade
—jurisdiction of shipping lanes and coastal and open waters
—environmental impact tolerance
—ownership of shipping

Future shipboard managers will require different skills in the performance of a greatly expanded range of functions, as ships become more and more integral parts of complex transportation systems subject to a variety of jurisdictions, controls, and interfaces. These skills will be superimposed on the traditional requirements of ship handling, operation, navigation, and so forth, as computers, ship automation, collision avoidance, automatic navigation, planned maintenance systems, and other developments take hold and become common features of modern vessels.

2. Shipboard management structure

Shipboard management is highly structured, with line commands and line functions rigidly defined. As noted by P. H. Fricke [1], this type of hierarchical structure was *functional* and *'emphasized the teamwork necessary in sailing ships'*. On a modern motor vessel though, teamwork is rarely required. Most shipboard tasks require a high degree of skill in all the ship departments, and most tasks are performed by *individuals*. Prestige and job satisfaction are, as noted by Fricke, a function of position in the shipboard hierarchy. This prestige once held in high esteem both for reasons of perceived skill as well as daring and romanticism, has been eroded by the fact that many traditional shipboard management decision functions were transferred ashore, while others have been transformed by innovation and electronic devices into a more technical function.

This trend, which started with the introduction of powered vessels, is now on the verge of reversal. The increasingly higher skills of shipboard staff, and their ability to use advanced electronic technology has introduced opportunities for better and more timely decision-making on board. Satellite communications systems furthermore establish instant communication between ship and shore allowing for more effective integration of decision-making. As ships became more complex and capital intensive and started to serve as components of integrated transport systems, more and more decisions were transferred ashore, the oft-stated reason being the lack of sufficient skill and training of ship's officers and crew. This idea is no longer necessarily valid, and many operators find that providing ship captains and their crew with effective control of the ship is not only possible but also preferable. Shipboard managers, if given explicit management objectives and requirements, are usually in a much better position to affect correct and timely decisions than those on shore.

It is vital, however, that shipboard management control and decision-making powers be clearly defined, and that effective procedures for the implementation and reporting of decisions be developed. It is thus opportune to consider the different shipboard management structures which recognize these important functional changes. In the future shipboard management must assume a functional rather than a line structure. A matrix approach to ship management structure which recognizes a semblance of a broad hierarchy, but which is largely based on a matrix structure, is much more in line with the actual requirements of modern ship management. Both in the deck and engine departments, watch-keeping officers basically perform identical functions. In fact, with the increasing use of bridge-controlled machinery, bridge watch-keepers will, in the future, need both navigational and technical training, as well as skills for the control of the myriad of electronic, computer, mechanical, and electrical systems under their management.

It may, therefore, be more effective to have a broad-based structure of management with ship's officers headed by a ship's master, a Chief Officer, and a Chief Engineer with all other officers of equal 'rank' divided into watch-keeping officers and officers with specialized skills or responsibilities.

The same approach could be taken in the organization of non-licensed crew. The resulting management structure would be that of a technical organization in which specialists and watch-keepers would perform their assigned functions, and be able to continually upgrade their skills. The resulting peer relationships among officers and crew respectively would be unburdened from hierarchical factors and could be expected to result in higher job satisfaction, greater visibility of job performance and ultimately a higher degree of prestige. It is felt that such an approach is advisable to assure that shipping attains the ability to stay abreast in the adaptation of new technology, unhindered by constraints of tradition and hierarchy. It would, for example, permit highly-skilled computer and electronics experts to join as licensed officers without the traditional concern of senior officers unfamiliar with new technology. Functional separation in the ship management structure would allow each to assume unique professional roles.

3. Personnel management

The demand for new skills, the decrease in permanency of shipboard jobs, and the public esteem which seafarers enjoy all produce changes in attitude, loyalty, and job satisfaction. The average age of seafarers has increased worldwide, and an increasing number of seafarers consider a shipboard job as a step in a career but not a career in itself. The average time new seafarers work on board before accepting a shorebased job permanently is now less than 10 years in most Western countries. Although the overall demand for seafarers has fallen, there is an acute scarcity of personnel with particular skills. Traditional hiring methods, however, make it difficult to advance broad-based skills, particularly where labour organizations are structured along lines of traditional skill separation. Technological changes are more difficult to introduce on shipboard because of traditional segregation, as well as the involvement of government departments, regulators, and the effect of international agreements. Attempts to set 'minimum' standards to assure an acceptable level of ship safety often result in constraints on the rate of technological adaptation and skill improvement as these 'minimum' standards are usually interpreted as *required* standards.

Work planning, a long-accepted practice in other industries, is only now being cautiously introduced on board ship. Yet it is vital if shipboard management is to assume a larger degree of control over ship management. Group sessions which encourage seafarer participation in the improvement of work-content and performance is a good way of improving internal communication and ship-management performance.

4. Social factors in ship management

The socializing process on shipboard is greatly affected by ship-management style, the cultural background of officers and crew, company rules, and the characteristics of the voyage. The personal world of seafarers is largely reduced to the organizational shipboard world, and the interaction of individual characteristics with the process of fixing, sustaining, and switching attention is therefore particularly important.

The perceived range and interrelationships of the organizational, social, and psychological variables, the 'reality' and 'affective' factors which affect their interaction with the shipboard socialization process are summarized in figure 1.

The mediating factors include such things as perceived pay-offs, explicit personal rewards (and other 'hygiene' factors), as well as the potential for autonomy and self-regulation within the work-role and social structure on shipboard. This would be most affected by a matrix-type shipboard organization and increased opportunities for education and training. Obviously, to be effective, the results of successful training must be linked with opportunities in the career structure. Rational agreement with, and expectation of general social benefits from the existence and objects of the organization

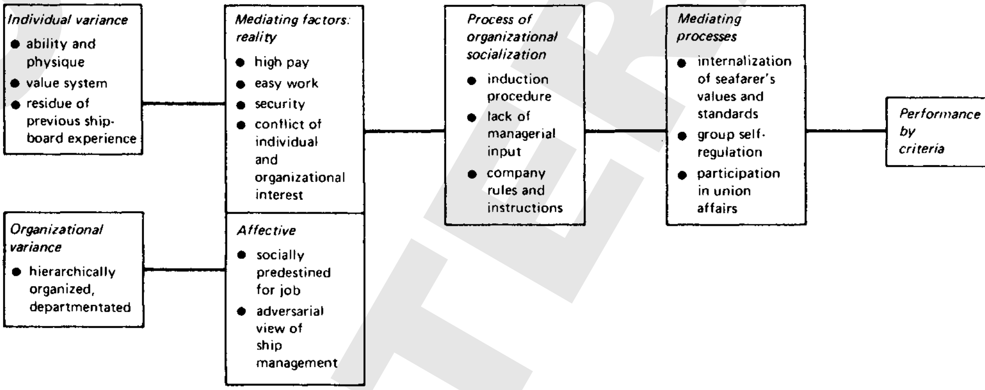

Figure 1. Major elements of the shipboard socialization process.

are also reality factors which influence seafarer behaviour and performance. These are not synonomous with motivating forces. Reality factors can be changed through the manipulation of shipboard management structures, information and decision feedback, and similar measures. These factors are influenced by the emotional evaluations of the aims and values of ship management and the company as perceived by the seafarer, and the ethical character of the shipboard social interaction, which includes consideration of prior values, such as preference regarding locus of control of behaviour, sympathy with organizational values, etc. These may be affected by the perception and valuation of the seafarer's social status by society at large; by the seafarer's perception of his own value; and by the interaction of individual and social values. For a ship management design to be successful these factors must be understood, in origin and structure.

On shipboard, group influences are generally found to be weak because of the training structure and the fragmented professional and social structure of the crew. Where larger complements exist, as on naval vessels, one might expect more evidence of group influence on the on-board socialization, and of course more explicit attention is paid to socialization of new crew members. It would appear that organizational variables are the most susceptible to adaptation, in the socialization of seafarers, if only because the surplus of recruits does not permit extensive selection on the basis of personal characteristics.

Very little is known about the effects of changes in the traditional structure of ship management on seafarer's behaviour and performance. Changes in the composition and size of ship crews as well as the rapid change in the function and skill requirements of many shipboard positions require a re-evaluation of the present shipboard management structure though, as reliance can no longer be placed on the traditional motivations, loyalties, and internal—and—external social factors. Both the role and status of the seafarer has undergone radical change. Furthermore we must recognize that increased training and skills of many seafarers in technological positions affords new opportunities of mobility to a variety of non-marine jobs which did not exist in the past.

5. Computer use in shipboard management

Great strides have been made in recent years in the adaptation of computers to the performance of many ship and shipping management functions as shown in table 1.

Micro-computers are increasingly used to develop cargo stowage and ship ballasting plans ashore and on shipboard. Similarly trim and stability calculations are now quite often performed using micro-computers or hand calculators. Computers are also used for cargo-loading/unloading control on tankers.

Weather-routeing can be performed using either shipboard or shorebased computers in combination with a satellite communication system. The need for shipboard computer use will increase with the introduction of ship traffic control.

Micro-computers now suffice for most ship management functions and a computer with a CPU-CRT 64K memory, 2 disc drives, printer, monitor, and various interfaces will be able to perform most ship management functions. Such a system is now priced at less than $10 000 (US), a sum which can be very quickly written off through savings. The problem is usually the acquisition of effective, reliable software which, if not readily available, may cost many times the cost of the hardware. Many programmes of use in ship management are available or can readily be adapted at low cost today.

There are a number of things that computers obviously excel in. They include the retention of data; calculations; the editing and aggregation of results; the listing of

Table 1. Computer use on shipboard.

Operations planning A	
Loading: cargo planning; stowage planning. Ship conditions planning; Trim Stability Ballast planning. Inventory and supplies, including optimum bunker planning. Maintenance and repair planning, including repair scheduling. Routeing; Weather routeing; Commercial routeing. Scheduling; Ship and cargo scheduling. Allocations; Fleet allocation; capacity allocation.	
Operations planning B	
Weather routeing. Ship docking. Precise steering. Collision prevention. Ship motions control Hull surveillance; Machinery surveillance.	Navigation control Propulsion machinery control. Monitoring of ship (machinery conditions). Cargo systems control (conditions). Cargo handling control. Communications; MIS: Ship traffic control.
Inventory control	
Consumable stores ordering. Spare parts inventory control and ordering.	
Cargo operations	
Trim and stability calculations. Loading plans and manifest. Checking conditions of hazardous cargo. Strength and stress under heavy loading or loads. Heel during heavy lifts. Loading of chemical and product oil tankers. Optimizing ballasting of vessels.	
General ship management	
Vessel payroll. Survey records. Planned maintenance. Ship accounts.	
Navigation	
Routeing. Course setting; Position calculations.	
Special purpose hardware	
Satellite navigation. Satellite communications. Anticollision radar. Engine room automation.	

information on orderly format; the review of plans and error detection; and the introduction and use of complex procedures by people with limited background and skill.

The computer can also provide reasons for change and improvement without personal involvement and personality clashes, and provide users with sense of status, power, and importance.

Ultimately it helps to improve efficiency of operations in direct proportion to the amount of competent effort devoted to the project.

On the other hand, the introduction of computers on shipboard will not assist in the acquisition of information or the performance of complicated non-repetitive tasks. Neither will it compensate for incompetent personnel or poor organization. Finally, it cannot exercise judgement or make decisions; nor can it miraculously save the situation, especially at short notice.

The use of computers on board ships must therefore be carefully thought out and planned. The main concern is usually with the acquisition, or design, of software, which in turn is largely based on the evaluation of communication requirements for control or decision-making, with particular consideration to:

—the availability and reliability of data;
—communication requirements and internal and external communication links;
—capacity of communication links available or required;
—transmission lag (real time, delayed, batch, etc.);
—format of data and data transmission;
—use of data and input format (if defined).

Next comes the design of the hardware configuration. Here the primary concern is usually with CPU speed and capacity, as well as input/output and storage devices. It is important that a shipboard computer system be designed for specific previously identified requirements and environment. Attempts to adjust requirements and environment to computer capabilities will usually fail.

Computers have revolutionized the management and operations of many industrial and commercial operations. Although used by shoreside shipping management for some time, multi-purpose computers have only recently been employed on shipboard. Experience with the introduction of small computers for stowage planning, stability calculations, and shipboard accounting/inventory use, has been quite good. Most modern microprocessors are 'user-friendly' and permit positive interactive operations and hands-on learning with a minimum of training. Initial objection to their introduction is usually overcome quickly through recognition by the crew of a computer's ability to reduce repetitive, monotonous tasks and to aid the decision-making process; the computer performs the menial computations and the operator makes the decisions. This permits operators to check many more alternatives in course-keeping, sequence of tank-use, stowage plans, machinery settings, and more. As noted in table 1, there are many uses for computers on shipboard which, when implemented, would free ship management for decision-making and ship maintenance functions.

This initial reluctance to accept and use computers on shipboard is gradually being overcome. Much depends on how computers are introduced, the amount of support provided, quality, reliability, and relevance of software, and the realism of the applications.

6. Low crew manning

In recent years, crews on some oceangoing tankers and Ro/Ros have been reduced to as few as 16. The USCG now permits manning by as few as 17 and some vessels such as the trailerships of Swedish Orient Line operate with a crew of 16. Reduced shipboard manning has led to the advance of the concept of a uniform ship rating for deck and engine officers and crew, which is readily justified by the increasing similarity of functions. The high degree of automation and computer use on deck and in the engine-room has led to the consolidation of ship and engine controls on the bridge, with practically all ship and engine functions remotely controllable and monitored. Ship machinery monitoring devices increasingly include performance measuring and fault diagnostics. This in turn permits more timely self-correction and adjustment or repair action. There are many concerns with the effect of reduced manning on ship reliability and performance. Indications so far are, that as long as an effective, previously planned maintenance programme is introduced and the ship has the capacity to carry occasionally a temporary repair-crew, then ships with reduced manning should prove equal in performance and reliability to vessels with more traditional manning scales.

The approach is particularly attractive with a fleet of sisterships. Effective maintenance planning, and sequential assignment of repair crews can quickly be introduced. Reduced manning also permits significant economies in the capital cost of shipboard quarters, and service facilities. A recent study indicates that a 6% savings in ship construction cost may be accomplished through the reduction of shipboard quarters from 32+4 to a 16+4 person capacity. This results in a 35% savings in deckhouse area, and somewhat smaller savings in fresh water supply system, reefer, storage, ventilation, air conditioning and other systems. Quite apart from this, machinery spaces can usually be made smaller in volume, and designed for machinery performance and maintainability with lesser concern for watch-keeping.

Reduced manning requires a completely different approach to ship management, a higher degree of training of shipboard staff and significantly more delegation of authority among shipboard staff. Across-the-board training of shipboard staff has the advantage of providing a much better appreciation of the issues, systems, and requirements of effective ship management and a comprehension of the inter-dependence of shipboard systems. With this much greater versatility of more highly-trained shipboard staff, reduced manning may actually provide more instead of less personnel on board a particular ship, who are capable of performing important functions.

7. Conclusion

The role of ship management is gradually changing. Although the traditional hierarchy is still in place, the function of officers and crew is radically different now from what it was few years ago. There are many reasons why structural changes should be introduced in ship management as well.

Technological developments have induced less hierarchical structures in many industries and operations with increasing use of interactive consultation (such as quality circles). The external image of seafarers may have diminished in some respects because of the image of traditionalism wrapped in a strict hierarchical ship management structure. Technological advances in ship management as well as job satisfaction, job loyalty, prestige, and performance of seafarers may be improved by a gradual move from the traditional structure of ship management towards a matrix type of organization with fewer hierarchical levels. This would encourage better trained but less experienced junior staff to better performance by providing them with greater responsibility while simultaneously assuring an exchange of technological knowledge and experience.