Design of a Remote Monitoring System for High Speed Craft

José Luís Lozano, Jordi Corbera

(*CETEMAR Centro de Estudios Técnico Marítimos*)

F. Xavier Martínez de Osés

(*DCEN – Polytechnical University of Catalonia*)

At present, the whole shipping industry is concerned about safety of navigation. In particular, attention is focused on High Speed Craft. There has been a sharp increase in numbers of this kind of vessel, which primarily carries passengers but is also known to carry goods. Some units can reach speeds of over 45 knots with capacity for 900 passengers. These passengers have a basic right to life and their means of transport should obviously follow all safety codes, regulations and IMO resolutions. This paper describes the development of a monitoring system that could automatically transmit safety parameters and position from the ship to a management control centre. Digital and analogical alarms, ship condition readings and other safety-related parameters may be recorded and transmitted in near real-time using the latest communications and positioning technologies.

KEY WORDS

1. Fleet Management. 2. High Speed Craft. 3. Safety

1. INTRODUCTION. In recent years, there has been a sharp increase in shipping traffic together with greater awareness by the public of safety and environmentally-related matters concerning marine transport. This increased awareness is influencing the establishment of much stricter legislation with respect to management and monitoring of sea-borne traffic, especially in port areas but also for sea navigation in general.

Much of the current work on marine safety is concentrated on vessel traffic control systems that offer an integrated view of the traffic situation in a given area. However, we should not underestimate other systems that help to improve fleet management, safety and exploitation. Such systems are particularly useful for fishing fleets where their introduction has been successful in improving exploitation and fishing effort management.

Shipping fleet management systems have very specific properties both from environmental and complexity viewpoints. They need to integrate a variety of sensors, technologies and operations that may provide information available both on board and on shore. This presents a number of problems when trying to integrate all necessary navigational architectures and systems. Getting down to basics, this will necessarily imply positioning systems, electronic charts and two-way communications.

Difficulties related to integration are not only present in the technological domain, but also in relation to regulations, control parameters, safety, official documentation, or shipping alerts, that are based on extremely complex systems which are often technologically obsolete. This means that when developing such navigation and charting systems, it is essential to have in-depth knowledge of the requirements of the shipping industry, whether operational, administrative or legislative.

A situation arises that is sometimes disparate and confusing with the traditional positioning systems, charts and communications and their legislation in comparison to new support, architectures and technologies. This opens up a horizon that is at once uncertain and attractive with the implementation of new monitoring and fleet management systems for the shipping industry. As for any fleet management system, it is particularly important in the shipping industry to manage the information flow between the ship and the shore-based control centre efficiently. Information that would be useful to exchange includes ship's position, attitude, condition and behaviour using different sensors (navigation systems, inclinometers, accelerometers, alarms, etc.) and transmission and updating of cartographic data to the ship navigation systems etc.

2. HIGH SPEED CRAFT.

Among the latest generation of ships are the high speed ferries. Some have capacity for 300 vehicles and 1500 passengers with a cruising speed of over 40 knots. Others that are in the project stage are designed for cargo only (1000 Tm) or mixed (800 Tm and 400 passengers), with average speeds ranging from 35 to 42 knots. Prototypes are currently on the drawing-board that will be over 100 metres in length and will reach speeds of 80 knots.

Such sizes and speeds obviously have very high-level demands on navigation and positioning systems. This is particularly so in port areas and for berthing manoeuvres. Such vessels work with an integrated ship control system on the bridge where computer screens provide the information from the DGPS, inertial systems, radar, VHF, Loran-C, echo-sounders and other instruments. The radar information is integrated into the ECDIS systems together with the information from the ship control system (maritime black box). These high-level demands on navigation and positioning systems for fast ferries may also be applied to cartography and communications, where the shore-based segment plays a vital role in the quality and quantity of differential corrections. This implies the implementation of new technologies and infrastructures in the port areas.

Thus, modern marine navigation demands certain performance qualities in the fields of communications, cartography and positioning systems that are directly related to the structural characteristics of such ships and the overall environment in which they operate. For example, in the fishing industry the demands are determined by the conditioning factors of the economic activity itself.

3. SYSTEM ARCHITECTURE.

The fleet management system, as proposed by Cetemar, is characterised by the acquisition of navigation and ship condition parameters and their subsequent automatic transmission to the centre responsible for managing the ship. The following subsystems are integrated on board the ship: positioning system, data acquisition, recorder module, GSM and satellite communications systems.

In the control centre, a PC computer is installed that includes the applications necessary to receive and display the condition and position of the ship. The output is shown on a digitised chart together with communications and historic analysis of data obtained from the ship.

4. OPERATION OF SHIP'S EQUIPMENT. The positioning system used is GPS with a 12-channel receiver and outside antenna. The data acquisition module comprises a control unit, four analogue sensors (two accelerometers and two inclinometers) and four digital sensors. Practically all the on-board equipment is integrated into a hermetically-sealed metal box that measures about 0·035 cubic metres, excluding the communications antennae, and is designed to interfere as little as possible with existing equipment and ships' ergonomics. The analogue sensors are aligned to the length and width axes of the ship and detect information about listing and heaving as well as accelerations fore and aft and port to starboard.

The recording equipment on board consists of an industrial PC, small in size, that manages the applications of positioning, communications and sensor data acquisition. All integrated elements on board the ship are connected to this PC, and the information obtained is formatted to provide the information package to send to the control centre.

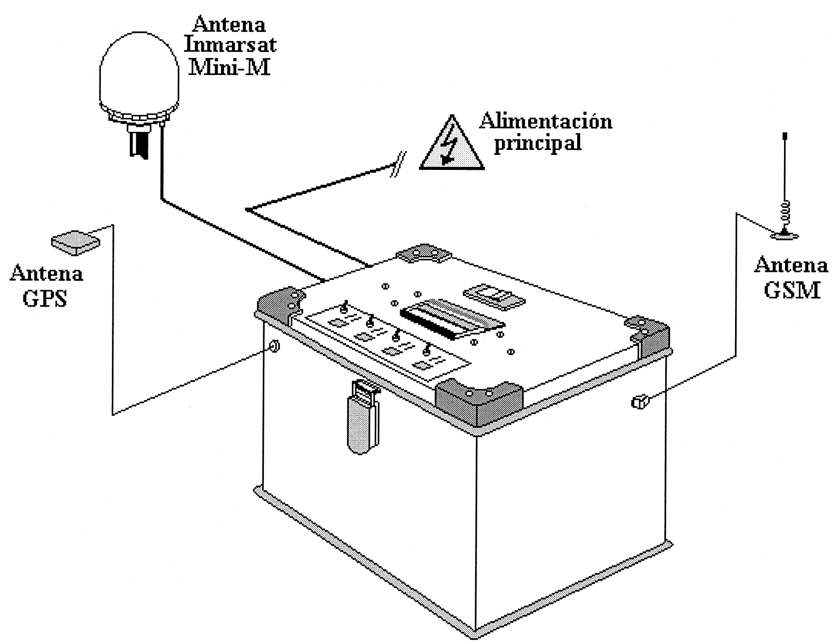

Figure 1. Module as installed on board ship. GPS antenna, Inmarsat Mini-M, GSM antenna and main module with the sensor recorder and the sensors and communications processing unit.

5. ACQUISITION MODULE. The acquisition module is configured to recognise three kinds of situation, depending on the interaction between sensor activation, temporal parameters and navigation, as follows:

(a) *Normal situation*: No sensor has been activated and all equipment is functioning correctly. The position and data from all active sensors are received correctly.

https://doi.org/10.1017/S0373463300008924 Published online by Cambridge University Press

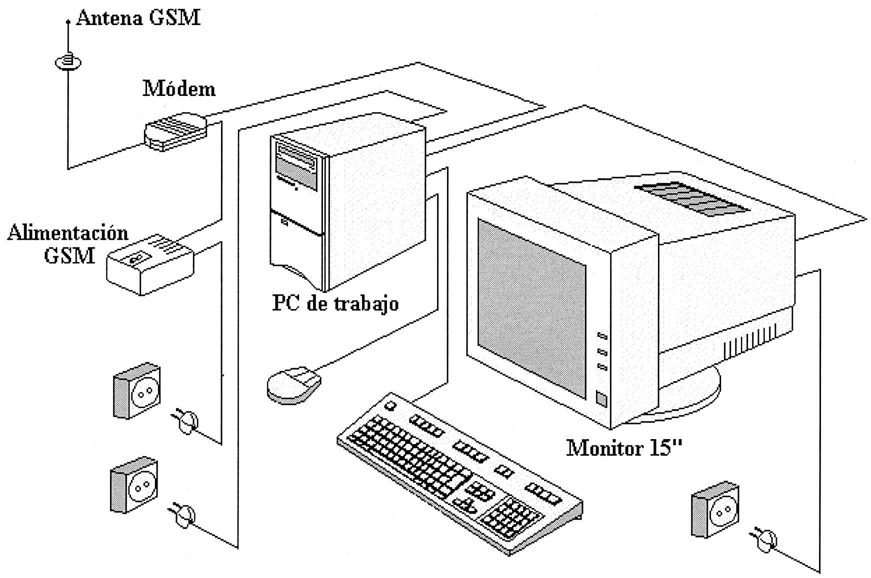

Figure 2. Devices installed in the management centre: communications unit (GSM) and data processing reported by the ship.

(b) *Risk situation*: Any sensor is activated without interaction with navigational parameters specified (for example, a fire sensor in the Engine Room has activated).

(c) *Emergency situation*: One or several sensors are activated and the risk interacts with at least one of the parameters specified (for example, a fire sensor in the Engine Room has activated for over one minute, or an accelerometer is activated and speed is reduced by 1/3).

The priority of the message sent to the control centre will depend on the conditions recorded, and the automated information will include the position and ship condition showing parameter values for activated sensors.

6. COMMUNICATIONS MODULE. The differentiating feature of the CETEMAR system, as compared to the more classic 'Maritime Black Box', is the implementation of a powerful communications system that facilitates emission of position and ship condition information to the management centre. At the same time the data are stored on the hard disk on board. In this way, the information may be received by the control centre in real time and the ship may be monitored at all times especially when it is involved in some kind of emergency.

The ship is fitted with two communications systems, GSM and Inmarsat Mini-M. The former has an approximate coverage of 20 nautical miles from the coast that facilitates economic and quick transference of the data packages. Since high speed ships do not usually cover long routes they are normally within GSM coverage for the major part of their voyage. Despite this, the Inmarsat satellite communications system is also installed to cover occasions when the ship is outside GSM coverage. This system guarantees global coverage as well as a back-up system should the GSM fail for any reason. The use of GSM or Inmarsat thus depends primarily on the type of navigation (inshore, high-seas, in port, etc.), operations and cost. Although

Inmarsat-C is the most used system for long-range maritime communication, Inmarsat Mini-M was chosen because of its improved data transmission rate of 2 seconds as against the 15 seconds for the C system, and because it offers voice and data under semi-duplex operation.

7. OPERATION OF THE EQUIPMENT IN THE MANAGEMENT CENTRE. The information from the ship is received in the management centre by means of a GSM modem, and it is introduced into the computer by a serial port connection. This computer manages the follow-up applications, communications and analysis.

8. REAL-TIME SHIP CONTROL MODULE. The Control Module processes the data packages received from the ship and translates them into visual information for the operator; in particular, it highlights whether there is a risk or emergency situation and its cause. The screen shows ship position on a digitised chart relating to the area through which the ship is passing. The status information collected from the sensors installed on the ship is shown as a series of analogue and digital indicators.

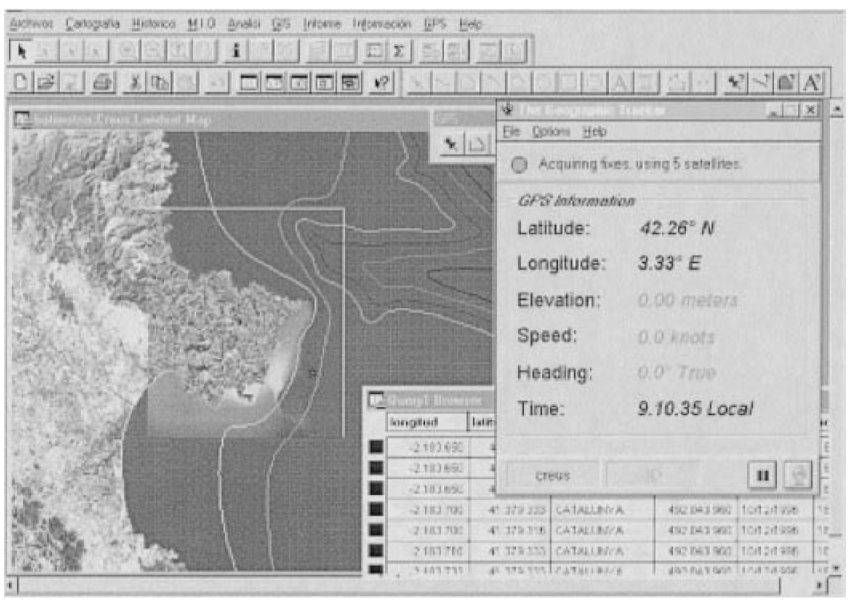

Figure 3. Integrated sensor data display with digital cartography positioning.

9. HISTORIC ANALYSIS MODULE. The analysis software facilitates the reconstruction of the ship's navigation history and status and provides the basis for the analysis and specification of its general operation; the interface with the management user is designed to provide a visual and intuitive environment. All the information collected over long periods of time is stored in different folders on the computer hard disk. This can be shown on the analysis module by choosing the name of the file or the dates of beginning and end. The positions are shown on the charts and the

https://doi.org/10.1017/S0373463300008924 Published online by Cambridge University Press

readings from the sensors and navigation parameters, recovered from the files previously chosen, are shown in tables. From this information, reports are made that aggregate all the information related to the ship or ships under study.

10. THE PROTOTYPE. The installation of all the elements that make up the shipping management system is basically founded on the ship recording equipment that integrates and manages the GPS module, the sensor data acquisition module, link to the communications module, GSM and Inmarsat Mini-M communications systems, and the analogue and digital sensors.

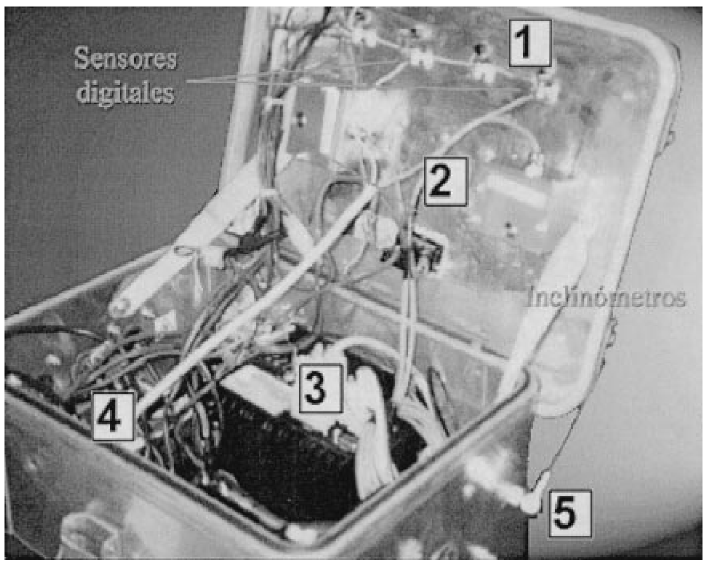

Figure 4. Interior of the Prototype System: 1. Digital sensors, 2. Inclinometers, 3. Control unit, 4. Sensor recording equipment, 5. Communications interface.

A general switch system provides on/off modes without having to open the cover of the box. The GPS and GSM antennae are adhered to the box by means of powerful magnets. In the prototype, four digital switches, installed on the lid together with their diode leads, are used to simulate inputs from sensors for the Fire Alarm, Water Level in the bilges, Fire in Engine Rooms and General Alarm.

The Inmarsat receiver is connected to the Mini-M telephone handset and earphone. Next to this is the GSM receiver. The recording equipment is connected to the communications systems using a RS-232 serial port; the data acquisition systems for the sensors uses a RS-485 series port. The data acquisition module for the analogical and digital sensors maintains continuous updating of the condition of the sensors using 12 connections to them. A secondary battery is used to power the system should the ship's mains power be interrupted. An interface unit manages the sensor box and both communication and positioning devices. For safety purposes, the recording device takes data from both analogical and digital sensors.

It must be stressed that the prototype is not an aid to navigation and for this reason an absolute positioning system must be provided.

Table 1.

	Actions					
Test-area	Report position	Set up sensors	Set up Inmarsat-Mini.M/G.S.M.		Report data sets	Ancillary data
Harbour	✓	✓	✓	✓	✓	✓
Coastal	✓	✓	✓	✓	✓	✓
Oceanic	✓	✓	✓	×	✓	✓

11. TRIALS. Two different trials were carried out in order to test the instruments and system architecture under three scenarios. These were completed at Palamós Port on the Costa Brava (Catalan Coast of Spain, Mediterranean). Table 1 shows the successful reception of position and sensor data for all areas except when the vessel was out of line-of-sight communication using GSM.

12. CONCLUSIONS. Within the shipping industry, any system used to transmit data and information through communications infrastructure to and from mobile targets and management centres, must be subject to a thorough analysis of the following: appropriate legislation, system requirements, end users' requirements, integration of the system and synergy with other systems. Safe navigation for High Speed Craft would be improved by the adoption of a management system providing the exchange of positioning and sensor data between ship and shore. In this way, the shore operator will be informed of ship condition at all times with immediate knowledge of any risk situation on board. In any fleet management system there are several different fields to be integrated. These include communications, cartography and positioning systems. In general, problems have been experienced in relation to the availability of and access to nautical cartographic information.

A system such as that described monitors the real situation of the ship and would help to prevent emergency situations and dangers for shipping. As such, it must have very high requirements in relation to reliability, integrity and communications availability to guarantee the flow of information and response between the mobile unit and the management centre. Therefore the communications system, in an architecture or configuration that is meant as an alert and control system, must have a duplicated configuration. The CETEMAR prototype duplicates this by means of the GSM and Inmarsat Mini-M. The system will automatically use one or the other channel depending on their availability or coverage.

https://doi.org/10.1017/S0373463300008924 Published online by Cambridge University Press