Development Smart Yacht Operational System and Marina Control System for Navigational Safety

Il-Sik Shin and Bae-Sung Kim

***Abstract*—In order to prevent safety accidents in marine leisure and small ships, a support system is required to warn dangerous situations at sea and inspect status of ship. Accordingly, this paper proposes designing and construction of smart yacht operational system and marina control system. Operation status and navigation information of leisure ship is managed by internal SW of a smart device and sent to the marina control center through mobile communication network. The systems allow yacht users to operate, manage and navigate yachts conveniently and safety by receiving diverse information about navigation and safety. In addition, the NMEA2000 standard was used to acquire information on yacht status, and the gateway for the overall NMEA2000 to Wi-Fi system was designed for transmission of information to the marine control center for verification of usefulness.**

***Index Terms*—Yacht operational system, marina control system, NMEA2000 to Wi-Fi.**

I. Introduction

Marine leisure sports represented by yacht were regarded as sports enjoyed by small group of wealthy people in the past, but it has recently been flourishing with gradual increase of consumers interested in related sports. Especially, there is a global booming of competition to purchase ultra-luxury yachts, and the attention is being focused on growth of the yacht industry with noticeable increase in yacht manufacture. The yacht industry is a high value added industry that combines tourism, sports and manufacturing business. Size of the global market of this promising new growth shipbuilding industry is 50 billion USD, possessing a market size corresponding to the global shipbuilding industry. As a field growing proportional to income, there is a global demand for 510,000 yachts per year [1]. Necessity for securing industrial competitiveness in the leisure industry including marine leisure is coming to the fore due to increase in demand from income increase and five-day workweek. This is linked to demand for the yacht industry such as motor boats and sailing yachts. Improved accessibility from expansion of traffic network is expected to show continued increase in marine tourism demand. Such trend is prospected to accelerate in the future. Also, marine leisure has already become an important axis of the marine industry, greater than the values discussed by economic power and equivalence, through growth of social conditions and living standards [2]. Keeping pace with this, the world government is placing multilateral efforts to prepare legal basis for growth of the industry as a future growth engine and to promote programs for popularization.

Leisure ship is a product that aggregated products of diverse fields including electrics, electronics and machineries. Background knowledge about the engine and fittings is necessary for operation, but most of operators are ordinary people and are exposed to collisions at sea and in-operation caused by non-perception of dangerous situations and lack of status check. To prevent such safety accidents in advance, a support system that warns dangerous situations at sea and inspects status of ships is demanded. In addition, unlike large ships and fishing boats, small yachts are not equipped with communication devices and have problems in figuring out positional information because they are often unrecognized by radar equipment at control centers. If a smart device with excellent penetration rate is utilized as a solution, yacht users can make use of data communication on existing mobile communication network services to secure channels for transferring positional information and data. The device can provide convenience / safety services [3].

Therefore, this paper suggests designing and construction of a smart yacht operational system which uses a smart device to protect safety of small leisure ships by warning dangerous situations at sea and monitoring and managing the status of ships. In the process of system development, the foundation for development of the integrated system for leisure ships is prepared by functional, compositional and operational mechanisms. The use of smart device can reduce cost and secure safety by providing marine traffic information based on connection with navigational communication equipment.

II. Development of Smart Yacht Operational System

Leisure ships are composed of propulsion system and navigation communication system. Studies on the integrated operational system that can integrate the two systems on one screen are being actively conducted. The smart yacht operational system provides increased safety of yacht navigation and efficient service to navigators by monitoring yacht status information (PMS, weather center, direction, speed, water depth, etc.), position (GPS), and surrounding environment using smart devices (smart phone, smart pad).

Fig. 1 shows the block diagram.

III. Leisure Ship Measuring and Monitoring System

Measuring and monitoring targets of leisure ships can be largely divided in engine, fitting, and hull sectors. Systems were

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shown in Table I after classifying into each sector. Each system was deduced through analysis on systems currently mounted on leisure ships [4].

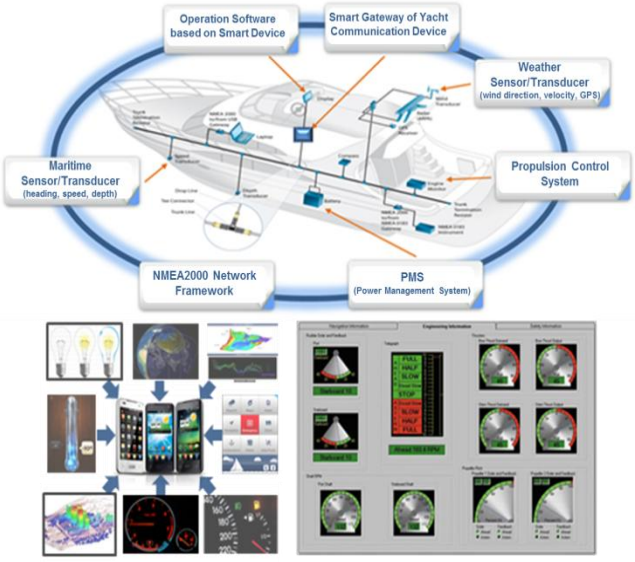

Fig. 1. Smart yacht operational system block diagram.

TABLE I: SUBJECTS OF MEASUREMENT AND MONITORING ON LEISURE SHIPS

Class	Name of System
Engine sector	Battery monitoring system, lubricant measuring system, fuel measuring system, engine temperature measuring system, generator monitoring system, RPM monitoring system
Fitting sector	Wind direction measuring system, wind velocity measuring system, rudder measuring system, position monitoring system, cabin temperature measuring system, lightning monitoring system
Hull sector	Flow measuring system, flood detection system, ship velocity measuring system, depth measuring system, bilge monitoring system

A. Battery and Generator Monitoring

The battery mounted on leisure ships is used to start the power and operate lighting, communication and electronic appliances. It is discharged with time and can be charged using a separate generator or small generator placed inside the engine.

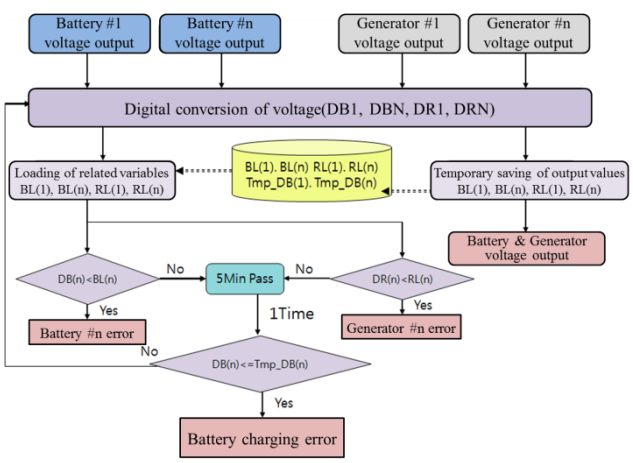

Fig. 2. Battery and generator monitoring system operation processor.

Power information analysis can be divided into analysis on battery output and generator output. The former inspects whether minimal voltage and current required to start the engine are supplied and whether the battery voltage rapidly reduced after starting of the engine can be recharged. The latter inspects whether proper output is coming out with starting of the generator. Normal operation of devices can be verified by converting voltage from the battery and generator into usable digital value and loading minimum output voltage of each device configured in advance.

Fig. 2 shows the battery and generator monitoring system operation process.

B. Fuel, Lubricant and Bilge Monitoring

Leisure ships use gasoline or diesel engine as the propulsion source. Fuel and lubricant must be supplemented or replaced at an appropriate timing by checking remains of fuel and lubricant. Bilge refers to wastewater that naturally occurs inside boats.

Minimum remains for alarm are configured for fuel and lubricant. Operation of the bilge pump is decided by converting resistance measured by the sensor to digital and referring to the minimum resistance value configured. The bilge pump continues to operate using sensor measurement when sea water infiltrates into the ship due to damaging of the bottom.

Fig. 3 and Fig. 4 show the operation processes of fuel and lubricant monitoring system and bilge monitoring system, respectively.

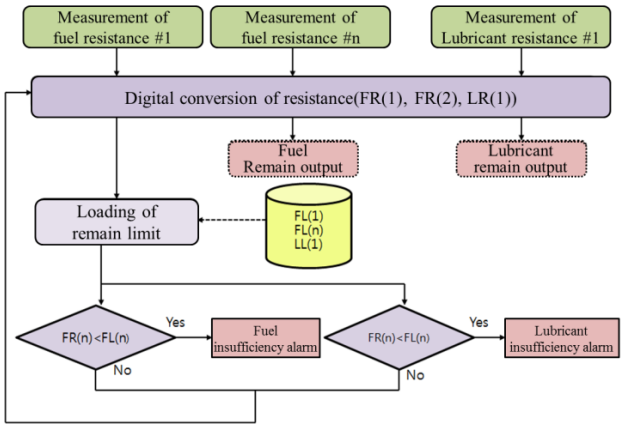

Fig. 3. Fuel and lubricant monitoring system operation processor.

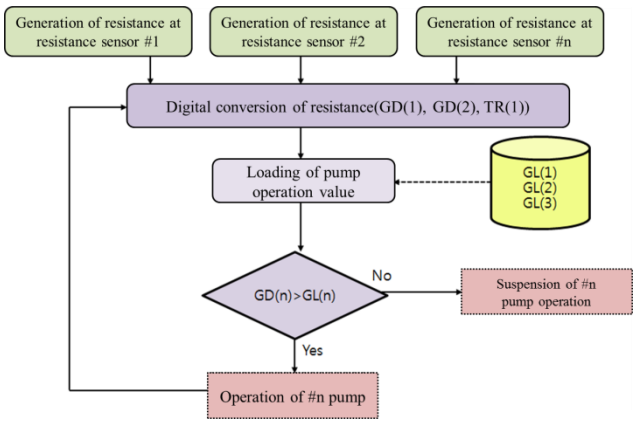

Fig. 4. Bilge monitoring system operation processor.

C. Engine Temperature and RPM Monitoring

This system provides important information about starting status of the engine. Since the engine is damaged by overheating when cooling water supply is insufficient, temperature information is essential. Output, speed and status of the ship can be examined through RPM.

Engine temperature and RPM information are measured using sensors and displayed as numbers or graphs. A function is added to stop the engine or create an alarm during emergency by setting limits on output and input.

D. Wind Direction and Velocity Monitoring

As a system that measures direction and velocity of wind at sea, the system provides basic information for safe navigation. The vane creates voltage by hall effect, and the anemometer creates number of revolutions, or frequency.

Fig. 5 shows the wind direction and velocity monitoring system operation process.

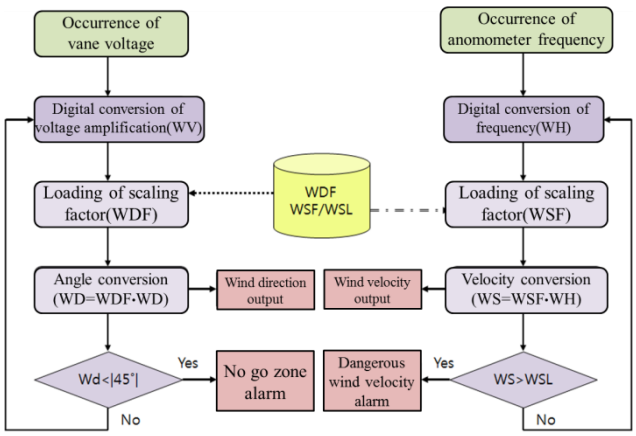

Fig. 5. Wind direction and velocity monitoring system operation processor.

E. Rudder Monitoring

This system notifies position of the rudder to the navigator. Examination of rudder position has recently become more important with automation of navigation system.

A resistance sensor is used to measure position of the rudder, and the required amount of modification on current rudder position can be found by comparing the desired direction and current direction.

Fig. 6 shows the rudder monitoring system operation process.

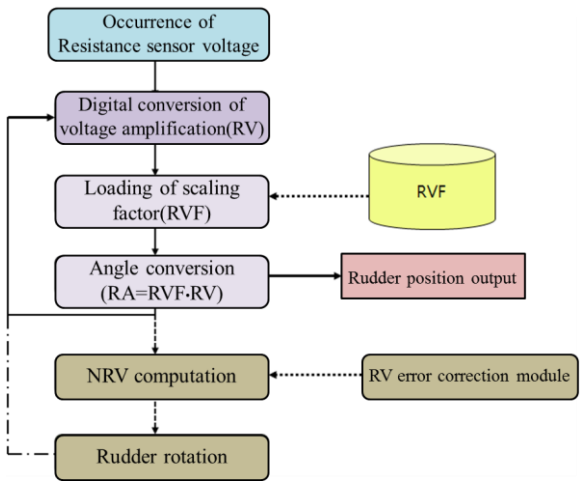

Fig. 6. Rudder monitoring system operation processor.

F. Position Monitoring

This is a system that uses GPS to examine current position of leisure boat. An antenna is used for GPS to smoothly receive satellite signals, and a separate and exclusive sensor is unnecessary. Unlike other systems, the position monitoring system must display a map. A broad display space is required to show current position by the bearings.

G. Temperature Monitoring

This is a system that measures temperature of the cabin superstructure and outside. Events are generated by postulating upper and lower limits of each temperature.

Fig. 7 shows the temperature monitoring system operation process.

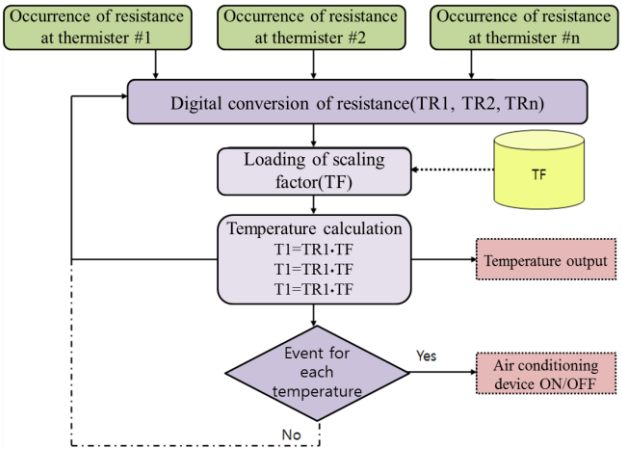

Fig. 7. Temperature monitoring system operation processor.

H. Flood Detection

This is a system that detects flood when the boat is stranded or bottom is damaged by collision with a floating material. Also, flood detection can detect the damaged part by installing the system in each closed area. The system provides a function to notify necessity of sail-back.

The signal generated by the grounding sensor always generates output of 0V when flood does not occur. When flood occurs, the anode is grounded and configured voltage will be displayed. The system is installed in each area that requires detection of flood, and alarms are created using measured information.

Fig. 8 shows the operation process of flood detection system.

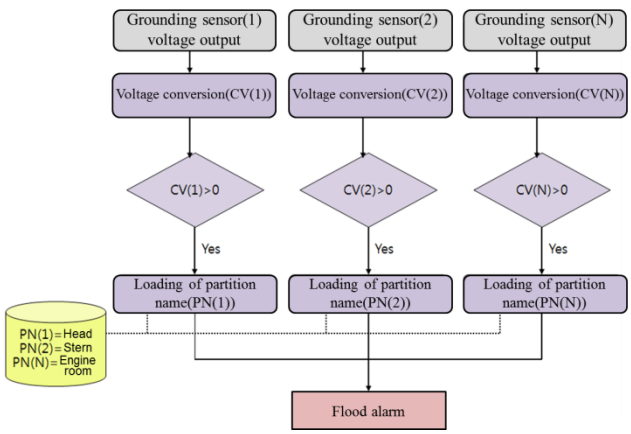

Fig. 8. Flood detection system operation processor.

I. Water Depth Measurement

Water depth measurement system is an essential system during navigation in shallow areas measuring distance from the ship bottom to seabed. Especially in case of ships on which a keel is attached to the bottom, this system is essential to prevent collision between the bottom and shallow seabed.

The ultrasonic sensor sends out usable voltage and converts voltage into distance using scaling factor. Fig. 9 shows the operation process of water depth measurement system.

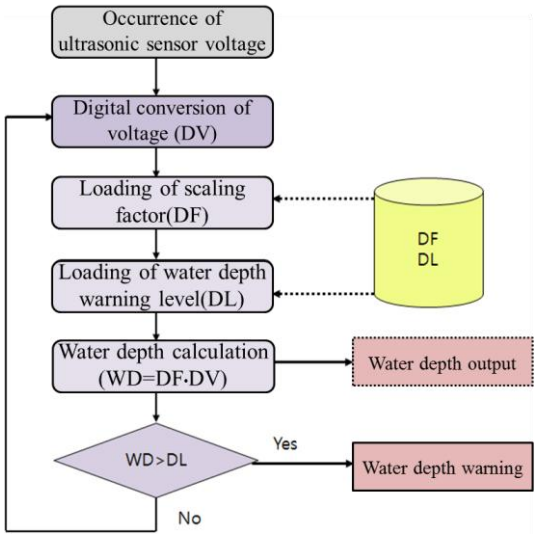

Fig. 9. Water depth measuring system operation processor.

IV. Course Recommendation System

With recent vitalization of leisure and tourism functions and increased attention on marine activities, marine spaces that had mainly been regarded as targets of fishery are being emphasized as tourism resources. Marine tourism was focused on coastlines centered on beaches in the past, but it is being expanded to include sea, underwater, and seabed. While yacht facilities and programs are growing proportional to quantitative growth, yacht users do not possess deep understanding about seas and required level of techniques and know-hows. Due to lack of information about accessible areas, they have a strong tendency to repeat navigations to simple courses and familiar regions. Course recommendation system for yacht navigation is developed to improve such problems and provide information.

The top priority of course design is safe navigation. Optimal course is provided according to the following procedure by investigating and analyzing the purpose of user and riders, environmental conditions including weather and marine conditions, tourism development plans, basic direction for construction of marine traffic network, availability of auxiliary navigation facilities, marine leisure activities, tourist attractions and natural landscape, economic feasibility, and leisure prohibition areas.

Fig. 10 shows the process of course recommendation system, and Fig. 11 is a course recommendation program manufactured according to the process.

V. NMEA2000/Wi-Fi

The NMEA2000 network protocol was analyzed for mutual information exchange and management between internal sensors and devices. NMEA2000 is a ship network standard that expresses data as PGN (Parameter Group Number) based on CAN (Controller Area Network), which is appropriate for real-time communication[5]-[7].

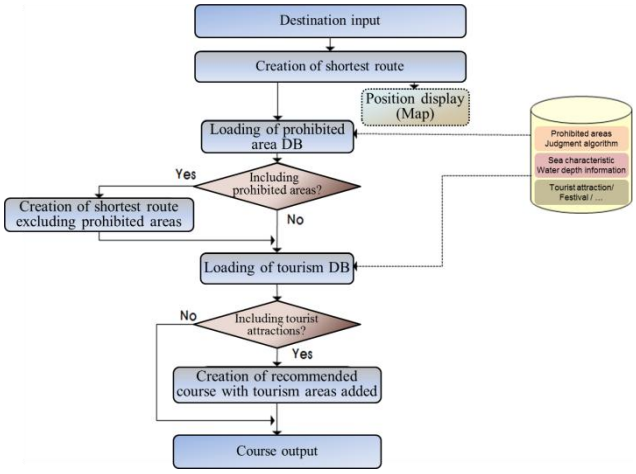

Fig. 10. Course recommendation system operation processor.

Fig. 11. Course recommendation program.

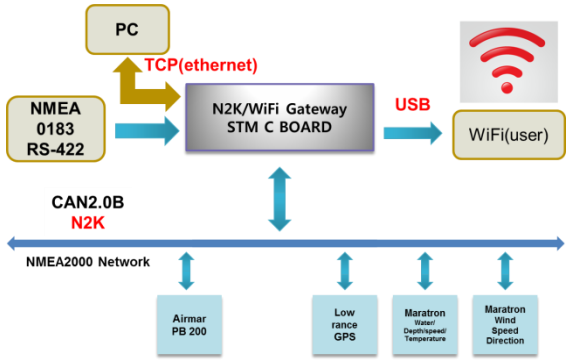

Fig. 12. Wi-Fi gateway.

Fig. 12 is the description on the structure of NMEA2000/Wi-Fi gateway[8]. In this system, a gateway that services Ethernet-based data through wireless LAN was created to monitor and manage necessary data transferred to and from devices on the ship using a smart device [9].

Fig. 13 shows the gateway module and data transfer test.

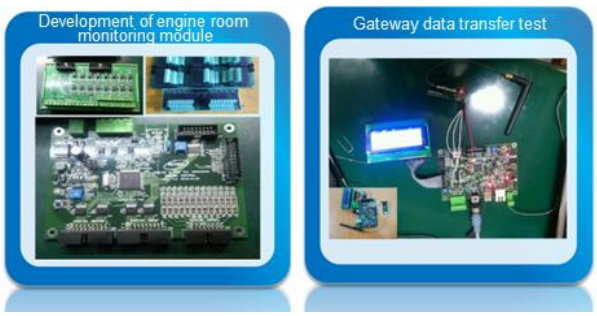

Fig. 13. Gateway module development and data transfer test.

VI. Marina Control System

Necessity for construction of a system that can connect facilities is being stressed out to improve efficiency of Marina ports and secure domestic and foreign competitiveness of facilities. Unlike general ships for which vessel traffic service (VTS) is applied, there is no infrastructure to support traffic control, auto entry and department, and marine safety monitoring of Marina ships. There is lack of infrastructure for management of Marina ships and facilities. In addition, since automation of facilities including entry and departure management has not been established, it is difficult to anticipate improvement in economic efficiency and high added value of Marine ports. To secure safety of human life, Marina ships and other nearby ships at sea and improve efficiency of Marina port facilities, development of an integrated management program for Marina ports is necessary. Also in case of Marina ports, facility and service items to be managed differ according to the type of operation. Facility operation status can be monitored on a real-time basis. The operation management program considering characteristics of Marina ports must be developed to support automatic facility management that takes marine situations into account and linkage between facilities and related institutions [10].

Therefore, a Marina control system which allows for increased convenience of Marina users, efficient integrated management of facilities, and monitoring of marine environment is proposed as a solution to current problems and needs.

A. Leisure Boat Auto Entry and Departure Report System

According to the Act on Entry and Departure of Ships, reporting of entry and departure must be done during marine leisure activities. However, there is an inconvenience of having to perform the report every time for temporary stays for supply of goods and fuel. Thus, an automatic entry and departure system using smart devices can be constructed to prevent such inconvenience, allowing systematic management at Marine control centers.

Entry and departure information is transferred automatically based on position information, and safe activity is helped by receiving the mooring situation and information. Fig. 14 shows the automatic entry and departure reporting system for leisure boats.

Fig. 15 shows the mooring yacht monitoring system.

B. Yacht Monitoring System

Locational conditions of Marina require calm water areas (calm water where wave height does not exceed 30cm) with small influence of waves and tidal currents as well as poor weathers such as heavy rain and typhoon. The places should not be intruded by other people or inflict large impact on mooring yacht. When Marina is distanced from satellite city, it is difficult to recognize the status of mooring leisure ship. Based on these requirements, the developed system installs a camera on Marina to check the status of leisure ship as an image through the internet or smart device.

C. Marine Leisure Prohibition Area Warning System

Leisure ships can be exposed to various dangers in the marine traffic environment as they are operated by non-experts. Leisure activities are strictly prohibited in courses where large ships enter, aqua farms, and military operation zones. Therefore, this system is developed to check position of the leisure ship at the Marina control center, examine dangers about leisure prohibition areas, and give warning to users.

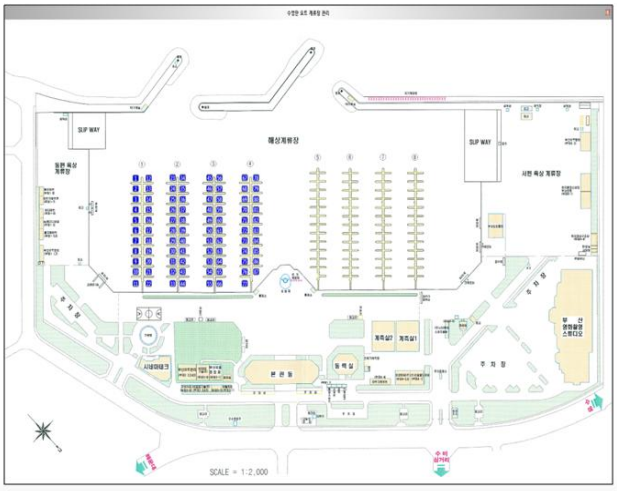

Fig. 14. Leisure boat auto entry and departure report system.

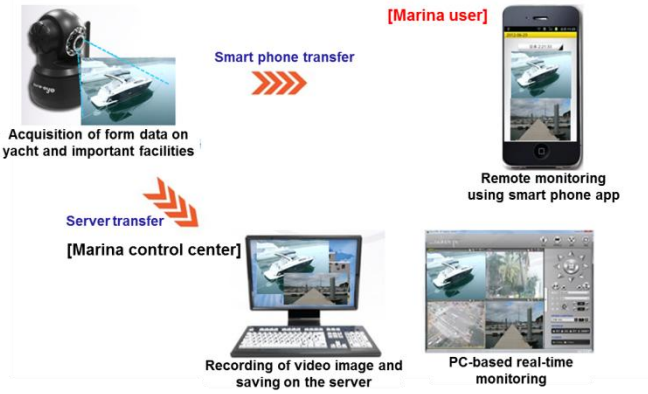

Fig. 15. Yacht monitoring system.

Fig. 16 shows the marine leisure prohibition area warning system.

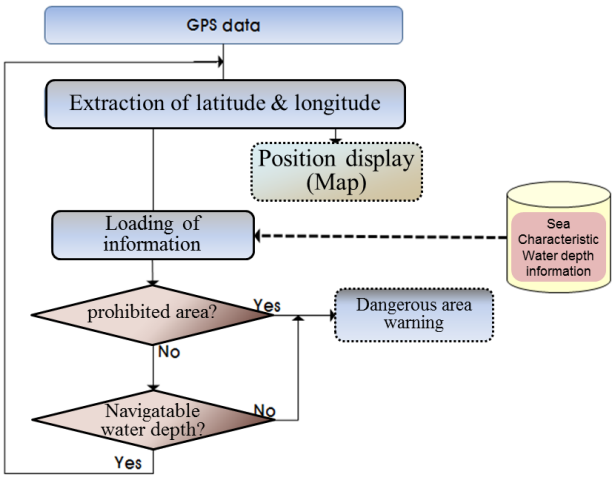

Fig. 16. Marine leisure prohibition area warning processor.

VII. Conclusion

Designing and construction of a smart yacht operational system that can integrate overall systems, guarantee safe

navigation of small leisure ships, warn dangers at sea using smart devices, and measure and monitor status of ships were described. The course recommended system linked with the operational system was provided to leisure ship operators, improving quality of services.

In addition, an integrated Marina port management system was proposed to secure safety of human life, Marina ships and other nearby ships at sea and to improve efficiency of Marina port facilities.

Accordingly, the smart yacht operational system and Marina control system proposed in this paper can guarantee safe navigation of leisure ships, increase convenience of Marina users, and be useful for efficient integration of facilities and marine environment monitoring.

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