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Dual purpose training : past, present and future : integration between human resources and marine technology

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DUAL PURPOSE TRAINING - PAST, PRESENT AND FUTURE: INTEGRATION BETWEEN HUMAN RESOURCES AND MARINE TECHNOLOGY

By

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DECLARATION

I certify that the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the university.

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ABSTRACT

The dissertation is a study of the current economic pressures, new technology onboard and the different training systems which reflect the changes onboard high technology ships.

A brief look is taken at reviewing the developments and evolution of different areas in the shipping industry, namely trade, ships, machinery and ports.

Economic pressures lead shipowners to cut the operating costs. Repair and maintenance, worldwide shortage of seafarers and manning costs are illustrated as the key pressure points for shipowners to do so. The actual remedies taken by shipowners are defined.

Impact of new technology and complex equipment on shipboard operations, and the international manning situation are investigated and discussed.

Modern technology and small crew size onboard brought the need to look carefully at the characteristics, abilities and limitations of the ship operators. The role of the officer of the watch is examined, taking into account manning and technological changes that have taken place. Special attentions and examinations have been directed to the practical weaknesses of the operators on small size crew ships.

Obviously, the Maritime Education and Training systems should accommodate to and reflect the impressive technological advances in automation, communication and the economic pressures. Integrated training of some developed countries and their main differences have been described, brought out and discussed.

Additionally, a brief look is also taken at identifying the advantages and disadvantages of the integrated training systems for different groups of interest, such as shipowners, ship personnel and maritime training institutions.

Finally, conclusions and recommendations are made towards better education and training, ergonomic design and life on board modern high technology vessels to enable the shipping industry in general and **Maritime Education and Training** systems in particular to cope with the challenges offered by the momentous changes in shipping.

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LIST OF ABBREVIATIONS

ARPA	Automatic Radar Plotting Aid
BIMCO	Baltic and the International Maritime Council
C1NM	Capitaine de Premiere Classe de la Navigation Maritime
COLREG	Collision Regulations
COMOSS	Committee of the Modernization of the Seafarers' System
DPC	Dual Purpose Crew
ECDIS	Electronic Chart Display and Information System
ENMM	Ecole National de la Marine Marchande
ETA	Estimated Time of Arrival
FOC	Flag of Convenience
GLONASS	Global Navigation Satellite System
GMDSS	Global Maritime Distress and Safety System
GPS	Global Positionning System
ILO	International Labour Organisation
IMLA	International Maritime Lecturer Association
IMO	International Maritime Organisation
INMARSAT	International Maritime Satellite
INS	Integrated Navigation System
ISCS	Integrated Ship Control System
ISF	International Shipping Federation
ITF	International Transport Workers' Federation
KSA	Korean Shipowners' Association
KW	Kilowatt
LNG	Liquid Natural Gas
LSM	Lloyd's Ship Manager
MAROFF	Marine Officer
MET	Maritime Education and Training

M-0	Man - Zero
MOT	Ministry of Transport
MSC	Maritime Safety Committee
MSE	Medium Speed Engine
NAVSTAR	Navigation Satellite Timing and Ranging
OBO	Oil - Bulk - Oil
OMBO	One Man Bridge Operation
OOW	Officer Of the Watch
RPM	Revolution Per Minute
SATCOM	Satellite Communication
SCC	Ship Control System
SM	Ship Mechanic
SOLAS	Safety Of Life At Sea
SOO	Ship Operation Officer
STCW	Standards of Training, Certification and Watchkeeping
UK	United Kingdom
ULCC	Ultra Large Crude Carriers
UMS	Unmanned Machinery Space
USA	United State of America
VLCC	Very Large Crude Carriers

1. INTRODUCTION

One of the main problems facing many developed countries is that they are losing their share of the shipping market because they cannot compete with others using lower paid crews from developing nations. As their shipping declines, other parts of their marine industrial infrastructure will decline, partially because of the lack of experienced mariners to fill shore positions.

It has been suggested that a solution to that problem may be to build more efficient ships with more reliable and more sophisticated operating and monitoring systems. These ships would be designed to be operated by smaller, better educated and better trained crews.

The challenge is for developed countries to recruit their own suitable educated young people and to train them to operate the new high technology ships. In this way shipowners, who operate their own ships by their own more highly trained nationals, could compete against those using older ships or larger crews.

It is worth noticing at this stage that the necessity for crew reduction was not only forced on shipowners by increased wages and reduced profits but also by the difficulty in finding young men who wanted to go to sea anyway.

New technology onboard ships have proved that it is possible to operate a large ocean going vessel with a crew of less that 10. The present development is towards the One Man Bridge Operation (OMBO), where the officer of the watch is also in charge of engine room supervision, radio communication, cargo handling, ballasting and trimming which are combined in a single area - at the Ship Contol Centre (SCC), which is the bridge.

Indeed, complex and new technology equipment onboard must not only be able to perform its required function, but also to interact with the operator, taking into account his characteristics, ability and limitations.

Sophisticated equipment and advanced instrumentations alone are not going to be the solutions for the economic pressures. The technical personnel have to develop special skills in the efficient and intelligent use of advanced technology.

With regard to the education and training of seafarers, the trend is towards breaking up the various duties of the ship's officer on duty at the SCC into various functions. The functions are, navigation, cargo handling, ship control and care of person, marine and control engineering, electrical and electronics engineering and machinery, maintenance of the ships and communication. Maritime Education and Training systems have to ensure that they produce competent officers capable of all the above functions in order to man modern ships.

It is the intention to have a mix of officers and ratings with a combination of skills in both navigation and engineering. The main task for the crew is thus to ferry the ship from one port to the other.

2. DEVELOPMENT OF WORLD SHIPPING

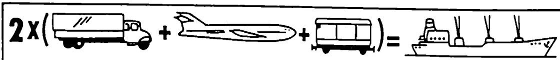
Whoever commands the sea commands the trade; whoever commands the trade of the world command the riches of the world and consequently the world itself.

H. MOSELEY, 1650.

Trade between people must be the oldest human activity. This results from the fact that others have skills or things that others need and want but have not got.

The basis of trade therefore is because different groups of people in different areas purchase different goods. Most of these commodities, about 70% of the world trade is in the carriage of raw materials, crude oil, coal, iron ore,....with much of this trade being from the developing to the developed countries.

To export or import these resources, a means of transport is needed. The cheapest known transportation mode is by sea (ship) because large ships can take a large amount of commodities at one time and they are the most fuel efficient means of moving things as shown in **Fig 2.1.**



The transportation work in ton-miles performed by ships sailing the world's oceans is twice as great as that carried by all the world's roads, railways and airways put together.

Figure 2.1: Transportation mode

Source: Rinman, T & Linden, R, (1978) Ports are a link in the transportation chain, this area of land and water permits the receptions of ships, their loading and unloading, the storage of goods, the receipt and delivery of these goods.

The major developments in these four areas are:

- trade
- ships
- machinery
- ports.

2.1 TRADE

Trade is widely spread around the globe. The largest seaborne trade is within the three principal developed blocks - Western Europe, the United states of America and Japan. The seaborne trade in developing countries is increasing steadily.

From **Fig 2.2**, it can be seen that the graph of the cargo carried by the world fleet is fluctuating. This situation occurs when the demand for ships exceeds the supply of ships and this happen very often in period of war and conflict as shown in **Fig 2.3**.

The freight depression Period from 1957 to 1967 coupled with the growth in demand of ships (Suez Crises), led to an increase of ship size and the birth of containerisation in order to cut operational costs.

When freight rates dropped in 1973 the big share of the total operational costs was the fuel, so speed was reduced. In the 1980s crew costs started to receive attention.

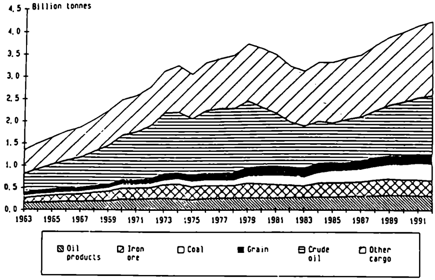
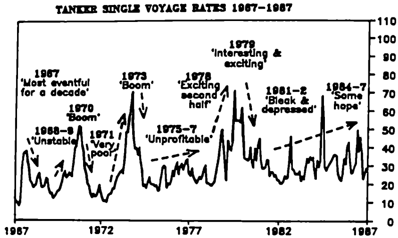
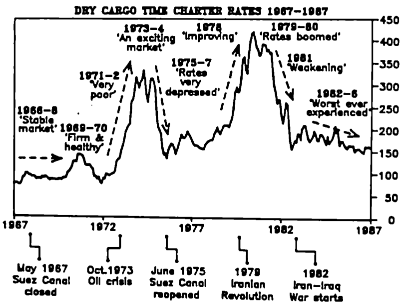


Figure 2.2: Cargo carried by world fleet 1963 -1992

Source: Shipping Statistics Yearbook 1993





Figures 2.3: Major political events

Source: Stopford, M (1988)

2.2 SHIPS

Human fascination with sea travel extends right back to the Egyptian times and before.

A wide variety of floating craft, rafts, boats and ships had been developed before the actual laws of physics relating to floatation, buoyancy and water resistance were understood.

The following are roughly the different stages in the development of the ship:

* The first was no more than a log or raft made by bundling together bamboo, reeds or brushes. Even animals skins and fruit shells were used.
* Rafts consisted of several layers of tree trunk together.
* The dugout. The side planks were added to the dugout; this eventually led to the fully planked boat, **Fig 2.4.**

After several refinements, until the middle of the nineteenth century, the latter became the large sailing ship, **Fig 2.5.**

* The transition from wood to composite construction e.g a combination of timber with iron or steel framing.
* Around the year 1850, the building of ships with iron and steel started, **Fig 2.6.**

It took thousands of years to reach the stage of iron ships and then only a few decades to see a complete transformation in sea transport.

In fact with the introduction of the high pressure boilers and the multiple expansion steam engines at the end of the 19th century, the size of both steam and wind driven vessels increased rapidly at first, then a standard with engine plus sails was not established until the First World War.

The First World War began a change in technology but it was slow. Liquid fuel oil started to take the place of coal. General cargo were carrying break bulk by liners and tramp ships all over the world. The cargo handling was by derricks or cranes in the most developed ports. The cargo carriers of the world steamed between 9 and 14 knots. The oil tankers did not exceed 12,000 tons deadweight but their number increased with the spreading use of fuel oil.

The Second World War did change almost everything. The main factors of the changes related to the shipping were:

* The break down of the established empires and their trading systems leading to new men and new ideas in techniques shipping.
* The massive development in methods of moving men and materials- artificial harbors, mobile landing ramps, forms of containerization, bow and stern doors and ramps... these were developed for the D DAY operation at the beaches of Normandy in June 1944. These developments are still in life on the marine scene.
* The pressure of the war brought into being the basic tools of today- electronics, radars, ship welding and computers.

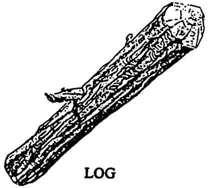
After the Second World War, there were considerable changes in the marine transport field. New types and sizes of tankers for carrying liquefied petroleum and natural gases came into being.

The importance of Middle East oil to western countries and to the United States of America was growing rapidly. However, the Suez crisis, the nationalization of the Suez Canal by the Egyptian government in July 1956 and the Israeli-Egypt war in May 1967 resulted in the closure of the Canal. The oil carriers had to take the route around South Africa. In order to keep down the cost of fuel oil, it was necessary to build bigger tankers. The race for the Very large Crude Carriers (VLCC) and the Ultra Large Crude Carriers (ULCC) was on.

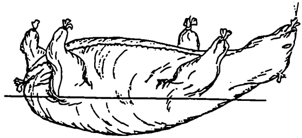
One of the characteristics of oil tankers is that they make one way of the voyage loaded and the other in ballast. So to overcome this uneconomical way, the introduction of multi-purpose vessels, i.e. the oil/bulk/ore (OBO) was developed. Such ships can carry oil on one way and various bulk cargoes on the other.

General cargo ships have seen a change in size but far more in type and concept because of the slow cargo handling on and off. The ship spends half or more of her time in port and only half at sea. In addition, the rise of labor costs and unit value of goods resulted in the introduction of the concept of **UNITIZATION**, which gives considerable pace to the shipping world, especially for the world's cargo handling.

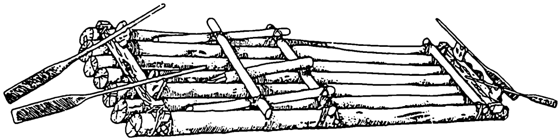
The result of this was and is **CONTAINERIZATION**; then the container ship and the RO-RO ship came out. Since the advent of these types of ships, the turn round times has been reduced by new cargo handling techniques. This means that the crew spend most of their time on board ship.



LOG

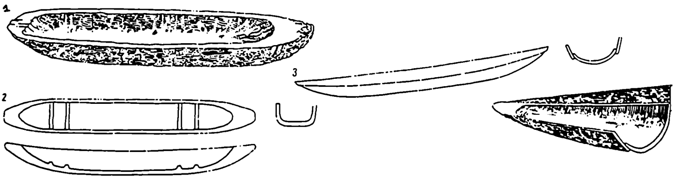


SEWED AND WATERTIGHT ANIMAL SKINS



LOG RAFT

* Binding together several logs was the first process in stability
* Improving the support by fitting cross beams over the log raft



Dugouts at various stages of development:

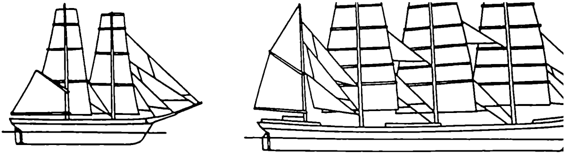
1- Thick-walled dugout, simple hollowed log

2- Thin-walled dugout with transverse stiffening members left projecting

3- Dugout with planks added

Figure 2.4: Different stages in the development of ships

Source: Dudszus & Henriot, (1983)



TWO MASTERS SAILING SHIP

FOUR MASTERS SAILING SHIP

The largest wooden ship was the Pennsylvania: 210 Feet

Figure 2.5: Wooden ships

Source: Dudszus & Henriot (1983)

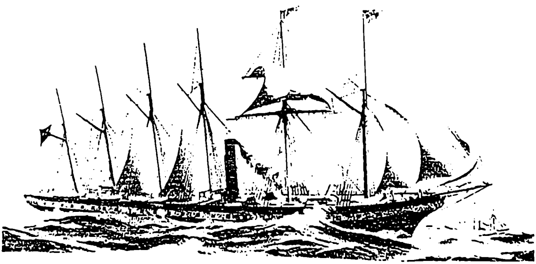
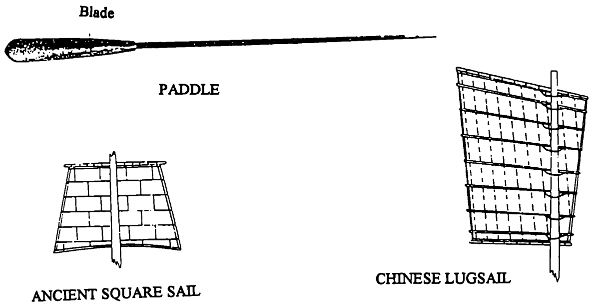


Figure 2.6: SS Great Britain - the first iron ship built (1843) and the first ship to be fitted with a screw propeller. The transition from wood to iron resulted an increase in ship size

Source: Brouwer, N.J, (1985)

2.3 MACHINERY

The whole story of the propulsion mechanism began by the natural power of flowing water for journeys down stream very early on, against the current, by man power with hands, poles, paddles, oars and later sails, **Fig 2.7.**



Boat Type	Striking Rate per Minute	Speed in Km/h
One man (6-7m lenght)	25 - 30	13.5
Two man (around 10m lenght)	28 - 32	15
Four man (around 12-13m lenght)	30 - 40	16
Eight man (around 16-18m lenght)	35 - 40	17.5

The usual striking rates are between 32 and 36 strokes per minutes, but the rate can be increased up to 44 per minute. This is the relationship between boat types, striking rates and speeds

Figure 2.7: Different means of propulsion

Source: Dudszus & Henriot, (1983)

With the advent of steam power, the paddle steam ship was created, and the first application was by Jonathan Hulls in 1737, **Fig 2.8.** Later on came the steam boat. The first vessel in the world using steam propulsion commercially was the Charlotte Dundas built in 1801, shown in **Fig 2.9.** Improvements were made between 1865 and 1880 with the introduction of the high pressure boilers and the multiple expansion steam engines, **Fig 2.10.**

In spite of the fact that steam engines generate little vibration, the steam turbine ships are on decline because of its high fuel consumption compared to the diesel engine. However, the steam turbine are suited for Liquid Natural Gas (LNG) tankers where the boil-off gas can be burned as fuel for the boilers.

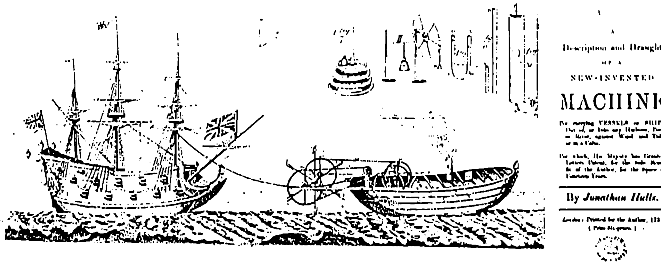


Figure 2.8: Jonathan Hulls featuring his proposed paddle steamer in 1737. For towing larger vessels, the boat was provided with a paddle-wheel at the stern

Source: Cornwell, E.L (1979)

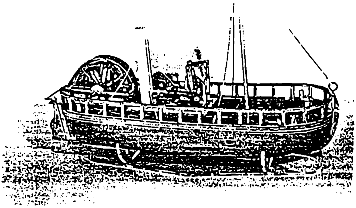


Figure 2.9: A model of the Charlotte Dundas which is the first vessel in the world using steam propulsion commercially (1801)

Source: Cornwell, E.L (1979)

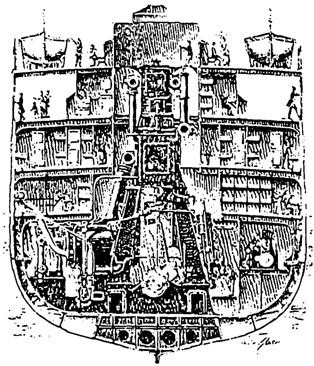


Figure 2.10: Steam reciprocating engined ship (multiple expansion engine)

Source: Alan, Cameron & Roy, Fardon (1984)

Nowadays, the efficient main engine for ships worldwide is the Diesel Engine developed by Rudolph Diesel and others. This compression-ignition engine burning heavy oil went to sea in 1913, which was a period of great activity, **Fig 2.11.**

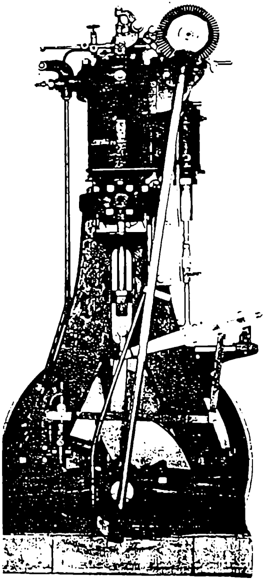


Figure 2.11: Rudolf Diesel's experimental engine of 1893 which was rebuilt and redesigned before successfully going on trial in 1895, it is now preserved in the MAN works museum at Augsburg

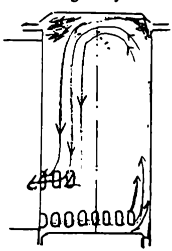
Source: Cornwell, E,L (1979)

In fact, the diesel engine comes in two basic forms: the slow speed diesel and the medium speed diesel.

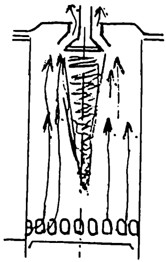
A large families of licensees worldwide constructed oil engines to their own ideas: MAN in Germany, KRUPP in Germany, SULZER in Switzerland, BURMEISTER & WAIN in Danemark, CARELS in Belgium, NOBEL in Sweden, WERKSPOOR in Holland and MIRLEES WATSON in Scotland.

In the early 19th century, a double action compression engine was necessary to obtain higher power. However, the complication of the double action system in the Four Stroke engine led to a change to the Two Stroke cycle engine.

The power output of the Diesel engine was pushed up by turbocharger and by increasing cylinder bore size. Therefore, the double acting engines were abandoned and all the engine builders adopted the much simpler single acting Two Stroke with a loop or uniflow scavenge air system shown in **Fig 2.12.**



LOOP SCAVENGE AIR SYSTEM



UNIFLOW SCAVENGE AIR SYSTEM

Figure 2.12: Different types of scavenge air system

To give an idea of scale, a typical slow speed diesel engine with bore 1.05 m, stroke 1.80m running at 105 RPM would develop 2948KW per cylinder. A 12-cylinder version engine would weigh around 1,600 tons and be nearly 26m in length and with an overall height of 14m. This is a "Cathedral" engine.

On ships such as Ro-Ro vessels and small container ships, there is a tendency to standardize the medium speed engine at approximately 400-500 RPM. Such engines are fitted with a gear box which lower the revolution per minute in order to improve the efficiency of the propeller.

Currently, design, refinement and prototype testings is immensely expensive, but has resulted in specific fuel consumption being reduced by 25% during the last two decades, from around 155g per brake horse power in the 1970s to about 115g per brake horse power in the 1990s.

Reduction of fuel consumption had two benefits for the engine builders. The first is that it has driven out the steam turbine and the second is that all the small license families who were not able to afford such programs have fallen out of the market. So far the biggest known manufacturers are MAN-B&W, SULZER, MITSUBISHI, PIELSTICK, MAK and WARTSILA.

2.4 PORTS

Ports were simple landing places on river banks where shallow draught vessels could come along side and load or unload their cargoes. The essential problem was shelter from the weather. The movement of cargo on and off the vessels was only manual, e.g the loading of coal as shown in **Fig 2.13.**

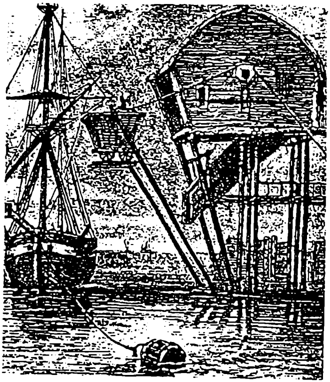


Figure 2.13: Coal drops in curvilinear fashion, with pivot to allow for fluctuation water level. This is a simple landing place (port)

Source: Gordon, Jackson (1983)

As the demand for trade goods increased, more and larger ships with the need for more space to receive them were required. So, the simple landing place developed into a port.

Port traffic increased and one of the most vital considerations in port development, beyond the depth of water and the shelter for vessels, was the clearance of cargoes fulfilled by the advent of the rail in the middle of the 19th century.

In the 20th century, road transport filled the space between the lines of the railway to give surfaces for the larger lorries which reach the quay side and have the ability to deliver goods right to the customer door.

The building of larger and specialized ships such as Ro-Ros and container ships occasioned some problems:

* The necessity to dredge the port, to build new berths or even new ports.
* The handling facilities for this new specialized ship-container gantries, grabs for bulk ore, suction pumps for grain.
* The requirement for more space and parking areas.
* The need to create maritime services- pilots, tugs, maintenance of facilities.

These are mainly the general development aspects of ports but from the above said, it can be concluded that ports are rather followers than leaders of maritime developments.

2.5 CONCLUSION

One of the main reasons for the existence of the marine industry is **World Trade**. It provides our bread and butter, as well as helping to finance the development of the industry.

Nowadays, **ECONOMY** and **PROFIT** have become a very important words to the shipowner. The competition for the International Shipping Market has become intense. Containerisation, Flag of Convenience registries and technology have contributed to this. To operate a merchant ship in an international environment requires a shipping company to compete with operators from all over the world.

The major operating expenses for a merchant ship are the cost of capital, fuel oil, manning, maintenance and repair, management, fees and dues, etc. The variation of these costs is minimal between similar ships even when they are registered in different countries, **EXCEPT** with regard to **MANNING**. Therefore, to compete internationally, shipowner has expressed increasing concern on crewing cost variances, but **HOW?**

3. STUDY ON ECONOMICAL AND POLITICAL ASPECTS OF TOTAL SHIP OPERATION COSTS

PROFIT - is an answer among others for the question
" Why operate or own ships? ".

A long time ago, we learned the following equation by heart:
PROFIT = REVENUE - COSTS.

It is also known that shipowners are price takers not a price makers, which means in simple words, **Maximum Profit at Minimum Costs**.

This chapter tries to define the shipping costs, identify some problems acting as key pressure points in operating costs and specify how managers and shipowners are trying to escape from high costs.

3.1 COSTS CLASSIFICATION

The shipping costs are classified into four categories, namely:

3.1.1 Voyage Costs (Variable costs)

These variable costs associated with a specific voyage and include such items as: fuel, port dues and charges (harbour dues, wharf dues, light house, buoys, pilotage, towage and port authorities, agency fees, etc.)

3.1.2 Capital Costs (Fixed costs)

These cover the cost of ships as well as the annual charges required to recoup the purchase price over the vessel's trading life and include such items as: planning, management of firm, accounting, banking costs, etc.

3.1.3 Cargo Handling Costs (Variable Costs)

These are variable costs as their amount varies with the quantity and nature of the cargo handled to/from the ship and include stevedores, dunnage, etc.

3.1.4 Operating Costs (Fixed Costs)

These are the expenses involved in the day-to-day running of the ship such as: manning, stores and lubes, repairs and maintenance, insurance, administration.

3.2 KEY PRESSURE POINTS IN RESPECT TO OPERATING COSTS

3.2.1 Crew Costs

The aim of shipowners is to achieve the best optimum cost benefit in ship handling by the reduction of operational costs.

Manning within the operational costs is not only the direct expenses of salaries and wages of officers and crew but also related to social insurance, pension contributions, the costs of crew repatriation from foreign ports and victualling.

After capital and fuel costs, manning represents the highest individual cost incurred by the shipowner and it is not unusual for manning costs to account for as much as 50% of the total operating costs. This applies particularly to the higher cost flags such as North Europe, USA or Japan and to the higher grade services like those deploying sophisticated container carriers, liquid gas carriers, complex gas carriers or reefers. These cost variations are shown in **Fig 3.1 and Fig 3.2.**

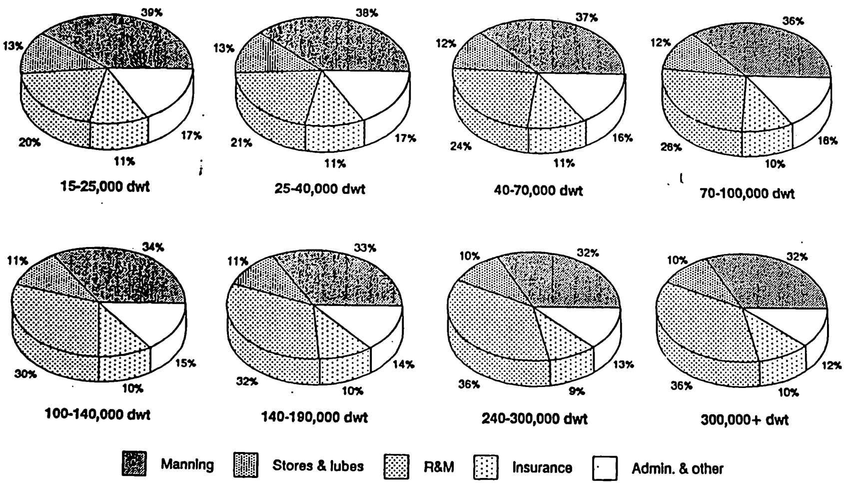


Figure 3.1: Variations in tanker operating costs by vessel size (% share)

Source: Operating costs survey, lecture notes, (1994)

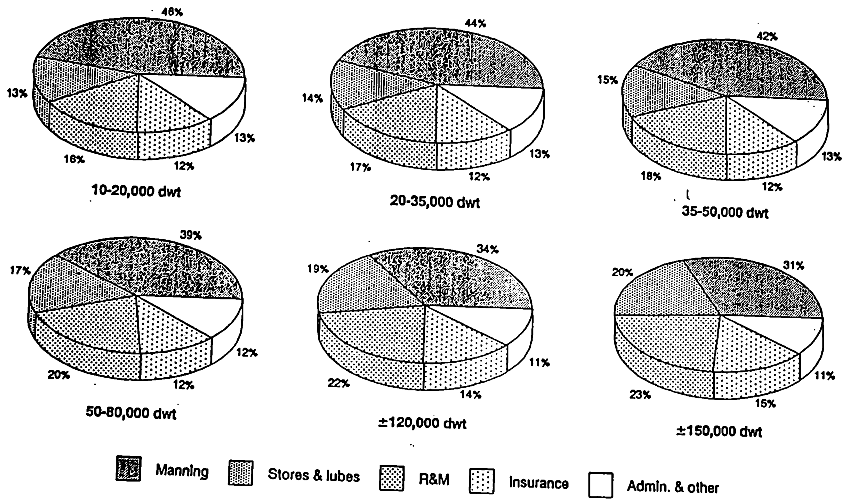


Figure 3.2: Variations in bulk carrier operating costs, by vessel size (% share)

Source: Operating costs survey, lecture notes, (1994)

3.2.2 Repairs and Maintenance Costs

The world fleet is ageing partly because of a boom in orders that occurred two decades ago. In the early 1970s the demand for oil was rising. Freight rates were high and many shipowners ordered new ships, especially VLCCs, as a virtual guaranteed way of making huge profits. In 1973 the price of crude oil was suddenly raised so the expected increase in consumption fell. Therefore, the amount of oil transported by sea fell as well. Very rapidly there were too many ships chasing too few cargoes. Later on, as there was so many tankers available, new tonnage being ordered fell; therefore, manyshipyards closed because of lack of work.

Today, 22 years after the last biggest boom, the industry is still suffering the consequences. According to Bimco Bulletin 5/93, September/October, page 7:

> " A large tanker expect to earn only 10,000-15,000 USD a day. A replacement would cost 100 million and would need rates of 50,000-80,000 USD a day to cover the cost."

It is not surprising, therefore, that many owners prefer to keep their ships as long as possible. As a result, according to Statistics and Market Review N° 1/2, January/February 1995 page 5:

> " As of January 1st, 1995, 58,4% of all merchant ships representing 49,8% of total tonnage (dwt) were older than 14 years. The overageing problem is especially serious for oil tankers and cargo passenger ships, but also for general cargo ships. At the beginning of 1995, the world merchant fleet had on average an age of 17,3 years, where as container ships represent with an average of 11,6 years the youngest fleet."

As shipowners seek to extend vessel trading lives, obviously ship repair and maintenance rise and the majority of the high costs in this component is attributed to older tankers, general cargo and passenger/cargo passenger ships as shown in **Fig 3.3.**

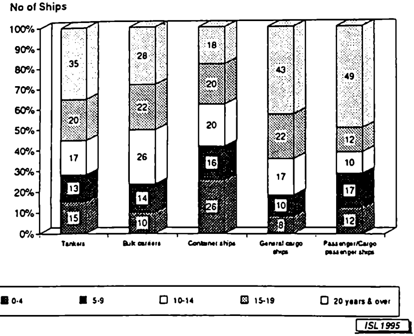


Figure 3.3: World merchant fleet - age structure by major ship types as of January 1st, 1995

Source: Shipping statistics and market review number ½ January/February 1995

3.2.3 Shortage of Seafarers

The first worldwide study of the supply and demand for seafarers was instituted in October 1989. At the command and funding of the Baltic and International Maritime Council in Copenhagen (BIMCO) and the International Shipping Federation in London (ISF). This analysis has been undertaken as a piece of independent research by the Institute for Employment Research at Warwick University.

Its aim has been to describe the present state of the labor market for seafarers and to make a tentative forecast of how this is likely to change between now and the end of the century.

The research team undertook three worldwide surveys, covering

* the total supply of qualified seafarers,
* the demand for them from companies and
* the training situation.

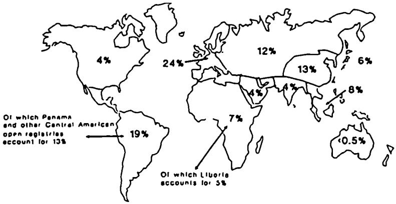
The results of the analysis indicate that in the year 1990 the total number of seafarers available to the industry throughout the world was about 1.2 million of which 400,000 are officers and some 840,000 are ratings.

The demand for seafarers was 1.06 million, of which 450,000 were officers and 610,000 were ratings. The simple conclusion was that there was a shortage of 50,000 officers and a surplus of 230,000 ratings.

The report does not go as far as analyzing the effect of the current shortfall of officers on vessel operation but says that some instances of ships could not sail for lack of crews.

Closer study of this research reveals considerable variations. For instance, Europe supplies 16% of the world's seafarer population but uses 24%, whereas the Far East supplies 22% of the seafarers but employs only 8% as shown in **Fig 3.4.**

Total World Seafaring Supply • 1.2 million



Total World Demand for Seafarers in 1990 is estimated at 1.06 million

Figure 3.4: World supply and demand of seafarers, (1990)

Source: Final report of the research ISF/BIMCO, (1990)

In a more recent survey conducted by the Korean Shipowner's Association (KSA) among shipowner's associations in Australia, Bangladesh, China, Hong Kong, Indonesia, Japan, Korea, Malaysia, Pakistan, the Philippines, Sri Lanka and Taiwan, the KSA found 38% of the crew available come from the Philippines with 136,000, China has 80,000 seafarers, Indonesia 50,000 and Korea 31,000. The survey predicts that by the end of this decade, China will replace the Philippines as lead supplier with 122,000 crew and Philippines will decrease to 67,000 (Seatrade Review February 1994).

According to Bimco Bulletin. Volume 89. No 2. April 1994, page 35, divulged that an important agreement was set up between the Vietnamese government, its crewing agency and the All Japan Seamen's Union, which will permit Vietnamese crew to serve on a number of Japanese owned short sea ships. They will replace Philippine crew, who are more expensive. Some 15,000 trained ship's crew are expected to be available on the open market in the medium term, a further 10,000 later. This will allow Vietnam to join the international manpower suppliers.

The ISF/Bimco study also revealed that the average age of ratings in the Indian sub-continent, which is one of the big suppliers, was alarmingly high and that there were virtually no younger generations to replace them. The report showed that the average age of these ratings fell in the 50-60 year old category. It said there were very few in the 40-50-year category and less in the 30-40-year category because recruitment had been very poor in recent years. The report said that a significant percentage of the supply of ratings from the Indian sub-continent would retire every year for the next 10 years and would not be replaced, **(see Appendix 1)**.

In order to forecast what will happen over the next ten years, the investigating team of the ISF/Bimco research have made assumptions and identified the following four important key issues: two affecting demand factors and two others affecting supply:

* Changes in the number and type of vessels;
* Changes in manning requirements;
* Wastage rates of qualified seafarers;
* Number of new entrants or cadets qualified each year.

The forecast study reaches the conclusion that by the year 2000 there is likely to be a shortage of 400,000 officers and more than 350,000 ratings to crew the world's merchant fleet.

The ISF/BIMCO joint study on worldwide demand for and supply of seafarers has forced the shipping industry to focus its mind on the manpower problem. Effectively, it was reported two years later that the number of trainees had doubled in 1992 in a study conducted by the ISF in Indian manpower. (Seatrade Review February 1994, page 99).

Perhaps the most significant development following the ISF/Bimco report is the progress which has been made towards the revision of the 1978 Convention on Standards of

Training, Certification and Watchkeeping (STCW).

It is inevitable that the shape of the world fleet will change with time; the number of ships reaching the end of their useful life is accelerating whilst the operational costs having bottomed in the mid-eighties is starting to rise, **Fig 3.5.**

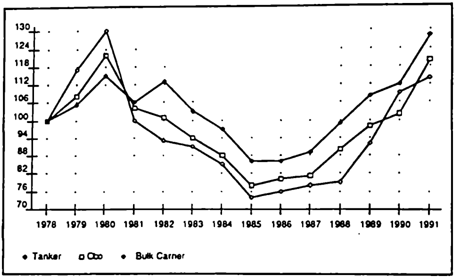


Figure 3.5: Relative movements in total operating costs, based on vessel of 120,000 dwt. (1978=100)

Source: Seaways, December 1992

The shortages of seafarers push crew costs up. Managers and shipowners should be prepared for this important element of daily costs as shown in **Table 3.1,** to continue to rise quite sharply due to the need to retain their personnel. A worse scenario might happen where shipowners and operators will not be able to control their costs as they will bid against each other for crew.

Handysize bulk carrier*

	1980	1985	% change	1990	% change	1995	% change
$'000/day							
Crew	1,233	1,603	30	1,932	21	2,835	47
Stores & equipment**	178	233	31	329	41	461	40
R&M***	164	274	67	548	100	769	40
Admin/management	137	288	110	397	38	507	28
Total	1,712	2,397	40	3,206	34	4,572	43

SOURCE: V Ships

NOTES: * Mid-1970's-built, open flag, European officers/Asian ratings; * exc lubes; *** exc drydock; forecast in late 1991.

Table 3.1: Vessel operating costs 1980 - 1995

Source: Costs: pressure on profits, (1993)

3.3 REMEDIES TO THE HIGH OPERATIONAL COSTS

3.3.1 Flags of Convenience

Many shipowners tried to cut costs by registering their ships under what are called Flags of Convenience (FOC) or Open Registers.

Open Registry began to be practiced at the end of the 1950s. It was used mainly by American companies especially oil companies who to escape very high American wage costs, built ships for registration in Liberia. The same case for Greece where the political unrest made it difficult for Greek shipping companies to obtain credit on the international market to built or buy ships that were to be registered in Greece so they registered their ships under Flags of Convenience, usually that of Liberia.

The Convention on the High Seas, Geneva 1958, Article 5 states:

> " Each state shall fix the conditions for the grant of its nationality to ships, for registration of ships in its territory, and for the right to fly its flag. Ships have the nationality of the state whose flag they are entitled to fly. There must be a genuine link between the state and the ship; in particular, the state must effectively exercise its jurisdiction and control in administrative, technical and

social matters over ships flying its flag."

The above article means that the shipowner has the responsibility to comply with all the rules and regulations prescribed and promulgated by its flag state including those that are imposed by international maritime conventions.

Unfortunately, it has been observed that some flag of convenience states have less stringent vessel inspection measures, much lower taxes and they permit shipowners to hire crews from anywhere, while the traditional countries sometimes say that at least some crew members must be their own nationals and they may also insist that crew numbers must not fall below a certain level.

Such FOC states are attractive to shipowners whose vessels would not be acceptable on safety grounds under other flags and whose country has high taxes and crew wages.

Depending upon the flag under which a ship is registered and the nationality of the crew on board, crew costs, as a percentage of the total operation costs, vary from 30% to 60%.

Table 3.2 shows that United Kingdom flag operators can still save about 50% on crew costs by flagging out. The crew cost employed on UK managed vessels under open registers was reported to have risen by 3% per year more than the cost of crew on UK flag vessels. Although this annual crew cost increase within the open register as shown in **Table 3.3**, it has a long way to run before the differences with domestic costs will disintegrate.

In other words, under flags of convenience, it is the company, not the law which is the guarantor of conditions on board. Each FOC state has his own status and requirements as can be seen from the list in **Appendix 2.**

	Filipino	*British*	*American*
Master	3,215	5,775	15,750
Chief Officer	2,080	4,990	12,230
Chief Engineer	3,025	5,300	15,225
Bosun	1,205	2,835	6,300
AB	1,005	2,100	4,515
Total crew cost: ($/year)	**436,000**	**846,000**	**1,970,000**

NOTES: Typical crew costs for a handysize tanker with a complement of 24 seafarers calculated by taking basic wages for the number of crew in each position and adding allowances for 'overlap' to cover travel, the cost of travel, leave as well as support costs and agency fees.

Table 3.2: Typical crew costs ($/month)

Source: Lloyd's Shipping Economist, June 1992

Management	*Fleet under national flag*	*Fleet under open registers*
UK	7	10
North European	5	6
North American	8	12
Far Eastern	—	12

Table 3.3: Annual crew increase (1990/1991 % change)

Source: Lloyd's Shipping Economist, June 1992

3.3.2 Second Registers

According to the International Transport Workers' Federation (ITF), the Second Registers copy Flag of Convenience countries in many respects, but consist mostly of nationally owned vessels. Any non nationally owned vessels on these registers are automatically classed as FOC. The Second Registers list given by the ITF Seafarers' Bulletin N°9 in 1994 is as follows:

Denmark (DIS), Germany (GIS), Isle of Man (UK), Kerguelen (France), Luxembourg (Belgium), Madeira (Portugal) and Norway (NIS).

3.3.3 Ship by Ship Basis

In these Ship by Ship Basis registers, the ITF recognizes that a majority of the vessels on the register are national, but there is also a substantial number of FOC ships also on these registers. Each ship is examined individually. The list of the Ship by Ship Basis according to the ITF is as follows: Hong Kong, the Philippines and Singapore.

3.3.4 Bareboat Chartering

The traditional way where the charterer exercises full control in operating the ship, crewing and securing certifications and insurance is Bare Boat Chartering. A number of shipowners act with charterers who perform only as dummies where the latter turns over the chartered ship back to the shipowner for full operation in exchange for renumeration.

In such cases, responsibility and accountability over the vessel's operational deficiencies become complex since the vessel is able to fly dual flags.

Within the world merchant fleet, 40% are registered under open registry as shown in **Fig 3.6**. The four practices mentioned above leave much to be desired. Their result is shown in **Table 3.4**, which may be regarded as not self-serving but it shows that a considerable percentage of vessel losses are those of FOC registries. Their average age is 17.7 years. This last figure clearly demonstrates the voluntary profit motivation at the expenses of " Safe Ships and Clean Oceans."

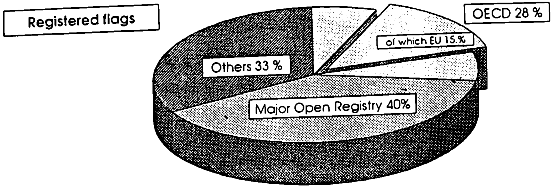


Figure 3.6: World merchant fleet by country groups as of January 1st, 1995. (% of dwt-tonnage, based on ships of 1000 gt and over

Source: Shipping statistics and market review number ½ January/February 1995

YEAR	VESSEL REGISTRY		TOTAL VESSELS LOST	PERCENT OF FOC TO TOTAL
	TRADITIONAL	FOC		
1988	2	1	3	33.33
1989	7	6	13	46.15
1990	3	9	12	75.00
1991	11	8	19	42.10
	AVERAGE PERCENTAGE			49.14

Table 3.4: Dry bulk cargo vessels lost totally with cargo 1988-1991

Source: Manning and training conference, 31 and 1 November 1992 at Singapore

3.4 CONCLUSION

The trend in shipping is for compagnies to register their ships under a flag which imposes low taxes and enables them to select crews from anywhere in the world. This means crews who are willing to work for low wages, resulting in lower manning costs.

However, the other solution for ship owners and some developped countries is to build more efficient ships with more reliable and more sophisticated operating and monitoring systems. That is to say, high-tech ships operated by small crew size, thus much lower manning cost which reduces the overall operating costs.

4. THE INFLUENCE OF MODERN TECHNOLOGY ON SHIPBOARD OPERATIONS

As shipowners wish to maximize the effectiveness of their ships, searching for a faster turn round and seeking to reduce the overall ship costs, the world has witnessed, in these last few years, a worldwide development and introduction of new systems in all key aspects of ship operations, such as bridge operations, engine control and operation, communication, mooring operations, cargo operations and not least the size and composition of crews.

Indeed, in the last few years, the talk is about an Integrated Ship Control System (ISCS) and the One Man Bridge Operation (OMBO).

The intention of this chapter is to review and to examine the impact of modern technology on shipboard operations and the international manning situation.

4.1 SHIPBOARD OPERATIONS

The challenge to shipping is to increase cost efficiency in ship operations and to improve safety against hazards to the ship. The previous chapter 3 has showed that manning costs are the main element to focus on in order to cut the operational costs.

Reduction in manning means that the crew workload should be reduced; therefore, the question that arises is:
How to reduce the workload without affecting the ship safety ?

In order to be able to answer this question, the needs need to be established, or to be more accurate, the functions to be carried out by the reduced crew, which may affect the workload.

The basic functions are:

* Navigation
* Ship propulsion machinery
* Manoeuvring and mooring
* Cargo handling
* Communication.

It should be kept in mind that the workload may vary depending on two main areas:

* The internal conditions such as competency of the crew and the technology available onboard.
* The working environment such as navigating in narrow waters which may require continuous and more accurate position-fixing. This creates a heavier workload than navigating in ocean areas which require longer intervals between position-fixes.

4.2 TECHNOLOGY DEVELOPMENT

Gufliemo Marconi's invention of wireless equipment (radio) in 1895 is the spark of the revolution in maritime technology today. The subsequent development of his invention is the Radio Direction-finding such as the actual Radar, which is a product of the Second World War. This application of Radio Echoes paved the way for more advanced technology and equipment development.

4.2.1 Ship Propulsion Machinery

According to Kinosita, T (visiting professor to the World Maritime University), stated that:

> "The birth of the Japanese first world ship "Kinkasan Maru" completed and delivered in 1961, in which the main engine was remotely started, stopped and manoeuvred from the bridge, has pioneered moves towards greater ship automation in the world".

Actually, the manning level for normal operating conditions is already zero. However, during engine operations, several basic measures need to be checked or determined and evaluated at regular intervals by means of thermometers, pressure gauges, tachometers and indicators.

Some measures have to be taken every day whereas others such as the indicator cards which serve the purpose of enabling the operator to follow alterations in the combustion conditions, and the general cylinder conditions have to be taken once or twice a month. It is important that the engine measures are continuously kept under surveillance in order to assess the general engine performance and assist in discovering operational disturbances at an early stage, and thereby preventing their development.

As these calculation procedures are time-consuming, and tedious, there are very often omitted due to lack of time. Computerization of engine automation systems which use expert software to monitor, control and even give a diagnostic in case of trouble, is common today.

The computer based expert system could be placed on a number of workstations, such as the bridge, control room and chief engineer's cabin or other vital areas of the ship.

The screen of the computer could display color mimic diagrams, bar graphs or status of the machinery shown by color symbols and text by using a tracker ball, finger touch screen or a key board.

In case of an alarm, as an example "Low level fuel oil settling tank", the officer of the watch (OOW) from the bridge, selects the relevant mimic diagram by pressing one or two keys. The system will then tell him how much fuel is left in the tank and if he decides, for instance, to fill the tank, pumping fuel from one of the bunker tanks. He merely selects the tank and the pump, and the system automatically carries out the task.

A number of routine operations can be handled in this way from the bridge, without calling the engineer or shifting the attention of the OOW from his primary duties.

An example of diagnosis is shown in **Fig 4.1.** The figure shows a model of a typical heavy fuel oil plant. It has been diagnosed that pump BA-PM02, which pumps fuel from the settling tank, via the preheater and the separator to the service tank, has insufficient pressure. By process of elimination, the system displays the appropriate action, in this case "filter cleaning or replacing".

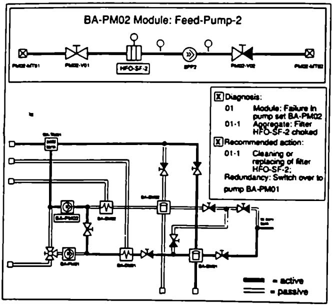


Figure 4.1: Example of a diagnosis in the case of a choked filter

Source: Marine Engineering Review, December 1993

Via the keyboard the operator has full interaction with all displays from the screen; the OOW can remedy any problem that does not require the presence of personnel in the engine. The modern diagnostic system, besides supplying the watchkeeping and alarm functions, it also pinpoints the cause of the trouble and facilitates instant action.

It thus relieves the operator from routine surveillance tasks in order to concentrate on keeping the engine in optimum running condition and related economic matters.
The expert system is a decision support capability which gives clear explanation on screen on what is happening during a process or malfunction and what must be done immediately to avoid any hazard.

4.2.2 Navigation

4.2.2.1 Collision Avoidance

The black round holes that officers spent hours peering into, are now a thing of the past since the advent of the radar, the automatic radar plotting aid (ARPA) and collision avoidance systems.

The word RADAR is an acronym derived from the words Radio Detection and Ranging. It is a method to determine distance and direction of objects by sending out a beam of microwave radio energy and detecting the returned reflections. It can be used in all conditions of visibility, but is particularly useful in poor visibility and at night. However, the radar can only tell us what the other vessel's captain is doing, not what he will do, or continue to do, or what you will do to avoid a collision situation. Indeed, a radar operator uses a relatively complex geometric and time consuming calculation procedures to track targets and analyze their movements.

Various attempts have been made to produce an aid to avoid collision, to assist the mariner in resolving the continuing problem of tracking targets, plotting and analyzing other ship movements when faced with heavy traffic and thus reducing the workload.

The final product from research has been the Automatic Radar Plotting Aids (ARPA). The Performance Standards for ARPA are discussed in the IMO Resolution A 422 (XI). In brief, on request by the operator, ARPA can track, display, process and continuously update the information of at least 20 targets in automatic acquisition and 10 targets in manual acquisition. It has also the the capability to stimulate the effect on all tracked targets of an own ship manoeuvre without interrupting the updating of target information. Further, it has the capability to warn operators by visual or audible signals in case a tracked target closes the range or transits a zone chosen by the operator. In the resolution, many others features are discussed in different areas, such as equipment used with ARPA, accuracy, performance tests and connections with other equipment.

The role of ARPA is to take data from the radar sensor, store the data in a database to obtain the relevant information and then display the data to the observer. The role of ARPA is thus seen to be the extraction and analysis of data, relieving the watch officer from a tedious and time consuming task. ARPA does not usurp the decision making role of the mariner, although the increased level of information and rapid appreciation of trial manoeuvres make it a powerful tool in assisting the operator to make a decision.

In spite of the improvement made by ARPA in collision avoidance and in time saving, in contrast with the traditional radar, many trials and research projects are underway in order to develop an expert system to be applied in collision avoidance. Research explores the possibility of an intelligent system, also called knowledge based collision avoidance system which could give solutions to problems; thus, assist navigators in solving both complex and simple collision problems more accurately and effectively. Using an expert system will increase ship safety, relieve the expert mariners on routine tasks and reduce further workload for the navigator.

However, at the time being, according to Safety of Life at Sea (SOLAS) V/Regulation 12 (j) (i), all the ships of 10,000 gross tons and upwards are required to be fitted with an ARPA complying with the relevant IMO performance standards.

4.2.2.2 Electronic Charts

The paper chart has been the fundamental navigational tool for centuries. All vessels are obliged under national and international rules to carry full appropriate and up-to-date charts to the voyage undertaken.

Safety of Life At Sea (SOLAS) V/Regulation 20 require that:

> "All ships shall carry adequate and up-to-date charts, sailing directions, lists of lights, notices to mariners, tide tables and all other nautical publications necessary for the intended voyage."

Updating a paper charts means that charts need a correction which is an unpleasant task but essential. The importance of using up-to-date charts is illustrated by the case of the Liberian tanker Marion. Lord Donaldson's Inquiry (1994) reported that:

> "In March 1977, the Marion anchor fouled and severely damaged an oil pipeline. Althouth the pipeline was clearly marked on update charts, the master was unaware of its existence because he was navigating with an uncorrected chart of nearly 20 years old."

There must be a temptation to save money or effort by using out-of-date or uncorrected charts. To give an idea of the task size, the Safety at Sea International Review (1994), reported in an article that:

> "The British Admirality produces some 4,000 individual Notices to Mariners per year, which, if applied properly to a typical ship's outfit of, say, 2,000 charts, would take about one-quarter of the full-time effort of an experienced officer."

On the economic side, the same article as above, reported that:

> "One tramp vessel operator has estimated that his annual cost of maintaining a ship's chart folio exceeds £20,000 taking into account

overtime paid, chart agent's fees and the logistics of getting the weekly Notices to his ships as they move around the world."

Updating a paper charts means that they should give the most recent results of survey work. That is why actually they become so cluttered with information, that they are difficult to read.

On the operators side, a paper chart system involves the use of a pencil, triangle and calipers to plot the course lines. It is a highly manipulative way to plot the intended voyage track line. Determination of distances involves physical manipulation and mental computation. In other words, it is time consuming and a high workload for the watchkeeping officer.

Technology is usefull for everybody, paper charts have little to offer, but charts, digitised and put into a computer, offer a whole new world. Today, technology offers electronic charting or more precisely, the Electronic Chart Display and Information System (ECDIS) which is intented to replace the traditional chart paper.

In contrast to the paper chart, the ECDIS is an integrated part of a real-time navigation system. It provides a full-colour display of the most important charted information, and the ECDIS can integrate all of the ship's navigational tools and thus display the ship's position continuously in relation to a planned track, navigational hazards and other vessels.

The introduction of this high technology will

* simplify and reduce the worload of the operators,
* Improve navigational and environmental safety, and
* Enhance the operational efficiency of a vessel.

The tedious manual job of updating a chart will be avoided since corrections by satellite broadcasting for automatic updating is possible as stated an article which appeared in the Safety at Sea Review (1991):

> "The Robertson Disc Navigation system stores digitised electronic chart on laser discs and these charts are automatically updated by satellite."

In simple words, the ECDIS is the equivalent of an up-to-date paper chart in terms of data content but with additional information added as appropriate. It is designed in such a way as to allow selective display and manipulation by the operators.

A wide variety of systems, from full integrated bridges down to simple small screen chart plotters were evaluated in several projects and trials. The consequent experiences provided valuable results. However, as there are many varieties of ECDIS format, the harmonization group who is composed of the International Hydrographic Organisation (IHO) and the International Maritime Organisation (IMO), set up a provisional performance standards for ECDIS in 1989. Among many others features, the provisional performance standards cover the definition of ECDIS, display of information, colours and symbols, route planning, monitoring and voyage recording and interface with other types of equipment. It has been submitted to the IMO Assembly for ratification, subject to final revision.

4.2.2.3 Positioning Systems

Tight competition in the shipping world requires increased position determination accuracy. Thus, the Estimated Time of Arrival (ETA) will be better calculated and met. Moreover, the accurate position determination results in shorter routes and saves money.

The Loran-C, Omega and Decca systems are all so called hyperbolic navigation systems and are considered as land based positionning systems. Of the three navigation systems, Omega is the only one which provides global coverage worldwide but at the expense of accuracy. Omega transmits on three frequencies, their propagation characteristics allow reception of the signals at many thousands of kilometres and even under water. The system provides accuracies at a level of 2 to 3 nautical miles.

Two satellite positioning systems were developed, one in the United States of America (USA) and the other in Russia.
The American system is called NAVSTAR GPS, which stands for Navigation Satellite Timing and Ranging Global Positionning System and the name of the Russian system is GLONASS, which stands for Global Navigation Satellite System.

What makes these new satellite systems, NAVSTAR and GLONASS, unique is their features of high accuracy and high availability, providing position information every second, 24 hours a day and 365 days a year.

The NAVSTAR as an example is composed of 18 satellites plus three active spares in fixed orbits providing the users with 24 hour navigation coverage, so any random position anywhere on the globe can be determined with an accuracy of a few metres. However, the accuracy for civilian users is deliberately downgraded to 100 metres.

Obviously, a system with ±100 metres accuracy cannot be used safely for harbor navigation, In order to improve the accuracy of the position obtained from the GPS in harbor navigation, a land based radio navigation system can correct the GPS position. This is termed as a differentiel GPS where the accuracy improvement is in the range of 15 metres.

With the availability of a reliable positioning system the watch officer is relieved of the responsibility to obtain positions at regular intervals at sea using astronomical navigation or visual navigation from coastal landmarks (e.g. lighthouses etc.). The routine workload of the watch officer is thus reduced due to the presence of accurate, continuous electronic navigation systems.

4.2.2.4 Automatic Track Keeping

The manual steering mode is still necessary and should be used in confined waters, restricted visibility, closing vessels or when any other circumstances deem it prudent.

However, whenever the nature of the surrounding waters and weather condition allows, the automatic pilot should be used. The majority of autopilots currently installed on vessels are designed for course keeping only. They aim to maintain the vessel on a pre-determined course and thus require directional information. Under constantly varying weather conditions, it is not feasible to continually reset the potentiometer. That is why, in the last 20 years, the invention and introduction of the Automatic Adaptive Autopilots (AAPs) which is in its simplest form, a good quality autopilot apparatus with a digital control system (microcomputer) producing the final rudder command signal. The gain settings are adjusted automatically to suit the dynamics of the vessel and environmental conditions.

A further high accuracy is provided if the autopilot is integrated with other types of equipment such as collision avoidance.

The use of an autopilot improves the profit margin of a vessel and contribute to the safety of the vessel by

* reducing manning levels required on the bridge;
* achieving fuel saving by allowing the vessel to stay on course with little deviation;
* providing accurate steering in circumstances of increased traffic density and close proximity of obstacles.

However, the officer of the watch (OOW) should bear in mind the necessity to comply at all times with the requirements of Regulation 19, chapter V of the SOLAS Convention, 1974, which underlines the importance of manual steering in potentially hazardous situations.

4.2.3 Communication

In an attempt to minimize the loss of life, the IMO, has developed the Global Maritime Distress and Safety System (GMDSS). Full implementation of the GMDSS will be achieved by February 1999. By then it will apply to all passenger ships and cargo vessels over 300 gross tons engaged on international voyages.

The basic idea of GMDSS was to provide an improved distress and safety communications system for shipping worldwide. This meant that the manually operated Morse system, which has formed the basis of the maritime distress system since the beginning of the century, had to be phased out.

GMDSS uses both radio and satellite communications. It is designed to alert search and rescue authorities, and other ships in the area, to a distress incident. GMDSS also provides for emergency communication and the promulgation of urgent safety information, such as navigational and meteorological warnings.

GMDSS divides the seas into four different sea areas based on coverage capability of Very High Frequency (VHF), Medium Frequency Radiotelephony (MF/RT) and International Maritime Satellite (INMARSAT) coverage areas.In each sea area where the vessel trades, IMO has specified the equipment required for implementation.

Despite this great advance in maritime safety, numerous false alerts were registered and are growing as stated in the Marine Engineers Review (MER), June 1994, which reported that:

> "Statistics show that the number of false alarms has risen from 93 in 1991 to 342 in 1993,..........,if it remains constant over the next five years- could mean more than 3,500 false alerts a year for the United Kingdom (UK) center alone."

The International Maritime Satellite Organization (INMARSAT) is currently examining a number of ways in which it can help to reduce the number of false alerts. In this connection, The Sea, January-February 1995, reported that:

> "In the meantime, proper training must be provided quickly for everyone who is handling GMDSS equipment and manufacturers must be told to improve designs."

Under GMDSS, commercial communications will be faster and more reliable in both the ship-to-shore and the shore-to- ship directions. It will enable crew members and their families to keep in touch with each other, without the support of operators at both ends.

However, as there is no requirement for a qualified radio officer to keep specified watches, there is thus a potential crew cost saving for the owner. The increased workload imposed on the master or the watchkeeping officer, dictates more careful design on the wheelhouse layout to ensure the best operation access to the equipment and an increasing demand for upgrading seafarers' knowledge on the GMDSS.

Fax and telephone advice is all very well but sometimes what is most needed is an expert eye on a problem, especially when deciding with machinery repair and maintenance.

It has been demonstrated through advanced applications for satellite based communication to send images, voices and fast transfer of data from practically any point to any other point on the globe in order to have a remote support from experts ashore in problem diagnosis, advice, cooperative decision making and supervision of the repair procedure, **(see Appendix 3).**

It is said that such applications could be extended to medical diagnosis and advice. Urgent diagnosis and treatment instructions can be given from shore-based doctor or consultant to ships' crew via satellite.

This expert advice and supervision increases the confidence of the crew to handle crisis situations and allows for improved quality standards in any required repairs, thus improving the safety and increasing the availability and utilization of ships.

4.2.4 Cargo Handling

Manufacturers' and designer concepts are governed by shipowners and ship operators who are constantly seeking to reduce crew levels and improve turn-round times.

The use of automation and remote control systems has been extended to new areas onboard; an example is the transfer to the bridge of the cargo control and monitoring systems, which has been made possible by the introduction of computer-based systems.

With the advent of unitization in the cargo trade, it has been possible to reduce the cargo lashing labor by providing hatchless container vessels stowage and cell guide arrangements, which reduce the necessity for cargo lashing, as shown in **Fig 4.2.** This has a direct impact on the number of crew required for efficient and safe ship operation.

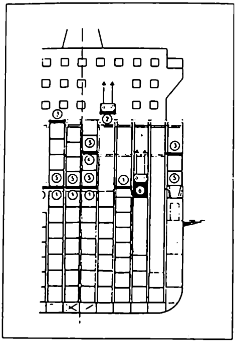


Figure 4.2:

1. The watertight covers locked in the closed position
2. A cover being operated
3. The covers of a discharged cell in the stowed position
4. Spare covers
5. A single TEU may be loaded into a forty foot slot without lashing
6. A container being unloaded

Source: The Motor Ship, January 1990

Dry bulk cargo vessels, have introduced of Self-unloading systems. Such system were originally developed to allow ships to handle cargoes at ports not equipped with their own gear, but are also used to reduce handling costs by minimizing the requirement for stevedores. This system has a high discharge rate, possibly more than 600 tonnes per hour. The cargo handling can be carried out with the hatches closed, which means that there are no delays because of bad weather, particularly relevant to such cargoes as coal and powdered cement. Fig 4.3 illustrates one type of the Self-unloading system.

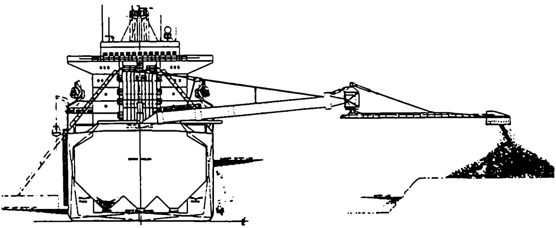


Figure 4.3: A computer controls flow rates of different cargoes, and a flexible midpoint joint in the 77 metres boom gives discharge at any point within the full radius

Source: The Naval Architect, January 1991

Both dry bulk and container vessels are nowadays provided with centralized ballast control systems for ballasting and deballasting.

On liquid bulk carriers, it has been demonstrated that by means of computer-based systems, it is possible to control and monitor the following equipment:

* Cargo pumps and valves;
* Ballast pumps and valves;
* Slop pumps and valves;
* Bilge pumps;
* Cargo and ballast tank levels;
* List, trim, ballast press sensors etc;
* Cargo temperature;
* Inert gas system and pressure.

All this can be done safely and efficiently by one man from the cargo control.

Stowage planning, stability and stress calculations are commonly computerized today; thus eliminating the need for dedicated personnel for these processes and reducing the workload of existing personnel.

4.2.5 Manoeuvring And Mooring

One of the most demanding and labor-intensive operations for a ship is her arrival at or departure from a harbor or dock area, where the ship will have to manoeuvre in very restricted waters and where moorings will have to be arranged.

Traditionally-equipped ships will in many cases only be able to do this with assistance from harbor tugs, and this operation will inevitably add to the risk of damage and to the workload of the crew. It is therefore obvious to try to improve this situation by improving the manoeuvrability of the ship. This is achieved by fitting a controllable-pitch propeller and bow-and-stern-thrusters. Moreover, a **joystick** by which the OOW can control the direction, the speed and the heading of the ship has been introduced. By means of these devices it is possible to move the ship in any way and in any direction, and a ship may therefore go alongside the quay without any outside assistance.

Once brought along side, the moorings are made fast by the complete mooring systems which consists of an automatic winch and a remote control arrangement. The automatic winch incorporates automatic line adjustment and a pre-set tension level, so that the vessel will remain securely moored despite changes in tide, wind forces or currents which can exert pressures on the vessel.

As far as manoeuvring is concerned, a bridge mounted automatic anchor brake release control may be provided to operate the windlass for anchors. The automatic windlass monitors both the length of cable veered and the speed at which it is running out. The two read outs are available to the officer on the bridge so the anchor cables can be controlled accordingly.

A considerable reduction in manning costs and in workload is achieved by the introduction of the joystick, modern mooring equipment and manoeuvring system. The use of the joystick will lower the incidence of human error while manoeuvring. Only one man is needed for anchoring operations. The mooring teams fore and aft consisting of only two men are necessary for docking and undocking.

4.3 INTEGRATED SHIP CONTROL SYSTEMS (ISC)

Ship bridge electronic systems, such as automatic track keeping or electronic position fixing system have been introduced to replace or assist the officer of the watch in specific separate functions. Such electronic systems, usually improve the efficiency or the performance of a particular function.

However, because of the increasing variety of tasks which now have to be carried out by an officer of the watch (OOW), this can lead to an undesirable increase in the number of displays on a bridge thus increase the workload.

The task of the watchkeeping involves physically moving between the various systems, extracting the desired information at the correct time intervals, assimilating information from different sources and making decisions based on the information at hand.

Reading information from one instrument and feeding it into another piece of equipment, with or without performing intermediate calculations is not only labour-intensive and time consuming, but provide opportunity for human error.

The watchkeeper must know how to operate a significant number of different systems, for example ARPA, RADAR, SATCOM and so on, all of which have a good understanding of the accuracy and potential errors inherent in each systems. The only possible solution in order to decrease the workload of the OOW is the integration of the various systems he has to operate on the bridge.

The objectives of such integration, are to reduce the number of different pieces of equipment to a minimum and ease the duty officers' workload.

That is to say, combining navigation systems in two or more electronic navigation aids together in a manner which produces a single set of navigation data. The benefits of this integration can be summarized as follows:

* Precise navigation,
* Increased safety,
* Highest economy,
* Easy control in ship handling,

* Decrease of workload for navigation,
* improved man-machine interface.

However, talk in the last few years is not simply of Integrated **Navigation** Systems (INS), but of integrated **Ship** Control Systems (ISCS), in which the function of navigation, machinery monitoring and control, cargo operations, ballasting and trimming, communication and all the other ship-operation systems, are combined in a single area - at the Ship Control Centre (SCC).

The state-of-the-art in integrated SCC systems today is directed towards OMBO. It is feasible today to sail a vessel from quay to quay with only one man on the bridge.
In recent years, many manufacturers of navigation aids and system designers have been developing ISCS suitable for all types and sizes of ship.

A leading manufacturer of ISCS is NORCONTROL AUTOMATION, Norway. The salient features of there "Norcontrol BridgeLine" system is discussed briefly below.

4.3.1 Norcontrol BridgeLine

Norcontrol has introduced a new bridge operation station concept, which satisfies the requirements for OMBO. The concept is based on a set of standard console modules. The bridge consoles use a design which gives a field of vision from a number of workstations. Known as the Norcontrol BridgeLine, the system includes the following Norcontrol systems:

* DataBridge, Integrated Navigation System.
* DataChief, Integrated Alarm, Monitoring and Control System for Machinery.
* DataMaster, Integrated Alarm, Monitoring and Control System for Cargo.
* AutoChief, Propulsion Control System.

The Norcontrol system functions, architecture and design are described in **Appendix 4 (a), (b), (c), (d).**

4.3.2 Bridge Layout

In the BridgeLine, the console modules contain the equipment necessary for the various workstations. One example is illustrated in **fig 4.4** which shows:

1. Redundant worstation for the engine/cargo monitoring and alarm;
2. Redundant workstation for combined radar display, ARPA and electronic charts;
3. Workstation for propulsion and steering;
4. Conning display;
5. Workstation for navigation;
6. Workstation for manuel steering.

Workstations for safety operations, route planning and communication are not shown on the illustration, but are included in the total concept.

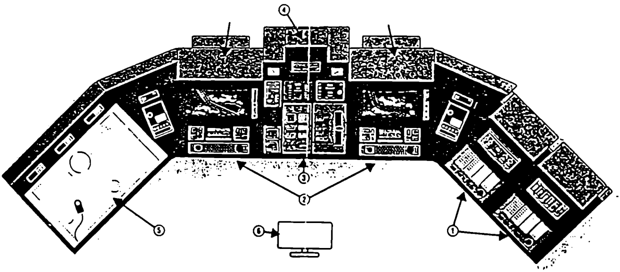


Figure 4.4: Norcontrol BridgeLine systems

Source: Norcontrol brochure, (1995)

The heart of the Norcontrol BridgeLine are the two redundants workstations, each with 29 inch high resolution colour display. The display has different modes:

* Radar display with the same functions as an ordinary radar display;
* ARPA display with same functions as an ARPA system;
* Electronic display with ECDIS functions;
* A combination mode with three layers of information on top each other, with radar on the bottom, the ARPA in the middle and the electronic chart on the top or as preferred by the navigator.

In addition, the bridge design i.e. bridge configuration, arrangement of consoles and equipment location should enable the officer to perform all the bridge duties from a convenient position on the bridge. This aspect is considered vital because visibility is a critical factor with respect to lookout. A field of vision of at least 10 degrees dead astern, 180 degrees ahead and 22.5 degrees on each side are available from the one man control position at the workstation, as shown in **Fig 4.5.**

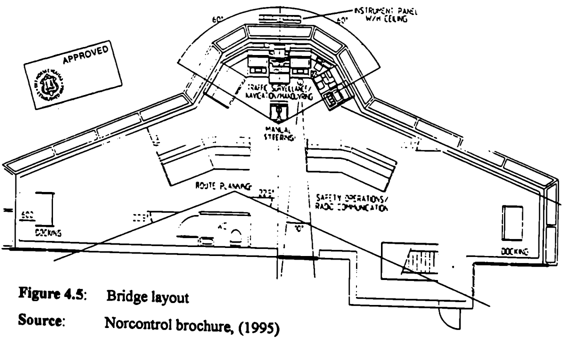


Figure 4.5: Bridge layout

Source: Norcontrol brochure, (1995)

4.4 INTERNATIONAL MANNING SITUATION

4.4.1 STCW and Sole Lookout Trials

The International Convention on Standards of Training, Certification and Watchkeeping (STCW) 1978, Chapter II/ Regulation 1 (9) states that:

"The officer in charge of the watch may be the sole lookout in daylight"

That is to say, someone has to assist the watchkeeper officer during the night time in order to comply with the convention.

The same regulation allows the officer of the watch to assess the operational situation and to take full account of all relevant factors such as state of weather and visibility, which may influence the capability of the watchkeeping officer to maintain a proper lookout without assistance, except the influence of darkness.

On this basis, it has been suggested that also the influence of darkness should be included among the relevant factors to be taken into account onboard ship.

The convention does not address the internal working conditions, nor does it make any assumptions as to what extent the bridge should enable the officer of the watch to maintain a proper lookout since it is not only the external conditions that influence the capability to maintain a proper lookout, but also the facilities onboard, the bridge layout and instrumentation have their utmost importance.

From all the above said, a question arise

* Is single-man watchkeeping at night feasible ?

If the answer is "YES", another question to ask is:

* What provisions are required to make single-man watckeeping at night feasible?

In order to answer these two questions, several trials were undertaken and the Maritime Safety Committee (MSC), approved in 1991 provisional guidelines on the conduct of trials in which the officer of the navigational watch acts as the sole lookout in periods of darkness (MSC/Circular 566).

Among the number of projects and trials which were undertaken by certain European countries and Japan, the following section will outline some of them.

4.4.2 Manning Approaches in Denmark, Germany and Japan

4.4.2.1 Manning Projects in Denmark

The Danish Ministry of Industry initiated a project called, Projekt Skib (project ship) in 1986. The aim was to design a number of ships which could be safely run by a crew of six.

* Master
* Deck officers (2)
* Chief engineer
* GP - ratings (2)

The shipping company J.Lauritzen A/S has built 4 reefers. The first vessel was Ditlev Lauritzen of about 17,000 dwt, delivered in 1990 with an overall length of about 165 metres and an engine of 12,000 KW.

The Svensk Sjöfarts Tidning 40, 1993, reported that:

> "The experience in general had been successful and without any major problems. Most arrivals and departures have taken place without the assistance of tugboats, even in narrow waters and bad weather conditions. The one man bridge is causing no problem at all and it is even leaving the officer of the watch with some extra time for performing

various kind of machinery operations. The saving on running costs was about 15 % compared to a similar ship under Danish flag with Danish officers onboard."

At present, the crew is extended by a first engineer, a cook steward and a messman.

4.4.2.2 Manning Projects in Germany

The German ship of the future project was begun in the late 1970s. Its principal objective was to produce advanced ship designs with low manning requirements.

The first two ships to be built were the container Noria Samantha and her sister ship Nord-Asia Susan of 27,600 dwt, delivered at the end of 1985. A high degree of automation has made it possible to run the ships from pilot to pilot with only one man on watch. The vessels have a crew of 14.

The shipping company Hapag Lloyd has seven container vessels such as the Hannover Express of 52,600 dwt which is manned by a crew of 14.
The crew includes:

* Master
* Ship officers dual qualified (4)
* Rating dual qualified (4)
* Bosun
* Crew members for catering (3)
* Radio operator

Those in the crew who take watches are divided into four groups and work six hours. The crew works two journeys and are free for one, it requires three crew groups to handle two vessels.

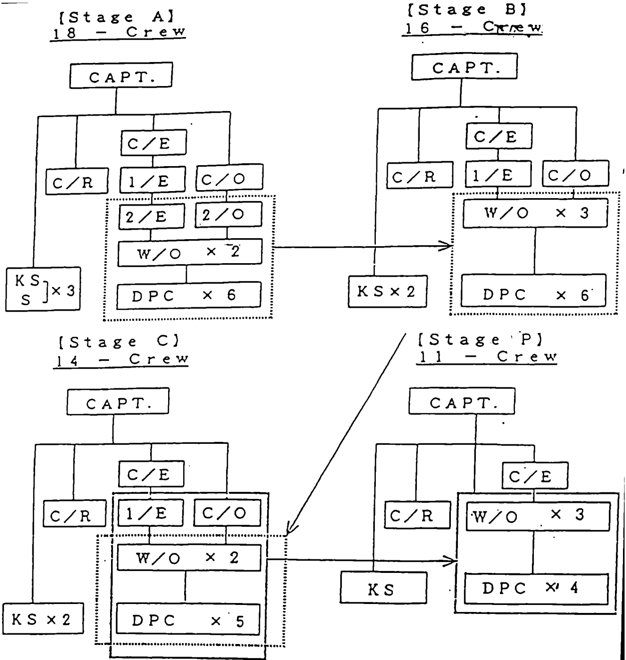
4.4.2.3 Manning Projects in Japan

In 1979, Japan promoted the so-called "Committee of the Modernization of the Seafarers' System" (COMOSS). The goal was the complete elimination of the departmental distinctions, with the substitution of a shipboard management team.

The system on manning has been classified into four stages and the reduction on manning in each stage shown in **Fig 4.6** is as follow:

* In stage A, the Japanese crew was reduced to 18 men in 1986.
* In stage B, another reduction to 16 men has been made in1988.
* In stage C, there was a further reduction to 14 men in 1990.
* In stage P (Pioneer), some shipowners tried to go further in crew size reduction at around 11 men. The pioneer ship was introduced in 1987.

A project called "Intelligent system" was introduced in the 1980s in order to further the reduction in manning. Certainly, the final objective is to develop a totally unmanned ships.



W/O: It is called watch officer, that means navigation officer or engineering officer after acquisition of common skills as officer

DPC: It is called Dual Purpose Crew, that means a person with common skills besides expert skills as deck or engine crew

KS: It stands for steward who studied and is trained in general affairs management on board

Figure 4.6: Manning system in Japan

Source: IMO Circular STW 25/INF.7, (30 November 1993)

Fig 4.7 illustrates the contrasting cost of manning a modernised ship with 11 Japanese crews or with 23 foreign (non-Japanese) crew. The fact that it is possible to operate the vessel at 27% (0.55/2.02 million) of the cost invalidates the need for new high-technology manning concepts.

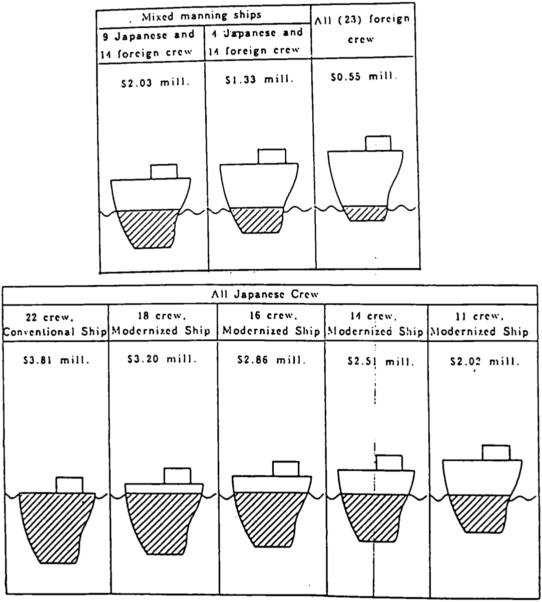


Figure 4.7: Comparison of annual crewing costs per vessel

Source: The Japanese shipowners' association (1993)

4.5 CONCLUSION

As it is seen, the main labour content has shifted from physically demanding and time consuming activities to monitoring and control-oriented duties.

It is imperative that the operator is capable of interpreting and evaluating the data presented by the system. Equally essential is the ability to detect any circumstances in which equipment is producing data which is inconsistent with the manner in which a situation is developping as observed from the radar, ARPA, ECDIS, etc.

This chapter highlights the technical innovations and developments in ship design and equipment such as automation, computerization and bridge layout which should contribute to the cost-cutting efforts of the shipowner by reducing crew size. However, from Fig 4.7 it may be asked to what extent is the introduction of modern technology appropriate to achieve cost reduction ? The solution may lie elsewhere.

One can understand the manufacturer for wanting to forge ahead with their own technology, especially in these days of competitive marketing. However, in some ways the end-user is getting behind. Furthermore, it needs to be realised that technology has increased the dimensions of the crew and the role of the watchkeeper, who are the end-user of such modernisation.

In this situation, the human element which is the most neglected area in shipping, plays a very decisive part. The next chapter will investigate these facets of modern technology, small crew size and human element in shipboard operations.

5. HUMAN ELEMENT ONBOARD HIGH TECHNOLOGY VESSELS

The introduction of new technology and complex equipment onboard must not only be able to perform its required functions, but also to interact with the operator, taking into account his characteristics, ability and limitations.

The objective on high technology vessels, or to be more accurate, Integrated Ship Control Systems (ISCS) is an attempt to improve the feasibility of the one man to operate the whole ship, precisely, One Man Bridge Operator (OMBO).

What are his duties, tasks and role? Obviously as a human being, he has weaknesses and limitations. What are they? How can the small crew size onboard ISCS handle the vessel? These are some questions which have to be asked.

This chapter will examine the new role, tasks and limitations of the watchkeeper officer and of the remaining crew as well.

5.1 CORE DUTIES OF THE OOW ON HIGH TECHNOLOGY SHIPS

As mentionned in the introduction, the objective of such high technology vessels is to operate the whole ship with one man on the bridge. The new manning levels and technology onboard ships have changed the role of the deck watchkeeper since many more operations are being concentrated on the bridge. In other words, such officers will have their hands full dealing with the following range of core duties and tasks:

* Bridge watchkeeping at sea and at anchor;
* Navigation of the vessel;
* GMDSS communications;

* Surveillance of machinery and plant;
* Fault rectification;
* Monitoring and operation of cargo;
* Monitoring and operation of ballast systems;
* Berthing, unberthing and anchoring operations.

The OOW is the master's representative, and his primary responsibility at all times is the safe navigation of the ship. Undoubtedly, the key function of the OOW is **LOOKOUT.**

5.1.1 Bridge Watchkeeping - Lookout

The term "Watch", according to Collins dictionary, means to "look attentively or carefully". Watch also means a "period of time for guarding". In nautical use it is the time of duty of one part of a ship's crew (usually four on/eight off or six on/six off).

The recent developments in the bridge design and sophisticated equipment onboard makes the need for a separate lookout less obligatory. It is doubtful whether a watch officer could satisfactorily fulfil his responsibilities, especially at night, under restricted visibility or in congested water, without the benefit of another person as lookout.

Despite the amendments to the Annex of STCW 78 undertaken at the 1995 conference of parties to the 1978 convention (STCW 95), little is changed in the watchkeeping provisions which is chapter VIII - (Watchkeeping) in the STCW 95, except that lookout provisions are proposed to be modified in light of experience derived from trials in solo watchkeeping.

For several years IMO approved trials involving vessels equipped for night operations with the officers of the navigational watch acting as sole lookout. This has been conducted by a number of countries, principally in North West Europe, and millions of dollars have been spent in equipping selected vessels for the purpose.

In May 1995, the IMO Maritime Safety Committee decided to discontinue the 24 hours solo watchkeeping trials. Only 8 countries, out of a total of more than 50, opposed the proposal to end the solo watchkeeping trials. They were the Bahamas, Denmark, Hong Kong, The Netherlands, Norway, Panama, United Kingdom and Vanuatu. The decision in May of the IMO's Maritime Safety Committee must be ratified at its next session, scheduled for May and June 1996.

There is currently a considerable amount of interest in the visual lookout aspect of navigational watchkeeping. The law is unambiguous on the subject of bridge manning; there must be a qualified officer on watch at all times. The necessity to keep a proper lookout is dictated by STCW 78/95 Conventions and by the International Regulations for Preventing Collisions at Sea (COLREG 72). For example, in the COLREG 72 Rule 5, lookout states:

> "Every vessel shall at all times maintain a proper lookout by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and the risk of collision".

The author believes that few mariners would disagree that ships which do not keep an adequate lookout are serious problems. Not maintaining a proper lookout at all time is highly dangerous; it is very bad seamanship; it is against the law and it should be stopped. Therefore, the OOW has to be fully aware of what is going on both inside and outside the bridge.

On a highly automated bridge the OOW will monitor information available on electronic screens and in addition he is expected to maintain visual lookout. The visual scene outside may not easily correlate to the electronic picture provided on the electronic screens. The OOW may even find the "user friendly" displays within the bridge more comforting in comparison to the sometimes dull and at other times perplexing visual scene (e.g. in fog, heavy rain, with background shore lights). This then leads to over reliance on electronic information. The risk involved is that the limitations of the radar to detect small vessels and objects is ignored, increasing the likelihood of risk of collision. In OMBO, this risk will be magnified since navigation and lookout are entrusted to one single person, leaving no margin for human frailty.

In my experience as a seafarer, once I finished my watch in the engine room, I liked to smell the fresh air on the bridge. I can guarantee that nine times out of ten the watchkeeping officer was chart correcting, filling weather reports, plotting satellite fixes (which is legitimate but it takes him off lookout), filling in safety equipment check lists, drawing cargo plans or any number of multiple paper generated activities but **NOT** I say **NOT**, scanning the horizon.

I suppose it is still considered a bit unacceptable for the OOW actually to sit down in the pilot chair with a cup of tea. The OMBO ships are designed so that everything including the coffee maker is within arm's reach. I pity the poor single watch officer who is supposed to sit in one of these comfortable large chairs, surrounded by radars, engine monitoring alarms, computerized readouts for all sorts and still stay bright and attentive and awake for his four or six hours watch.

Muirhead, P.M (1995), aptly sums up this aspect by a rhetorical question:

> "Can the bridge watchkeeper achieve the lookout from his comfortable chair?"

5.2 LIMITATIONS AND PROBLEMS OF SMALL CREW SIZE

5.2.1 Bridge Safety System

Since the OOW is alone on the bridge, all the lives of all those onboard are dependent upon the alertness of a single human being.

There has been extensive trials undertaken by a number of administrations whose owners were anxious to make the running assisted by a number of pieces of equipment designed to keep lonely officers of the watch awake and to ensure that he has not been taken ill or fallen asleep. One of them is the so called "dead man alarm" which is the only new equipment recommended in connection with one man bridge watchkeeping. The system is adjustable up to 12 minute intervals. The officer of the watch should acknowledge the alarm, if not, there will be an alarm transfer system to warn the master and the back-up navigator.

The more sophisticated alarms are movement sensitive and reset themselves whenever there is a movement on the bridge.

It is said that the technical solution appears to be to link the alarm to the autopilot so that it is always in operation whilst at sea.

5.2.2 Practical Limitations

More attention to safety systems and emergency procedures will be necessary as crews are reduced. In case of fire, the actual high-tech vessels are in no way more dangerous than other ships, but the low manning scale may be the cause of fire being detected rather late, and a small crew has less power for fire-fighting than a crew of traditional ships. New state-of-the-art ships may be able to operate under normal operating conditions, but some important questions in relation with practical limitations to minimum manning of merchant ships do arise.

* In the event of one or two crew members of the crew being incapacitated, can the remaining crew take care in an emergency situation without placing the ship and environment in jeopardy during the remaining part of the voyage ?

* Can such vessel render assistance to another vessel in distress or take emergency measures to cope with an emergency situation such as fire, flooding, power loss, failure of critical equipment, etc ?

* How long can a crew member remain onboard performing his duties efficiently before repatriation for the rest ?

* Crew familiarity and continuity which may sometimes be considered an advantage can also be a limitation. To what extent do crew members stay together, sail on the same ship or same class of ship ? Crew complacency can prove to be a phenomenal safety hazard in these circumstances.

* Personnel selection procedures and criteria (i.e. skills, physical conditions, personality factors, expectation levels, psychological profile).

* To what extent do crew members receive training and education to upgrade skills or to broaden their skills? To what extent can a person perform both deck and engineering functions, or possess dual qualification?

* An integrated ship may be a boon when it is new and the crew freshly trained. But what happeneds, when the ship becomes older and is perhaps sold on to another owner ? Will the new crew be able to adapt to it ? Will the members be able to learn its ways and cope with its idiosyncrasies ? Will the product manuals survive ?

These are some questions that can only be answered when studies and various trials are completed. However, it has up to now been assumed that some criteria for a safe reduction of the ship's crew must be:

* that a certain redundancy of equipment is required in order to be able to cope with an unpredictable emergency situation;

* that sufficient operational procedures should be established and practised in order to improve the efficiency of the ship and the crew in all conceivable situations;

* that the ship is ergonomically designed and equipped in order to reduce the workload for the crew, the risk of accidents and breakdown of equipment;

* that the crew is trained and qualified accordingly.

These criteria relate especially to the following areas:

* Seaworthiness, including stability, strength and watertightness;
* Navigation and manoeuvring;
* Engine room procedure;
* Cargo handling;
* Mooring;
* Fire detection and extinguishing;
* Personal safety, rescue operations, abandoning ship;
* Prevention of pollution.

When considering the practical limitations to minimum manning of merchant ships, the important area that must be carefully weighed is that of maintenance which is missing from the above said.

5.2.3 Maintenance and Repair

A revolution in the condition in which sea-going engineers work has largely exchanged watchkeeping for Unmanned Machinery Space (UMS). More reliance is placed on condition monitoring and alarms to replace the eyes and ears of the watchkeeping engineers, and on data logging to achieve continuous monitoring of the engine's behaviour. That is to say, on the utter **RELIABILITY** of the equipment.

Reliability is defined as:

> "The ability of an item to perform a required function, under given environmental and operational conditions and for a stated period of time".

Maintenance is carried out to prevent system failures, and to restore the system function when a failure has occured. The prime objective of maintenance is thus to maintain or improve the system reliability and operation regularity.

The procedures and precaution needed to keep machinery in good operational condition fall into three basic categories:

* Operation
* Monitoring
* Maintenance

Operation

Maintenance has to include the way in which the machinery is used. A disciplined routine will ensure that nothing is overlooked, and that the machinery is not exposed to risk or rough handling. The operations could include starting, running and stopping all shipboard machinery.

Monitoring

Monitoring covers reading and interpretation of the behaviour of the running machinery, and examination of conditions which do not interfere with the engine's availability for service (i.e. pressure, temperature, indicators such as cylinders pressures, etc.). In a well planned condition monitoring installation, diagnosis can be achieved without dismantling, so that overhauls can be safely deferred.

Maintenance

Maintenance requirements differ somewhat between the type of engine, age, design, running hours and nature of employment of vessel. Each manufacturer provides full maintenance and overhauling information.

Maintenance starts with daily attention like checking oil level, hand lubrication and taking readings. It goes on through weekly, monthly and then longer checks (usually quoted in terms of running hours). The attention required or recommended mounts in complexity, from filter changes, cleaning the cooler, cleaning and resetting the injectors (currently at something like 3000 and 5000 hours), to exhaust valves at 5000 to 10000 hours, through major overhauls at perhaps 30000 hours. However, the economic conditions have obliged shipowners to reduce the crew size onboard and to seek the longest possible overhaul and maintenance periods and so the need for frequent checks has been designed out of modern machinery as far as possible.

That is to say, that crews on small ships are dangerously dependent on the successful operation of the automated equipment. Actually, there are considerable reservations about the vessel's ability to handle repairs with a very small crew whose principal task is to monitor machinery; the size of the small crew is only the number needed to navigate the ship safely.

To this end, while carrying small crew the question is:

What are the maintenance and repair options on board ?

• Shore Personnel or Riding Crews

In some companies' fleets, the maintenance is shifted to shore personnel or to special "riding crews" that are carried onboard ships to perform the needed maintenance. In these cases there is a need to prepare written standards describing the checks of major equipment, maintenance intervals and execution timing of the maintenance work.

However, Toshitaka Hamamoto, reported in Seaways, November 1991, that:

> "In Japan, the crew complement of 11 is intended for minimisation of the operational crew. No maintenance work on the hull or the machinery can be done by the crew, and all kinds of repair work, including those previously done by the crew, require support by on-shore personnel. Therefore, more items of repair work are required when the vessel is docked, resulting in a greater maintenance cost than a comparable M-Zero vessel".

The same article goes on by saying that

> "Mixed manning, which is positioned as an alternative to the modernised ship concept, makes possible a higher level of maintenance by utilising the greater manpower available onboard in addition to the crew cost advantage achieved by replacing some of the expensive Japanese members of the crew with less expensive Southeast Asian Seafarers".

It is also recognised that "riding crews" are used to do routine maintenance, but these people have no interest in keeping the ship clean. Riding crews can get away with making a mess in the engine room and leaving it to the crew to clean up after them. The accretion of dirt in the engine room from a hot, oily atmosphere is well understood by every engineer and traditionally, the cleaning of machinery spaces has occupied many manhours.

The planning of employment of such shore personnel or riding crews definitely is more easy for vessels which are employed on a regular schedule.

*** Additional Crew Members for Restricted Period**

There are some provisions of additional crew members for restricted period, such as electronic experts to maintain the automated systems. It is said that the radio officers are phased out even while electronics are assuming a great importance onboard. Would it not make more sense to retain and retrain him as an electronic officer ? This person could handle electronic repairs and preventive maintenance, and act as the GMDSS operator and maintainer.

*** Redundancy**

A certain degree of redundancy of the machinery and equipment can reduce the requirement for instant repair in case of damage, but the safety of the basic operation in connection with navigation from one port to another should be maintained or improved. However, this solution results in too many functions whose existence and usefulness may lead to the risk of incorrect action especially when the level of mental strain is very high.

At the end of the day, excluding "first aid" maintenance, repair and maintenance will become "depot based". Marine engineering, in the true professional sense, will become a shore based profession.

5.2.4 Psychological Problems

While industrial safety records and statistics almost always focus attention on damage caused to property in material and financial terms, or injury to personnel, loss of production and earnings, very little is said about the damage to the mental health of the individuals working under stress, which has contributed to accidents or casualties.

The working condition onboard high techology ships, which is among other things determined by the crew reduction that keeps in step with the automation of sea-going vessels and the existence of high-tech systems, leads to the situation where a number of psychological problems arise and affect the operators.

*** Monotony**

Every watchkeeper soon learns that time passes quickly during a busy, active coastal watch where there is plenty to occupy the mind. However, during the night on longer voyages (deep sea), there is less stimulus and the body responds by becoming less active. Watches are not or only very rarely interrupted by external or internal circumstances (i.e. target ships, conversation, changing activities, etc). As a result of monotonous work, this leads to increasing fatigue, decreasing attention, dimnishing responsivness and declining performance.

*** Vigilance**

This term is defined as the careful attention that individuals give to a situation, so that they notice any danger or trouble that might arise. The state of low vigilance and the resulting detriment to attention can be explained by the very low physical and mental demands of a night watch on the OOW.

*** Isolation**

One article on Seaways, October 1991, began by saying

> " When is a person only partly a person? - when, they are forced to live most of their time in isolation".

Less time in port because of the speed of cargo handling; and, for tankers, isolated berths far from town; increase seamen's isolation both from home and from "normal society", and often lead to a reluctance to leave the ship even when there is an opportunity.

The OMBO has to work and live in a system where isolation spreads from the hours of work to their leisure time. The usual result of this is a deterioration of social capabilities such as less social interaction, loss of communicational and cooperational skills.

*** Stress**

Onboard conventional or high-tech ships, seamen are in permanent anxiety and tension filling due to the external stimuli such as noise, heat, vibration, etc, and to internal stimuli like isolation and permanent strain.

The result of the stress lead to hypertension and even to some deseases like gastro-intestinal ulcers.

The use of alcohol and tobacco as an alternative to the types of tranquilizing drugs more readily available ashore may escalade within high tech ships since seafarers have much more responsibilties, thus an increase in tension, strain and isolation.

*** Motivation**

Onboard high-tech ships it is difficult if not impossible to obtain job satisfaction. The growing complexities of the shipping industry and the development of means of ship/shore communication have together resulted in transferring more and more decision making from ship to shore tending to leave the ship's command with little more authority than vehicle drivers. The master or chief engineer has no control over decision making, and has to obtain permission from the owner or manager for every decision of consequence.

Decisions, control, supervision and planning are mostly carried out by automated systems onboard, (computerized) shore offices and much of the performance monitoring is by shore based remote controlled data logging. The results of this situation are frustrations, less efficiency, loss of skills, reduction of self-esteem which results from loss of responsibility for decision making and may be most importantly job dissatisfactions having a negative influence on the behaviour of seafarers.

5.2.5 Mixed Crews

Crew members are not only pushed down by technology but also by economic pressures. High wage costs for crews from developed countries encourage shipowners to employ a smaller crew or cheaper seafarers from developing countries, and at worst both of them. This last leads to low manning levels which are composed of multi-racial and multi-cultural crews.

Mixed nationality crews, with consequent problems such as lack of social life, comradeship, friendship, sympathy and communication between crew members onboard may lead to new psychological problems since crew members are subject to much more isolation and loneliness; thus, more stress. These are enhanced due to different nationalities, mentalities, cultures, religions and language barriers.

The more the size of the crew decreases, the greater is the need for the crew members to communicate, to understand each other and to act as a team. The lack of communication acts to widen the distance between the members of the crew. The fire onboard the Scandinavian Star (passenger RO-RO ferry) on 7 April 1990, which allegedly had nine nationalities onboard, was aggravated by language barriers both between crew members, and between crew and passengers. This incident clearly illustrates the language problem results. In case of any event, seafarers tend to panic in their own language. It is a sad fact that lessons in maritime safety are often learnt at the cost of human lives since in this incident 158 passengers died.

As far as language difficulties are concerned, the Lord Donaldson Report 1994, recommends that

> " IMO should adopt English as the International language at sea and minimum standards of comprehension and ability to communicate should be set, suitable for both every day and emergency situations".

It is worth noticing that, it has already started on the development of an "IMO language" for use on ships. This is basically a simplified, standardised form of English, which was designated to improve communication between ships and shore.

Small and mixed crews means that there will not be many opportunities for the crew members to meet each other. It is in the interests of shipowners to ensure that welfare, living and employment conditions, and may be more importantly the salary of their crew members, are as attractive as possible. If not, the result leads to an unhappy ship, job dissatisfaction, less motivation and low moral. In other words, the safety of the ship is threatened, and such crews may desert a ship in time of emergency rather than use their best ability to prevent disaster.

5.2.6 Fatigue and Working Hours

Human being are not machines. Humans are good at assessing situations, applying knowledge and solving problems. Humans are bad at sustaining long repetitive tasks, concentrating hard for long periods without breaks; they are subjects to the dulling effect of boredom, tiredness and fatigue.

In shipping history, loading and discharge operations typically took a long time. As a result, seafarers had the opportunities to visit foreign lands, and experience exotic cultures. This aspect of the job was one of the things that motivated many young men to pursue a career in the merchant marine.

Stays in port, today, are often too short due to the increasing technology in ports and on ships, tight competition in the shipping industry, tight ships schedules, containerization, speedy turn around of ships, faster bulk and liquid cargo handling operations, 24 hours working in many ports, etc. Adding to all these factors the reduction of crew members, that is to say that the pressure on seafarers is increasing, there is hardly any time left for seamen to go ashore, and gone are the days when a ship could lay up in port for an extra night so that the crew could get adequate rest.

Seafarers sleep on noisy, vibrating, rolling and pitching platforms. Furthermore, the human body is set and synchronised by daylight, sleeping during day time and broken sleep is not as beneficial as unbroken sleep at night. In other words, the traditional watch rotation system with four hours on and eight hours off, seems designed to interfere with normal sleep cycles. This is another factor which could increase the likelihood of fatigue, since it fails to provide a long rest period each day for uninterrupted sleep and relaxation. This issue is not directly related to crew size, except to the extent that vessels with smaller crews may take heavier demands on crew members' time and stamina, aggravating any possible effects of fatigue.

It is known that excessively long work periods, sleep loss or sleep disruption are likely to result in serious fatigue that can increase the likelihood of human error, degradation of human performance in mental tasks involving memory, slowing down of physical and mental reflexes, increases the reaction time in critical events and reduces the operator vigilance and attention.

When the oil tanker Exxon Valdez ran aground in Alaska in 1990, most of the media tried to imply that the accident came about because the ship's master was under the influence of alcohol. This suggestion was subsequently dismissed in court and it emerged according to ITF Seafarers' Bulletin number 6, 1991, page 26 that

> "Exxon had applied to the US Coast Guard for permission to reduce the crew complement from 33 for which the vessel was designed to the 19 that were onboard when she ran aground. The masters of ships like Exxon Valdez were instructed to keep overtime hours to an absolute minimum so as to give the impression that the vessels were being run as efficiently by smaller crews as they were with the normal complement. In other words, the tanker's crew, and particularly the master and other bridge officers, were working under severe stress and were being forced to do the work of other seafarers who had been "rationalised" in addition to their own".

More than just a lack of sleep, fatigue can also be caused by stress, boredom, loneliness, and isolation - problems that have always faced seafarers, but which appear to be getting worse (small and mixed crew).

Little information is available to indicate the increase or decrease in working hours as crews have been reduced. Some labor organisation are genuinely concerned that smaller crews mean more hours worked, more fatigue for the remaining licensed and unlicensed personnel, and therefore degradation of safety.

Management responds by saying that properly managed, average working hours need not to increase and that in some cases fatigue may decrease, for example in engine rooms certified for unmanned operations, engine department personnel can work days only instead of standing four hour on and eight hours off watches.

One of the problems in attempting to link crew size-fatigue-casualties is that casualty investigations, until recently, did not attempt to include "fatigue" as a cause of accident nor even list the number of crew onboard. In fact, in June 1991, in co-operation with the International Labor Organisation (ILO), the IMO started to investigate the problem of fatigue in manning and safety and for this purpose a joint IMO/ILO group of experts on fatigue was set up. In March 1993, the IMO/ILO group of experts on fatigue prepared draft guidelines for the investigation of accidents where fatigue may have been a contributory factor. These guidelines have been approved by the Maritime Safety Commitee (MSC) and circulated as MSC/Cir.621. The MSC invited member governments to use the fatigue data form given in MSC/Cir.621, and to submit it to the Organisation in order to establish a database of factors in maritime accidents derived from the fatigue factor. The first detailed analysis of the above data should be carried out at the 66th session of the MSC in spring 1996 or earlier.

However, in the amendment to the annex of STCW 78 undertaken at the 1995 conference of parties to the 1978 Convention (STCW 95), there is a provision where fatigue should be prevented by an adequate rest.

> "10 hours rest in any 24 hour period which could be divided into two periods, one of which must be of 6 hours; and permitting the 10 hours rest to be reduced to not less than 6 hours for not more than 2 days and provided that not less than 70 hours rest were provided each week."

This provision is set in Chapter VIII- Standards Regarding Watchkeeping, Section A-VIII/I- Fitness for Duty.

The overall aim of any legislation on working hours and rest periods should not only be to improve condition for individual seafarers, but perhaps more importantly, to improve safety of life at sea and to protect the environment.

5.3 CONCLUSION

Despite all the problems of small crew size and single manning, it can bring human benefits if all the consequences are correctly deduced and if human-machine interface is properly designed and integrated.

Vessels designed for smaller crews are technically more sophisticated than the conventional ships. They broaden the seafarer's responsibilities. Small crews require wider skills. In addition to the conventional duties the crew will need to be well trained in crisis management and emergency response. A safe and efficient watch requires that the watchkeeping officer is competent, properly qualified and sufficiently rested even with the best bridge equipment. More attention need to be directed towards physical and psychological fitness for duty while recruiting future seafarers.

The primary objective of any industry is to run a profitable business, at the same time safely move cargo, protect the crew and the environment; thus the common goal is **"SAFETY"**. The variable is the **"METHOD"** used to attain that terminal objective, which is **Education and Training of maritime personnel**. Such Education and Training should reflect the technical innovations in today's ships.

6. DUAL PURPOSE TRAINING

Mainly due to the impressive technological advances in automation and communication, and to the economic pressures, a number of changes have taken place.

* Reduction in crew size onboard ships
* The birth of a new profession the "**Bivalent**" officer which seems to be the keyword and a class of ship operation manager for the future
* The breakdown of the traditional departmental boundaries (deck, engine and radio department)
* Shift in main labour content from physically demanding activities to monitoring and control-oriented duties
* Availability of Computer Based Teaching (CBT) and Computer Assisted Learning (CAT) systems
* Progress in simulation technology enabling simulators to be used as efficient teaching tools.

All these changes are reflected in Maritime Education and Training (MET) for ship officers. In fact, they give a new dimension to MET systems in an increasing number of countries such as France, the Netherlands, the USA, Germany and Japan.

This chapter will describe how these leading maritime countries are integrating their MET systems to accommodate the changes described above. The emphasis will be placed upon studying the MET for the personnel intending to conduct duties on the management (Master, Chief mate, Chief and Second Engineer) and operation (Officer of the watch) level onboard.

6.1 TERMINOLOGY

As can be seen from the heading of this chapter and from the introduction, two concepts are used **"Dual Purpose"** and **"Bivalent"** officer. In fact much more than these two names are attributed to ship officers who have received an integrated training process (both deck and engine). For example,

* polyvalent
* multivalent
* multi purpose
* dual trained
* maroff
* general purpose
* integrated
* ship operation officer
* dual officer
* cross trained officer

In essence, they are terms for various blends of the same basic constituents, namely skills and competence in the deck and engine department. These names are confusing and not clearly understood by those who are not familiar or have not been introduced to the new officer profile.

In practice, the two clearly discernible classes of officers are **"Semi-integrated"** and **"Fully-integrated"** officers.

Fully-integrated officers means that they are fully educated and certificated to the highest levels of both the deck and engine department. This is the case in the French MET system where the officers are able to carry out the full range of duties in both departments. However, it is very difficult for the Captain to carry out, at the same time, the tasks of both Captain and Chief Engineer - especially if the technical level of the crew is not good enough. Therefore, until recently there has not been any ship with Fully integrated officers occupying both positions onboard ship.

Semi-integrated officers means that they are fully trained, educated and certificated to hold the highest certificate in one discipline (e.g. nautical stream) and trained for the watchkeeping role in the other department (e.g. marine engineering stream) or vice versa. In other words, they have their primary duties in one department but owing to their additional skills, they may work in the other department in a supportive role - a navigator who can also work in the engine-room or an engineer who can also keep a bridge watch (i.e. the system in the Netherlands).

6.2 INTEGRATED TRAINING OF SOME DEVELOPED COUNTRIES

6.2.1 MET in France (Polyvalent)

The maritime education in France is controlled by the maritime administration, but the education training and assessment is integrated with the national education system. In 1967, Polyvalent training was introduced. Actually, it is offered at four main merchant marine institutes (Ecoles nationales de la Marine Marchande - ENMM), located in Le Havre, Marseille, Saint- Malo and Nantes.

Fig 6.1 provides an outline of the Polyvalent programme. The main stream of studies and shipboard service are sequenced as follows:

* Entrance examination for holders of Baccalaureate (12 years of general education) and a physical aptitude certificate.

* First year of studies at ENMM (total hours are 714 and one hour equal 60 minutes), and 1,5 month shipboard service.

* Second year of studies at ENMM (total hours are 712). It includes two weeks in simulator (bridge and engine), an examination and 1,5 month shipboard service.

* Third year of studies at ENMM (total hours are 756). It includes two weeks in simulator (engine and bridge) and an examination which lead to the diploma as cadet officer in the merchant marine (Diplome d'eleve officier de la marine marchande).

* 10 months of shipboard service in which
  - 4 months as a cadets (2 on deck and 2 in the engine), following which students obtain the certificate of competency as watchkeeping officer (Diplome d'Eleve Officier de la Marine Marchande).
  - 6 months as polyvalent officer (3 on deck and 3 in the engine).

* Fourth year of studies at ENMM (total hours are 650) and a final examination to obtain the advanced diploma in the merchant marine (diplome d'etudes superieures de la marine marchande), which entitles the holder to sail as chief mate or second engineer. This diploma becomes a certificate of competency as master (Capitaine de Premiere Classe de la Navigation Maritime - C1NM) after 36 months of effective seatime of which 16 months each have to be spent on deck and in the engine.

Theoretically, it takes about 8 years from entering the system of MET at the age of 18 to the award of the highest certificate at an age of about 26 years.

One of the objective of this trainig scheme was to increase the mobility of ships' officer between shipboard employment and the shore side industry. It is said that the polyvalent officers are welcomed ashore and encounter no difficulty in finding jobs ashore when they decide to stop seafaring. However, as the number of ships under the French flag is decreasing, students have difficulty in completing the 10 months sea service.

Consequently, this period may last 2 years and even 3 years if the military service is to be included.

France has probably the highest entrance standards for merchant marine officers training in Western Europe because of the high entry level general education required - (Baccalaureate).

Another characteristic item which deserves special mention is that of the 4 weeks which are devoted to simulator training (2 weeks in bridge simulator training and 2 weeks in engine room simulator training) is in lieu of qualifying shipboard service. In effect a certified watchkeeping officer in this system completes only seven months of qualifying shipboard service instead of the requisite twelve months. The simulator training was introduced in 1991.

It is interesting to notice that at the end of each academic year, students have an examination; thus four examinations in their academic studies. On the other hand, watchkeeping certificates and the management level certificates are issued on the basis of sea service experience.

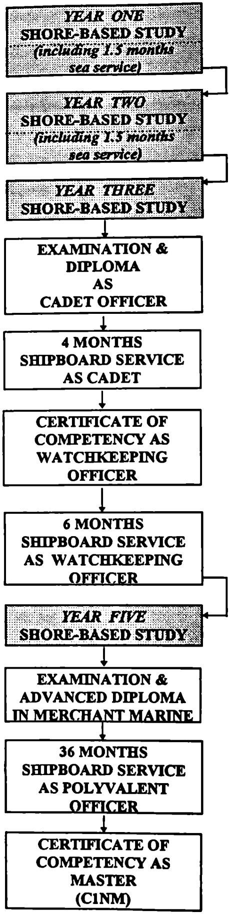


Figure 6.1: French polyvalent officers' training and certification scheme

6.2.2 MET in The Netherlands (Maroff)

Maritime Education and Training for officers of deep sea ships are currently provided at four higher vocational training institutions namely Terrschelling, Amsterdam, Rotterdam and Vlissingen.

In 1985, the Netherlands introduced dual purpose training and, since 1988, it has completly replaced the separate nautical and engineering programmes (monovalent training).

The entrance requirements for maritime officers are that the student should have completed pre-university education including passing final examinations in mathematics and physics. Students at this stage have an average age of 18.

The dual purpose marine officer programme is illustrated in **Fig 6.2.** This scheme represents four years of studies which can be described as follows:

* The first year of study at the training institution covers general subjects where all the subsidiary subjects are taught and consist of 34 periods per week (one period equals 50 minutes). At the end of the year, students have a course in a simulator, which is mainly to get to know the facilities (teams of 5 students).

* The second year of study at the training institution consists of 34 periods per week. This year is used for the professional qualification to theoretical watchkeeping level (job oriented subjects) including part task and full mission simulator training (40 hours per students in a simulator, teams of 2 students).

* The third year is the sea training year. It consists of 330 days onboard to do practical training in both department tasks under the supervision of a mentor onboard ship (one of the officers). Besides this, students have seatraining manuals which contain various

subjects to be dealt with by the trainee. Collecting technical data and assignments have to be sent periodically to the assigned mentor (one of the teachers).

* The fourth year of study at the training institution consists of 28 periods per week. These are specialist studies, which means that students choose to limit the studies in either the nautical or technical subjects to the watchkeeper level, but to carry on studies in other disciplines to a higher level (major and minor lectures). This last leads to major and a minor exams. Simulator training is conducted in this year too (40 hours per students, 20 hours as a team of 2 students and 20 hours on their own).

Upon completion of the exams, students are rewarded

- Bachelor of Science degrees by the Ministry of Education
- Lowest level watchkeeping certificate in both disciplines from the Ministry of Transport.

Depending on which exams were major and minor, students will receive the higher level certificate in their respective field (deck or engine) after four years sea service and four weeks of short courses.

Actually, a four-year-study programme for the fully-integrated marine officer is under discussion.

In the Netherlands the main purpose of the semi-integrated marine officer called "**Maroff**" has been crew reduction, which, together with new sophisticated ships, should reduce crew costs for the non-subsidised shipping companies which are in majority in the Netherlands.

Nautical academies usually have a large degree of freedom to structure the syllabus, timing allocations, teaching material, etc. This is not the case in the Netherlands where there is a national approach in functional skills required by the bivalent (Maroff) officer for a nautical education. The syllabus of the course for (Maroff) is designed by the Ministry of Transport, the Royal Dutch Association of Shipowners and the Federation of Unions of seafarers.

As can be seen from the above description of the Dutch system, the number of students in simulator training is reduced gradually untill finally exercices are done by the students on their own. This is done by the fact that students become more experienced and used to the simulator system. But, it has the advantages of maximising the number of simulator hours per students, enhance their technical and communication ability, and is a means to introduce the bridge team concept, since in critical situations in real life they will most probably be working as a teamwork.

The effectiveness of the training during the third year is wholly dependent upon the committment of the shipboard mentor of each trainee and the monitoring of the training by the shore-based lecturer. The question is whether officers onboard small-crew high-tech vessels will have time to devote to this activity. Moreover, it is of vital importance that the trainee's job assignments be evenly distributed among deck, bridge and engine room activities, which lead to alternative periods of duty on the three areas mentioned above. This new feature of integration is certainly asking for adaptations in the overall shipboard management structure and should have the loyal support of all involved.

Shaded areas show shore-based

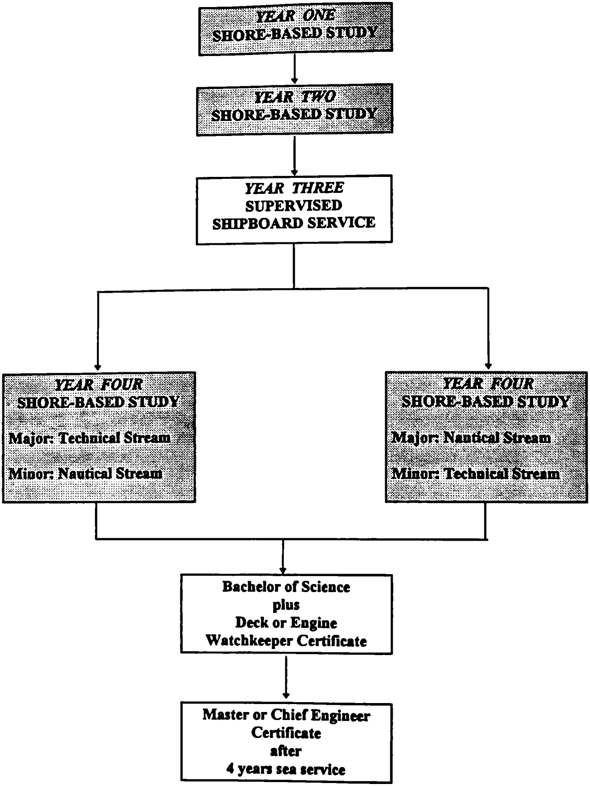


Figure 6.1: The Netherlands' semi-integrated marine officers' training and certification scheme

6.2.3 MET in Japan (Major and Minor)

Mercantile Marine Universities are the highest educational institution for ship's officers in Japan. They are located in Tokyo and Kobe and belong to the Ministry of Education.

Dual oriented education was started in 1984 in these universities. The first graduates who qualified to take examinations for both navigation and engineering were sent out in September 1988.

The entrance requirements for the maritime officers are that the applicants should be graduates from a senior high school. Students at this stage are on average 18 years old. However, there is no age limit. Applicants should pass entrance examinations consisting of an achievement test and a health examination.

The two universities mentioned above, have a four-year-academic system as shown in **Fig 6.3** and described below

* Students have to chose their main stream (engine or deck) at the matriculation.

* In each of the first three years of studies, students have one month of shipboard service on the training ships which belong to the Institute of Sea Training of the Ministry of Transport (MOT). The number of contact hours for the three years of shore based studies are respectively 495 hours, 570 hours and 570 hours. One hour corresponds to a 50-minute lecture.

* The fourth year of shore based studies includes three months of shipboard service. The number of contact hours is 473 hours.

* At the end of the fourth year of studies, students receive a bachelor of science degree.

* Students are sent to the Institute for Sea Training (MOT), which is located in Yokohama with a branch office in Kobe. This institute has two large sailing ships, two turbine training ships and two diesel training ships. Students follow a six-month-sea training course.

* The students who have successfully completed the navigation and engineering courses as well as the sea training course are qualified to take the examination for certificate of competency as watch officer Deck-engine (De) or Engine- deck (Ed) or the so called (Major and Minor).

* Examinations are supervised by the Ministry of Transport and consist of physical, intellectuel and practical examinations.

* Candidates who are successful in the examination can serve onboard merchant ships.

* An officer holding a certificate of Third Grade Marine Officer is qualified to appear for a written and oral exam, on completion of the prescribed period of sea service on vessels of defined engine power. Candidates who are successful in these examination can serve onboard merchant ships as Second Grade Marine Officer.

* An officer holding a certificate of Second Grade Marine Officer is qualified to appear for a written and oral exam, on completion of the prescribed period of sea service on vessels of defined engine power. Candidates who are successful in these examination can serve onboard merchant ships as First Grade Marine Officer.

Theoreticaly, it takes 7 years from entering the Japanese MET system at the age of 18 to the award of the highest certificate at an age of about 25.

The main priorities of the modernization of the seafarers education and training system in Japan are

* Technological innovation in ship's which lead to Man-Zero (M-0) ships concepts featuring unmanned machinery space, necessitating review of the manning and qualification for such ships.
* The recovery of the competitive power in the shipping industry and the assurance of job security for Japanese seamen onboard Japanese flag vessels in international trade.

Japan has provided many simulators to various developing countries. They have reputed simulator production facilities but strangely enough, they do not train their students in simulators during the training process.

For the award of the highest certificate of competency the students should have the requisite time of sea training plus a written and an oral examination.

Shaded areas show shore-based studies

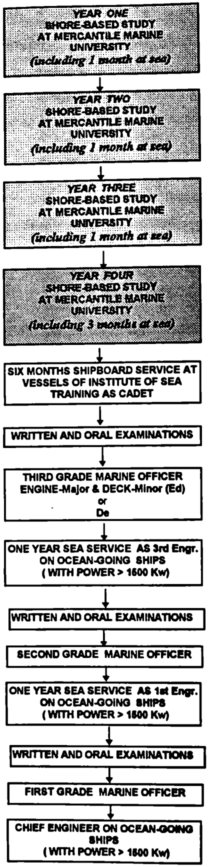


Figure 6.3: Japanese (Major-minor) officers' training and certification scheme

6.2.4 MET in Germany - Hamburg (Ship Operation Officer)

Hamburg Polytechnic offer education and training for the so called Ship Operation Officer (SOO) since 1989. The two biggest German compagnies manning their vessels with SOO are the Hapag-Lloyd and the Hamburg-Sud, both located at Hamburg.

All the German applicants who begin their seafaring carrier must pass by the vocational school in order to receive their Ship Mechanic (SM) certificate. This certificate has been created in 1983, and is a certification for multi-purpose rating cpable of deck and engine duties at the support level.

The duration of SM education and training is 3 years. The apprentice spends 10 weeks each year at the vocational school and the remainder at sea. In essence, it is 30 weeks shore-based studies and 2.5 years training at sea.

After successfull completion of the 3 years training, the apprentice receives the Ship Mechanic certificates which is a condition for further studies, to become SOO and Master (Ship Manager).

The SOO programme is illustrated in **Fig 6.4.** This scheme represents four years of shore-based studies consisting of eight semesters, which can be described as follows:

* The first four semesters are considered as the Foundation Studies where the students receive education in general subjects, such as mathematics, computing, economics, maritime English, etc. Each semester is 18 weeks in lenght. These two years of shore-based studies consist of 114 periods of 45 minutes each.

The number of periods per semester is as follow:

- First semester: 28 periods
- Second semester: 30 periods

- Third semester: 28 periods
- Fourth semester: 28 periods

* The second four semesters are considered as the Main Studies, where the students receive education in professional subjects related to their future duties onboard. It contains subjects such as automation, engines combustion, auxiliary systems, engine electronics, etc.

Another highlight of this segnent of education is simulator training. Students have 10 periods of 45 minutes in simulation training. The last two years of shore-based studies consist of 92 periods of 45 minutes each.

The number of periods per semester is as follow:

- Fifth semester: 28 periods
- Sixth semester: 30 periods
- Seventh semester: 28 periods
- Eighth semester: 6 periods in simulator training, and the remaining time is dedicated for thesis and final examination.

* After successfully passing the final examination, students receive a diploma as SOO.

* The graduates have to spend 48 months as SOO onboard in order to obtain their unrestricted licence as Master (Ship Manager).

* It is worth noticing that:

- SOO do not receive an academic degree.
- Education and Training is fully integrated.
- The duration of the curriculum for SOO is longer than similar in France, Japan and the Netherlands.

- Since the condition to become an officer at the management or operational level is the Ship Mechanic certificate. It means that the crew members onboard includes the support level know each other from there entry at the vocational school. This could result in an improvement for the ship efficiency and social life onboard.

Shaded areas show shore-based

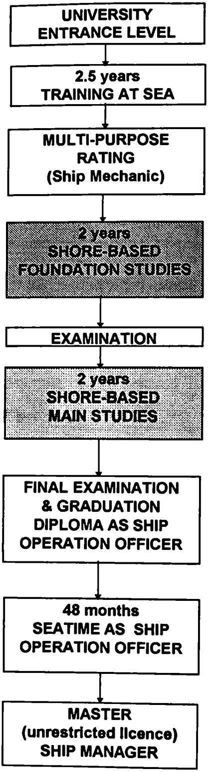


Figure 6.4: German (Hamburg) Marine Ship Operation Officers' training and certification scheme

6.3 COMPARATIVE STUDY OF MET CERTIFICATION SYSTEMS LEADING TO MASTER/CHIEF ENGINEER (UNLIMITED) LICENCE/CERTIFICATE

The integrated training system of the four countries mentioned in section 6.2 is summarised below, where it can be seen that the MET systems and the certification processes are very similar in structure.

Table 6.1: Summary of the integrated training system of the four countries

COUNTRIES ITEMS	FRANCE	THE NETHERLANDS	JAPAN	GERMANY (Hamburg)
SINCE	1967	1985	1984	1989
NAME	POLYVALENT OFFICER	MAROFF	(De or Ed) MAJOR & MINOR	SHIP OPERATION OFFICER
EXTENT OF INTEGRATION	FULL INTEGRATION	SEMI-INTEGRATION	SEMI-INTEGRATION	FULL INTEGRATION
MONOVALENT EDUCATION	PHASED OUT	PHASED OUT	STILL EXISTS	PHASED OUT
AGE AT ENTRANCE LEVEL	18 YEARS	18 YEARS	18 YEARS	16 - 18 YEARS
QUALIFICATION AT ENTRANCE LEVEL	BACCALAUREATE	HIGH SCHOOL EDUCATION	HIGH SCHOOL EDUCATION	SECONDARY SCHOOL EDUCATION
YEARS OF SHORE-BASED STUDIES	4 YEARS	3 YEARS	4 YEARS	4.5 YEARS
MINIMUM QUALIFYING SEATIME	4 YEARS	5 YEARS	4 YEARS	6.5 YEARS
LECTURE HOUR DURATION	60 MINUTES	50 MINUTES	50 MINUTES	45 MINUTES
MIN. AGE WHEN HIGHEST CERTIFICATION OBTAINED	26 YEARS	26 YEARS	26 YEARS	27 - 29 YEARS
MET system type	Sandwich	Sandwich	Sandwich	Front-ended
BACHELOR'S DEGREE AWARDED	YES	YES	YES	NO

6.4 MAIN DIFFERENCES IN MET SYSTEMS

6.4.1 Pre-career General Education

The STCW Convention does not state any period of pre-career general education as a compulsory prerequisite for the schemes leading to the certificate of competency.

There is no big difference in the periods of the pre-career general education. Most countries require periods of about 12 years. However, after 12 years of general education, do they have the same educational standards ?

6.4.2 Entry Requirements

Once again, the STCW Convention does not specify examinations or testing procedures or standards. Administrations and institutions are thus free to choose whether a subject is checked by oral, practical or written examinations and set their own standards.

As mentioned above, one of the first things that a document on recruitment and basic training needs to address is the educational standards of those recruited, and other factors that may be taken into account in their selection. Most countries do have an entrance examination (i.e. Physics, Mathematics and English language) and a physical selection test (i.e. eyesight, hearing and physical fitness). In state-of-the-art ships, these two tests are no longer enough, a psychological test must be introduced for the new applicants for nautical schools. This has been discussed in chapter 5 of this dissertation and at length by the International Maritime Lecturer Association (IMLA) during the Second International Workshop on Human Relations and Conditions Onboard Ships at Rijeka on 6 and 7 October 1988.

Some argue that this criterion is not considered because of the fact that a small number of candidates apply for nautical vocation, therefore there is no use for psychological selection. All the candidates who apply enter the schools. As a former seafarer, the author believes that this is a bad excuse.

6.4.3 Sea Service Before Shore-Based Studies

In some institutions, after completing the basic minimum safety courses (e.g. survival at sea, basic fire fighting) the student has to obtain minimum shipboard service before being admitted to the theoretical studies leading to a certificate of competency, while others take up their theoretical studies normally after their entrance at the institution.

Some argue that it is a bad idea to send cadets at sea on the basis "**see if they like it**" since it is unfair to both ships and cadets, who have been taught a short introduction to the shipping industry. The ship, nowadays with minimum crew, is faced with not only introducing the cadet to his work, but also with the responsibility of an untrained person in a dangerous environment.

Despite the aforesaid, there is a notion that cadets should be sent to sea first to "**see if they like it**" which is only natural. This first contact between cadet-ship-sea has a great relevance to the the future career of the seafarer. The cadet may have expected a sea career to be filled with romanticism, adventure and exotic experiences. He will need a first-hand experience to realise the harsh realities of a sea career. The old saying "**prevention is better than cure**" is the most suitable direction to follow at this early stage. Moreover, the cadets will be better prepared to get the message from the lecturers after being at sea.

6.4.4 Type of Training Systems

The type of training systems differ from country to country, Some use the "**Front-ended**" system where the applicants will complete all the theoretical studies first; then they take sea training. Others use the "**Sandwich**" system, which requires alternation between school and sea time.

In more maritime nations the education ministry and the shipping ministry are both involved in the training and certification of the seafarers. The education ministry provides shore based education and training, whereas the shipping ministry or its department provides opportunity for sea service. Further, academic awards are granded by the education ministry, and certificate of competency by the shipping ministry. There is bound to be a lack of co-ordination in the bureaucratic systems of both ministries.

The **Front-ended** system eliminates this problem by completing all shore-based training and academic awards before commencing seagoing service and certification.

6.4.5 Maritime Educational and Training Schemes

New technologies require new skills. The profession of the modern ship officer - besides the effective management of people - requires handling data instead of handling equipment. More strictly speaking, there has been a development from producing and collecting information to widely automatic acquisition, compilation, processing, interpretation, assessment and selection of relevant information.

Effective data handling requires the capability to use a computer and data processing techniques, to acquire, store, analyse and assess data, and to have a complete understanding of the controlled process and the ship as a total and integrated system.

It is observed that

* Operating systems using electronic technology and man-machine interfaces like keyboards, screens, and software tools like flow diagrams, icons and menues have become very similar in different applications such as bridge operation, engine room operation and loading office operation.

* The skills needed to operate electronic based systems are often not very high.

One man operated bridges are feasible, but the person in charge must be well trained in the operational use of the equipment. This can only be obtained by efficient training courses and probably by using simulators.

But training alone is not enough. It is imperative that the new generation of seafarers has a very sound grounding in mathematics, computers, electronic navigation principles and all aspects of automation if he is to operate and maintain the new sophisticated system which are coming on stream.

There is a difference in the education training schemes offered. Variations are noted in the lenght of shore side studies and sea time, and in the number of contact hours with trainees in the various subject groups which are not described herein.

The duration of theoretical shore side studies for the highest certificate is between 3 and 4 years in dual purpose training. As the study load of training programs is very high, there will have to be better teaching methods, which imply more use of simulation systems, videos, computers, etc.

Sea training is an essential part of cadet training, and it is important that they are properly prepared and can benefit fully from it. A task book and set projects are essential elements in this period. The overall sea training time within the training system scheme is shortened by the introduction of simulators. Thus, trainees are gaining competence, experience, performance through simulators in less time and without any risk or damage to property.

Theoretically, sea time after entrance into an MET institution vary between 3 and 5 years for the highest certificate.

6.4.6 Certificate of Competency

After completion of the Maritime Education and Training by the students, most countries are issuing two kinds of certificate

* Bachelor of science degree which is the key to recognition in the national system which indicates that the student has the required level of knowledge during shore based training
* After a compulsory minimum period of sea time, high and low level certificate of competency is delivered. This is a "license to drive" (e.g. pilots, car, etc).

Both certificate are assessed on the basis of shore written or oral examinations. In essence, the assessment for certificates of competency test the ability to retain information rather than to apply it to real tasks on a ship. To be more accurate, competency standards concentrates on the way they are achieved rather than the standards to be achieved.

It is questionable, though, whether in the circumstances of today's shipping industry, given the increasing specialisation of ship types and reduction in crew members made possible by technological developments, reliance can continue to be placed on this approach to determining competence.

It is felt that, for the future, seafarers will be qualifying in a new way. Testing will not be knowledge-based but function based.

As Peter Muirhead stated in an article from Lloyd's Ship Manager (LSM), 1994

> "If training can be brought closer to the job, a more reliable and valid assessment of required competence is possible".

The same writer goes on by claiming that

> "The development of simulator system can help to bring maritime training closer to shipboard practices and allow their facilities to be used to measure students' performance".

It is interesting to notice that the world "competence" does not appear in the 1978 convention at all other than as part of the term "certificate of competency". The revised STCW 78 Convention has included a new provisions where all simulators used in the training of seafarers or in evaluating their skills or competence would be required to meet general performance standards and personnel using them would have to be appropriately qualified and experienced. These provisions are illustrated in Regulation I/12, Code A-1/6 and Code A-1/12.

6.5 Conclusion

The different countries and academies develop different systems for dual certification. It comes as no surprise to discover that there is no uniformity in the different schemes. Problems in establishing Maritime Education and Training for bivalent officers may be due to

* Uncertainties about the later employment of the dual purpose officer on different ship types
* Uncertainties about the extent of integration (specialist onboard?)
* Lack of international harmonisation and lack of internationally recognised standards of safe operational practices on high technology vessels.

Although, physical fitness examinations for duty onboard is implemented in most countries, the situation regarding the mental fitness or psychological examinations for duty onboard is unknown. Psychological examinations must be compulsory in a time where the mental stress onboard is increasing, the crew number is coming down and one man bridge is on every mouth.

Training the bivalent officer, particularly the syllabus contents, must be based on an analisys of what the job or tasks onboard involves and the skills required to do the job. As the study load of training programs is very high, better teaching methods and equipment (i.e. computers, simulators, etc) are vital for the new officer profiles.

Sea experience and knowledge based approach for the delivery of certificate of competency should be phased out by assessing the officers in function based or standards which have to be achieved.

The emphasis of the two paragraphs above is on simulators which are usefull in training, retraining, revalidating certificates and in using them one may shorter the overall sea time for trainees. A fundamental question that must be addressed is:

To what extent is simulator training capable of replacing traditional training and of shortening the sea training period ?

Seafaring is not a life-long employment and thus maritime education must simultaneously prepare these highly qualified seafarers for a profession ashore. The training system must be structured in such a way that graduates receive a sufficiently broad education to be able to return to a maritime career ashore when their seagoing career is over (i.e. management and operation analysis, economics, shipping, etc).

At the end of the day, future bivalent graduates from the nautical institutions will - hopefully - worldwide qualify as deck and engine watchkeepers to international standards. However, one may ask
" why do we need such dual trained personnel and one man bridge operations ?".

7. ADVANTAGES AND DISADVANTAGES OF DUAL PURPOSE OFFICERS

In the previous discussion in the different chapters a number of advantages and disadvantages can be clearly seen. However, the challenge in shipping involves different interest groups (i.e. shipowners, seagoing labour, maritime training centres, port authorities, etc).

From an economic perspective, if the total benefits exceed the costs, there will be some interest groups who win and some who lose.

In general, the dual purpose officers offer a wide variety of advantages and disadvantages. This chapter will identify some of them for three different groups of interest namely shipowners, ship personnel and maritime training institutions.

7.1 SHIPOWNERS

The main aims of the shipowners is to reduce expenses and operate the ship at lower cost than the competitor. Dual purpose manning provides the following advantages and disadvantages:

Advantages

* Lower crew costs.
* More efficient ship operations, leading to better ship utilization and increased annual revenues.
* Easier to recruit good quality officers as job satisfaction is higher.
* Temporary transfer of crew to handle labour intensive problems.
* Technologically sound to have dual purpose officers.

* Attracts better quality recruits.
* Better understanding of ship systems leading to more competent use.
* Dual purpose training allows more flexibility in utilization of crew for the owner.

Disadvantages

* Increased capital costs in high technology labour saving equipment
* Lower crew size may be partly offset by wage increases for dual purpose crew
* Shipowners are hopeful and sceptical about reduced crewing in the future, but at the cost of new automated ships, minimal enroute maintenance which was previously performed en route.
* Increased shore based maintenance costs.
* High level of reliability needed.
* Increased demands for improved conditions service.
* The costs of producing a dual purpose officer is very high.

7.2 SHIP PERSONNEL

The concern of ship personnel is to acquire the span of qualifications required to fill a position onboard which has been tailored to suit an optimum manning. Dual purpose manning provides the following advantages and disadvantages:

Advantages

* Higher pay and prestige
* More flexible career path
* Individual transfer capabilities promote job security.
* Improved teamwork and flexible workforce.
* Greater challenge and job satisfaction.
* Improved technical and diagnostic skills.
* Better prospects of promotion to senior management.

* Better understanding of the ship as a total system.
* Better cooperation between bridge and engine.
* Higher job interest by wider variation in work content.
* Higher skill concerning integrated ship systems.
* Dual purpose officers will breack down the barrier of ignorance that exists in some ships between the deck and engineering department.
* A personal advantage to the more highly trained dual purpose senior officer will be the job opportunities both at sea and ashore.
* Ease of recruitment.

Disadvantages

* Increased costs of training.
* Need for existing officers to retrain or lose career opportunities.
* Reduced ability to respond to emergency situations at sea and in port (lack of manpower).
* Too many diverse tasks onboard thus greater workload.
* Rotation of duties required to retain proficiency in both disciplines.
* Problems may emerge when shifting from one ship to another.
* Loneliness of working on ships with small crews.
* Fear of change.
* Senior staff may fell threatened that the dual trained officers may get priority in promotion.
* Possible personal (psychological) problems.
* Navigator loose feel for situation.
* Potentially less motivation for navigation and tasks on deck.

7.3 MARITIME TRAINING INSTITUTIONS

The aim of the maritime training institutions is to produce ship personnel with adequate competence to carry out the various functions onboard

Advantages

* Opportunity for training institutions to upgrade equipment and increase training capacity.
* Stimulate review of teaching methods, etc.
* Increased ability to achieve broad educational goals in the long term national interest.
* Training institutions are motivated to streamline courses and cut some extraneous courses in order to accommodate training in the second discipline. The net result could be a more skilled graduate.

Disadvantages

* Increased recruitment difficulties due to higher entry requirements and need to compete with other high technology industries.
* Reduction in throughput with consequent increase in unit costs and possible reduction in number of training institutions and jobs for educators.
* Training more complex, challenging and expensive.
* Potentially inferior education in special subjects.

7.4 CONCLUSION

It is evident that different groups of interests have differents advantages and disadvantages depending on their policies, objectives, and priorities.

The advantage in the ship is that the combination of the two top functions into one person, is a good opportunity to omit the everyday conflict of interests existing in the two persons in different disciplines.

However, the nature of shipping produces certain common areas of interests. All companies are concerned about the health and safety of their employees, environment and ships.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1 CONCLUSIONS

This paper has attempted to address what is seen in the actual shipping industry namely: economic pressures, new technology onboard and the different training systems which reflect the changes onboard high tech ships.

The three largest shipping costs are the capital, bunkers and manning costs. However, for shipowners manning is the main element to focus on in order to cut the operational costs.

The traditional method adopted by operators and shipowners to reduce the operating costs is to register the ship under a Flag of Convenience. Which imposes low taxes and enables them to select low paid crews from anywhere in the world.

However, in response to a rise in serious casualties; serious shortage in the numbers of well qualified, competent and experienced seafarers; the ageing profile of the world fleet; the increasing cost of maintenance and repairs and the number of national and international regulations imposed on shipping; shipowners are facing an escalation in operating costs.

In order to cope with this trend, all the parties concerned are reducing manning levels and introducing modern technology and equipments in all key aspects of ship operations.

The most significant introduction of high technology is the integration of these new systems in the bridge which has resulted in an Integrated Ship Control Systems (ISCS). The final objective is to improve the feasibility of the One Man Bridge Operations

(OMBO) and thus achieve small crew size.

High technology, complex equipment and small crew size onboard require a careful look at the operator who is the end user of the high technology. In fact many problems that have always faced seafarers (i.e. stress, monotony, isolation, fatigue, etc) appears to be amplified on this state-of-the-art ships.

Moreover, the high tech ships shifted the main labour content from physically demanding activities to monitoring and control-oriented duties. That is to say that the changes breakdown the traditional department boundaries and new professional (Fully and Semi-Integrated Officers) is born.

This new profession offers different advantages and disadvantages for different interests groups (i.e. ship personnel, shipowners and maritime training institutions) depending on their policies, objectives and priorities.

8.2 RECOMMENDATIONS

It is our responsibility (Professors, Lecturers, Instructor, etc) to offer the appropriate Training and Education to the future seafarers in order to protect our planet from major casualties and pollution. In the other hands, shipowners must make doubly sure that history does not repeat itself (Amoco Cadiz, Braer, Exxon Valdez, Estonia, etc), and must treat trained seafarers as an asset and as an investment.

An old proverb say:

> "Those who ignore the past are condemned to relive it"

Herein are some recommendations for:

Manufacturers

* Manufacturers should agree to a uniform performance standards for their new equipments onboard i.e. ECDIS, ARPA, Integrated Navigational System, etc.

* More attention should be paid to ergonomic design (equipment, bridge, etc) for the users.

Safety

* "Dead Man Alarm" is of prime importance onboard OMBO vessels and should be compulsory.

* There should be a recognised standards of safe operational practices on high tech ships.

Maritime institutions

* There should be an uniformity in the different MET schemes adopted by the different parties concerned.

* Every potential crew member onboard small-crew high-tech vessel must be required to undertake psychological examination to ensure that he has the correct psychological profile for such service.

* Sea service before shore-based studies should be adopted by all the maritime academies e.g. the German Ship Operation Officer (SOO) training system.

* As the study load of training is very high, advanced teaching methods and equipment are vital for the new officer profiles.

* Officers should be assessed in a function based or standards approach to be achieved instead of knowledge based approach.

* Introducing new manning levels and training the bivalent officer must be based on a careful analysis of what the job or tasks onboard involved and the skills required to meet the challenge of this change.

* Small crew size needs more training in crisis management and emergency response and English language.

* Seafaring is not a long life employment and thus maritime education and training must simultaneously prepare these highly qualified seafarers for a profession ashore.

Life onboard

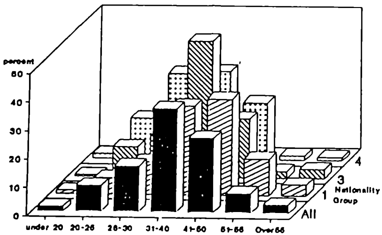
* Manufacturers of the state-of-the-art ships should take into account the social life onboard while designing the vessel: swimming pool, gymnasium room, video films, computers, attractive common crew area, attractive and big enough crew rooms for those who wish to have members of their family onboard, etc.

* Quantity and quality of the food is essential.

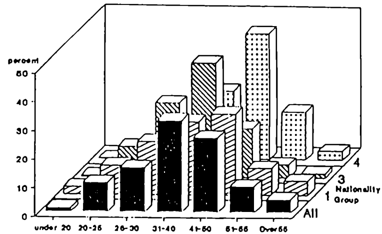
APPENDIX: 1

AGE STRUCTURE AND NATIONALITY GROUP OF SEAFARER

Officers and Cadets



Ratings



Nationality Group 1 Europe, N.America, Canada, Australia, New Zealand, Japan. (6871)

Nationality Group 2 Central and South America. (139)

Nationality Group 3 Far East. (5045)

Nationality Group 4 The Indian Sub-Continent and the Middle East. (3287)

Nationality Group 5 African (68)

Numbers in parentheses indicate number of seafarers on which the estimates are based.
Sample numbers for Groups 2 and 5 were too small for meaningful analysis.

Source: Final report of the research ISF/BIMCO, (1990)

APPENDIX: 2

STATUS AND REQUIREMENTS OF THE INTERNATIONAL REGISTERS

Registry	Number and Tonnage of Vessels	Nationality Requirements for Crews[a]	Age Restrictions on Vessels	Ratification/Extension of				FOC Status	Legislation for "Dual" Registry
				Solas[b] 74/78	Marpol[c] 73/78	STCW[d] 78	ILO 147[e] 76		
Panama	5,217/49.6 million grt	None	Vessels of more than 20 years need special inspection.	Yes	Yes	Yes	No	Yes	Yes
Liberia	1,672/55.2 million grt	None, except officers must have Liberian licence.	Vessels must not be more than 20 years although waiver for re-registrations may be considered.	Yes	Yes	Yes	Yes	Yes	Yes
Danish International Register	456/5.1 million grt	Master must be Danish subject. Crew must hold certificates issued country which has ratified STCW.	None	Yes	Yes	Yes	Yes	No	No
Gibraltar	49/613,076 grt	Master, CO, & CE must be British.	None	Yes	Yes	No	Yes	Yes	No
Honduras	966/945,067 grt	90% crew should be Honduran if available.	Over 25 years needs safety certificate	Yes	No	Yes	No	Yes	Yes
Hong Kong	387/6.9 million grt	Master, CE & RO must hold certificates of competency issued by the Hong Kong Maritime department.	None	Yes	Yes	Yes	Yes	No but has been subject to ITF boycotts	No

* Cargoships of more than 100 grt as recorded by Lloyd's statistical tables for end June 1992.

(a) CO - Chief Officer; CE - Chief Engineer; 2nd E - Second Engineer; RO - Radio Officer
(b) SOLAS - Safety of Life at Sea, 1974 and 1978 Protocol.
(c) MARPOL - Prevention of Pollution from Ships, 1973 and 1978 Protocol.
(d) STCW - Standards of Training, Certification and Watchkeeping, 1978
(e) ILO No. 147 - Merchant Shipping (Minimum Standards), 1976.

Source of Data: Ship costs in the 1990s.
The economics of ship operation

APPENDIX: 3

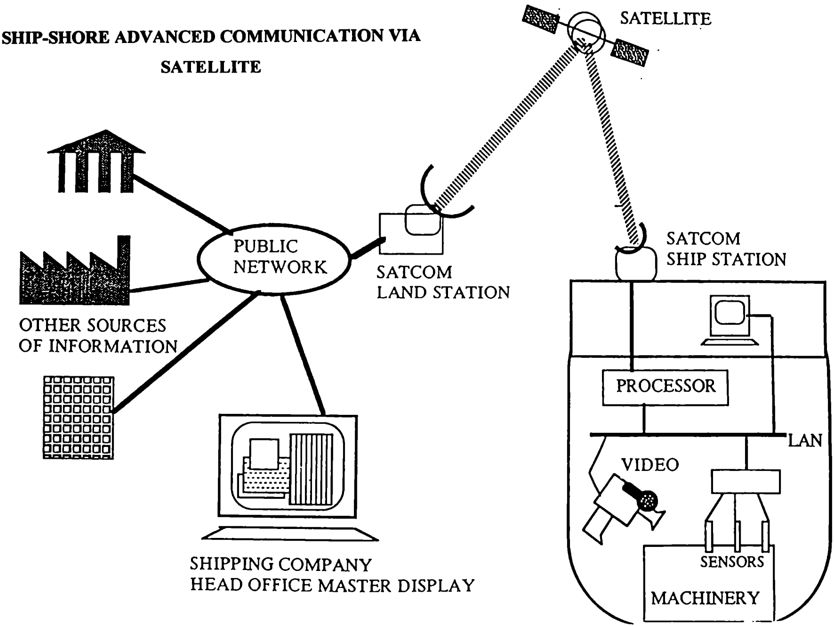
Advanced Communication Through Satellites

In the 15th International Maritime Propulsion Conference, "Future Ships: Setting targets for design development". An article written by Nicholas,P,Kyrtatos (1993) states that

> "An interactive communication followed between the engine manufacturer's expert ashore and the chief engineer onboard. The chief engineer used the hand-held camera in the engine room to show the presumed damage and the expert manipulated the remotely operated (from ashore) fixed camera, in order to advice the crew to take apart a piece of machinery. The damaged part (a defective fuel pump) was positionned so that the experts ashore could operate and focus the camera and by direct observation, using image processing on frozen frames and running software for engine diagnosis, identify the damage and advice the necessary repair procedure. Furthermore, the dismantling and machinery of the damaged part in the ship's workshop, followed a drawing from the manufacturer's archives which had been transmitted in the meantime and was supervised by the experts ashore.......The scenario served well to demonstrate the functionality and full capabilities of the advanced communications environment."

The following figure shows the ship-shore advanced communication via satellite.

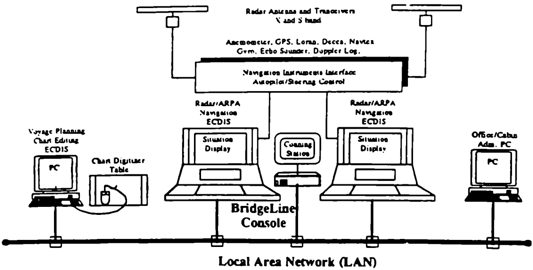
SHIP-SHORE ADVANCED COMMUNICATION VIA SATELLITE



APPENDIX: 4

DataBridge Functions, Architecture and Design

- Presentation of Radar signals
- Arpa functions
- Presentation of navigation information.
- Position Estimator
- Route Planning / Chart Editing
- Course/Speed Control
- Conning Display
- Tracking Functions
- Reports on printer and/or display
- Interface to fulfil requirement for total integrated ship control system
- Stand-alone and integrated configuration



APPENDIX: 4 (Contd)

DataChief Functions, Architecture and Design

Remote monitoring of temperatures, pressures, flows, levels and other process variables.

Remote monitoring and control of power plant including power management.

Remote monitoring and control of stand-by pumps, valves, regulators, fuel transfer system and bilge pumps.

Operation through mimic pictures with direct addressing of process variables with trackerball.

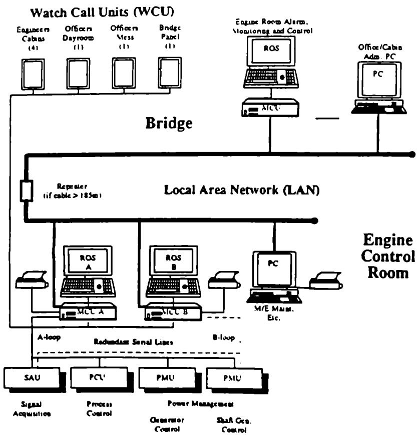
Functional operator panel with direct addressing to functions.

Reports on printer and/or display

Possibilities for both centralized and/or local operation.

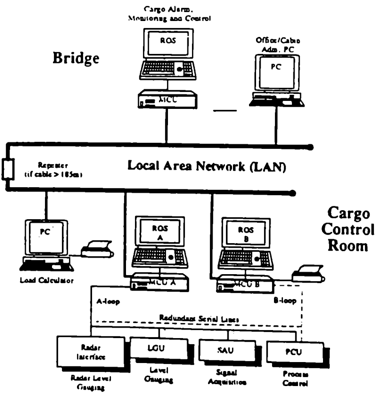
Interface to fulfil requirement for total integrated ship control system.

Engineers watch calling system and navigators safety system.



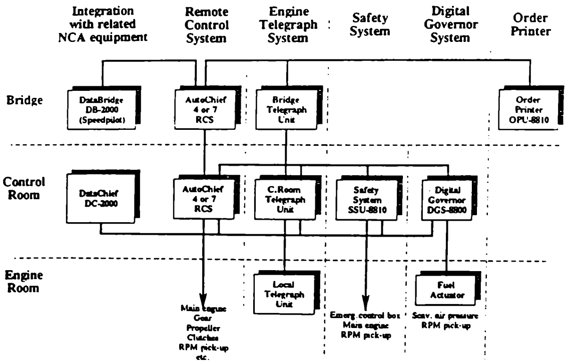
DataMaster Functions, Architecture and Design

Control of pumps, valves and sequences with special logic.
Start/stop and cavitation control of cargo pumps, ballast pumps and COW pumps.
Alarm and monitoring with log functions.
Automatic discharge and stripping programs.
On-line load calculator.
Operation through mimic pictures with direct addressing of process variables with trackerball.
Functional control panel with direct addressing to functions.
Reports on printer and/or display
Input from cargo and ballast levels
Interface to tank radar sensors from several manufacturers
Possibilities for both centralized and/or distributed operation.
Interface to fulfil requirement for total integrated ship control system.



AutoChief Functions, Architecture and Design

- Remote control for manoeuvring of the main engine(s) according to classification societie's rules and engine manufacturer's requirements.
- Engine telegraph for transfer of commands between bridge, engine control room and engine room.
- Safety functions for the protection of the main engine(s) according to classification societie's rules and engine manufacturer's requirements.
- RPM control of the main engine(s)
- Speed control of the ship
- Order printer for orders and events relating to the manoeuvring of the ship.
- Functions to suit all kind of engine configurations. (Low/medium/high speed, single/multiple engines with power take-offs, controllable/fixed pitch propellers)



Propulsion Automation
Main Systems

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