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1. Objectives

Operational competitiveness of shipping companies is largely dependent on the way they respond to market forces including:

- Economic trends
- Legislation or regulatory requirements
- Competitive activity
- Technological advances
- Industry structural changes
- Factors affecting crew availability

Several of the above factors may act simultaneously to create a need for improved or changed processes at any moment, and the factors (as well as the strengths of influence) may vary over time.

Successful companies deal with the above by ensuring that their business processes enable them to operate efficiently at all times, and that all necessary information to enable decision making is available when needed and at the point of need. This requires integrated fleet management processes and support systems. However, this is a highly challenging task for shipping operators as they often rely on numerous proprietary applications often different ones for different vessels.

The objective of the study is to review integrated fleet management approaches and to suggest credible options, their strengths and weakness.

2. Target Stakeholders

- Ship operators particularly fleet managers who are thinking to upgrade their systems
- Ship technology providers who wish to examine new developments affecting their product development plans
- Charterers
- Owners/operators/managers
- Agents/Brokers

3. Glossary Terms

ARETOPS	A Reference System Architecture and Technology Platform for the Shipping Sector
ARKTRANS	
CCS	Cargo Community System
CRM	Customer Relationship Manager
D2D	Door to Door
EFFORTS	Effective Operations in Ports
EMSA	European Maritime Safety Association
ERP	Enterprise Resource Planning
ETA	Estimated Time of Arrival
EU	European Union
FP	Framework Programme
HR	Human Resources
HSE	Health and Safety Executive
ICT	Information and Communications Technology
IDES	ISM driven Data Exchange for Ship operation
IMO	International Maritime Organisation
ISM	International Safety Management
ISO	International Standards Organisation
IT	Information Technology
ITEA-DS	
OEM	Original Equipment Manufacturer
PCS	Port Community System
SCM	Supply Chain Management
SNAME	Society of Naval Architects and Marine Engineers
SSN	SafeSeaNet
STCW	Standards of Training, Certification and Watch-keeping
TMSA	Tanker Management and Self Assessment
UN ECE	

A *Fleet* contains a number of Ships of different types (e.g. tankers, bulk-carriers) and can be subdivided according to geographical/topological criteria (Mediterranean fleet, Atlantic fleet etc.). A ship can be a member of several fleets.

Chartering is the arrangement made between a ship owner and a cargo owner for the transportation of goods by means of one or more ships. The goods are transported from the shipper (sender) to the receiver. In order to make this market more flexible as well as cost and time efficient, a brokerage network is in place. By means of brokerage, transportation agreements are reached in a more sophisticated manner.

Ship Maintenance involves the planning, execution and monitoring tasks undertaken by Superintendents, Officers and crewmembers to maintain a vessel. It includes Spares Inventory Management; Defect Reporting and Tracking; Work planning and Maintenance preparation, Maintenance reporting and tracking

4. Approach

In the maritime sector there are several IT companies offering a wide variety of software packages supporting business processes specific to fleet management. The aim is to ease the management decision making process and help the ship's crew with their tasks. The most common applications include voyage planning, spares inventory, purchasing, ship management, route planning, container loading, cost tracking, loading calculations, accounting, cargo loading and training.

The result is that Maritime IT systems purchased and in use by ship owners and operators currently consist of a combination of applications from many different software vendors using different software platforms/processing hardware and interfaces. As such they are not necessarily compatible and do not, as a whole, offer optimized performance or result in the most efficient use of information for decision making.

The requirement, unchanged for many years now, is for integrated fleet management systems which includes all the functionalities listed above but with seamless integration between the packages. The architecture of future integrated fleet management systems should be such as

to ease the introduction of new business software packages as they become available. Modularity and standardization are key parameters in such a system, but it would be important to analyze why such methods have not work up to now.

This study will review the currently available software packages and the early fleet management systems now becoming available in terms of their applicability to future integrated fleet management systems and the implications to business and ship operations.

Key areas to be addressed include detailed process models in the following areas:

- Chartering
- Fleet Scheduling and voyage management
- Maintenance and Purchasing
- Crewing
- Compliance management
- Integrated process models (extending to all the process described above)
- Integration and optimisation technologies with specific reference to the synchronisation of the main schedules under which a shipping company operates (the crew schedule, the fleet schedule, the maintenance plan, the delivery schedule of spares, other supplies, and the financial budget).

References

Key Publications

Key projects

1. ARETOPS
2. ARKTRANS
3. EFFORTS
4. Ides
5. ITEA-DS

Key journals, conferences / events

Digital Ship

Journal of Commerce

Key web sites

http://www.ship-technology.com/

http://www.thedigitalship.com

5. European Initiatives and Funded Projects

5.1 European Perspective

The European Union is committed to supporting the maritime industry which provides a major contribution to the competitiveness of European business and has adopted a global strategy to improve the European fleet's competitiveness which is a major facilitator for international and worldwide trade. (Ref)

The European Union's Transport Logistics Action Plan[1] proposes a Single European Transport Document to streamline cargo and traffic information exchange between authorities and between authorities and other stakeholders. There is also a need to convert completely from the use of paper documentation to electronic messaging; this is being achieved in some quarters.

CargoDoc, an electronic Bill of Lading developed by Electronic Shipping Solutions (www.essdocs.com) has been used for the first time recently - Digital Ship March 2010

In order to provide an efficient and competitive maritime industry there is a need to ensure that all stakeholders are kept fully informed and updated of events, The European Commission supports the use of advanced and interoperable IT systems to support activities such as booking, invoicing, tracking of passengers and cargo.

In recent years, a number of information management systems have been developed or are under development in the maritime sector which satisfy the needs of small clusters of stakeholders. These tend to be autonomous and are not always capable of communicating and inter-acting with each other and hence the efficiency of information transfer between stakeholder clusters is limited. Interoperability is restricted. A requirement therefore exists for improved information management across the maritime sector and this is now being addressed and promoted under the European Maritime Transport Strategy.

Future fleet management systems which are used by ship owners, operators and managers to run their businesses and fleets will need to be have suitable interoperability capabilities to

[1]A transport document is required today to follow the carriage of goods (Reg. 11/60 and Directive 92/106/EC); According to the Freight Transport Logistics Action Plan, a Single European Transport Document will be established that can be used in all transport modes enhancing the framework offered by multimodal waybills or multimodal manifests

enable them to interface and exchange information efficiently with the information management systems of external bodies and organisations (such as AIS, LRIT, customs, port authorities, administrations, vessel traffic management systems etc) as well as within their own organisations. It is important therefore that stakeholders and, in particular, suppliers of maritime fleet management ICT systems, understand the future strategic maritime information exchange and management processes being promoted by the EU through Initiatives such as those described in the following sections.

5.2 European Initiatives

There are several EU Initiatives aimed at providing for the integration, simplification and interoperability of existing and future maritime information systems to improve the efficiency and reduce the cost of operation and improve safety and environmental aspects. These will have significant implications on information flow in future D2D transport and logistics systems. Future fleet management systems will have to have the interoperability to interface and exchange information efficiently within the maritime scenario resulting from these Initiatives. Some of the more important initiatives, which impinge on fleet management systems, are described in the following sections.

Cargo Community System (CCS) – defined as a community system that, based on *an integrated series of procedures, rules, standards, and ICT tools, supports the automatic exchange of data, information and documents related to the handling, storage and transport of cargo.* Developed to handle the exchange of information related to cargo and cargo clearance, it dealt with the exchange of cargo related information and mainly with the acceptance, handling and storage of containers on the terminals with the aim of decreasing the enormous amount of paper and other information exchanges necessary to handle and store the millions of containers.

Port Community System (PCS) - A PCS is defined as a community system which based on *an integrated series of procedures, rules, standards and ICT solutions supports the automatic exchange of data and documents related to the port authorities' clearance of ships and cargo upon arrival, stay and departure of vessels*. In quite a number of ports worldwide, the Port Authorities have taken the lead in developing Port Community Systems. A PCS primarily supports the requirements of governmental agencies, but also the requirements of

the cargo interests. A PCS covers Customs requirements and handling, Immigration as well as the information exchange dealing with the necessary services in a port and the handling of ship and cargo.

SafeSeaNet:

The European Commission, in response to its maritime safety legislation (Directive 2002/59), launched the development of a SafeSeaNet (SSN) to provide a European Platform for Maritime Data Exchange between the EU maritime Administrations promoting co-operation in preventing maritime pollution and accidents at sea. SafeSeaNet includes the EIS (European Index Server) operated by the European Maritime Safety Agency (EMSA) which provides a "hub and spoke" network (including authentication, validation, data transformation, and logging) for sending requests to and receive notifications and responses from users. SafeSeaNet is intended as the main platform for information exchange in the EU maritime domain in terms of port arrival and departure notifications, notifications on dangerous goods, maritime security notifications, incident and accident information, AIS, LRIT and pollution monitoring.

e-Navigation - This is an International Maritime Organisation (IMO) led concept based on the harmonisation of marine navigation systems and supporting shore services driven by user needs. e-Navigation encompasses human factors, standards, procedures etc and is more than a system comprising of integrated subsystems and equipments. E-navigation is *'the collection, integration and display of maritime information aboard and ashore by electronic means to enhance berth-to-berth navigation and related services, safety and security at sea, and the protection of the marine environment'*

e-Maritime - The objective of the European e-Maritime initiative is to promote "coherent, transparent, efficient and simplified solutions in support of cooperation, interoperability and consistency between member States, sectors, business and systems involved in the European Transport System. The e-Maritime Initiative includes facilitating the take-up of the latest enabling ICT technologies and the development of internet based interactions between the various information systems and stakeholders to improve the interoperability, sustainability of maritime transport and to improve its integration into the overall EU transport system.

Voyage plans – *refer to AIS etc Marnis emaritime leaflet*

e-Freight- action of the EU Freight Logistics Action Plan which denotes the vision of a paper-free, electronic flow of information associating the physical flow of goods with a paperless trail built by ICT across different modes of transport

e-Customs - aimed at providing a paperless environment for customs and trade by making Member States' electronic customs systems compatible with each other and creating a single, shared computer portal

Single Window Concept - A Single Window environment is defined (UN ECE Recommendation 33, Recommendations and Guidelines on Establishing a Single Window) as an intelligent facility which allows the stakeholders involved in trade and transport to lodge standardized information, mainly electronic, with a single entry point to fulfill all import, export and transit related regulatory requirements. The implementation of a single window requires standardisaton and harmonization of information and, in particular, data. The benefits provided by the Single Window include reduction in cost simplification of procedures, reduced reporting burden avoiding duplication, and improved accuracy. The Single Window approach has been in use since the early 2000s and is being promoted by the European Union and for maritime related industries by the IMO. Examples are the Customs Single Window, Port Single Window etc.

Port Community Systems, such as those in operation in Finland, France, Norway and Spain, incorporate a single window environment; there is also an e-Customs Single Window project which is aimed at producing functional specifications in 2011. Both the EU's e-Navigation and e-Maritime initiatives also promote the concept of a single window approach to achieve their goal.

5.3 Funded Research Projects

European R&D projects, part funded by the EC, which have relevance to future fleet management systems include:

ARETOPS *(A Reference System Architecture and Technology Platform for the Shipping Sector)* – The project, which was funded under the FP? programme ran between January

2000 and December 2001. The aim of the ARETOPS project is to create a shipping sector specific reference architecture and to use it for the development of an open technology platform supporting the integration of key IST services/applications for the shipping industry. ARETOPS aims to facilitate e-business solutions in the shipping sector. It will form the basis for an automated system linking information providers for navigational use and ship management, and data from ship controls systems to the integrated ship-office computer.
The project will develop a Reference System Architecture and an Integration Platform. The Reference System Architecture will be broad enough to support strategic tactical and operational shipping processes. It will cover all the shipboard systems including integrated navigation and engine monitoring and control and it is flexible to accommodate future business requirements. The Integration Platform will consist of a core integration component and three standard interfaces, i.e., the Shipping Applications Interface, the Ship Sensors Interface and the Shipping Information services Interface. ARETOPS is now aiming at producing a more generic shipping reference system architecture addressing ship and office management applications, ship monitoring and control systems, and external information services. Key developments will include: definition and standardisation of information interchange between shipping applications (e.g. planned maintenance, crewing, loading, chartering); specification of key ship monitoring parameters and their associated sensors and processing requirements (e.g. validation, aggregation, data fusion, analysis, predictions, and interaction with management applications); protocols to interface ship sensory systems, distributing the information and interfacing on-board sub-systems; interfacing to various communication services and applications; standard interfacing facilities to external information services (e.g. Electronic Navigation Charts, weather services, classification information).
Website: http://www.aretops.org

ARKTRANS

Website - www.arktrans.no

EFFORTS *(Effective Operation in Ports)* – this was an Integrated Porject under the FP6 programme which began in May 2006 and was completed in October 2009. Research aims at creating innovations, which can be categorised as:

- Development of new products and services
- Improvement of existing products and services
- Improvement of processes to e.g. increase productivity or sustainability
- Optimisation of organisations to e.g. improve effectiveness in relation to productivity or contributions to the society

Website: www.efforts-project.org

IDES *(ISM driven Data Exchange for Ship operation)* - which has proposed an ISM/ISO compliant shipping reference model providing the integration framework for a shipping information and communication system

FLAGSHIP

FLAGSHIP (European Framework for Safe, Efficient and Environmentally-friendly Ship Operations) focuses on improving safety, environmental friendliness and competitiveness of European maritime transport. The project will contribute to a further increase in the capacity and reliability of freight and passenger services and to a reduction of negative impact from accidents and emissions.

Its overall mission is: *create the mechanism by which the expertise of all the required actors can be brought together in real time, independently of their location, and given to the right people, in the right format, at the right time and incorporating the highest level of knowledge, so that they can better manage all the questions which confront a ship operator: issues relating to the ship itself and its equipment (e.g. hull monitoring, equipment diagnostics, maintenance planning), its day-to-day operation (e.g. navigation, cargo, rule compliance) as well as emergencies and other exceptional situations (collision, fire, etc.).*

Particularly relevant are the Business models developed 'Manage commercial operations' and 'Operate ships sustainability' and ship lifetime operation value chain models. A topic addressed that is currently of particular interest to the industry is requirements to record operational indicators in the context of recommendations from IMO's Marine Environment Protection Committee. The project has taken into account developments associated with a mandatory CO2 Design Index for ships and an interim CO2 operational index, to establish best practices for voluntary implementation of GHG-reduction instruments. e-Maritime should develop solutions to facilitate information management for monitoring the fuel efficiency of ship operations, particularly under EU Flag states.

Also the project has developed advanced facilities tools for rule compliance. Regulations cover safety and marine pollution risks; certification of equipment and operational procedures. In the near future regulation might also involve continuous online monitoring, for instance connected to emission trading or by utilisation of alternative abatement technologies to prescribed solutions. Issues addressed include:-

- mechanisms for automatically updating legislation and rules, keeping them permanently updated;
- how those rules can be mapped to a specific type of ship, in a specific trade and arriving in a specific port;
- optimising regulatory reporting with reporting to owner and others.

A Text Search Engine allows the user to search the regulations that may apply to them. A lexicon of Marine terms was created for allowing metadata of the regulations for advanced search.

6. Fleet Management Systems

6.1 Current State of the Art

Ship owners and operators are facing increasing competition worldwide and to be successful necessitates improved efficiencies in all aspects of ship operations in order to reduce operating costs and to maximise profits and the returns on capital investments. The trend is for highly efficient and automated shipboard management (enabling reduced crew levels) and similar approaches for shore based operations (which results in reduced staffing levels) which leads to increased reliance on ICT (both on-board and shore-based).

Many ship owners and operators are therefore investing in ICT based ship operational management systems to help reduce the operating cost and to provide a competitive edge in the world market. Large shipping companies are already investing in their own ICT systems with software packages such as accounting software, documentation management software and some have their own intranet. However, the flow of information between the shipping companies and other various maritime stakeholders has been limited in the past because of the incompatibility of their IT systems to communicate efficiently with each other because each stakeholder has its own dedicated IT network.

On the commercial side of ship operations, the use of web-based software applications is gaining in importance both in terms of e-commerce generally and in fleet management processes such as spares procurement, generating bills of laden and e-commerce such as booking services, ticketing, and tracking/tracing of cargo. Integration and utilisation of web based services will become an essential part of fleet management in the future.

Real time asset management is essential in today's competitive markets and in the maritime sector ship owners and operators must be able to manage their fleets in real time and hence fleet management has become more complex. Owners and operators must deal with globalization, regulatory compliance, environmental requirements and ever-changing business and market conditions. Control and monitoring of individual vessels, during their voyage, to ensure that each is operating with optimised efficiency and safety is now possible because of the availability of the latest ICT and modular software packages becoming available and making it possible to estimate through life support and vessel life cycle costs of different vessels in a fleet.

Shipwide information collection is now possible and this can be transmitted in real time to shore based operation centres. Large quantities of real time, accurate data can be made available on each individual vessel concerning the voyage/route, Ports of call, state of health, performance, cargo-related information, etc which can be analysed and the results used in the business processes of the owners/operators to optimise efficiency, reduce costs and risks, and improve safety. This enables operators to manage and plan their fleet operations from ashore and to take any necessary actions as the need arises Fleet management systems also enable operators to establish common operating standards and procedures across their fleet of ships to ensure industry compliance, consistent performance and safe, reliable and environmental friendly operations.

6.2 Communication Systems

The communication infrastructure currently available in the maritime sector has enabled shipping companies to integrate their ships within their own overall IT networks. However, integration technology for the shipping industry must take into account the communications systems in use today and the ones which will be available in the foreseeable future.

Communication systems available-to and used-by the maritime and transport industries cover the spectrum of terrestrial (land lines, fibreoptics, telephone, HF/VHF/ UHF radio) and satellite communication systems; the availability of these has enabled the use of the internet, web-based processes and the possibility of real time information flow. The choice and availability of the different types of communications depends on the geographic location, for example, mid-ocean will not have the same modes available as in coastal areas or in-harbour (where cellular phones and wifi may be available) The method of communication for information exchange between ship and shore should be optimised such that the most cost effective and efficient mode is selected automatically, for example, high speed communications being used for urgent and rapidly changing information and slow speed communications for slowly changing.

In terms of fleet management, utilising the most appropriate and cost effective mode of communication between ship and shore is important as it enables efficient data gathering, data distribution and data processing such that continuously updated fleet wide information can be available instantly over an entire fleet at any time, in any office, for analysis and decision making. Ref.

6.3 Fleet Management Application Software

The relatively small market for ICT in the maritime sector has resulted in most ICT suppliers being small companies that have developed equipment/software-packages for specific applications within shipping operations. The global market for fleet management software is small and has been estimated as 300-400 million euro (Ref. –digital ship June 2010 issue) and there are estimated to be over 100 maritime software suppliers worldwide in the small fleet management sector. Many of these companies are specialist providers for small packages such as chartering, maintenance, procurement, quality and safety, voyage management etc. Such a small market, does not warrant much funding in terms of software development and hence the market is not really viable for small companies.

Fleet management software now becoming available from ICT suppliers incorporates some or all of the individual and discrete software packages and functionality listed below:

- Administration and Documentation management Vessel Drawings/Handbooks

- Financial management
- Chartering
- Fleet Scheduling
- Loading/Unloading
- Maintenance and Repair
- Purchasing and Inventory
- Crew Management and Payroll
- Voyage Management
- Fleet Management
- Quality and Compliance

The relatively few large companies in this sector with the expertise to develop integrated information systems for the maritime sector can supply a suite of software covering most of the applications listed above; these are usually based around Planned Maintenance Systems. However, few vendors can deliver a truly integrated fleet management system which includes all the processes associated with maritime fleet management and which have the required interoperability and interfacing capability to exchange information efficiently with existing and future information management systems.

6.4. Administration and Documentation Management/Vessel Drawings/Handbooks

The ever increasing administrative burden being placed on fleet owners and operators and the need for ensuring compliance with the various maritime authorities, HSE and environmental etc means that there is a need to automate and simplify documentation and procedures and minimise costs. The purpose of Document Management System is to track and store electronic documents or images of paper documents. There are numerous software packages available which enable the management, control and updating of documentation and administrative procedures which ensure common operating standards both on-board and ashore and facilitate knowledge sharing across a fleet. Documentation management allows the same versions of documentation to be available across fleets with updating being performed to ensure that correct up-to-date information is available to all stakeholders across

fleets and that all the necessary compliance documentation required by the various maritime authorities are maintained and up-to-date.

Documentation management software also provides for document lifecycle management including archiving and revision control of all documents which can be held in a central database. Documentation can include OEM handbooks and training manuals, documents from certification authorities etc (as well as internally generated documentation) updates of which can be made available automatically to all relevant stakeholders as they become available.

6.5 Financial Management

Ship owners and operators need to comply with internationally recognised accounting standards and provide regular Management and Statutory accounts as well as satisfying their own financial reporting needs. Financial management software covers a whole range of processes related to finance from the preparation of top level corporate financial reports for the board of directors/senior management, the provision of support to the general accounting processes, down to detailed reports and documentation covering items such as crew expenses/petty cash items. The accounting software therefore needs to interface with a many internal company departmental systems such as HR (for personnel/crewing costs), Purchasing (inventory, sales) and should be capable of generating all necessary reports and documentation and also provide the necessary documentation for external stakeholders such as suppliers customers. Examples of these are listed below:

- profit and loss sheets. operating statements, budget statements
- shore accounts, onboard accounts, voyage accounts
- ledgers
- cash flow analysis, cost tracking, costs per vessel
- equipment/spares
- purchase orders, payments, invoicing, claims, crediting accounts
- purchasing history

6.6 Chartering

Charterers are the shipping industry's customers who hire ships or space on ships in order to transport their goods and products. Some charterers also own vessels. Typical vessels chartered include bulk carriers, general cargo vessels, container vessels, refrigerated ships tankers and gas carriers. *Chartering* is the arrangement made between a ship owner and a cargo owner for the transportation of goods by means of one or more ships. The goods are transported from the shipper (sender) to the receiver. In order to make this market more flexible as well as cost and time efficient, a brokerage network is in place which in effect acts as the middle –man bringing together ship operators and charterers. Brokers, essentially find cargoes for ships and ships for cargoes. By means of brokerage, transportation agreements are reached in a more sophisticated manner. While in port, charterers and ship operators utilise the services of agents who transacts all business on their behalf and under their direction and also coordinate many activities such as providing supplies, arranging facilities in a timely manner, arranging bunkers and arranging all the appropriate port documentation.

The availability of real time on-board information in the latest ship owners IT systems means that very reliable information can be provided for the ship charterer who can use the information as part of his distribution information system and improve his stock control. Having the right information available at the right time is essential for a successful charterer or broker.

6.7 Fleet Scheduling

A *Fleet* contains a number of Ships of different types (e.g. tankers, bulk-carriers) and can be subdivided according to geographical/topological criteria (Mediterranean fleet, Atlantic fleet etc.). A ship, which can be a member of several fleets, is usually chartered for transferring cargo (which may be multiple types) from a one port to another. Ship owners/operators plan and allocate a schedule for each voyage for all ships in a fleet and prepare short term and long term plans and schedules for their fleet(s) of ships.

Fleet scheduling has traditionally been carried out using spread sheets and manual decision making but while this can be handled for small fleets, larger fleets make the task of

optimising fleet schedules too complicated to be carried out manually. Ship scheduling is the most detailed level of planning fleet operations.

Aspects to be taken into consideration in planning and generating a voyage schedule include:

- List of ports to be visited during a voyage
- Types and quantity of cargo to be transported
- Agent, brokers and suppliers to be contacted and services and facilities required at ports
- Initial route planning, speed, estimated fuel requirements
- Anticipated weather and sea conditions
- Turn round time in ports, available berthing windows (estimated time to berth (ETB) and estimated time to departure (ETD)

During a voyage there is a need to :

- Update voyage plans and routing
- Provide vessel position and tracking information
-

From a fleet planning and scheduling aspect, Ship Operators need to have at their disposal:

- Voyage schedule for, and details/statistics of, each vessel
- Position and track of each vessel in real time
- Performance information on each vessel
- Information on all ports visited
- Information on all agents and brokers
- Information on suppliers and bunkering
- Cargoes to be transported

Software packages and process modeling take the above into consideration so that the information required by the various stakeholders is readily available in a timely manner to ensure that the logistics chain works efficiently. Accurate fleet and ship scheduling can contribute to a reduction in operating costs and thus yield increased profits. Several IT companies provide fleet scheduling packages.

6.8 Loading/Unloading

Cargo handling, loading and unloading are critical from a safety viewpoint, ship stability, and ballast control. Software has been available since the 1980's and has progresses significantly since then. Instantly calculates the ship's condition

Tankers –Traditional methods of tanker cargo handling have been replaced with microprocessor based electronic control systems, with loading/unloading control possible from the bridge, cargo control room or at workstations at vantage points in the ship to enable the crew easy access when required.

Container vessels – the loading/unloading of container vessels presents a difficult problem because the stowage/positioning of the containers affects the and ballast ?

6.9 Maintenance and Repair

It is essential for ship owner/operators to maintain an efficient operational fleet of vessels to maximize returns and to maintain their reputation for the provision of good service. Well planned maintenance reduces repair costs and time out of action and can reduced the risk of accidents; it also ensures that the vessel is compliant with the requirements of classification societies, regulatory authorities and equipment manufacturers. The conventional method of carrying out maintenance and repair is based around planned maintenance and many owners operate a Planned Maintenance System which these days may be computerised. Such systems apply to onboard equipment/machinery/hull and ease the task of planning, execution, monitoring and documenting associated with maintenance and repair.

In order to optimize the maintenance process and further reduce costs, the trend is now to move to preventative maintenance, which is defined as 'the maintenance carried out at predetermined intervals or corresponding to a prescribed criteria and intended to reduce the probability of failure or the performance degradation of a component' Ref. The emergence of condition and performance monitoring systems is making a significant contribution to the move to predictive maintenance.

Condition and performance monitoring systems continuously monitor systems and equipment and determine the amount of degradation in condition and performance. This is achieved by

utilising historical data bases of fault conditions (which have now been built up over the years) and using expert systems/pattern recognition based techniques to predict condition and deduce the causes of faults/performance loss. Ref Condition monitoring systems collect, store, display, report and analyse condition assessment data from a variety of sources. *This information is employed to identify the optimum time to conduct maintenance activity, which in turn realises savings by reducing downtime for unexpected repairs.*

An essential part of the maintenance/repair process is the timely availability of spares, materials and any services/facilities should these be required. The use of preventative maintenance means that these requirements can be planned into the process in a cost effective manner. Advantages of using a preventative maintenance system include:

- Better control of spare parts resulting in reduced costs
- Reduced repair costs and down time
- Extended equipment life
- More efficient purchasing system

In terms of fleet management, on-board systems can provide real time information, via communication links, on the state of health of a vessel enabling shore based offices to advise on actions to be taken, carry out trend analysis, ensure that the appropriate spares/services are available when a vessel comes into port to minimize down time and costs. It is also possible to apply the process across fleets of vessels.

There are several suppliers that provide software packages covering the technical management of fleets and ships mainly based on planned maintenance but now moving to include condition based maintenance. Application software is available for on-board and shore based fleet offices. It is likely that all major system and equipment will be fitted with condition monitoring to provide state of health information; this will improve reliability and maximise availability of systems and vessels.

The Maintenance and Repair Management process is based on the following tasks:

- Setting planned maintenance scheme
- Managing Fleet Maintenance Database
- Producing Vessel Maintenance plan
- Condition monitoring

- Generate and manage weekly work plan
- Defect recording and analysis
- Preparing for maintenance execution
- Record maintenance completed and provide reports.

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6.10 Purchasing and Inventory

The Purchasing and Inventory functions, in terms of fleet management, entails all the activities related to the purchasing of spares and services so that delivered product is fit for purpose and meets the required specifications and is available in a timely manner. Activities include:

- Raising and reviewing requisitions
- Raising purchase orders
- Approval and payment of invoices
- Managing vendors/subcontractors and approved suppliers lists
- Maintaining list of suppliers prices, performance
- Raising and reviewing requests for quotations
- Manage inventory/stock levels, raising product receipt notifications
- Perform budget tracking and forecasting

Application software currently available provides full control and management of all purchasing/inventory data throughout these processes and provide interfaces with other departmental systems such as accounts (for financial information) and maintenance planning (availability of spares etc). Such systems provide greater visibility of information and the accurate, detailed information available enables faster decision making and supplier response time as well as accurate spares tracking.

6.11 Crew Management and Payroll

Fleet operators need to crew their ships with suitably experienced qualified and trained crew, in line with industry and statutory regulations, and ensure that they are able to retain

competent crew members who are becoming increasingly hard to find. Improving crew welfare is an important task of the ship manager if crew are to be retained especially as there is an acute shortage of well trained crew.

Crew selection should take into account certification requirements of IMO, STCW and with other relevant international regulations. Improving crew welfare is an important task of the ship manager if crew are to be retained especially as there is an acute shortage of well trained crew

The role of individual crew members has changed considerably with the installation of the latest ICT equipment on board. For example, as a result of real time data acquisition and transmission to shore based centres, it is now possible to diagnose on-board problems from shore based centres and suitable advice passed to on-board crew to repair faults. This means that there is less need for as many skilled and competent engineering personnel on-board; however, the rapidly changing ICT technology means that updating of the competence of engineering crew is essential.

Competent crewing of ships, which is the responsibility of the ship owner/operator/manager, is an essential part of the business which requires organisation and maintenance of records; sometimes this is carried out by fleet owners/operators or crew is outsourced from suitable agencies worldwide. Whichever route is taken to ensure satisfactory crewing, crew information management is a vital part of overall fleet management. The tasks which are associated with this activity include:

- Crew recruitment, interviewing, vetting and selection
- Crew planning and scheduling and vessel crew lists
- Crew payroll and salaries (including tax deductions, overtime payments, holiday pay, expenses etc.)
- Visa applications/joining ship and repatriation
- Crew performance appraisals, defining training requirements, organising training
- Crew certification, historical and training records
- Crew welfare/medicals

Software packages are available from several maritime IT suppliers which handle all crew related activities and which have the capability to interface with other relevant processes such

as accounting, HR, and which maintenance all personnel records. As crew do not stay on the same ship for long periods, there is an increasing need for crew information management.

6.12 Voyage Management

Optimised voyage management, planning and routing is recognized as an essential requirement for cost effective, efficient and safe fleet and vessel operations. Effective management and planning covers all aspects of a voyage from berth-to-berth whether it be for short sea shipping or long distance ocean crossings. All stages of a voyage from leaving dockside, harbour manoeuvring, the en-route portion, to final docking at journeys end are covered.

A vessel's voyage plan should identify a route which: takes into account any relevant ships' routeing systems, ensures sufficient sea room for the safe passage of the ship throughout the voyage, anticipates all known navigational hazards and adverse weather conditions, takes into account the marine environmental protection measures that apply and avoids, as far as possible, actions and activities which could cause damage to the environment.

Ship routing on the basis of the weather forecast is also of growing importance in shipping and more and more ship owners have realised the advantages of using weather routing to ensure smoother and safer sea passages. Accurate weather routing to avoid bad weather can provide the possibility of cost savings on sea-fastening and cargo reinforcements and damage to cargo; delays due to cargo salvage can also be minimised. Maritime services companies now provide software for forecasting and routing advice for commercial fleets worldwide and provide vessels with the safest and most efficient routing possible taking into account wind and sea conditions for the period of the voyage This information is used to define a track which will provide the fastest, safest crossing possible, taking into consideration all weather, cargo and special ship factors.

The need for accurate estimated time of arrival (ETA) planning in order for the ship owners to satisfy customers demanding information on where their cargo is, arrival time, and where and when it can be picked up and the need for "just-in-time" logistics has generated a requirement for accurate voyage planning and updating. Optimised voyage planning can also contribute to improvements in fuel consumption.

Voyage Management Software packages are available which take all the above aspects into consideration, in terms of single vessel and overall fleet activities. In-built facilities to cover voyage events and their reporting, daily reporting and voyage time logging are included as standard. While fleet management software is ashore, vessels carry their own on-board voyage planning facilities. Available software packages enable the planning of all voyage and cargo operations and track their actual progress and allow the monitoring of the actual performance and operational efficiency**.**

A knowledge of the voyage plans of vessels entering and in a region can enable maritime authorities to control and manage traffic in their region and avert any problems which can arise. It is the intention of the e-maritime initiative (See section ?) etc

6.13 Quality and Compliance

Quality, Compliance and Safety Management are essential processes in shipping companies which have to comply with the demands of statutory regulations, standards laid down by maritime organisations such as the IMO (ISM Code, SOLAS, MARPOL), TMSA, Standards bodies such as ISO, and the requirements of classification societies. These aspects are particularly relevant to fleet management which control vessels in international waters; international and national regulations co-exist which overlap and have inconsistencies, reporting formats differ and compliance enforcement agencies are organised differently in different countries. These activities generate substantial amount of administrative work which can be considerably reduced by the use of appropriate compliance application software

The company Quality Management System and its associated procedures should be compliant with, for example, the appropriate ISO standard, and should ensure that quality procedures are adhered to across all activities. Procedures should cater for activities such as incident management which entails the recording and documenting of incidents and occurrences, analysis of reports to identify causes and rectification action to eliminate faults or improve processes.

The Company Safety Management System and associated procedures should be compliant with the requirements of the IMO and ISM code, mandatory and statutory regulations and

international codes and standards and should have a defined structure and be implemented according to the ISM Code.

Software packages are available from several suppliers which cover all aspects of quality, safety and compliance which substantially reduce the workload associated with reporting, maintaining procedures and improving processes. For example, when combined with real time data gathering and communications, such functionality can provide accurate measurements of processes for bench marking which can lead to process improvements across fleets.

6.14 Application Software Suppliers

There are several application software suppliers in the maritime sector; many of the software application packages are based on Microsoft technologies and standard PCs to take advantage of the legacy ICT equipment and associated operating software. Many of the suppliers are specialists in sectors of the maritime market and provide application software packages which are capable of being interfaced with other application software to provide a combined suite to cater for the needs of ship owners and operators. There are a few suppliers who provide a suite of programmes which comprise of several of the applications described in the previous sections. Very few, however, can claim to provide a comprehensive suite of programmes covering all aspects of fleet management; fewer still can claim a software suite which can be fully integrated with external applications such as port community systems, VTMS and logistic chains. An overview and description of the various application software packages described above together with details of suppliers and their products is provided in 'Best practice in shipmanagement software', Tim Power, published by Digital Ship, November 2004,

Typical suppliers of fleet management application software are:

ABS Nautical Systems - offers fleet management software solutions to maritime industry for managing the principal operational expenses associated with a vessel, boat or offshore rig.

Solutions are offered covering areas such as:

- Maintenance Management
- Supply Chain Management

- Workforce Management
- Safety Management
- Supporting Solutions

Website: www.abs-ns.com

BASS – which is based in Norway, is a leading provider of fleet management software for ship owners, ship managers, and operators of rigs, FPSOs and offshore units world-wide. BASSnet 2.6, its latest fleet management system, whcih is based on Microsoft technologies and the Microsoft.net platform, is a powerful, integrated software suite designed to assist ship owners, ship managers and offshore companies in managing their companies and includes modules covering activities such as:

- Maintenance
- Procurement
- Document management
- Operations
- HR management
- Quality and safety management
- Risk management
- Self assessment (TSMA)
- Accounting
- Report generation

Website: www.bassnet.no

Danaos Management Consultants - is a leading maritime I.T. supplier serving over 500 customers globally. Danaos offers a comprehensive suite of products and services that include an integrated suite of software modules that automate all the functions of a shipping company (accounts and financials, chartering and voyage planning, vessel operations, bunkering, freight collection, spares, stores and provisions supply cycles, technical, planned maintenance, vessel monitoring, repairs and dry-dockings, crew and MGA, full ISM follow-up), linked with an integrated communications package (email, fax, telex, GSM, BlackBerry)

with comprehensive MIS and user-defined reporting and incorporating user-defined KPIs and their follow-up.

Website: http://web2.danaos.gr/

Mespas*:* *www.mespas.com*

Star Information Systems A/S - is a leading Norwegian supplier of maritime software for ship and rig management which comprise of tightly integrated solutions including planned maintenance (PMS), asset management, project management, safety / HSEQ, insurance, guarantee claims, marine purchasing and e-commerce.

The Star systems are based on standard Microsoft technology and use databases such as Oracle and MS SQL Server. The systems can be linked to any 3rd party software such as accounting, chartering/operations, crew/wages, etc.

Website: www.sismarine.com

Ulysses (www.ulysses-systems.com)
Vector (www.vector.gr)
Marine Software Limited (http://www.marinesoftware.co.uk)
Xantic (www.xantic.com

Key Publications

1. Katsoulakos, P.. *"Monitoring and expert systems in development of fault diagnostics"* International Conference on Computers in Engine Technology. March 1987
2. Katsoulakos, P., et al *"Expert systems and marine applications"*. Trans. I.Mar.E ™ Vol. 101 October 1988. Denny gold medal for best paper in 1988.
3. Katsoulakos, P. et al. *"The impact of Information Technology in Advanced Systems in future fleet Management"* SNAME Symposium New Orleans April 1989
4. P Katsoulakos "e-business developments for ship operation and management" International Conference in e-Procurement in Shipping, LL, London, Feb 2001
5. T Power, Best practice in ship management software Digital Ship Nov 2004

7. Integrated Fleet Management ICT Systems

7.1 Overview

An integrated fleet management system should essentially be a comprehensive suite of software (which should include all the required discrete software packages described in section 6) seamlessly integrated to provide shore based management, onboard crew, other vessels and shore based authorities with the relevant information to ensure optimised fleet efficiency and safety. It should be possible to customise the generic software suite to suit individual company's specific requirements, for example, in terms of vessel type, cargo, environmental conditions, shipboard machinery/systems, and internal company procedures and policies. Ship owners should be able to select and procure an integrated suite of modular software packages that provides a single solution to satisfy all main areas of their operations and business.

The benefits of implementing integrated fleet management systems based on the latest ICT technologies include:

- Provide user friendly man-machine interfaces
- Enable common operating standards and procedures to be applied across the fleet.
- Provides an efficient and cost effective means of process improvement and bench marking
- Ensure compliance with the increasingly maritime regulations
- Provides a means of sharing common information

7.2 Information Exchange Standards

In future, ship owners and operators, in addition to having their own internal information systems, will need to communicate and exchange information efficiently with an increasing number of external maritime stakeholders such as:

Classification societies and regulatory authorities

Charters, shipping agents and brokers

Port authorities and flag states and navigational services

Suppliers (such as financial and insurance services, shipyards, engineering services, stores, bunkers etc)

Future integrated fleet management systems should, therefore, have the interoperability to ensure the operation and information exchange capabilities envisaged in the common information sharing environments in the proposed e-maritime, e-navigation, e-freight, e-customs scenarios. Important aspects of information exchange are the actual interfaces, message formats and information exchange protocols which will be used in this new maritime information scenario. Different standards currently exist and there is a need to standardize for the future. In addition, information systems will need to communicate with each other on a more flexible basis both in terms of an increased and changing number of information systems which need to communicate together and the different levels of legacy and new enabling technology and software employed.

Service Oriented Architectures (SOA) are being promoted as a means of significantly improving the interoperability of information systems and services which should make it much easier for systems to communicate with each other and make system reconfiguration easier in line with changing business requirements and the information to be exchanged. This is achieved by using *services* are as the modular building blocks in information systems as opposed to hardware blocks enabling existing or new *services* to be added or removed as required. *Services* must therefore be easily requested or addressable on a network interface. Standard formats and protocols must be used by all parties concerned so that users can easily have access to required information. (Ref)

Electronic information exchange in the maritime sector is now increasingly being used. Information on a number of existing standards and recommendations related to information flow in the maritime industries[11] has been issued by the MarNIS project. EDIFACT (Ref) has been adopted widely in sea transport in the past; however, much effort is now being expended in standardizing on XML. A version called Shortsea XML, specifically adapted for the maritime sector, is being proposed as the preferred messaging format; this is being supported by EU initiatives such as SSN and e-Maritime

[11] Interim Report on Standards, MarNIS Deliverable Ref. No. D-HA3C, 16th May 2006

8. Conclusions and Recommendations

- The maritime industry is slow to invest in the latest ICT technologies and information systems with the result that current methods of information retrieval and usage are slow, expensive in manpower and potentially a source of errors which could affect safety and security.
- While significant strides have been made in recent years in simplifying and automating maritime administration and business information, the major stakeholders do not operate as a cohesive group and tend to operate separately
- The current state of the art in fleet management systems is such that there are several suppliers which claim to provide 'integrated fleet management systems' but while these combine many of the software applications which go to make up a total system, few provide a full set of fully integrated software.
- The market is essentially made up of smaller software companies which provide specific application packages (e.g. planned maintenance systems (PMS)) which have to be interfaced with software from other suppliers to make up a composite fleet management package. This often results in ship owners purchasing application packages from several suppliers to make up their own fleet management systems which can result in inefficient and sometimes incompatible systems.
- Future fleet management systems must be capable of operating on legacy ICT equipment while having a future proof capability and must be capable of interfacing with existing standard back office ICT (e.g. purchasing, accounts).
- Adoption of information exchange standards are essential for the efficient and cost effective integration and operation of fleet management systems with other maritime information systems. In terms of messaging formats, a version called Shortsea XML, specifically adapted for the maritime sector, is being proposed as the preferred messaging format and is being supported by EU initiatives such as SSN and e-Maritime.
- The EU Initiatives put in place to ensure the future of maritime transport, such as e-Freight, e-Customs, e-Navigation and in particular, the over-riding e-Maritime Initiative, will facilitate the change to the use of ICT, and integrated electronic information management and exchange.

- Both the EU's e-Navigation and e-Maritime Initiatives and the IMO promote the concept of a single window approach for common reporting and ease of access to information in order to reduce the manual paperwork which reduces potential errors.
- European policy and strategy should facilitate
    - The harmonisation of standards in terms of information exchange
    - Achieving an interoperable environment in maritime information systems
    - Encourage the seamless deployment of ICT across the maritime industries
    - Raising of awareness of developments and legislation in maritime related information management systems
    - Interoperability and standardisation are crucial for optimised performance in the future maritime scenario and therefore industry adoption of Service Oriented Architecture technologies is important