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ANALYSIS OF THE CURRENT STATE OF SHIP MONITORING SYSTEMS AND WAYS TO THEIR IMPROVING

This article provides a comprehensive review of the K-Chief 600 system, yielding essential conclusions regarding its features. It shows next advantages: Time Savings and Efficiency, the K-Chief 600 system affords vessel operators real-time access to critical data and controls, leading to time savings and ensuring the vessel's efficient operation; User-Friendly Interface, the system's interface is designed for quick adaptation by operators, facilitating easy monitoring and control of various ship equipment aspects; Reporting and Analysis Capabilities, the system offers reporting and data analysis capabilities crucial for logging, equipment performance analysis, and maintenance planning; Flexibility and Expandability, its modular design renders the system flexible and expandable, enabling adaptation to specific vessel needs. Beside of pointed advantages, also disadvantages taking place, such an: High Costs and Installation, a major drawback may be the high cost of the K-Chief 600 system, potentially limiting its accessibility to certain operators; Need for Personnel Training, effective system utilization requires training for operators and vessel personnel, constituting a time-consuming and expensive process; Dependence on Electronic Systems, similar to any electronic system, there is a risk of failure or malfunctions, necessitating specific spare parts and technical support. In line with pointed advantages and disadvantages, there are some ways to improve such a systems: Increased Accessibility, developers could explore avenues to reduce the system's cost, making it more accessible to a broader range of operators; Increased Automation, expanding functionality for greater automation of control and monitoring processes can enhance shipping efficiency and safety; Reliability and Cybersecurity, continuously updating the system to enhance reliability and protect against cyber threats is a critical aspect of further improvement. In summary, the K-Chief 600 system proves to be a powerful tool for shipboard control and monitoring. However, cost considerations, personnel training, and safety concerns must be factored in for its effective use.
Key words: *ship monitoring systems, real-time data access, maintenance planning, personnel training, electronic systems reliability, automation in shipping, cybersecurity, maritime safety, vessel efficiency.*

Бігун С.В., Сіманенков А.Л., Іванов А.А., Житник Д.В., Поливода В.В. Аналіз сучасного стану систем моніторингу суден та шляхи їх вдосконалення. *Ця стаття глибоко розглядає функціонал системи K-Chief 600, зосереджуючись на ключових аспектах, що визначають її ефективність. Серед суттєвих переваг варто відзначити можливість операторів суден зекономити час та забезпечити ефективну роботу судна завдяки реальному доступу до критичних даних та управлінських функцій. Інтерфейс системи, спроектований з огляду на зручність користування, дозволяє*

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операторам швидко адаптуватися, спрощуючи моніторинг та управління різними аспектами обладнання судна. Звітність та аналітичні можливості системи відіграють ключову роль у веденні журналу, аналізі продуктивності обладнання та розробці планів технічного обслуговування. Модульна конструкція K-Chief 600 надає гнучкість та можливість розширення, що дозволяє пристосовувати систему до конкретних потреб конкретного судна. Однак серед недоліків варто відзначити високі витрати та складність встановлення, що може ускладнити доступність для певних операторів. Для ефективного використання системи важливо провести навчання операторів та персоналу, що може займати багато часу та ресурсів. Залежність від електронних систем також вносить свої виклики, оскільки існує потенційний ризик відмов та потреба у спеціальних запчастинах та технічній підтримці. У зв'язку із зазначеними плюсами та мінусами, перспективи вдосконалення системи включають зниження вартості для більш широкого кола операторів, розширення автоматизації функцій контролю та моніторингу для поліпшення ефективності та безпеки, а також систематичне оновлення для підвищення надійності та кіберзахисту. Загалом, K-Chief 600 виявляється потужним інструментом для управління та моніторингу суднового обладнання. Проте, для його ефективного використання важливо розглядати витрати, проводити якісне навчання персоналу та удосконалювати аспекти безпеки.

Ключові слова: *системи моніторингу суден, доступ до даних в режимі реального часу, планування технічного обслуговування, навчання персоналу, надійність електронних систем, автоматизація в судноплавстві, кібербезпека, безпека на морі, ефективність судна.*

Description of the problem.

Introduction. Maritime shipping is a key sector of the global economy, playing an important role in transporting large volumes of goods and ensuring global connectivity. The growth of maritime transportation poses challenges to the safety, reliability and efficiency of shipping. One of the critical aspects in this context is ship monitoring systems, which play a crucial role in ensuring safety and optimizing fleet management.

Despite the advances in modern technology, existing ship monitoring systems still face a number of challenges, such as limited accuracy, lack of functionality, and the need for further improvement. This article is devoted to analyzing the current state of such systems and identifying ways to improve them to ensure a high level of safety and efficiency in modern maritime transportation.

This study will conduct an objective analysis of existing ship monitoring systems, identify their advantages and disadvantages, and propose innovative solutions for further improvement. The main focus of the work is on the development and implementation of new technologies aimed at ensuring safety and optimizing shipping management in the demanding conditions of the modern global market.

Problem statement. Navigation and monitoring of ships in modern environmental conditions is becoming increasingly difficult due to the growth of maritime traffic and high competition in shipping. Ensuring safe navigation, efficient fleet management and timely response to hazards require the improvement of ship monitoring systems. It is necessary to study the current state of ship monitoring systems and identify their shortcomings that may affect the safety and efficiency of maritime transportation.

Analysis of recent research and publications. In today's world, where a large part of important processes and operations are carried out thanks to complex technological systems, control and monitoring become a priority for safety and efficiency [1]. This is especially true for shipping, where safety, reliability and compliance are important aspects. A modern solution for this is the implementation of monitoring systems, such as, for example, Ship@Web [2].

Systems like Ship@Web are designed to provide continuous monitoring, control and management of the main technical parameters of ships and increase their level of safety and productivity. By providing remote access to data and control over critical systems, they open up new opportunities for operators and vessel owners in the form of diagnostics, data analysis and management decision-making [3, 4].

Systems like Ship@Web have several important advantages and relevant applications [2]:

1. Remote monitoring and control: One of the main advantages of such systems is the ability to remotely monitor and control important processes, such as automated systems on ships. This makes it

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possible to remotely monitor and intervene in the operation of equipment even remotely, which is critical for ensuring safety and efficient management.

2. Reliability and security: Systems like Ship@Web are typically designed with high standards of reliability and cyber security in mind. This allows you to protect critical systems from unauthorized access and failures, ensuring the security of operations.

3. Convenience and accessibility: Access to the system through a web browser makes it possible to work with it from any place where there is an Internet connection. This allows operators to communicate with ships or other objects from anywhere in the world, which is very convenient.

4. Data monitoring and analytics: Systems like Ship@Web are capable of collecting and analyzing large amounts of data. This allows operators to identify trends, make predictions and make management decisions based on the collected data.

5. Decision Support: An important feature of systems like Ship@Web is the ability to provide decision support. Operators can receive data that helps in solving complex tasks and choosing optimal solutions.

6. Integration with other systems: These systems can be integrated with other subsystems such as maintenance systems, scheduled maintenance systems, etc.

In general, systems like Ship@Web are important for ensuring the reliability, security and efficiency of managing critical technical systems. They are relevant in shipbuilding, aviation, industrial complexes and other industries where high-performance and safe management of equipment and processes is necessary.

System concept. Kongsberg system Ship@Web is designed for continuous access to the vessel's main data both on board and ashore. The Ship@Web system can display data from the marine automated system K-Chief 600 [5]. The Ship@Web system provides secure access to the isolated K-Chief 600 system based on modern solutions. Based on web technologies with a secure communication framework, Ship@Web can also be used to view and use historical data through applications such as Trend, Report and Export.

Key features. The integration between the process network and the administrative network provides:

- Access to automation data
- Organization and storage of data
- Presentation and decision support
- Automatic and manual vessel reporting
- Display in a web browser
- Display of subsystems such as engine monitoring, power management, fire system, storage systems, etc.
- Representation of lists such as crash views and process views.
- Representation of counters, event logs, emissions of gas emissions.
- Navigation structure identical to the K-Chief 600 system.

The aim of this study is to analyze the current state of ship monitoring systems in order to identify their weaknesses and suggest ways to improve them. The study is aimed at developing and implementing new technologies that will improve the accuracy, reliability and functionality of monitoring systems to increase safety and optimize shipping management. The analysis of various aspects of current systems will identify potential obstacles and define strategies for further improvement to ensure the sustainable and safe operation of ships.

Presentation of the main material.

System architecture. The architecture of the Ship@Web system (Fig. 1) is basically a proprietary K-Chief 600 automation system with an installed server/ firewall solution.

The main role of the server is to be a connection point to external networks that need information from the K-Chief 600 system.

The server acts as a web server that hosts applications that can be used from anywhere using a regular web browser.

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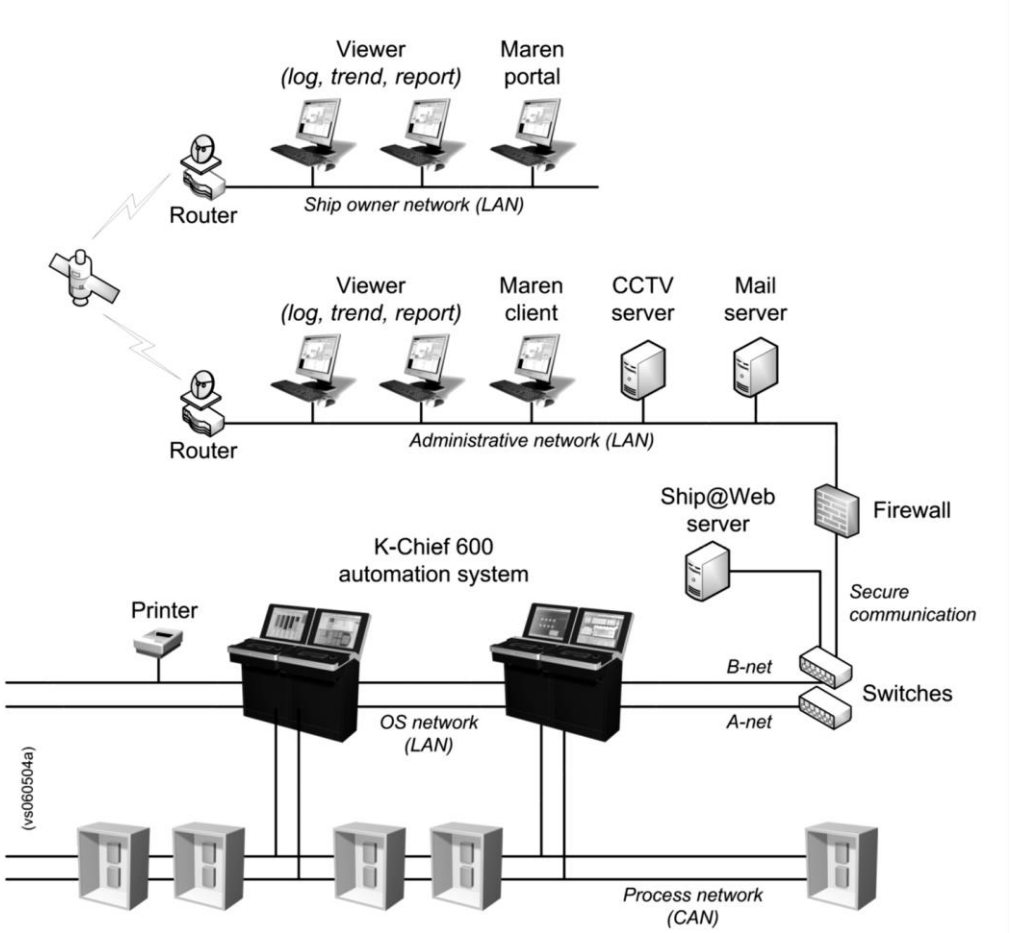

Fig. 1 – System architecture

Server Ship@Web is located in a separate VLAN from the K-Chief 600 processes LAN, and all computers connecting to the K-Chief 600 must be authorized by the firewall. This provides a high level of security for the K-Chief 600 system, protecting LAN processes from unauthorized access and other threats from the administrative network. The server contains no visual or interface units and can be maintained remotely. Its operation and maintenance are not required by the crew on board.

The K-Chief 600 offers cost-effective solutions that can be tailored to specific needs. The modular design provides flexibility in customizing the system for specific requirements, covering the entire spectrum from simple alarm systems to highly integrated control and monitoring systems.

Component systems may include:

– Alarm and monitoring system
– Auxiliary control system
– Energy management system
– Drive control system
– Ballast automation system
– Cargo management and monitoring system
– Heating, ventilation and air conditioning system
– Fire extinguishing system

The K-Chief 600 is based on Kongsberg system technology, where each vessel configuration is created using standard modules communicating via dual redundant process buses and networks [6]. The system can be configured for all types of vessels, including oil tankers, bulk carriers, container ships, Ro-Ro vessels, reefers and other special purpose vessels.

The main purpose of the system is to provide the ship's officers with all the basic alarms and status information they need to ensure the safe and efficient operation of the machinery, the cargo handling system with auxiliaries and other equipment.

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The K-Chief 600 is designed to meet classification society requirements for unmanned engine room operational control.

The main units of the K-Chief 600 system are operator stations, a duty call system, distributed processing units and dual redundant process buses and a network.

1. Operator stations. Operator stations are used to receive alarm signals and have the ability to monitor and control the system. They can display interactive process diagrams, provide the ability to control the on-call system and print various logs. They also provide access to distributed processing units for checking variables, controlling hardware, setting parameters, and more. Changes to restrictions or parameters in one operator station are automatically updated in all other stations. All operator actions, such as starting or stopping pumps or changing alarm limits, are logged and time-stamped. When a variable or state changes significantly, the distributed processing unit updates the database at each operator station.

All information displayed at any operator station is always up-to-date, and the amount of data transferred over process buses and the local network is kept to a minimum, guaranteeing extremely fast access to data. Any alarm or event is time-stamped to the nearest 10ms.

Specially designed process mnemonics contain easily readable information about the engine of the equipment and the surrounding equipment. Control of various process plants and machines is performed directly from any operator station. Full monitoring and alarming capabilities are provided in both the engine room and control cabins.

2. Panels. The K-Chief 600 operator interface consists of a standard monitor and two separate specialized operator panels, one standard and one optional. The standard panel has a trackball, a digital key, buttons for processing alarms and transmitting commands. The optional touchscreen-based panel is an optional panel. It contains softkeys for quick selection of available functional displays, process mnemonics and alarm lists on the monitor. A virtual keyboard is also available on the touch screen.

3. The interface between man and machine. K-Chief 600 monitor images are user friendly. Because they are similar to other Kongsberg systems, the operator will be familiar with the placement and basic functions. Specially designed images contain easy-to-read information about the system. The top panel is located at the top of the image and contains various function buttons such as split screen and home page. The system status (e.g. sea mode) is also shown. The top panel has two alarm lines that show the last two alarms and the number of unacknowledged alarms.

Interactive heading navigation is located directly below the top bar. The operator uses this tool to understand his place in the file structure. Each heading has a drop-down menu for additional information. This method of navigation helps the operator in quick access to all views and at all levels, and also helps the operator to remember the structure of the system.

The split-screen feature, available as a softkey on the top panel, allows the operator to view up to four images simultaneously. One of the four windows is always active, which is easily recognized by the larger frame. The various views can be resized at the operator's discretion, and a zoom function can be used for individual views. This split-screen feature helps the operator quickly and efficiently switch between different images and provides flexible and convenient viewing.

Alarm groups are clearly displayed on the left of the image. This is a compact and expandable column that contains all the necessary information for the operator. To make the process efficient and easy to use, so that the operator can quickly find where the alarm is located on the mnemonic, the K-Chief 600 system has a «go to mnemonic» function. By simply clicking on the softkey next to the alarm status, a mnemonic image opens, with an interactive red zoom circle showing where the alarm is located.

Chief 600 system also includes a context-sensitive help function. Access to help is provided by clicking on questions in dialog boxes. Context- sensitive help provides easy and accurate information on issues of interest to the operator.

Integrating third-party hardware is a new and exciting opportunity. The operator can control various devices using the operator station. Also, third-party software can be opened through K-Chief 600.

The «Favorites» feature is located at the bottom of the image. The operator can use «Favorites» to specify which image they want to have instantly available. After saving Favorites, the operator can also use the numeric keypad on the control panel to open them.

Intermediate operator stations are used to provide local access to distributed computing installations.

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4. Two-channel redundant industrial network (process-bus). The two-channel redundant process bus uses CAN (Control Area Network) technology to provide communication between Distributed Computing Units. Each unit is connected to two completely separate buses for maximum reliability.

5. The two-channel redundant operator station network uses standard LAN (local area network) or Ethernet network technology for communication between operator stations and other PC-based devices. Each Operator Station is connected to two completely separate networks for maximum reliability.

6. Distributed computing units (DPUs) are used to monitor analog or digital sensors and provide analog/digital output to other devices. Several varieties of Distributed Computing Installations are available to solve specific management and monitoring tasks.

Intelligent DPUs form the basis of the system. These units interact with each other through a high-capacity redundant process bus. All monitoring and automation functions are performed by the DPU, while centralized operator stations (OS) provide the human-machine interface. To configure tasks for a specific Distributed Computing Facility, parameters are loaded into the block. This allows it to perform signaling functions, control functions, security functions, or any combination of these functions, which simplifies the separation of system functions. Communication between Distributed Computing Installations takes place through the CAN Control Area network, known for its high reliability. In case of block failure, the power supply, communication bus or sensors are not affected. Built-in system test (BIST) detects failures of DPU, process bus, cables and connected sensors. The operator will receive a warning about any detected malfunction. Cargo control and monitoring system, ballast and control system can be integrated through two-channel redundant LAN network. The FleetMaster information management system can also be integrated into the K-Chief system via an administrative network, allowing for the creation of user-defined trend displays and customized reports. Equipment from manufacturers such as valve control systems, fire alarm systems and level gauges can be integrated through serial lines connected directly to Operator Stations or through a process network.

Submission of information. Graphic presentation of processes is carried out using individual screen forms that provide the operator with easy-to-read information about each subsystem and adjacent equipment. The process view shows the relationship between the blocks and devices used to control the respective process. A standard set of static and dynamic symbols is used to display the process. Further monitoring of process settings and parameters is possible directly from any Ship@Web client using the navigation line in the top bar. However, control of blocks and parameters is possible only from the K-Chief 600 system.

The availability of process views depends on the specific delivery of the system. Typical processes are cargo management, ballast management and power management.

If an alarm condition occurs, this will be indicated by the corresponding dynamic symbol on the process view.

Alarm notifications are visualized as graphic and text objects. The color mark indicates the importance of the alarm; red for normal alarms and magenta for high priority alarms.

Viewer. Viewer (Fig. 2) application displays online data generated by the K-Chief 600 marine automation system. Process information can be made available anywhere on board the ship via the ship's administrative network or in an office ashore using a conventional personal computer.

The data is presented using a user interface similar to that used by the Kongsberg K-Chief 600 marine system.

Viewer application interfaced with the ship's K-Chief 600 on-board process network (LAN), giving approved users remote access to critical information. For example, the Chief Engineer can check the parameters of the main engine or other critical indicators at any time of the day from his office.

The main functions of the Viewer include:

– Display of logged vessel data using a user interface similar to that used in the K-Chief 600 systems.

– Display of process mnemonics from the K-Chief 600 system.

– Display of the complete history of alarms registered on board the vessel.

– Displaying alarms, tag values and history through lists such as «Active alarms», «Alarm history», «General information about tags», «Event history», «Forbidden tags», «Overriding tags», «Counters», «List tanks» etc.

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– Providing owners/operators with an overview of basic vessel information, allowing for better shoreside support.

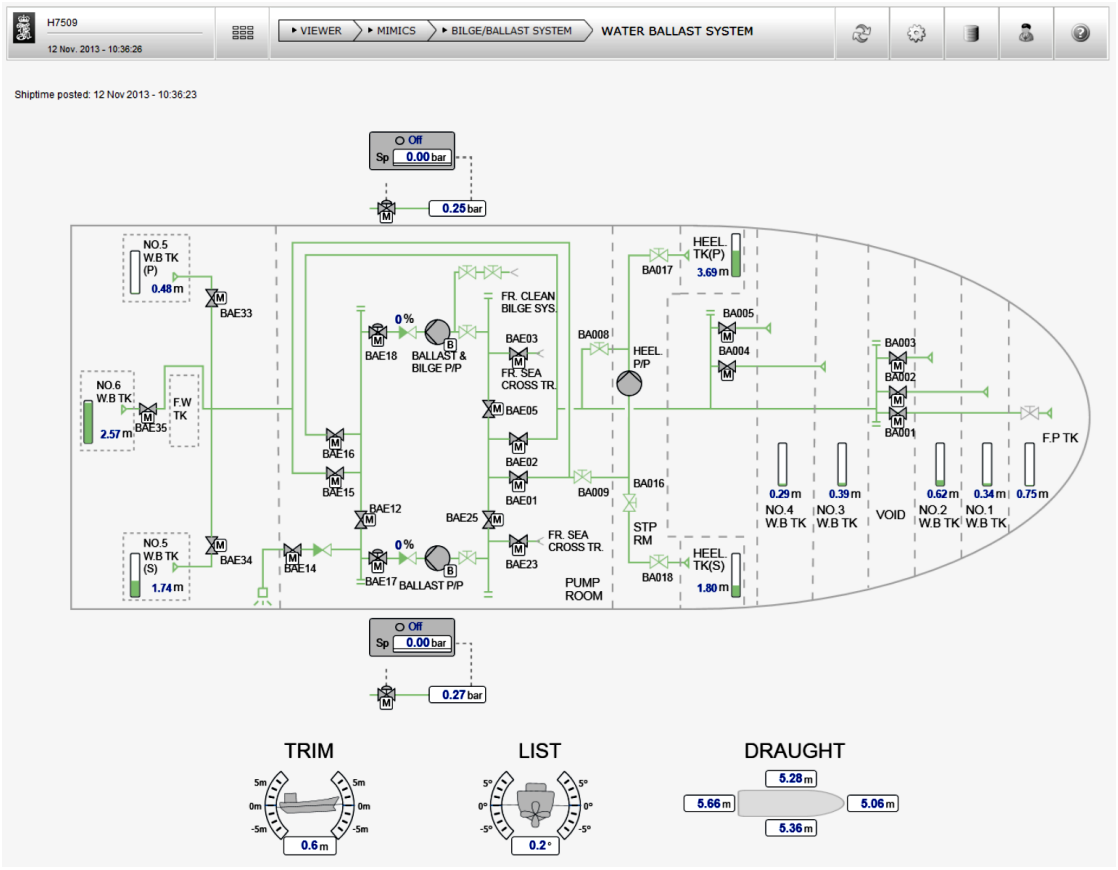

Fig. 2 – An example of a graphical representation of the process

The Viewer application can also be used to create an interface for an onshore office. This allows the user on land to observe in near real time the same information that is available to those on duty in the engine room of the vessel in question.

Viewer user interface is carefully designed to support the operator in his daily work. In addition, the screen layout is similar to other Kongsberg systems, such as the K-Chief 600 automated system, so the operator is instantly oriented to all important system functions.

Construction of trends. Trend application records and displays vessel process data generated by the K-Chief 600 automated system. It can be used to create custom tabular views.

Trend application provides an effective tool for displaying and analyzing data in the K-Chief 600 automation system. It provides the user with an effective tool for visualizing logged data without using an operator station. Up to 365 days of data can be displayed simultaneously.

Trend application can be used to analyze information such as fuel consumption, compressor running time, power generation and other key parameters in the automation system.

« Trend » can be used in different ways. Typical uses of the app include:

– Recording specific tags to monitor changes in a selected value over time.

– Help in setting up regulators.

– Monitoring the condition of vessel components such as the main engine, compressors, pumps and auxiliary engines [7].

– Providing data to establish the sequence of events that led to a particular incident.

– Ensuring recordkeeping of high-frequency trends and analysis of parameters for the long term.

– A permanent record or basis for analyzing events such as equipment start/stop or emergency shutdown.

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Report generation. Report application provides reports based on online information generated by the K-Chief 600 automated system. Report data can be printed or saved as electronic documents in PDF and XML formats. The application contains a predefined set of report templates. With the Report Builder, the user can also create reports with their own defined information.

Depending on the user's access rights, the « Report » application includes two modules – « Report Designer » and « Report Generator ».

« Report Designer » allows ship crew and ship owner to create individual report templates. « Report Generator » allows you to generate reports during a certain time interval based on templates created by « Report Designer ».

The « Report » application can be used in various ways. Typical uses of the app include:

– Automatic generation of reports from the automation system, including all connected equipment.

– Documentation of testing of critical processing systems.

– Generating standard reports such as daily report, flight report, fuel consumption reports [8].

– User-defined reports for components such as main engine, auxiliary engine and turbochargers.

– Reports can be automatically exported via email or FTP.

Export module. Export application transmits online information from the K-Chief 600 automated system to recipients of third-party firms in the administrative network. Typical recipients of data are systems for scheduled maintenance and load calculations.

The upper level of the automatic control and monitoring system. Module allows the user to quickly get an overview of the current and past performance status of vessels in a fleet or group of vessels.

The system is designed for constant data import from on-board automation systems. Data is transferred from on-board automation systems using the export function to Ship@Web. This data export is configured onboard the ship.

To export the data of mandatory, recommended and optional categories, it is necessary to use several mandatory labels. Required labels are used in calculations, while recommended labels can be used for filtering and display. Optional labels are used only as references, for example in trend analysis. The intervals between exports can be configured, usually from one hour to 24 hours. A longer interval means better compression and therefore lower communication costs. Also, the sampling rate of the labels is adjustable, usually one sample every 5 minutes.

The system provides several key performance indicators (KPIs). The primary KPI is a calculated value that represents fuel consumption per nautical mile (kg/mile), known as CPM (consumption per mile). This can be calculated either through water (STW) or by speed over ground (SOG). The first method only takes into account the performance of the vessel through the water, while the latter method also takes into account the route of the vessel, i.e. it will avoid the current against the vessel's course.

CPM is represented as the actual value and the deviation from the target performance.

Colors are used to emphasize these values. In the performance graph, fuel deviations are plotted around the target value as a filled area; areas above target indicate overspending, while areas below target indicate fuel economy.

The system has several modes, in particular:

- Analysis of fuel consumption.
- Analysis ship loading
- Speed analysis.
- Average cost analysis.

Analysis of fuel consumption. This mode shows the fuel performance of several selected vessels. It is divided into two sections that can be used simultaneously: Ship View and View Comparison.

The VESSEL mode can be used for detailed analysis of fuel performance and related information, while the COMPARE view allows side-by-side comparisons.

You can quickly switch between these two modes by clicking on the signature.

Fuel View, Compare. This view is basically the same as the Vessel view, except that you can compare the two views side-by-side or stacked.

You can select the same vessel and then select a different time period or two similar vessels to compare. As with the vessel view, you can add additional tags to display.

Analysis loading the vessel (TRIM VIEW) shows performance data at various drafts. This view is divided into two other sections: single vessel analysis and comparison [9].

SHIP mode is primarily used to analyze the optimum pitch angle and related information, while COMPARE mode allows side- to-side comparisons. Switch between these two modes by clicking on the signature.

Speed analysis. This mode shows the optimal speed for the selected vessel. The optimal rate is calculated based on historical data for the current sediment and the so-called economic rate calculated on the basis of the target productivity. It is possible to activate several ships at the same time and switch between them by simply clicking on the name of the ship. The first time this mode is opened, a list of courts is displayed. Choose the ship you are interested in.

HULL VIEW average consumption mode is used to display average fuel consumption data for a vessel over a long period. Data can be filtered based on speed, wind, precipitation, etc.

Just like in the form of fuel, it is possible to activate several ships at the same time and switch between them by clicking on the name of the ship.

The points on the graph represent actual measured data. A linear trend line shows the overall performance trend. The dotted line represents the forecast.

The red line represents the CPM limit for performance.

Conclusions

Based on the review of the K-Chief 600 system, several important conclusions can be drawn:

1. Advantages:

– Time savings and efficiency: The K-Chief 600 system provides vessel operators with real-time access to critical data and controls. This helps in saving time and ensures efficient operation of the vessel.

– User-friendly interface: The user interface of the system is designed in such a way that operators can quickly get used to it and can easily monitor and control various aspects of the ship's equipment.

– Reporting and Analysis Capabilities: The system provides reporting and data analysis capabilities useful for logging, equipment performance analysis, and maintenance planning.

– Flexibility and expandability: The modular design of the system makes it flexible and expandable, allowing it to be adapted to the specific needs of the vessel.

2. Disadvantages:

– High costs and installation: One of the main disadvantages may be the high cost of the K-Chief 600 system, which may be limited to some operators.

– Need for personnel training: Effective use of the system requires training of operators and vessel personnel, which can be a time-consuming and expensive process.

– Dependence on electronic systems: As with any electronic system, there is a risk of failure or failure, which may require certain spare parts and technical support.

Ways to improve:

– Increased availability: Developers can consider ways to reduce the cost of the system and make it more accessible to a wide range of operators.

– Increased automation: Expanding functionality for greater automation of control and monitoring processes can help improve shipping efficiency and safety.

– Reliability and cyber security: Constantly updating the system to increase its reliability and protection against cyber threats is a critical aspect of further improvement.

Overall, the K-Chief 600 system is a powerful tool for shipboard control and monitoring, but costs, personnel training, and safety considerations must be considered for its effective use.

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