22

Development of VBA Based Ship Technical Corrective Management System for Marine Engineers

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1. Introduction

Recent research works aim at developing an advanced tool, based on expert system principles to solve ship auxiliary machinery troubleshooting (Cebi et al., 2009). In a broad sense, expert systems are computer applications, which embody some/no algorithmic expertise to solve certain types of problems.

An expert system, also known as knowledge based system, is a computer program that contains the knowledge and analytical skills of one or more human experts, related to a specific subject. In this sense, some advantages common to most computer systems could include the following (García, 2003):

- Control over maintenance activity.
- Control over spending.
- Facility or consulting history.
- Easy to obtain ratios and indicators.

Some disadvantages would be:

- High initial investment in equipment and programs and manpower for the implementation.
- Bureaucratic system.
- Increased staff dedicated to indirectly unproductive tasks.
- The information provided is often not sufficiently reliable.

An example of expert system is the SHIPAMTsolver (Cebi et al., 2009).

This system was developed based on PRO-LOG language. It was developed utilizing a considerable amount of information and collected data on the different types of ships machinery systems, system failures, system indicators, and troubleshooting methods through textbooks, handbooks, and interviews with chief engineers who are the marine experts on ship marine system.

Nowadays, maintenance activity in ships is proposed to be developed with GMAO (computer maintenance management system) software (Louit et al., 2009; harris et al., 1999; and Vosniakos and Wang, 1999). To analyze the obtained data with this software, it is evident that for an adequate resolution of each problem, an adequate model selection to determine the time taken for a particular component or system to reach failure is essential, which can in turn lead to wrong conclusions and decisions. The gap between researchers and practitioners of maintenance has resulted in the fact that although many models rely on very specific assumptions for their proper application, these are not normally discriminated by the practitioner according to the real operating conditions of their plants or fleets. To solve this problem, this data is sent to land for analysis by experts (Macián et al., 1999; MS Excel, 2009).

Thus, earlier research works on Internet-based ship technical information management system was developed (Lee at al., 2006). In that case study, implementation of an IDE (Integrated Data Environment) that represents the CALS (Continuous data acquisition and life-cycle support) was proposed. It was an environment where each participant could access data during the entire lifecycle of a product, without limitations imposed by the geographical location, heterogeneity in hardware, software and platform.

Vast amount of documents produced during the entire lifecycle of a ship were systematically and integrated managed. This method has the advantage of being able to continuously maintain and improve the shipbuilding information system, and consequently increase the productivity and further advancements in shipbuilding technology. Further, this technology shows the advantage of implementing the integration and optimization of design, manufacturing and management system to collaborate between expert groups. Particularly, it can integrate the islands of automation prevalent among the departments and related companies.

Analysis of real situations in ships reveals whether the maintenance software is a private software or one developed by shipping companies, on their own. In spite of this, most marine engineers tend to implement its work activities in Microsoft Office, due to this private software does not let them adapt the software to suit ship characteristics and equipment in a user friendly manner.

The problem arises when a new crew boards the ship and finds a different Microsoft Office maintenance data structure from that in other ships. Consequently, they need to invest too much time to understand the data processing structure. This problem also becomes significant when this data needs to be transferred from Microsoft Office to its GMAO software for analysis on land, at the end of each day, week or month.

However, it is expected that from the corrective maintenance analysis of data on land, wrong conclusions can be drawn as most of the data must be understood on ship and, necessarily, this private software must be improved.

To solve this problem, the Department of Energy and Marine Propulsion of University of A Coruña launched an action program to research for a methodology based on MS Excel and VBA, to structure this maintenance data and form the base for future friendly GMAO applications.

In the present chapter, the first prototype of this complementary application was developed in collaboration with experienced marine engineers who improved and tested these applications during the working periods for a year, under real ship conditions.

2. Objectives

The objective of this chapter is to develop a suitable method of adaptive maintenance computer application that could be modified to suit the maintenance conditions for each ship, by the marine engineers. Once the application was developed, it had to be tested under real ship navigation conditions to test the new improvements.

3. Materials and methods

In this chapter, the first prototype of a complementary corrective maintenance application is proposed to be developed in collaboration with experienced marine engineers.

3.1 Marine engineers

Marine engineers must be the sole personnel to utilize this software and introduce the data. Thus, a more personal and bureaucratic system will not be needed, and the information will be reliable. Utilizing this information, these marine engineers will develop its statistical studies of control charts and Weibull analysis on board, to reduce its maintenance cost.

3.2 Maintenance

Maintenance is defined as a combination of all technical and administrative actions, including supervision actions intended to retain an item in, or restore it to, a state in which it can perform a required function.
It is a set of organised activities that is performed to maintain an item in its best operational condition, with minimum cost. Activities of maintenance function could include either repair or replacement activities, which are necessary for an item to reach its acceptable productivity condition; else these activities, should be carried out at minimum possible cost. Five types of maintenance are listed in Table 1.

Run to Failure Maintenance (RTF)	The required repair, replacement or restore action performed on a machine or a facility after the occurrence of a failure to bring this machine or facility to at least its minimum acceptable condition. It is the oldest type of maintenance.
Preventive Maintenance (PM)	It is a set of activities performed on plant equipment, machinery, and systems before the occurrence of a failure to protect them and to prevent or eliminate any degradation in their operating conditions.
Corrective Maintenance (CM)	In this type, actions such as repair, replacement, or restore will be performed after the occurrence of a failure to eliminate the source of this failure or reduce the frequency of its occurrence.
Improvement Maintenance (IM)	It aims at reducing or eliminating entirely the need for maintenance.
Predictive Maintenance (PDM).	It is a set of activities that detects changes in the physical condition of equipment (signs of failure) to conduct the appropriate maintenance work to maximize the service life of the equipment without increasing the risk of failure.

Table 1. Types of maintenance

3.3 Main engine combustion system

In our case study, the principal systems to be analyzed for corrective maintenance are the main engines and auxiliary engines of a merchant ship. Therefore, these services are described. On analysis of the services to operate diesel engines, there may be differences in characteristics and extent, depending mainly on the size and speed of the marine engines. The main services are cooling, lubrication, fuel, start and reverse motion, and remote control and automation (rowen, 1996; Taylor, 1996). Figure 1 shows that the fuel system is more complicated when heavy fuel is used. Due to the high viscosity of this fuel, it does not always flow by gravity, requiring heated tanks to reduce the viscosity, especially in cold waters. Although sedimentation tanks are also installed, centrifugal or similar purification systems are necessary to extract water and other waste. As sedimentation tanks are present, the fuel is pumped into the tanks via the service purification equipment. The big slow two-stroke engines and four times of high power, are suitable to support heavy fuels, and are significantly cheaper than light, though they necessitate more complex equipment (heating tank preheaters, lined pipes, etc..) plus a maintenance plan for the engine because of the high waste combustion. Therefore, the importance of this maintenance plan is clearly related to an adequate management system.

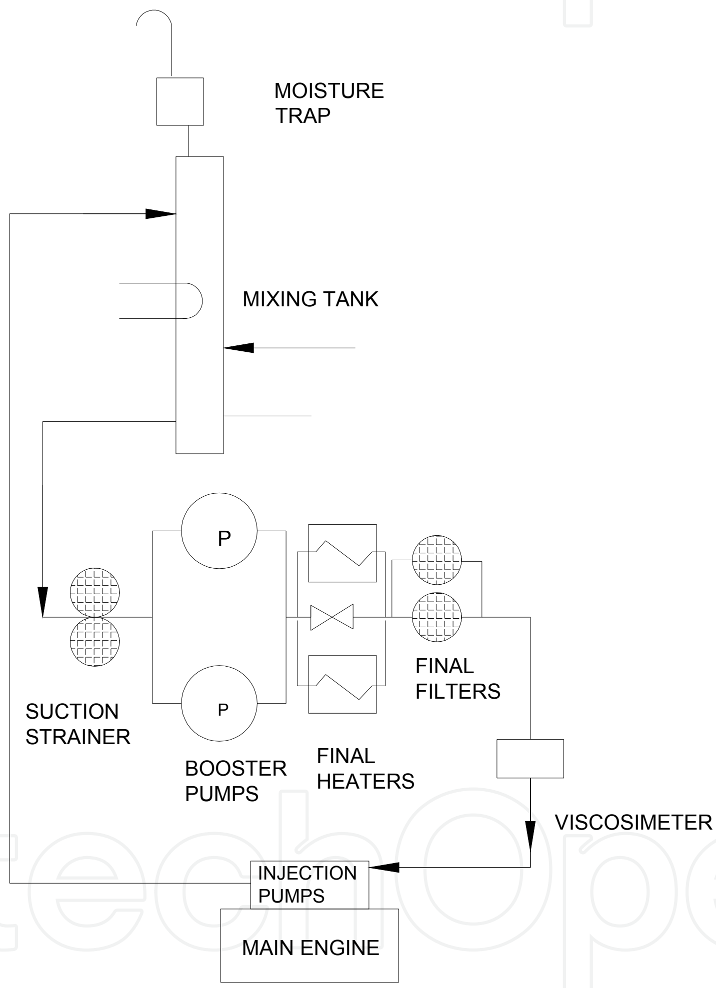


Fig. 1. Fuel treatment and service system

In Figure 2 the main engine lubricating-oil circulating system is shown. Oil, draining from the bearings and cooling passages at the bottom of the crankcase, passes into an independent sump that is built into the double bottom below the engine, from where it is drawn by the lubricating-oil circulating pump, for redistribution via a filter and a cooler. A full flow filter is provided in the pump discharge line. It could be of the duplex, basket type, but better filtration is usually afforded by a disposable-element or self-cleaning simplex unit, with a standby filter in a bypass. Filtered oil is distributed to the engine bearings, for governing and control service to the valve gear and for piston cooling.

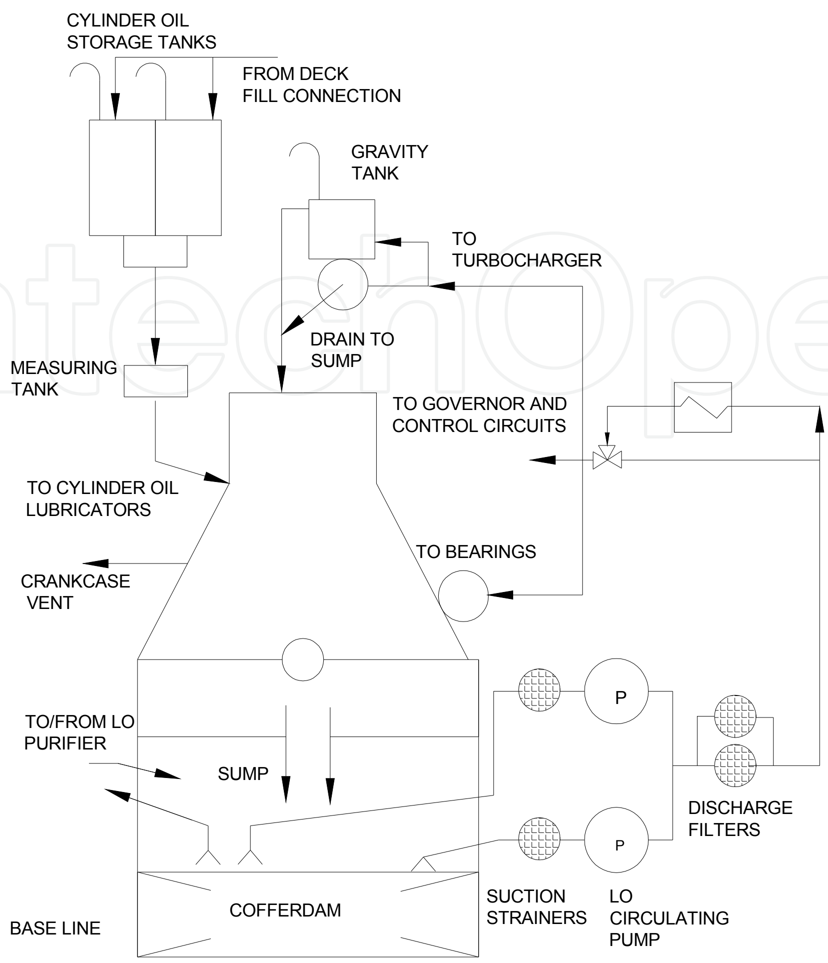


Fig. 2. Main engine lubricating-oil circulating system

3.4 Visual Basic for Applications

Due to the vast amount of documents produced during the whole life of a ship, it is proposed, based on marine engineers' experience, to structure this data in Microsoft Excel spreadsheets. The principal problem encountered when such spreadsheets are used, is to obtain a clear structure and an adequate and easy access to a comprehensive spreadsheet. To solve this problem the VBA (Visual Basic for Applications) and hyperlinks in Microsoft Excel were proposed to access an adequate structure and spreadsheets.

As explained earlier, Microsoft presents the VBA, whose code is compiled (Microsoft, 2009) in an intermediate language called P-code (Microsoft P-Code, 2009); the latter code is stored by the hosting applications (Access, Excel, Word) as a separate stream in structured storage files (eg., .doc or .xls), independent from the document streams. The intermediate code is then executed by a virtual machine (hosted by the hosting application). Despite its resemblance to many old Basic dialects, the VBA is not compatible with any of them, except Microsoft Visual Basic, where the source code of VBA Modules can be directly imported, and which shares the same library and virtual machine (Mathworks, 2009).

Another advantage of this methodology is that, with such files, most computers will not require a high memory resource, and the processor and information will be accessible for expert economists, that can help to solve the problems with the adequate control method. Further, this software can be adapted to ship equipment in a user friendly manner.

4. Results

4.1 Maintenance activities

The first step in developing our application was to study the principal maintenance activities in the main and auxiliary engines. These activities were obtained from collaboration with marine engineers, during its working periods. Results are summarized in Tables 2 and 3.

Main and auxiliary engines	
Element	**Task**
Compressor 1	Clean with water
Centrifugal filter	Clean
Turbine	Water blasting
Oil	Analysis
Combustion	Pressure
Relief valve	Check operation
Bypass valve	Check operation
Leaking fuel	Check
Air leaks	Check
Turbocharger	Cleaning air filters
Automatic alarm stops	Check operation
Rotocaps	Check operation
Air cooler	Check pressure drop
Regulator	Oil change
Mechanical over speed	Check operation
Injector	Check operation
Piston rings and cylinder	Check operation
1 cylinder injection pump	Check operation
Shirt	Check operation
Piston cylinder 1	Check the cooling gallery
Air compressor scan	Replace
Main bearing	Inspect
General review	

Table 2. Tasks in the main and auxiliary engines

Fuel centrifuge	**Oil centrifuge**	**Compressors**
Sewage pump fuel	Purifier oil pump	Oil Change
Oil Change	Oil Change	Air filter
Intermediate Maintenance	Intermediate Maintenance	Non-return valve compressor
Increased maintenance	Increased maintenance	High pressure switch valve
		Low pressure switch
		Compressor safety valves
		Refrigeration compressor Gallery

Table 3. Task in fuel treatment and lubricating-oil circulating systems

4.2 MS Excel file

The Department of Energy and Marine Propulsion, in collaboration with marine engineers, developed the structure of the prototype application showed in Figures 3 to 6. In Figure 3 it is evident that most marine engineers prefer to structure the data as preventive and in corrective data. All the existing spreadsheets were hidden. Access to each of them was done in VBA, and with hyperlinks to each main screen.

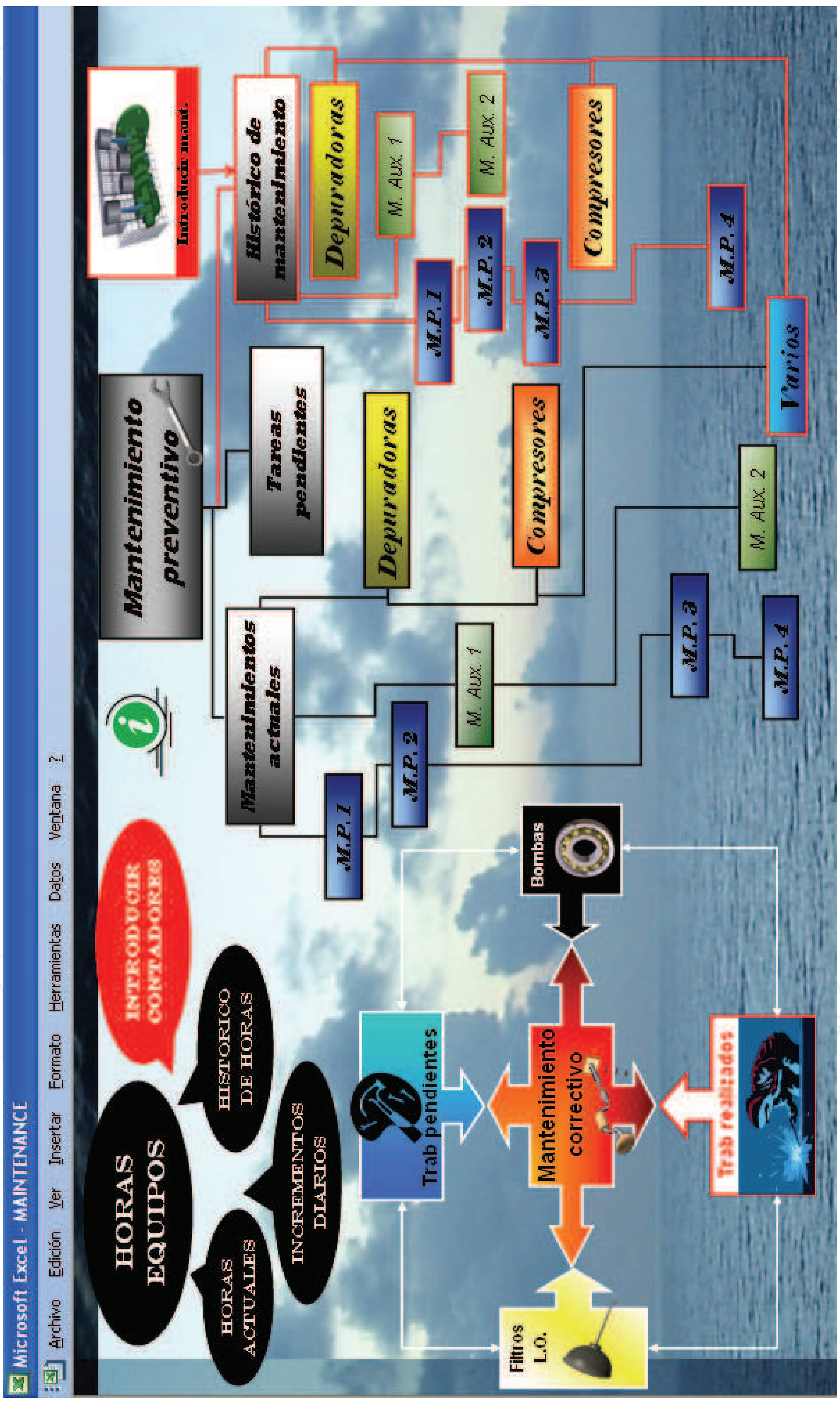
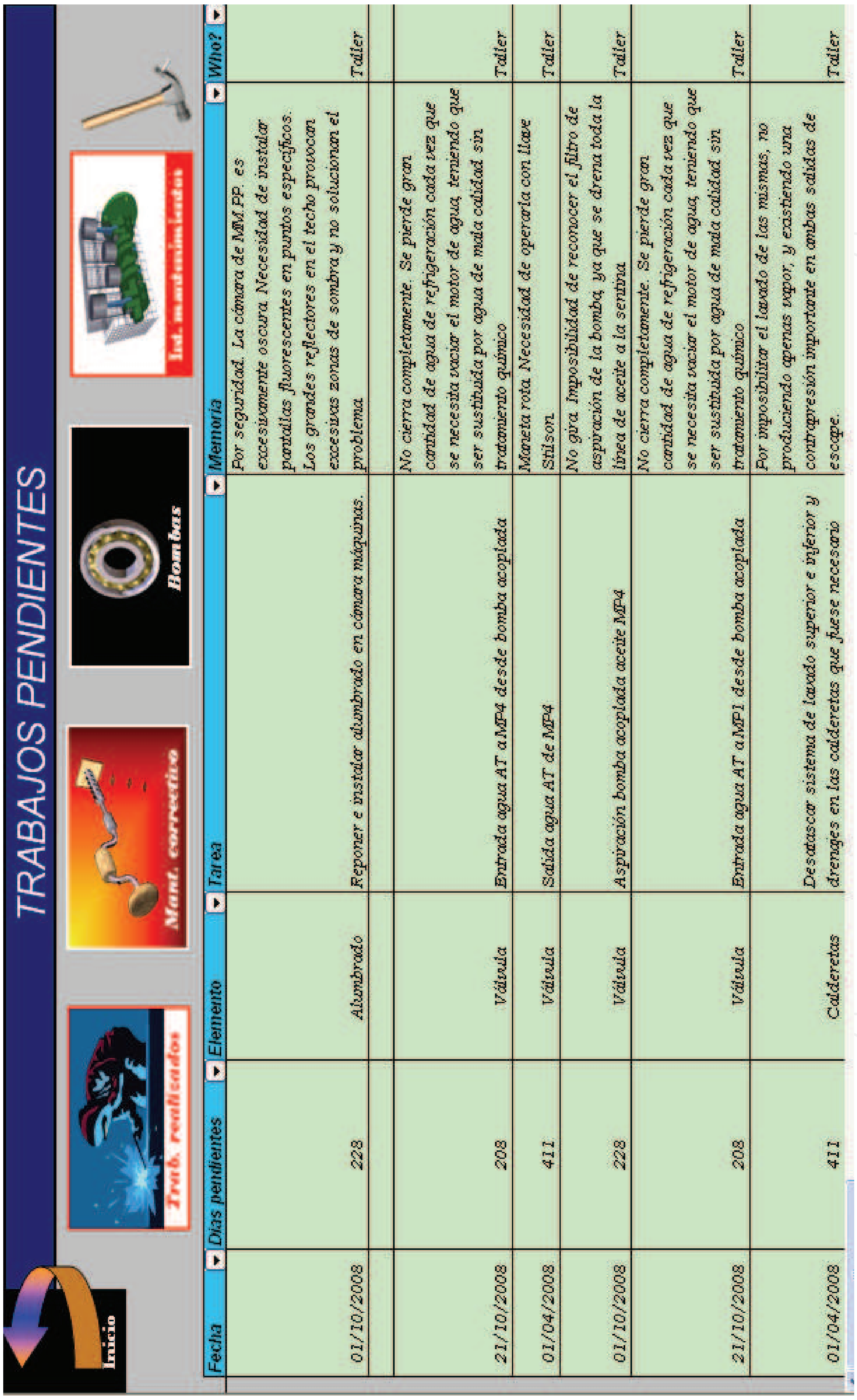


Fig. 3. Maintenance application structure



Fecha	Días pendientes	Elemento	Tarea	Memoria	Who?
01/10/2008	228	Alumbrado	Reponer e instalar alumbrado en cámara máquinas.	Por seguridad. La cámara de MM.PP. es excesivamente oscura. Necesidad de instalar pantallas fluorescentes en puntos específicos. Los grandes reflectores en el techo provocan excesivas zonas de sombra y no solucionan el problema	Taller
21/10/2008	208	Válvula	Entrada agua AT a MP4 desde bomba acoplada	No cierra completamente. Se pierde gran cantidad de agua de refrigeración cada vez que se necesita vaciar el motor de agua, teniendo que ser sustituida por agua de mala calidad sin tratamiento químico	Taller
01/04/2008	411	Válvula	Salida agua AT de MP4	Maneta rota. Necesidad de operarla con llave Stilson	Taller
01/10/2008	228	Válvula	Aspiración bomba acoplada aceite MP4	No gira. Imposibilidad de reconocer el filtro de aspiración de la bomba, ya que se drena toda la línea de aceite a la sentina	Taller
21/10/2008	208	Válvula	Entrada agua AT a MP1 desde bomba acoplada	No cierra completamente. Se pierde gran cantidad de agua de refrigeración cada vez que se necesita vaciar el motor de agua, teniendo que ser sustituida por agua de mala calidad sin tratamiento químico	Taller
01/04/2008	411	Calderetas	Desatascar sistema de lavado superior e inferior y drenajes en las calderetas que fuese necesario	Por imposibilitar el lavado de las mismas, no produciendo apenas vapor, y existiendo una contrapresión importante en ambas salidas de escape.	Taller

Fig. 4. Pending task screen

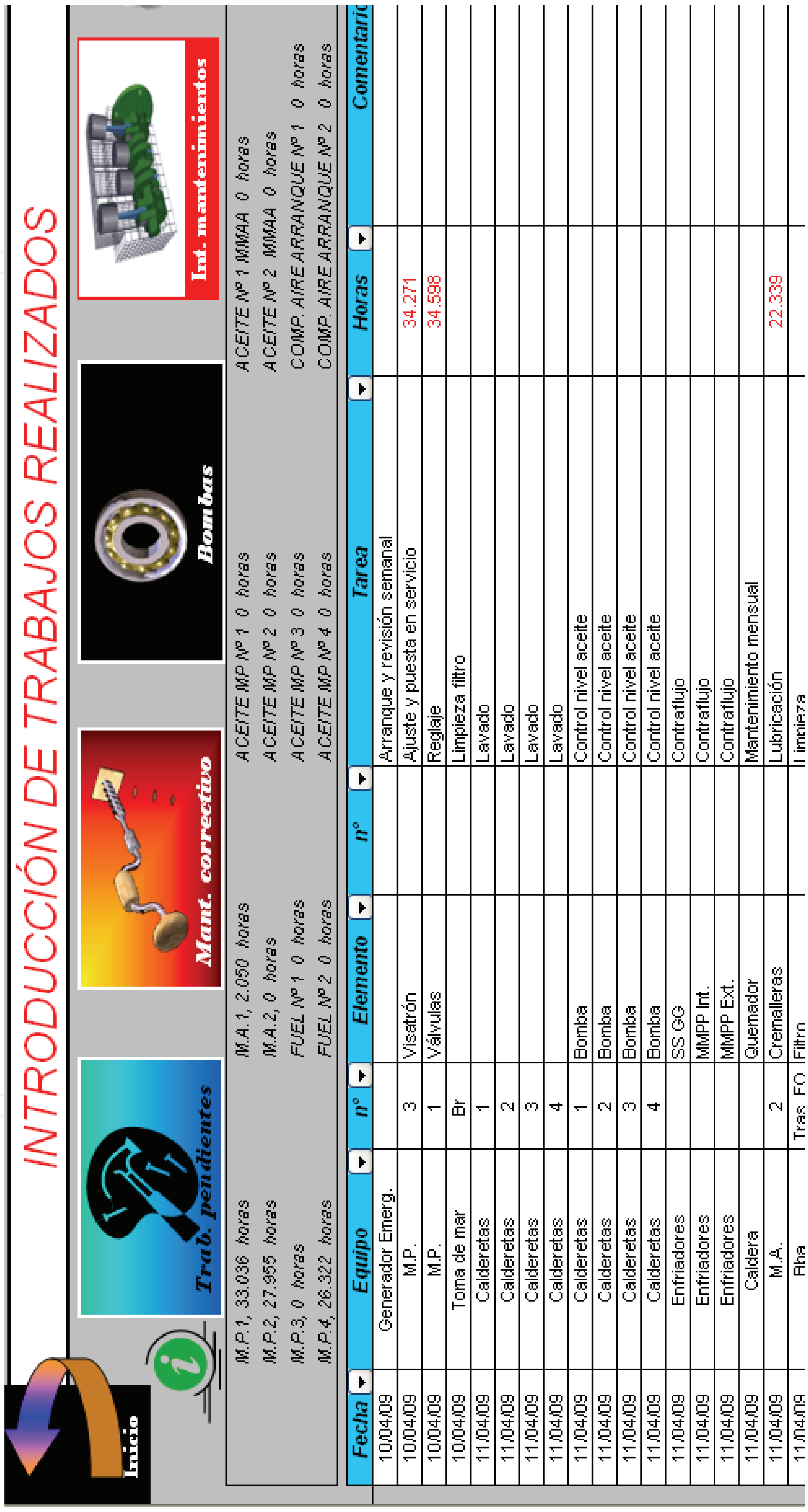
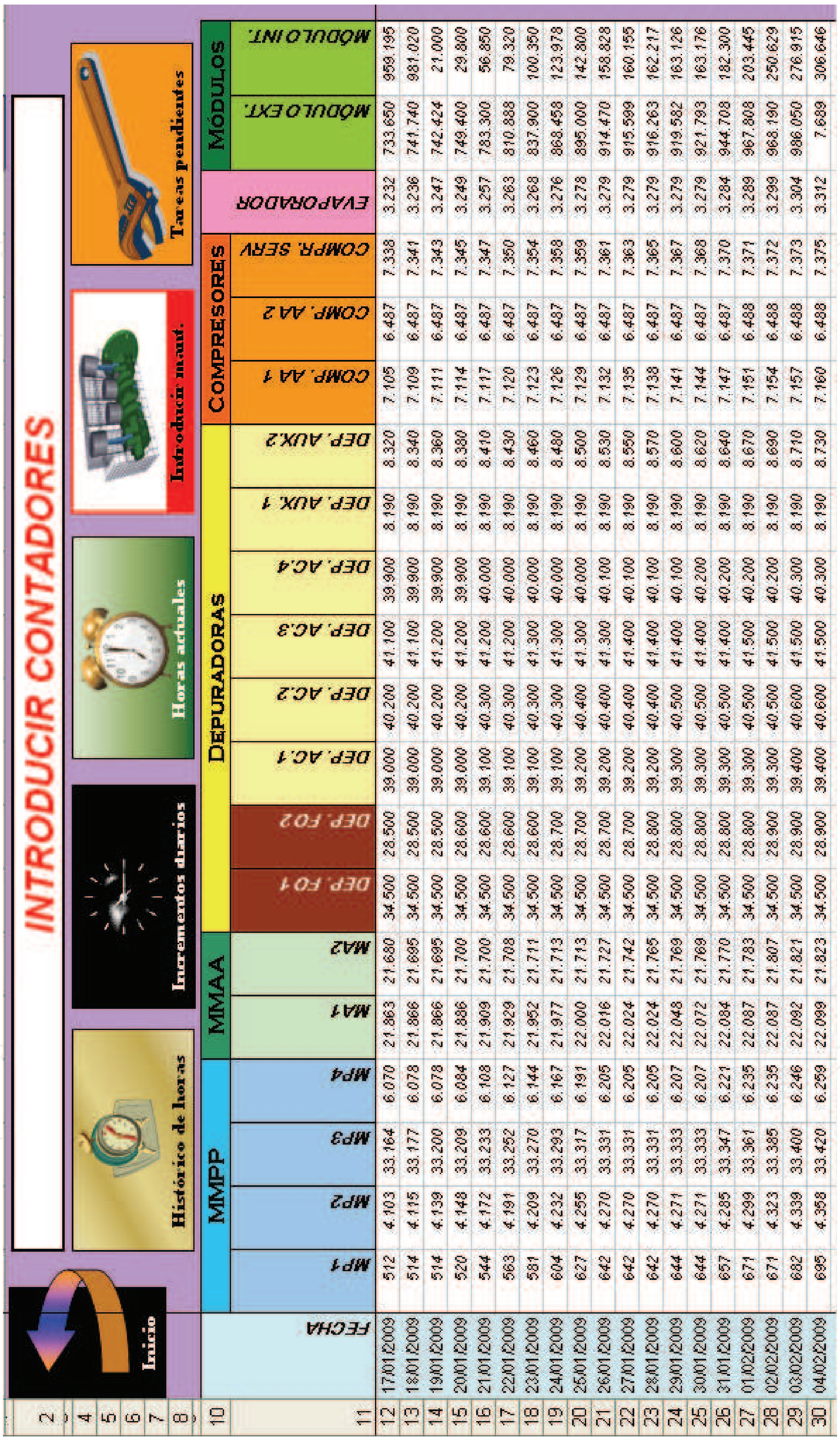


Fig. 5. Task finished screen



	MMPP				MMAA		DEPURADORAS								COMPRESORES				MÓDULOS	
FECHA	MP1	MP2	MP3	MP4	MA1	MA2	DEP. FO1	DEP. FO2	DEP. AC.1	DEP. AC.2	DEP. AC.3	DEP. AC.4	DEP. AUX. 1	DEP. AUX.2	COMP. AA 1	COMP. AA 2	COMPR. SERV	EVAPORADOR	MÓDULO EXT.	MÓDULO INT.
17/01/2009	512	4.103	33.164	6.070	21.863	21.680	34.500	28.500	39.000	40.200	41.100	39.900	8.190	8.320	7.105	6.487	7.338	3.232	733.650	959.195
18/01/2009	514	4.115	33.177	6.078	21.866	21.695	34.500	28.500	39.000	40.200	41.100	39.900	8.190	8.340	7.109	6.487	7.341	3.236	741.740	981.020
19/01/2009	514	4.139	33.200	6.078	21.866	21.695	34.500	28.500	39.000	40.200	41.200	39.900	8.190	8.360	7.111	6.487	7.343	3.247	742.424	21.000
20/01/2009	520	4.148	33.209	6.084	21.886	21.700	34.500	28.600	39.000	40.200	41.200	39.900	8.190	8.380	7.114	6.487	7.345	3.249	749.400	29.800
21/01/2009	544	4.172	33.233	6.108	21.909	21.700	34.500	28.600	39.100	40.300	41.200	40.000	8.190	8.410	7.117	6.487	7.347	3.257	783.300	56.850
22/01/2009	563	4.191	33.252	6.127	21.929	21.708	34.500	28.600	39.100	40.300	41.200	40.000	8.190	8.430	7.120	6.487	7.350	3.263	810.888	79.320
23/01/2009	581	4.209	33.270	6.144	21.952	21.711	34.500	28.600	39.100	40.300	41.300	40.000	8.190	8.460	7.123	6.487	7.354	3.268	837.900	100.350
24/01/2009	604	4.232	33.293	6.167	21.977	21.713	34.500	28.700	39.100	40.300	41.300	40.000	8.190	8.480	7.126	6.487	7.358	3.276	868.458	123.978
25/01/2009	627	4.255	33.317	6.191	22.000	21.713	34.500	28.700	39.200	40.400	41.300	40.000	8.190	8.500	7.129	6.487	7.359	3.278	895.000	142.800
26/01/2009	642	4.270	33.331	6.205	22.016	21.727	34.500	28.700	39.200	40.400	41.300	40.100	8.190	8.530	7.132	6.487	7.361	3.279	914.470	158.828
27/01/2009	642	4.270	33.331	6.205	22.024	21.742	34.500	28.700	39.200	40.400	41.400	40.100	8.190	8.550	7.135	6.487	7.363	3.279	915.599	160.155
28/01/2009	642	4.270	33.331	6.205	22.024	21.765	34.500	28.800	39.200	40.400	41.400	40.100	8.190	8.570	7.138	6.487	7.365	3.279	916.263	162.217
29/01/2009	644	4.271	33.333	6.207	22.048	21.769	34.500	28.800	39.300	40.500	41.400	40.100	8.190	8.600	7.141	6.487	7.367	3.279	919.582	163.126
30/01/2009	644	4.271	33.333	6.207	22.072	21.769	34.500	28.800	39.300	40.500	41.400	40.200	8.190	8.620	7.144	6.487	7.368	3.279	921.793	163.176
31/01/2009	657	4.285	33.347	6.221	22.084	21.770	34.500	28.800	39.300	40.500	41.400	40.200	8.190	8.640	7.147	6.487	7.370	3.284	944.708	182.300
01/02/2009	671	4.299	33.361	6.235	22.087	21.783	34.500	28.800	39.300	40.500	41.500	40.200	8.190	8.670	7.151	6.488	7.371	3.289	967.808	203.445
02/02/2009	671	4.323	33.385	6.235	22.087	21.807	34.500	28.900	39.300	40.500	41.500	40.200	8.190	8.690	7.154	6.488	7.372	3.299	968.190	250.629
03/02/2009	682	4.339	33.400	6.246	22.092	21.821	34.500	28.900	39.400	40.600	41.500	40.300	8.190	8.710	7.157	6.488	7.373	3.304	986.050	276.915
04/02/2009	695	4.358	33.420	6.259	22.099	21.823	34.500	28.900	39.400	40.600	41.500	40.300	8.190	8.730	7.160	6.488	7.375	3.312	7.689	306.646

Fig. 6. Screen of working hours

4.3 Time to develop the application

Time utilized to develop the application was much less than the time taken to configure most of GMAO applications, because most of the data is similar, in the same kind of service in different ships. It took about 35 hours to develop the basic application, according to calculations.

Another advantage was that it was not necessary to undertake a prior course of study on how to employ the spreadsheet. However, if necessary, a tutorial was added, as shown in Figure 7.

Finally, it becomes very easy for engineers on board to develop a graphical representation of data, and to do statistical data analyses that will help solve the different operational problems.

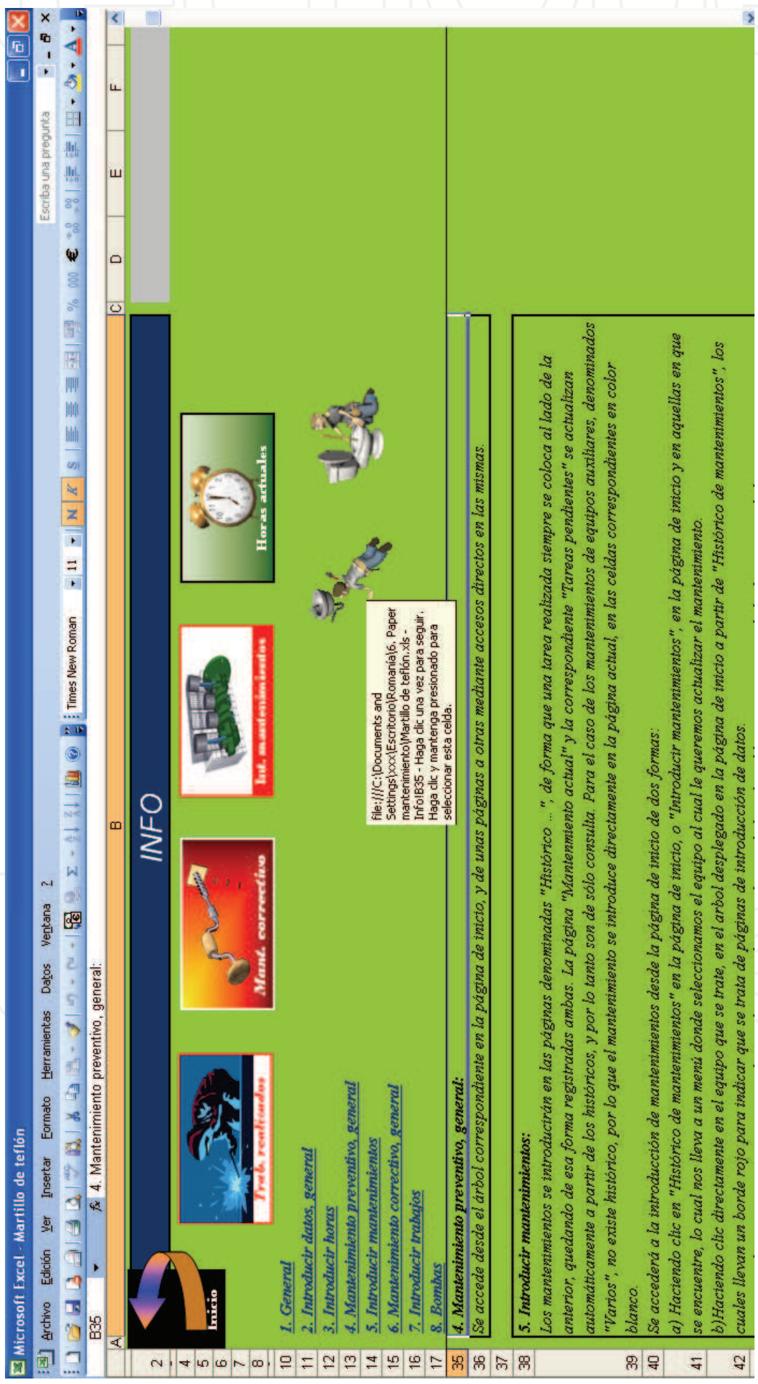


Fig. 7. Information screen

4.4 Application test on ship

A practical case study was done in a merchant ship during its sea lane of activity for a year. During this period, two expert marine engineers trained in this application employed it. As a result of this application, parameters like fuel oil filter mean life were implemented because of a greater importance of time between filter changes and centrifuge operation.

Particularly, in its application, during working periods, an excessive waste of filter was detected, that was caused by the lack of maintenance of the earlier automatic systems.

In other cases, an adequate stock allowed the same replacements to be located in different equipment, to solve a failure in the lubrication system (bearings).

5. Discussion

As obtained in earlier research works, the complexity of marine systems and time constraints on the operational processes require effective corrective actions to be performed, to manage and troubleshoot in auxiliary machinery aboard ships.

Due to the vast amount of documents produced during the whole life of a ship, it is proposed, based on the experience of the marine engineers, to structure this data in Microsoft Excel spreadsheets. Once the software was selected, the structure of the information was defined.

In Figure 3 it is evident that most marine engineers prefer to structure the data as preventive and corrective data. All the designed spreadsheets were hidden. Access to each of them was done in VBA and with hyperlinks t each main screen.

In corrective data, the filters mean life, pending task, and finished task are stored, as shown in Figures 4 and 5.

The preventive section, as seen in Figure 6, is related to the number of working hours of each equipment such as the main engine, auxiliary engine, compressors and purifiers, besides others. Related cells easily permit a way to consider the time remaining to begin a maintenance task. Further, it was possible to add a very simple alarm that warns anyone who is near a maintenance process. Therefore, the proposed methodology ensures the required supervision by shipboard personnel.

However, the time elapsed to design this kind of application was much less than the time taken to configure a typical GMAO software as most of the data is similar, used in the same kind of service in different ships.

Another advantage was that it was not necessary to undertake a prior course of study on how to employ the spreadsheet; however, if necessary, a tutorial was added, as shown in Figure 8.

Finally, it is very easy to develop a graphical representation of data, and to do statistical data analyses that will help solve different operational problems on board, and export this to another application like Microsoft Word. Further, due to the small size of the obtained files, they can be accessed anywhere in the world by the Internet, to allow maximum availability of the information.

Finally, on testing this methodology in real navigation, an excessive waste of filter was detected due to the lack of maintenance of the earlier automatic systems. In other cases, an adequate stock inventory file allowed the location of replacements in different equipment to solve a failure in the lubrication system.

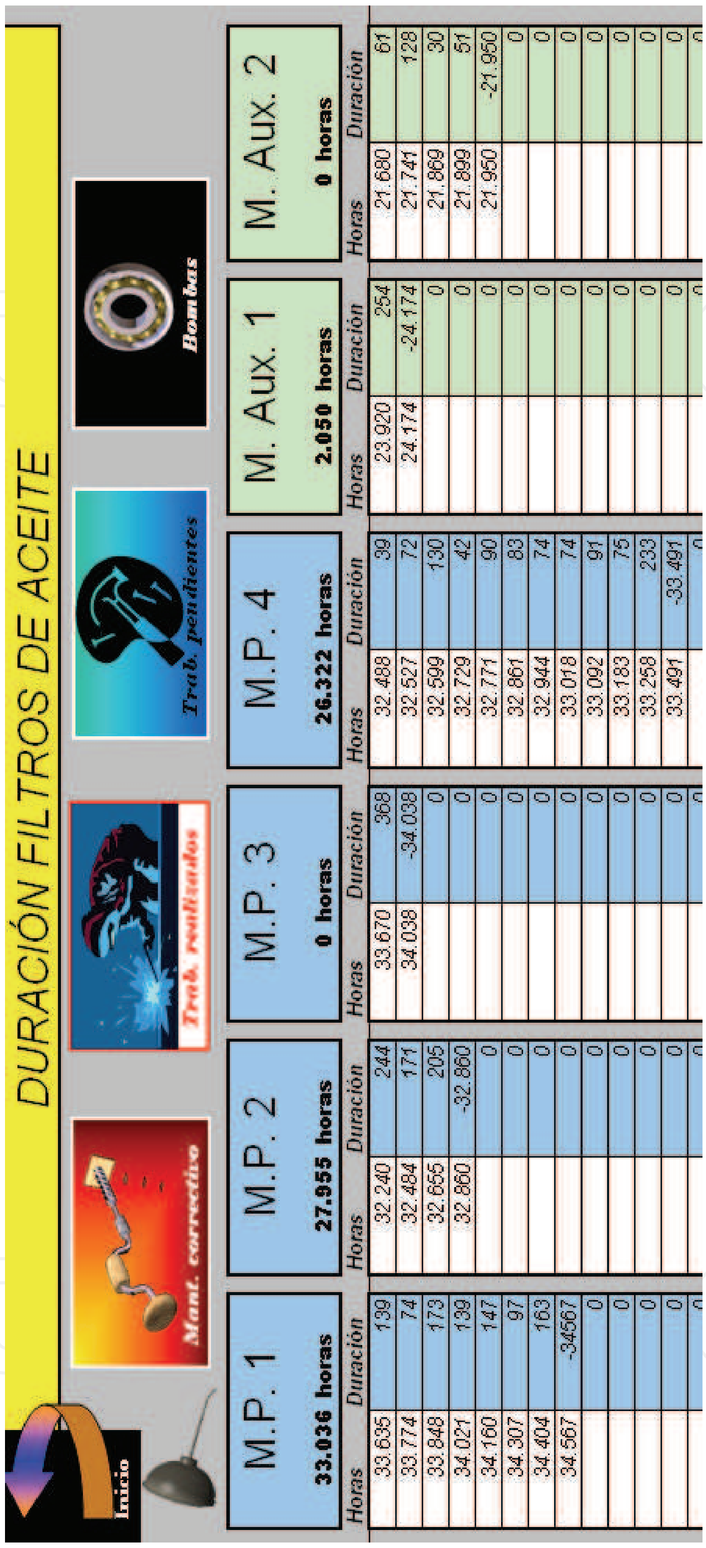


Fig. 8. Corrective maintenance of filters in the main and auxiliary engines screen

6. Conclusions

As evident, this practical case study, based on the marine engineers' maintenance process enabled an improvement in the methodology.

Particularly, the methodology based on Microsoft Excel spreadsheets and VBA permitted easy implementation of ship maintenance. For example, corrective maintenance problems such as, detecting unexpected failures and locating replacements in the storeroom were observed.
Finally, research work in the future must be done to develop a GMAO that would reduce the time elapsed to develop such applications, and to adapt the software to suit the characteristics of each ship.

7. Acknowledgements

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