A NEW ON–BOARD COMPUTER SOFTWARE DESIGN APPROACH

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SUMMARY

At BSHC, a new designing technology of the projects is assumed in order to enhance its on–board systems. The applied Object Oriented Conception in programming is based on JAVA2 language. Using built–in JAVA Virtual Machine (JVM) provides platform–independence for developed applications, in other words the programs can be moved freely from one type of operating system to another. This allows the user to use open source operating system, which is free. The supported operating systems are: Linux/Unix, Windows, Sun OS and Mac OS. This maximizes the benefits of using JAVA2 built programs.

If additional operations are needed, like specific data visualization, readings from input devices such as ADC, I/O devices, etc., JAVA provides an opportunity to load C/C++ developed modules to already existing applications. This is possible thanks to JNI – Java Native Interface. JNI also allows to load system–dependent C/C++ modules.

1. INTRODUCTION

The necessity for direct control of ship’s behaviour in real operating conditions is precondition for widening the capabilities of the developed on–board loading software. In this matter, except of the developed program modules for loading plan preparation and the relevant calculations for intact strength and stability of the ship, were added tools for expert assessment and calculations for longitudinal strength, floatability and overall ship condition in case of damage situation. This type of system is called Emergency Response System. The most important requirements for the system are:

• time for reaction and analysis of the damage;
• making suggestions for correcting or minimizing the effects of the damage.

In order to achieve high performance and fast communication with the user, currently at BSHC the development of On–board systems is based on a new conception. At the very beginning the base software was written in FORTRAN and C++ using the techniques of systematic approach for creating complex programs and methods for modular and structural coding. Because of some methodological and technical difficulties in the coding process in the development for Windows operating system, a new ways of preparing the source code were sought. The new conception is put into practice using new generation of programming languages (JAVA, C#, Visual C++). They allow the software to be built for different operating systems (Windows, Linux, UNIX and MAC OS).

The purpose of the new conception is to give the operator more flexible, more reliable and more efficient working environment. It characterizes with:

• powerful graphical user interface
• all the data is being visualized via the interface of the program in real time;
• monitoring of all critical data for the ship in real time – when they are off the admissible values determined by the certifying organizations, the operator receives the necessary visual and sound signal;
• DAQ Device Management – capability to receive digital/analog signal from sensors and its real time processing;
• ability to manage executive devices.
• user level access control – every operator has an access level, identified with his username and password. The access level is determined by the administrator of the program(for example, the Captain);

2. DESCRIPTION OF THE NEW CONCEPTION

2.1. OFF–LINE DATA FLOW METHODOLOGY

The main point of this method is its appliance with earlier prepared computer or mathematical model of the ship and can be used for assessment of her strength and stability during loading and unloading operations. The off–line method is a simulation of the ship’s behaviour. When the necessary data is entered by the operator, it reflects to her floating position, strength and etc. (Fig. 1). The presence of an operator is obligatory.

The visual interface creates an easy and fast connection between the user and the core of the program. When the input data is received by the program core, it processes the data, makes the necessary calculations and the data is saved locally on a file database or SQL server. After the data is processed, the result is displayed to the operator in an appropriate way. The data can also be loaded from a previously saved user data set.

2.2. ON–LINE DATA FLOW METHODOLOGY

In on–line mode the presence of a computer model of the ship is not a necessary requirement – everything depends on what the purpose of the system is (Fig. 2). For complete realization of the method, a presence of measurement/managing devices and sensors is needed. Once again, the connection between the operator and the program core is the visual interface. Transition from off–
The on–line method allows collecting data from ADC–DAC devices, its analysis and preservation. The connection between the program core and the data acquisition devices is accomplished via JNI libraries, which take care of the data management from and to the ADC–DAC devices. A vast number of parameters could be monitored, influencing the stability and the entire ship. If a deviation is found from the given or admissible values, the system signals for the unexpected situation. The control over any managing devices (pumps, valves) gives the ability for ship righting and stabilizing as fast as possible via managing of the water ballast if an emergency or extreme situation occurs.

2.3. ON–LINE DATA FLOW METHODOLOGY WITH INTRANET (LAN, WAN) AND INTERNET CONNECTIVITY

In order to achieve the desired flexibility of the system and expand its capabilities of exploitation, a new module is under development (Fig. 3). This module will add network support, which can be combined both with On–line and Off–line methods. It allows communication in INTRANET (LAN, WAN) environment and through the Internet. This ensures the connectivity of two or more similar systems unified in one network, called “Ship Emergency Response Network” (SERN), which gives the ability for data synchronization between compatible systems. This includes sending and receiving cargo plans, stability data, damage situation if any, etc.

The connectivity is realized by Java based server program running on Linux/UNIX platform. It manages the data flow between two programs and stores data in SQL database for further use and analysis. One of the capabilities of this approach is its ability to accept connections and quires from mobile devices, such as cell phones and PDA, and send back the results in appropriate form. The only requirements to the mobile device are the presence of GPRS service and suitable capabilities of this approach is its ability to accept data synchronization between compatible systems. This includes sending and receiving cargo plans, stability data, damage situation if any, etc.

The developed coastal ERS provides:

• quick preparation of the initial ship cargo plan;
• localization of the damage;
• assessment of the current condition of the damaged ship;
• suggestion for ensuring the seaworthiness of the ship for safe passage to the nearest port.

The computer system can be used in two versions: as loading software (which includes cargo plan preparation and intact stability estimation, etc.) and as Emergency Response System (ERS). ERS makes assessment for the actual ship condition and offers an adequate suggestion about the necessary actions for limiting the consequences of the failure.

The computer system is developed. The main program package includes the following modules for:

• controlled access module which operates with constant ship data concerning general particulars, principal dimensions, geometry, hydrostatic properties, capacity, masses, etc.;
• corrections – water density, free surfaces influence, etc. – data referring to the particular loading case;
• localizing the cargo and service compartments – setting the weights of service loads and ballast, mass and location of the cargo;
• correct distribution of service loads and payload by compartments (loading plan preparation);
• calculations of weight distribution, static moments, CG and CF positions, definitions of current displacement, fore and aft drafts, as well as static heel and trim angles, etc.;
• calculation of the intact stability of the ship;
• estimation of the ship’s damaged stability in emergency condition (damage stability);
• determination of shear forces and bending moment in intact or damaged ship (shear forces and bending moments);
• floatability assessment (floatability);
• prediction of parameters of damage conditions;
• comparative analyses based on the mandatory criteria for ensuring the safe voyage;
• print–outs – tables, diagrams and output reports for current cargo plan, available services and ballast, strength and stability parameters, etc.;
• providing graphical visualization of all necessary input/output data.

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The development of the system is based on the requirements for safe ship exploitation according to the following regulative documents:

1) MARPOL 73/78 (as amended);
2) IMO Resolution A.167;

Session D 30
The main communication panels between the operator and the software package (ERS) are shown below. In this case ERS is developed for Chemical Tanker.

The Main program window is shown in Figure 4. From here user can choose the type of operations that can be simulated. Program version and current ship condition name are displayed on the title bar. The "OPTIONS" menu allows to access all program features, as follows:

- **Ship initial data** – included registration data, main dimensions and light ship;
- **Corrections** – gives the ability to change the water density between 1.000 and 1.030 t/m³, free surface correction enables/disables on GM and ZG, dead cargo (can be added with its coordinates on X, Y and Z axis);
- **Destination** – allows to edit port of loading, port of discharging and voyage number;
- **Stores** – crew and provision;
- **Service Tanks** (Fig. 5) – provides management of all available service tanks (m³, tons, % or m level), separated as follows – Fuel Oil Tanks, Lubricating and Bilge Oil Tanks, Fresh and Cooling Water Tanks, Other Tanks and Cofferdams;
- **Water Ballast** (Fig. 6) – this option allows to manage the volume of the ballast (m³, tons, % or m level);
- **Cargo Operations** (Fig. 7) – the option allows to manage the cargo loaded on the ship (m³, tons, % or m level), its type and density;
- **Cargo Plan** – this option allows to review all tanks total weight – services, ballast and cargo; summary tables show the name of the tank, its filled level in percents, current density, volume, current weight and the moment of its free surface; also port of loading, port of discharging, loading case, current date and voyage number are displayed.

**Information Window** (Fig. 8) – the main monitoring window. It includes the primary information about the floating condition during cargo plan preparation. Every modification made by the operator immediately reflects on the data displayed. This includes: Displacement (Displ), VCG, metacentric heigh (GM), Roll period (RLP), Heel, Trim, Draft Aft (DraftA), Mean Draft (DraftM), Draft Forward (DraftF), Heavy Fuel Oil (HFO), DWT (Deadweight), Distance of Invisibility (DOI).

After the preparing of the cargo plan is finished or during its preparation the ship’s stability and longitudinal strength can be monitored.

**Strength & Stability** – this option access charts representing ship's stability, bending moments and shear forces applied to the hull with hers current cargo plan in intact or emergency condition;

"Stability diagram" (Fig. 9) – represents visually the stability zones (A and B, altogether with GM(liquid)); below it is the "Legend" for the X and Y axis and tables containing all important information, including the IMO requirements;

"Bending Moment diagram" (Fig. 10) – accesses chart representing ship's bending moments applied to the hull with hers current cargo plan; the blue and the green lines represent the limiting values for "Seagoing" and for "Harbour" respectively; below the chart you can find a table containing all the essential information for the ship's structure frames and the stress level;

"Shear Forces diagram" – accesses chart representing ship's shear forces applied to the hull with hers current cargo plan;

**Graphics & Diagrams** – this option reviews bar chart representing ship's load distribution diagram, hydrostatic forces and total forces diagram, applied to the hull with hers current cargo plan and/or emergency condition;

**Damage stability** – an option, which predicts ship's behaviour when she is in emergency condition (Fig. 11); it allows to flood most of the compartments and assess the ship's survivability under the new conditions; the influence of the damaged tank is calculated instantly and the new position of the ship has taken;

**Ship Righting** (Fig. 12) – the system can perform changes to the cargo plan using the water ballast tanks or/and the cofferdams to correct the heel angle, if there is any; despite this option is available, we recommend the operator to make the corrective changes manually; after the righting process a summary will be displayed with the performed changes;

**Print Outs** – option for printing of various documents regarding ship's condition, load, stability, etc.; damage reports can be printed only when the system is in emergency condition; "Damage compensation report" can be printed only when "Ship Righting" has been performed;

**Save/Load Condition** – set condition name for the current loading condition; saved/deleted cargo plans, or replace an existing one.

The "UPDATE" position of the main menu gives the opportunity to perform live updates. If there is a new version of the program available online user can automatically upgrade to the current version on the server.

The "HELP" position gives the operator full description and help about the software package.

### 4. PERSPECTIVES FOR FURTHER DEVELOPMENT

BSHC continues to develop the Emergency Response Systems and this will be done in two directions:

- ship grounding – this also includes all actions which have to be taken in order to take the ship down
- sea towing – conditions and requirements.

In addition a separate module called "SEAKEEPING PREDICTIONS" is under development, which can be added to the structural diagram of On-board systems.

The seakeeping predictions include determination of natural roll, pitch and heave periods of ship motions,
calculation of motion amplitudes and speed loss at given sea state and course angle, prediction of the probability for ‘green water’ and slamming occurrence, evaluation of wave shear forces and bending moments.

The module is optionally activated after compiling the cargo plan and can provide:

- Information about ship behaviour in waves when advancing at constant speed and arbitrary heading — motion parameters, accelerations, wave loads, speed loss, strength parameters in still water and waves, stability;
- Advisable operation parameters (speed of advance and heading) at given loading condition and environment, from the view point of operational stability and seakeeping.

Bibliographic References:


3. BISHOP, J., HORSOPOOL, R., WORRALL, B., "Experience in integrating Java with C# and .NET".


Figure 1. Off-Line Data Flow Model

Figure 2. On-Line Data Flow Model
Figure 3. On-line Data Flow Model with INTRANET (LAN, WAN) and Internet connectivity
Figure 4. Main program window

Figure 5. Service Tanks
Figure 6. Water Ballast

Figure 7. Cargo Operations

Figure 8. Information Window
Figure 9. Stability Diagram

Figure 10. Bending Moments Diagram
Figure 11. Emergency condition

Figure 12. Ship Righting