JOURNAL OF MARITIME RESEARCH

Vol. IX. No. 2 (2012), pp. 33 - 38
ISSN: 1697-4840 www.jmr.unican.es

Document Management Tool for the Maintenance of Vessels

A. Munín[1,3], A. Martínez[1,*], B. Santos[2,4] and A. Paz[2,5]

ARTICLE INFO

Article history:
Received 28 December 2011;
in revised form 30 January 2011;
accepted 20 March 2012

Keywords:
Information management tools, maritime regulation, ship maintenance

ABSTRACT

Due to the own activity of the vessels, these are forced to carry out very demanding maintenance policies and surveys. The success of the maintenance process is interesting for all agents of the maritime transport chain; from the loader, interested in the goodness of the transport conditions, to the authorities watching over the safety and prevention at sea. The maintenance policy in the vessels is mainly determined by the mentioned authorities through rules and codes. Therefore, in order to accomplish with the minimum standard legally demanded, those responsible for maintenance must be currently informed of the application of these rules (and their consequences) to the vessels and to the vessel equipment. However, due to the heterogeneity of the sources of maintenance requirements and the different scope of them, this task is highly complex. Thereby, the aim of this paper is to develop a toolable management document to intrinsically relate maintenance information with the operating and dimensional characteristics of the vessel. The results provided by the tool will be particularized to the user's searched objective. The user will be able to easily access, analyze and detect the necessary documentation for the design of a maintenance scheduling.

1. Introduction

According to The White Paper: European Transport Policy (European Commission, 2010), the maritime safety is one of the main goals followed by the European Union (EU),. Three fundamental aspects are comprised by the maritime safety policy in EU: the protection of the embarked people, the vessel safety, the maintenance, and finally the environmental conservation. These points have been translated to several European rules. From them the minimum standards required are extracted in order to ensure the safety of all vessels which operate in European ports. Due to the high impact in cost and time on all maritime transport activities and their agents (ship owner, charterers, loaders, forwarders, administrations and insurance companies) the ship maintenance is not only a milestone of the holistic maritime safety but also of the maritime business.

Recently ship owners have increased their interest in a correct maintenance management of their fleets. This is so not only for the consequent cost reduction and the productivity increase, but also for the need to achieve a quality level of the maintenance. This last point has become an essential aspect to scrap the ship inside Europe (European Commission Blue Paper, 2007), and out of Europe (Hong Kong Convention, 2009). Those issues have also had a deep impact in the second hand ship market.

Despite of increasing interest in the vessel maintenance, the difficulties to apply a correct maintenance are also increasing due to the higher demanding requirements. Hence, in order to cope with the problem of maintenance document management a methodology is introduced in this paper through a software support tool. This tool integrates the information from different sources according to the management necessities, assuring the coherence of the stored data and an efficient access to it.

Its last aim is to serve as a backup tool for developing ship maintenance policies and so for fleets without depending on ship type, classification or flag. In order to ensure the utility of the tool, it is necessary to guarantee the correct automated data processing for vessel and fleet. This approach implies the characterization and the structuring of knowledge related to current preventive maintenance legislation, Classification Societies Rules, equipment manufacturer information and shipping companies experience mainly.

The extraction of the information from the previous sources will contribute to the creation of a platform with a wide base of useful knowledge for preventive maintenance.

[1] University of A Coruña, Escola Politécnica Superior, Campus de Esteiro, c/Mendizábal, 15404 Ferrol, Spain.
[2] Integrated Group for engineering Research. Talleres Tecnolóxicos, Campus de Esteiro c/Mendizábal, 15403 Ferrol, Spain.
[3] Naval and Oceanic Engineer. Galician naval Technology Center, Tel. +34981337400-3880, Fax. +3498133741, Email: inaamd01@udc.es
[*] Corresponding author. Assintant Professor, Email: amartinezl@udc.es, Tel. +34337400-3848, Fax.+3498133741.
[4] Computer Engineer, Email: borja.santosdiez@udc.es, Tel. +34981337400-3880.
[5] Computer Engineer, Email: alpaz@udc.es, Tel. +34981337400-3863.

This platform will be the base of the maintenance policies for vessels and fleets. The maintenance policy will be specified in different tasks that assure preventive maintenance through the integration of the whole maintenance requirements demanded by the different applicable sources.

State of the art Most of the maritime safety projects related with the documentation management in the EU (boosted by the Sixth and Seventh Marco Polo Programs) were directed to the quick and easy information exchange between ship and port authority or Administration. This has been so in order to improve port competitiveness and promote the intermodality. For this the e-Maritime Concept (White Paper, 2001) was introduced.

The EU promoted this concept (as a part of 6th and 7th Marco Polo Programmes) through different projects like MarNIS (Maritime Navigation and Information Services) (Jarvis, 2099), or ISEMS (Integrated Safety and Emergency Management System) (Rodseth, 2008) (that includes the Maritime Information Management (MIM) (Transport Research Knowledge Centre. 2010).

These projects are focused on the reduction of harbor stay through the optimization of the documentation exchange but they do not deal with the maintenance management of vessels.

Despite the correct ship maintenance having been transversally discussed in other European projects (like TELEMAS (Bruns-Schüler, et al., 2004) or RECYSHIP (2012), the information management of maintenance has not been their main goal.

The main advances in the application of the integrated preventive maintenance have been achieved in the land industry where the production process and the maintenance are optimized as a unique process (Ershun, Wenzhu and Lifeng. 2010). In addition to this, it is important to point out the preventive maintenance based on parametric models applied to nuclear plants (Damien, et al., 2007) and the determination of the minimum survey frequency through risk analysis in gas and oil plants (Khan, Sadiq, and Haddara, 2004).

However, the application of these previous advances to the naval sector is not applicable, due mainly to the high diversity of vessels and the wide diversity of the applicable regulation in a global sector. This inevitably provokes excessive number of surveys in ships and an incorrect integration of different types of maintenance (Bijwaard and Knapp 2009). Thus, in order to minimize the previous adverse effects of naval equipment maintenance, manufacturers together with ship owners have tried to standardize the information through different projects (this is the case of SHIPDEX Protocol).

Nowadays in the merchant fleet the use of CBM programs (Condition Based Maintenance) is very spread out. These programs are based on the integration of predictive maintenance and conventional maintenance policies. However, to obtain a useful planning (task frequencies and specifications) it is necessary to know authorities and manufacturer requirements (warranty maintenance, for instance).

From a wider point of view it is necessary to point out that, in recent years, the information management in the whole marine sector has become a milestone due mainly to most European shipyards having evolved to synthesis centers. This leads to several distributed agents using different tools in need of quick access to ship information. This is so not only in the construction stage, but also during the whole life cycle of the ship (Product Data Management).

In other sectors this problem has motivated the development of on-line platforms for information flows (Soon-Sup et al., 2006). Hence the PROTEUS project (Bangemann et al., 2006) generated a maintenance integration platform with a web portal (e-maintenance) which linked different subsystems (a maintenance data base and an e-documentation server among them).

Therefore, out of the maritime sector, software which integrates maintenance systems to complex structures (Son, 2009) has been developed. However, the complexity of vessels and of the marine framework (Zhao, Qi, and Zhang, 2010) is not close to the complexity of these structures (as its boundary conditions are particular to its activity).

The heterogeneity of the maintenance documentation sources and formats is a well-known problem in the maritime sector, and until now without a clear solution. Due to this, in this paper a new methodology is introduced and a supporting application is developed. These developments try to provide results of high applicability for future definition of maintenance policies for shipping companies. This will allow the definition of common tasks that meet different levels of the requirements demanded by manufacturers, authorities, classification societies, or by any other role in the marine sector.

2. Methodology

Next, the selected method to tackle the introduced problem is detailed. Thus, in the following paragraphs the treatment of the information sources and an initial approach to the information platforms will be introduced.

2.1. Structure for the classification of the information

Heterogeneity of information sources is responsible, to a great extent, for the absence of formats and common access methods in the available ship information. This leads to a great complexity in the treatment of that information, and also to a considerable difficulty in the information application, which slows down operations and updating of ships. In order to structure the documentation, the following steps are proposed:

1. Current documentation classification according to its sources and application scope. To this, once the piece of documentation is identified, a hierarchy between them is established depending on their application scope (International, European, National).
2. The relationship between the documentation selected before and the affected equipment and systems is defined. At this point, the integration with maintenance information from manufacturers, and equipment providers, is carried out.
3. A new relationship is defined connecting maintenance information with dimensional and operating conditions in ships (typology, length, keel laying date, etc.).

4. And finally a system to retrieve relevant information from the documentation is established: actions, aims and maintenance periods. This new piece of information, linked with the relationship explained before, will allow the suitable integration of different documents.

A lot of the documentation treated is, in fact, regulations that are binding on ships, and at the end they are protecting the common good, through periodic surveys that ships undergo. Hence, its knowledge and correct integration make possible an efficient scheduling of stops for survey and repair.

All this work of current rules classification focused on maintenance is enshrined in the necessity of knowing the dependency between the different documents, and to establish an order criterion in the information for the software tool.

From a computational point of view, the numerous processes that are involved in marine maintenance and the information flow between them bring up a problem of great complexity. Due to this, the methodology to develop a software tool is set up in a way that allows dealing with its development in different incremental steps, so independent modules are generated, and after that they can be integrated and communicate with the previous ones in order to carry out their functions. This will be a methodology based on prototype.

The mentioned methodology uses a planning less thorough and detailed in favor of obtaining a group of incremental prototypes, with the goal of refining user requirements and then being able to design correctly the final system.

As a beginning for the application of this methodology, the development of a first model and a prototype are proposed. They will give support to basic operation of business logic related with information management.

3. Problem analysis

Next, a practice of the methodology described is explained. This means its application to specific documentation, a platform development and its verification on a real case.

3.1. Documentation order and meaningful information extraction

In this step not only a certain order in the documentation is significant, but also finding a dependency between the different rules and documents is relevant. Defining actions and maintenance tasks demanded by them, their application scope according to the ship type and characteristics, and what protocols and certificates demanded are finally obtained, are important stages in this analysis.

To deal with the wide documentation applied to a ship, first of all it is necessary to analyze the regulation from administrations. In that way, an organization that has the major international projection was chosen. This is, without any doubt, the International Maritime Organization (IMO). It has established, during the last years, a policy focused in increasing safety, and this is reflected in a variety of Codes, Resolutions and Conventions. The practical application of all these regulations in Europe is carried out by the Paris Memorandum of Understanding on Port State (Paris MOU). In Spain, these are matters of Ministerio de Fomento, which exercises them through Dirección General de la Marina Mercante (DGMM) and through Outlying Maritime Administrations (Capitanías marítimas). The surveyors from DGMM apply Reales Decretos (RD), which rule aspects related to maritime navigation inside Spain. Therefore, the selected legal sources are the same as the other European countries where, apart from obeying international regulations, have to obey European maintenance and survey regulations..

Other organizations that have to be taken into account to analyze the maritime rules are the Classification Societies (SSCC), due to their importance in the construction and maintenance of ships because they grant ships with their Class Notation. Furthermore, there are national administrations that delegate in the Societies to make the surveys. These guarantee ships fulfill the current rules. As a knowledge base according to surveys, certificates and minimum maintenance requirements demanded by SSCC, in this work the following Societies are considered: Det Norske Veritas (DNV) and Lloyd's Register of Shipping (LR). Their rules are consulted as well as the checklist that their surveyors handle.

The summary of all entities that develop and apply the marine legislation to ships are represented in figure 1.

In figure 2 it can be observed, as an example, the type of relationship established between the different OMI Resolutions from the code of larger scope (MARPOL) to the resolutions that are amendments of it, or those which rule the actions that are a consequence of the code (MEPC 95(46).

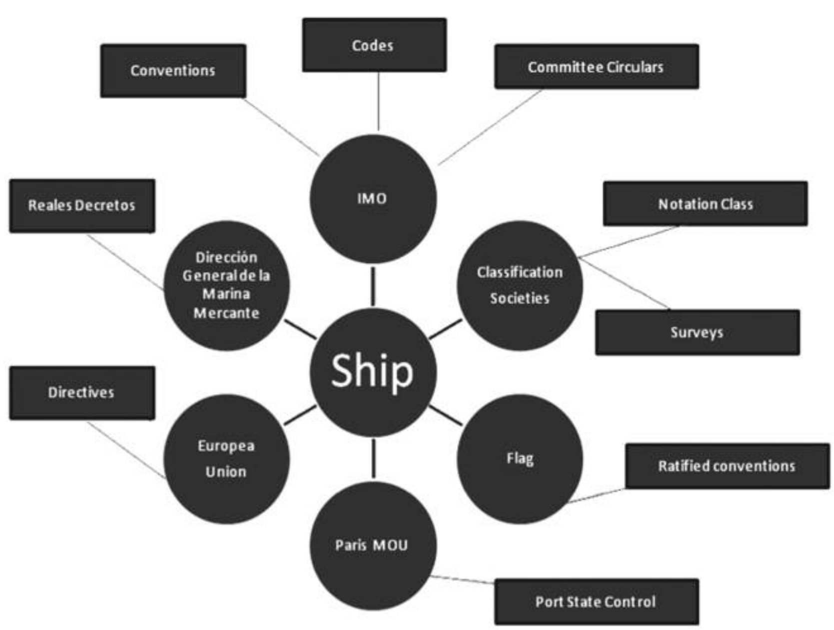

Figure 1: Main organizations and rules in the European maritime framework

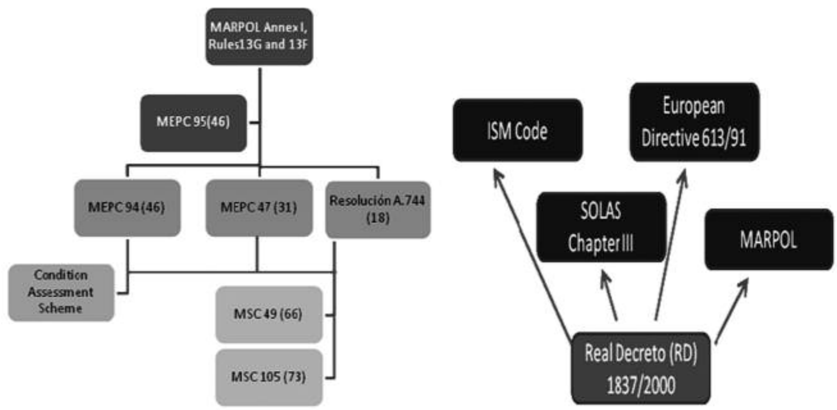

Figure 2: Regulation hierarchy

In the same way, the European and National Regulation are analyzed. The usual case is that Spanish Regulation (RD and rules) is a transposition of the European rules, or directly an adaptation of OMI Regulation. In every examined case, linked to ship maintenance, a relationship is looked for among these rules and international codes.

Another source of information, that has to be taken into account, is provided by the equipment and system manufacturers. This kind of information presents a clear dependency of the previous rules.

Finally, with the aim of integrating and processing the information from all these studied sources, a retrieval procedure is articulated for each relevant document. This is: application scope (affected ships), coming into force dates, tasks to do, affected areas (systems, hull, equipment, whole ship), obtained certificates, demanded protocols to elaborate and resources needed to do the tasks.

The developed work in this section has been structured according to the affected ships. This division is due to the important differences among the maintenance task applied to each part of the ship and, from the point of view of the regulation; this is the structure that best fits the aim of classifying the documentation. According to this, the following fields have been established: *Hull, Systems, Machinery, and Whole ship*.

In 'Hull', all those documents that affect to the structure of the ship are integrated. Examples of hull maintenance task are maintenance of anticorrosive system (including anodes) or maintenance task carry out on structural deficiencies found by the Port State Control.

In 'Systems' a functional division of the ship is applied, so basic systems of ships are defined as: fire detection system, fuel system, oil system, bilge water system, etc. For each system, the equipment which makes it up is defined, too and relationships between documents, that have an influence in ship maintenance, are established. Those documents are manufacturer information and regulations. Both sources determine all the equipment maintenance. Predetermined times to do overhauls, to change pieces, lubricant oil, etc., are specified.

'Machinery' embraces the propulsion system of the ship and the electrical generation system (main engine, gearbox, shaft and propeller on one hand and generating sets on the other hand).

The preventive maintenance, which is applied to this group, is strongly encouraged by manufacturer recommendations, based on the knowledge that they have of their own product and on the Codes of exclusive application on this type of systems.

Lastly, in 'Whole ship' all those documents that affect to the ship as a whole, and do not mention any of the other division defined before, are included.

3.2. Ship characterization

The last group of relationships is needed to obtain a correct and efficient documentation management: dimensionally (length, beam, draft, GT's, NT's, deadweight, load capacity) and operationally (type of ship, route, keel lying year).

Knowing these data and their links to the document application scope, a system can be developed to search for information about maintenance referred to a specific ship.

4. Design and implementation

In order to implement the explained methodology, filtered searches are established that integrate the three studied fields: current regulations, manufacturers information and ship details (Figure 3). These filters are part of the software tool that is designed for the optimized use of documental management.

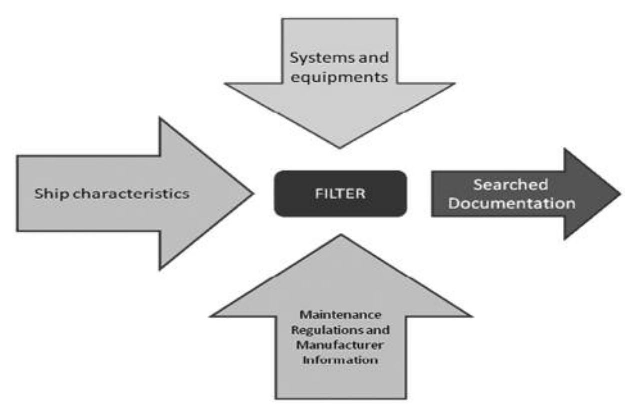

Figure 3: Functional software tool scheme.

Generally speaking, vessel maintenance (and by extension, fleet maintenance) is a really complex task: many interrelated processes are involved, where the outputs of some are used as inputs of others complicating that data flow and therefore its management. The different kinds of maintenance to be performed over a vessel (preventive, predictive and corrective), the routing logistics management and the available resources, or the scrapping process of the vessel are some examples of interrelated complex processes that provide mutual feedback.

To address this problem, the development of a software platform that allows the integration of homogeneous modules responsible for the automation the aforementioned processes is proposed. The presented platform provides common mechanisms for process collaboration and for homogeneous access to the different knowledge sources needed for the operation of these processes.

Therefore, aside from the involved process automation itself, the other key point in the development of a tasks automating system, arising from vessel maintenance, is the management and structuring of both the information that feeds the system and the information generated by it.

To a great extent, this is so due to the heterogeneous nature of the aforementioned information in terms of source and format: digitalized paper documents, images, optical storage devices or even knowledge from experts, obtained thanks to their experience in the field of vessel maintenance.

As a result of a detailed study of the involved processes, the different information sources, the volume of data that the system will potentially handle and the most recent technologies in this field, software architecture is proposed for the integral management in vessel maintenance. The architecture is designed as a distributed flexible and fully scalable solution, based on the existence of different nodes, each of them carrying out a specific role. At the same time, these nodes will be internally structured in three independent layers: a data access layer, a business logic layer and a user interface layer.

The proposal of this architecture is schematized in Figure 4, where it can be seen that at least an information management node exists where functions such as storage, access and management of the information handled by the system are integrated. Through the implementation of a series of wrappers, different storage technologies are adapted as information nodes. That will be used transparently outside these nodes through the public API they provide. On the other hand, these nodes have a private management API that allows the registration of new internal information nodes, extending this way the system's capabilities.

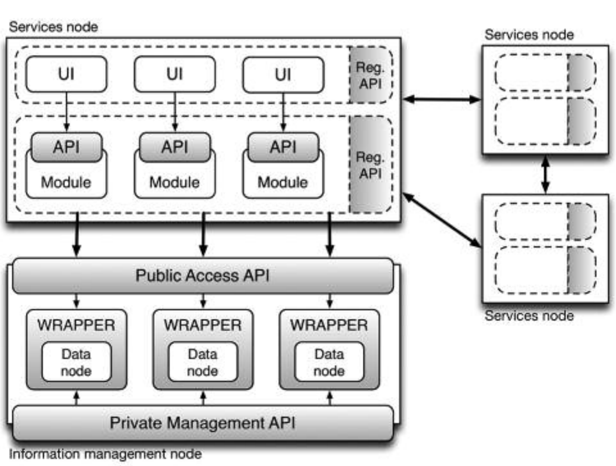

Figure 4: Software architecture

The information management nodes are complemented through the existence of the services nodes: a set of nodes, interacting with each other and with the information management nodes which are responsible for providing the operations of the business logic layer.

Each service's node is divided in turn in two well-differentiated layers: on one hand, an operations modules registry and on the other, a user interfaces registry. Each operations module has a public API which is accessed by the corresponding user interfaces responsible for the representation of each module. Just as happens with the information management nodes, these nodes also have APIs for the registration of new operations modules and user interfaces, so that the flexibility and scalability of the system are again accentuated.

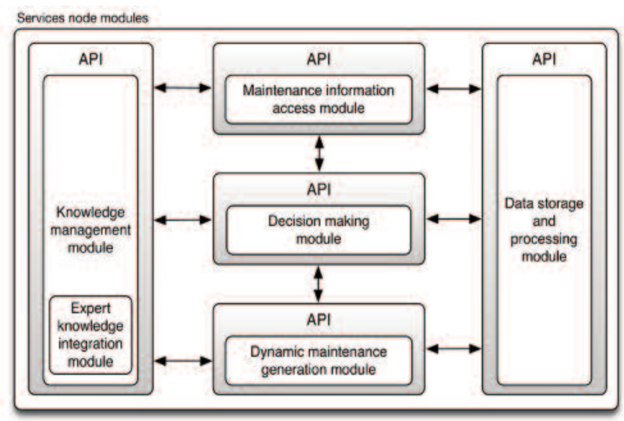

Figure 5. Detail of the business logic modules

In Figure 5 is shown, as an example, the modules registry of a services node, including the main operations modules needed for providing support to the whole vessel maintenance process. The figure is also useful to illustrate the needs of intermodular communication through the public APIs.

As it was previously mentioned, one of the great difficulties in the development of this system is the management of all the involved information. From a technological point of view, it is needed a non-conventional solution that provides good results in the storage of large amounts of information, most of it as documents, as well as the existing relationships that in many cases will be dynamic relationships.

To solve the first of these needs, the document-oriented databases are a good choice, designed and optimized for document storage and retrieval (CouchDB, 2011; InfiniteGraph, 2011). For the storage and management of the existing relationships, those solutions oriented to the storage as graphs are more appropriate, where there will be nodes and edges connecting those nodes and representing relationships among blocks of information (yperGraphDB, 2011; MongoDB, 2011; Neo4j 2011).

There are proposals that face the problem with a hybrid approach, combining the benefits in storage and retrieval of a document-oriented database with the efficiency of a graph database for representing existing relationships within that information. (OrientDB, 2011).

In the present context and given the needs, it seems that this latter hybrid solution is the most appropriate. However, it is a not much exploited approach, so there is no solid information base related to performance and other key factors when choosing among several solutions. Due to the volume of information that the system will handle or the complexity of the relationships that might exist, it will be necessary to explore deeply the possibilities that a solution of this kind offers and study its performance under the circumstances of this specific problem.

4.1. Verification

To check the utility and efficient of the application, the prototype for documentation management is tested on real cases. This allows measuring the accomplishment level of the objectives in this project, focusing especially in critical elements: effectiveness of established relationships between information packages and the correct integration carried out by the used filters.

The real ships selected to the trials are a container and a bulk carrier. These ships data are loaded in the application, taking into account their main equipment, according to: 'Hull', 'Systems' and 'Machinery', and their operating and dimensional characteristics. On the other hand, information provided by manufacturers is also loaded as well as the regulations that affect directly or indirectly the ships, establishing at the same time all the relationships between documents.

5. Conclusions

The treatment of all information that involves the management and operating of a ship has always been a difficult issue because of the extent and variety of the managed documents. For this reason, in this paper a feasible information structure was looked for in a way that will be useful for later generating the ship maintenance scheduling.

The selected approach is suitable for the current formats that contain the maintenance information. But, in the searching of a bigger efficiency in ship management systems, a future aim would be the standardization of the information generated by the different sources (authorities, Classification Societies, manufacturers). In that way, this information could be accessible and common to all users and all sources. The absence of this standardization makes it that nowadays there are only software tools that deal with specific maintenance phases but not as a whole, which prevents having a really integrated management of a ship or a fleet.

References

Bangemann, T.; Rebeuf, X.; Reboul, D.; Schulze, A.; Szymansky, J.; Thomesse, J.P.; Thron, M. and Zerhouni, N. (2006): PROTEUS: Creating distributed maintenance system through an integration platform. Computers in Industry 57 (539-551)

Bijwaard, G. E.; S. Knapp (2009): Analysis of ship life cycles—The impact of economic cycles and ship inspections.Marine Policy.33(350-369)

Bruns-Schüler, K., et al.: TELEMAS. Tele-Maintenance and Support through Intelligent Resource Management for Ship Operation. 2004. Project co-founded by the European Community under the "Information Society Technology" Programme.

CouchDB. [Online]. http://couchdb.apache.org/ [05/02/2011]

Damien, P.; Galenko, A.; Popova, E.; Hanson, T. (2007): Bayesian semiparametric analysis for a single ítem maintenance optimization. European Journal of operational research. 182 (794-805)

Ershun Pan, Wenzhu Liao, Lifeng Xi (2010): 'Single-Machine-based production scheduling model integrated preventive mantenence planning' Int. J. adv. Manuf. Technol. 50: 365-375.

European Commission. White Paper: "European transport policy for 2010: time to decide" 2001. http://europa.eu/legislation_summaries/environment/tackling_climate_change/l24007_en.htm

HyperGraphDB [Online]: http://www.kobrix.com/hgdb.jsp [23/03/2011]

InfiniteGraph [Online]: http://www.infinitegraph.com/ [23/03/2011]

Jarvis, D.J. MARNIS. Maritime Navigation and Information Services. Final Report. 2009. Sixth Framework Programme Priority.

Jin-chao Zhao, Huan Qi, Yong-ming Zhang (2010). Modeling and assessing a new warship maintenance system. J. Marine Science. Appl.9 (69-74)

Khan, F. I; Sadiq, R.; Haddara, M.M. (2004): Risk-based inspection and maintenance (RBIM) Multi-attribute Decision-making with aggregative risk analysis. Process Safety and environmental Protection 82, (B6) 398-411.

MongoDB. [Online]. http://www.mongodb.org/ [16/02/2011]

Neo4j. [Online]. http://neo4j.org/ [21/03/2011]

OrientDB. [Online]. http://www.orientechnologies.com/ [24/03/2011]

RECYSHIP. Pilot Project to dismantle and decontaminate of end-of-life vessels. 2009-2012. http://www.recyship.com/

Rodseth, O.J. (2008): ISEMS: Integrated Safety and Emergency Management System, Sixth Framework Programme. Flagship.

Son, Y.T. (2009): Study of RCM-based maintenance planning for complex structures using soft computing technique.International Journal of Automotive Technology, Vol. 10, Nº 5 (635-644)

Soon-Sup L. Jong-Kap Lee, Beom-Jin Park, dong-Kon Lee, Soo-Young Kim. Kyung-Ho Lee (2006): Development of internet-based ship technical information management system. Ocean Engineering. 33 (1814-1828)

Transport Research Knowledge Centre (2010): Thematic research summary: Efficency in sustainable mobility.