Extending the Capability of Vessel Integrated Automation System for Damaged Control Flooding System in 80 Meter Offshore Patrol Vessel

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Abstract. Indonesia is an archipelago country that owns thousands of islands. The worthy treasures must be protected properly from any maritime disruption such as foreign invasion, pirate, hijack, terrorist, illegal fishing, illegal logging, etc. The internal ship also needs to be protected from any disaster at sea caused by natural and enemy. There is a high demand for many numbers of modern OPVs that have the capability of a warship in terms of safety and security system. One of the features is the DCFS (Damage Control Flooding System). The system assures that the ship could intact from hull damages on any recoverable scale. In this research, DCFS was built for working automatically under the integration of the installed VIAS (Vessel Integrated Automation System). A sub-program was developed so that the DCFS capable of automatically switch on/off all ship alarms and sensors systems, fire and bilge pumps systems, even main engine and auxiliary engine when the emergency call situation declared. Integrated DCFS under ship automation system will work faster than any human response to the sources of disaster can be detected and override much earlier. All integrated DCFS can be monitored in a progressive LCD multi-screen by interactive windows and menus as the results of this research.

Keywords: PLC Module, Control System, Integrated Automation, VIAS, DCFS, OPV

1. Introduction

Modern ship design has been grown linear with the development of an electronic system. The ship’s electronics fill almost all the equipment, apparatus, and system inside the vessel. The existences make many benefits of easiness operation, improving safety and security [1], less energy, fewer crews number [2], and full maintenance program [3]. The advanced electronic and information technology brings the ship to a higher level of automation from remotely operated till the future autonomous vessel.

Ship accidents become a catastrophic event that changes the rule of the game in the shipping industry from the ancient age to this modern era [4]. Ship accidents always happens and repeat all the time in shipping history. This disaster always happens as look likely unavoidable situation as simple thinking about the unlucky or lucky matters for the ship. The milestone of the technology development to avoid ship accidents came when the famous Titanic sank a hundred years ago. Then learning from this deadliest disaster during peacetime, then the subsequent evaluation recommended changes the maritime regulations, leading to the establishment of the International Convention for the Safety of Life at Sea (SOLAS) in 1914. The regulation has always been improved and upgraded refer to the marine disaster occurred in the yearly events. But revised SOLAS regulations and modernized ships look likely to only to reduce the number but not eliminate the accidents in totally. Some maritime accidents such as sunk, capsize, fire [5], explosion, crashed or collision, grounded, etc. still happens every year [1]. Moreover, in the military vessels, they face risk damage caused by mine, torpedo, bomb, and missile that possibly cause flooding and fire [6]. Ridiculously, this might be happened due to human error during peacetime.
2. Literature Review

In the first step of the development, DCFS is carried out by evaluating the principle dimension and the general arrangement of the 80 Meter OPV as shown in Table 1 and Figure 1.

Table 1. Ship’s general arrangement data

| PRINCIPLE DIMENSION 80 METERS OPV                  |
|--------------------------------------------------|
| Length Over All (LOA)                            | 80.00 meter |
| Length Water Line (LWL)                          | 72.25 meter |
| Breadth (mld)                                    | 14.00 meter |
| Height (mld)                                     | 7.95 meter  |
| Maximum Draught                                  | 2.50 meter  |
| Maximum Speed                                    | 22 knots    |
| Crews                                            | 60 persons  |
| Medical Crews                                    | 10 persons  |
| Passengers                                       | 26 persons  |
| Water Cannon @ 300 m³/hr                         | 4 units     |
| Helicopter medium size                           | 1 unit      |
| Fuel Oil Capacity                                | 280 KL      |
| Fresh Water Capacity                             | 60 KL       |
| Endurance (at cruising speed)                    | 3000 NM     |

Figure 1. General Arrangement of 80 Meter Offshore Patrol Vessel (OPV).

The main duty of this 80 meters Offshore Patrol Vessel is to a floating base that has the capability of unlimited patrolling tasks for surveillance and security acts to protect Indonesian sea-territorial from any illegal activities and securing national sovereignty. 80 meters OPV is designed by using a combination of high tensile steel AH-36 as the main hull and marine aluminum 5086 as the superstructure. The designed ship powered by 2 (two) units medium speed marine diesel engines with a rating of continuous heavy duty which is capable of operated remotely from the ship’s wheelhouse.

**Damaged Control Flooding System (DCFS)**

DCFS is a standard system for naval vessel or warship of any type and size [7]. Even the system is very well known capable of protecting the ship from flooding due to damage in any ship hull but there is no common implementation in a commercial vessel also in any service vessel [8]. Operational costs always a problem even in warships. For example, Canadian Forces have priority to reduce the operating costs, approaches to fewer crew levels without obstructing operational capabilities and safety [9]. DCFS can reduce crews because this automation facility needs less people to overcome the ship’s shell damage and fire control. This project has several objectives including a state-of-the-art review of damage and fire control technologies, modeling and simulation of damage control activities and the evaluation of how automation will affect the crewing levels required to maintain the ship’s damage and fire control.
capabilities, material identification to resist damage and fire, and the choose of right technology such as a wireless condition monitoring systems [10].

Varela [11] explain how the importance of a ship control system to support emergency planning decision when flooding been occurred. Flooding times and stability parameters are measured, allowing for the crew to take the adequate measures, such as isolate or counter-flood all of the rooms, before the flooding takes incontrollable. The simulation is supported by a virtual environment in real-time, which provides all the functionalities to evaluate the seriousness event and any consequences of the situation, as well as to test, monitor, and carry out final emergency actions. The flooding simulation combined with virtual monitoring may require a large computational power to ensure the accuracy of the simulation results [12]. Therefore, the availability of automation systems onboard a ship not only functioning for any real damage and fire accidents but also can be used for training and exercise situations. The functionality will approach the crew’s awareness in many scenarios of flooding and fire.

Detect of flooding in the ship, by required sensor or transducer will automatically send a notification to the system to take an action. Progressive flooding inside a damaged ship can seriously endanger the safety. Level sensors can be used to detect the flooding, then based on the data finally the breach acts can be estimated. For decision support, the prediction of flooding extent and the intermediate phases is necessary. For this purpose, a new simplified, but still reasonably accurate, flooding prediction method called DCFS has been developed as shown in Figure 2.

Concerning the ship flooding simulation, Varela and Soares [13] developed a Virtual Reality based Decision Support System to assist the coordination of damage control teams and to take the appropriate countermeasures in case of flooding, fire, and possible chemical/biological contamination onboard the military vessels. For the specific case of progressive flooding, simulation allows the crew to quickly capable of check which compartments have been flooded, the order by which they will flood, and how much time they will take to be flooded. Ideally, the simulation must complete in time for the operator to take the adequate countermeasures before the ship enters into an irreversible capsize or sinking situation. Within this scope, the simulation ends when the stability is recovered or when the ship
capsize. The current paper presents an onboard decision support system for ship flooding emergency response. The system runs a simulation of the progressive flooding of ship compartments given an initial condition, which includes the current load and damage conditions of the ship. As the way system decide to improve or control when the flooding happens. The controller or micro-controller will contribute here.

DCF System will take an action to overcome the flooding, by implementing the Data-acquisition (DAQ) using PLC [14] to make the real sensors will automatically notify the real situation. The actuator will work to turn off the valves on and to turn on or off the pump needed. Relationship between equipment, when the ship’s hull broken, for example, caused by hit missile from the enemy during duty, it may make leak damages to the construction and seawater will come inside the ship, then low-level sensor detector triggered and the emergency alarm will on. Signal then could be sent to operate the pump automatically, some of the pumps can operate, then crews will reconstruct those damaged hulls immediately. During the emergency conditions, it can be arranged that the system will run another seawater pump such as a ballast or GS pump to support the effort to remove leak water overboard.

Figure 3. Schematic Diagram of the Developed Damage Control Flooding System.

DCF System planned mainly to overcome flooding in the engine room and accommodation room where placed in the lower part of the main deck. There is two options provide for the DCFS, series of reaction components group to determine the situation and series of action components group to overcome the situation.

3. Research Methodology

DCFS consists of hardware in the form of modules, software to processing data, and electronic control. PLC-Modules are used for data acquisition (DAQ) and interface for all input-output systems. DCFS as a part of the military type vessel therefore will be designed and applied for the 80 meters OPV as the requirements code to achieve UMS Notation. Therefore, the main idea of this research work is how the most efficient of the pump arrangement which is integrated into automated DCFS to fulfill the minimum requirements of the UMS Notation. DCFS is integrated with well’s established VIAS technology.

The other purpose of this study is to maximize the use of the ship’s existing systems and minimizing any new installation when adopting DCFS and then proposing UMS Notation by designing the optimal use of integration automation for the DCFS and finally when the UMS’s requirements are achieved, the successful system will be built in a complete and effective built-in MIMIC.
4. Technical Analysis

The availability of data will be a key performance to build a sophisticated modern engineering model [15]. Operational data of the equipment on-board the ship and the sequence operational information will be collected and re-arranged to perform DCFS under the mode of VIAS. VIAS become efficient tools to handle the engineering solution for effective protection from the risk of fire and flooding. The existence of a sub-program will be developed specifically for DCFS. See Figure 4 as the proposed system. The final model that is built based on the form of GUI (Graphical User Interface) can be used to simulate any scenario of fire disaster on a ship and overtaking flooding that may come simultaneously [16]. The existence of water from the fire extinguisher system may perform flooding in some ship’s compartments. The emergency bilge system acts to pump out the water so that ship’s stability and safe draught always maintain good conditions. When the fire and/or flooding occurred inside the engine room then the automation system will shut down the main and auxiliary engines and other machinery [17]. VIAS can also arrange the closing and opening of watertight doors automatically under sequences that are set up by logical programming. Even responsive detectors and the alarming system work well in alerting crews but they need a certain time to indicate the sources of alarms [18], then even wasting a lot of time to hurry toward the fire and/or flooding point. It is common sense in a conventional system. DCFS–VIAS offers an interactive MIMIC screen to monitor and show any single fire and/or flooding point progressively. Based on the logical control as shown in Figure 3 for example, then, this VIAS can do execution to handle many acts as stated above.

VIAS also has an Internet View System that capable of sending emergency messages to the Headquarter or any SAR institution in an earlier time if necessary [19]. Earlier acts usually produce a successive ending for any emergencies situation [20] instead of other political issues. Integrating the 80
meters OPV may also give economic benefits in the form of fuel-saving, fewer crews, less maintenance by adopting a power management system (PMS) and an integrated power management system (IPMS), etc. Ship Owner should not consider that additional budget to adopt DCFS-VIAS as a cost but it is an investment to keep the ship always safe and get a possible longer lifetime, off course the most important is to avoid any fatalistic accident during ship operational times.

5. Conclusion

The new module DCFS has been proven to work under DAQ that connecting the sources of data to the automated control all of the operational fire and bilge system and finally they can be displayed under the MIMIC screen for crew monitoring. Inserting a lot of water on-board a ship when fire extinguishing works make the ship heeling may be changed. Instead of progressive working of emergency bilge pumps then using a tank stabilizer can make it easier to adjust the angle of healing in any situation. All features possibly to be integrated into one automation act.

From all of the development works in building a new DCFS module under VIAS technology, then this project concludes that the following goals have been achieved:
1. New DCFS module capable of using the existing fire and bilge system on-board the 80 Meters OPV. It means that there is not any additional pumps and sensor & extra alarm system, but certain minor installations still in demands for improving system compatibilities.
2. The complete system on the new DCFS module has been built effectively in the form of a virtual MIMIC display. Input and output data of the new module DCFS-VIAS can work progressively in taking over any potential disaster especially which are caused by fire and flooding.

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