USE OF NAVIGATION SIMULATORS FOR DEVELOPMENT AND TESTING SHIP CONTROL SYSTEMS

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Introduction. As the results of the analysis of accidents show, the main cause of collisions of ships at sea is a subjective factor [1]. In recent years, the intensity of shipping and speed of ships has significantly increased, which has led to a significant increase in the flow of information processed per unit time. Only through the use of rigid organizational and technical measures, the strengthening of requirements for the training of specialists, it is possible to contain the growth of the number of collisions. Analyzing these data, the experts concluded that a significant reduction in accidents can be achieved only by reducing human intervention in the management process, that is through the development of automated and automatic control systems. Modern vehicles are increasingly equipped with computer software systems (digital control systems). The use of digital control systems increases their reliability, accuracy and flexibility as well as gives them new opportunities through the use of a complex mathematical device. In addition, automatic systems are much cheaper than traditional ones with the crew. Given this, a number of European companies and research organizations in the next two decades are planning to completely rotate the seagoing vessels [2–4].

The use of a complex mathematical apparatus in the control systems algorithms requires their preliminary testing to ensure the correct functioning of the system. The first land-based development of control algorithms was launched in the aviation and space industries in the 60's of the last century. So, for the development of satellite orientation systems at the Keldysh's Institute of Applied Mechanics RAS was created a stand of half-level modeling. It consisted a simulator of a magnetic field and a layout suspended on a string. String hanger really provided imitation of one degree of freedom (rotation of the layout in a horizontal plane). The use of two such stands gave a fundamental opportunity to study the relative motion of two objects of management, which was of interest in the framework of the joint flight of several satellites (the configuration «formation flying») [5].

In the literary source [6] describes another, one of the first systems of semi-natural modeling on the aerodynamic suspension used by the Langley Research Center in the Research Center in the United States. On the model of the satellite were installed three flywheels, a magnetic system for unloading; the system of determination of orientation consisted of 12 phototransistors, as well as tachometers measuring the speed of the flywheels; the laws of management were implemented as part of the so-called logical block. The purpose of the stand was to demonstrate the steady operation of the control system and to work out the stabilization algorithms.

With the advent of modern computing machines, the creation of powerful software simulation simulations appeared new possibilities for the development of semi-natural modeling systems. These systems began to be called "software simulators with hardware-in-the-loop simulation" elements.

Parallel with half-level stands, purely virtual stands were also used to study the satellite's motion, with one or another degree of detail in the simulation of space conditions, the dynamics of rotation of the apparatus, the operation of sensors, onboard systems and actuating elements.

In the Kherson State Maritime Academy, within the framework of implementation of an international investment project funded by the International Maritime Employers' Committee (IMES), with the support of the Marlow Navigating Crewing Company and the Maritime Transport Workers' Union, has established a unique complex of training equipment that can provide training for marine specialists at the highest professional level.

The simulator equipment has a Certificate of Compliance with the Shipping Register of Ukraine, Software License of Transas Marine International, Statement of Compliance Det Norske Veritas, confirming its compliance with the established requirements.

Fig. 1 shows a fragment of the work of the Academy's cadets on full mission DP vessel simulator [7–8].

Fig. 1 – Full mission DP vessel simulator

In 2018, the authors submitted an application for an invention - a method of using navigational simulators for development and testing ship’s control systems. The method suggests connecting to the navigation simulator the simulation equipment of the control system (system blocks, data exchange program, program modules of the control system) via local computer network and organize the date’s exchange between the navigation simulator and simulation equipment of the control system.

The data's exchange program receives movement's parameters of the ship from the navigation simulator, its initial processing and transmission to the program modules of the control system. The program modules of the control system provide further processing of the received information in accordance with the established functional algorithms in order to form the output signals to the actuators. The generated output signals are sent by the data's exchange program back to the navigation simulator to account for their influence on ship's dynamics. This allowed to loop the navigation simulator (own ship, targets, surrounding objects, weather, circumstances, etc.) with imitation control equipment for the organization of fully automatic control. In this case, use of navigation simulators for development and testing of software modules ship control systems allowed to obtain all the advantages of modern simulators, namely: mathematical models of ships, targets, sensors, swimming areas, weather conditions, excitement, interference, equipment failures and process visualization.

Relevance of research. The use of navigation simulators in a loop circuit with the simulation equipment of the control system (system blocks, data exchange programs, software modules of the control system) is quite relevant direction, which allows to obtain a platform for development and testing highly intelligent ship control systems, considering the global trends in the full automation of ship management processes in the next 10–20 years.

Formulation of the problem. As follows from the above, it is necessary:

– create an imitation stand of dynamic modeling for the development and testing of highly intelligent ship control systems by connecting to the navigation simulators with its capabilities (bases of navigation areas, ship models, targets, sensors, actuators, weather conditions, circumstances and etc.), simulation equipment of the ship system control (system blocks, data exchange programs, software modules of the control system) through the local computer network;

– create a data's exchange program between the navigation simulator and simulation equipment of the control system;

– check the work of the information modeling system in a loop circuit with simulation equipment of the control system.

Results of research. Imitation stand of dynamic modeling consists of navigation simulators and simulation control system equipment.

The structural diagram of the imitation stand of dynamic modeling is presented on Fig. 2.

The navigation simulator's equipment [8–9], are shown in Fig. 2, includes:

– models of command devices (blocks 1–5), simulate the work of navigation systems and sensors;

– the Instructor's workplace (block 6), where in the program Navi Trainer Instructor are created and saved tasks (navigation areas, ships, targets, weather conditions, circumstance, equipment failures are selected), ships are assigned to virtual bridges and tasks are started;

– visualization channel models (blocks 7–11), display the visible part of the vessel and the scenes surrounding the vessel;

– dynamics models (blocks 12–13), simulate the dynamics of the ship, targets, other objects of the scene, waves, etc.

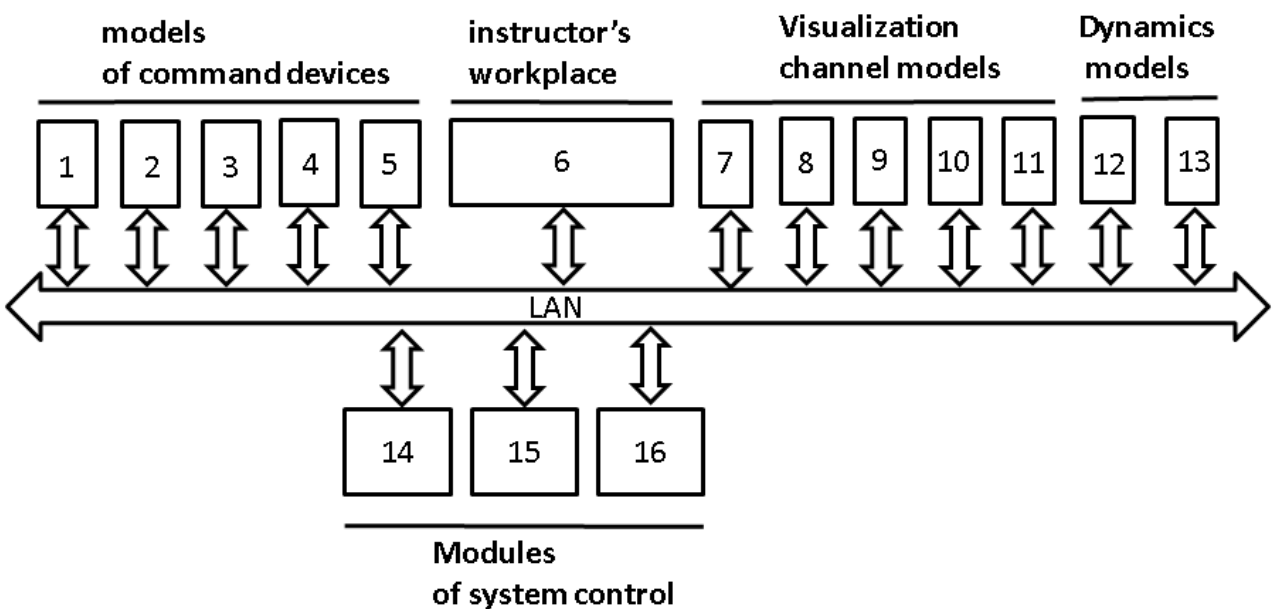

Fig. 2 – Structural diagram of the imitation stand of dynamic modeling

The imitation equipment of the ship control system shown in Fig. 2 includes system blocks 14–16 with the data exchange program and software modules of the ship control system.

The navigation simulator and simulation equipment of the control system are integrated into the local computer network (LAN) for data exchange.

The data’s exchange between the navigation simulators and simulation equipment of the control system is organized in the data exchange program, interface which is presented in Fig. 3.

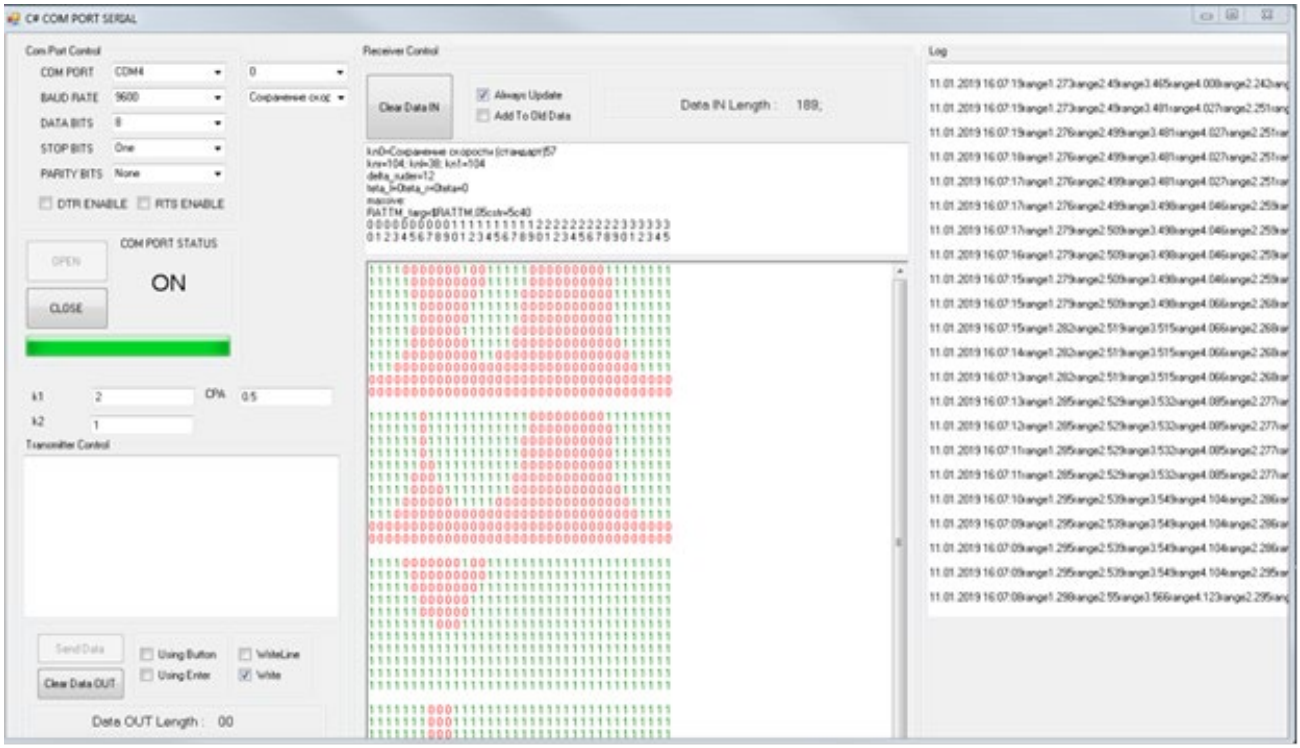

Fig. 3 – The interface data’s exchange program

The data exchange program is located in one of the blocks of simulation equipment of the control system, provides data exchange on the local computing network using the COM port emulator and the NMEA protocol [9]. The NMEA protocol, developed by the National Marine Electronics Association, is a specialized protocol to support the compatibility of marine navigation equipment from various manufacturers. NMEA transmits data from GPS receivers, sonar, radar, electronic compasses, barometers and other navigational devices used on ships. Most navigation programs that provide real-time data display also support and "understand" the NMEA. NMEA messages consist of a series of comma separated data sets. Each individual message is independent of others and is completely "completed". The NMEA message includes a header, a set of data in the form of ASCII characters, and a checkbox field to verify the authenticity of the transmitted information.

The data exchange interface allows to select the required COM port for exchange, configure the exchange parameters, view incoming information, configure pre-processing parameters, etc.

Conclusion. In these theses, the result of the work on the creating and testing of an imitation stand of dynamic modeling was announced, namely:

– created an imitation stand of dynamic modeling for the development and testing of highly intelligent ship control systems by connecting to the navigation simulators with its capabilities (bases of navigation areas, ship models, targets, sensors, actuators, weather conditions, circumstances and etc.), simulation equipment of the ship system control (system blocks, data exchange programs, software modules of the control system) through the local computer network;

– created a data's exchange program between the navigation simulator and simulation equipment of the control system;

– checked the work of the information modeling system in a loop circuit with simulation equipment of the control system.

The results of the conducted research showed that the created imitation stand of dynamic modeling can be used as a platform for the development and testing of highly intelligent ship control systems.

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