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DISABLING THE DYNAMIC POSITIONING OF THE VESSEL AS A CAUSE OF THE NEGATIVE INFLUENCE OF HUMAN FACTOR IN MARITIME TRANSPORT

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Introduction. One of the important stages in the organization of work on maritime transport is the formation of a crew, taking into account behavioral characteristics at the time of taking managerial decisions. This approach is conditioned by security measures in accordance with international standards and regulations.

During the control of the vessel, both in real conditions and during practice simulations, a number of difficulties arise related to the negative manifestation of the human factor [1, 2, 10, 14]. Such manifestations are directly reflected in the result of passage of locations and other maneuvers [11, 12] at the time of command control by the crew on the bridge. The situation is complicated by the fact that in addition to the factors directly affecting each specialist [3, 8, 13], factors of influence from the team members exist [16, 4]. The more complex the task and the features of the location [15], the larger is the amount of information signals that the navigator faces [9, 17]. Especially the complexity of the process increases in the face of a sudden increase in information. This situation is typical for exiting from the dynamic positioning of the vessel. At the time of decision-making, the number of such information signals may exceed the threshold of perception, which leads to a loss of concentration of attention and, as a consequence, raises the subjective entropy of the navigator [4]. World practice shows that the human factor remains the most common cause of catastrophes in maritime transport in present day [5].

Thus, the purpose of this article is to analyze the movements of crew members resulting in a decrease in the level of safety during the management of maritime transport.

Methodology. The main goal of the article is to determine the interactions of navigators leading to a decrease in the level of safety during the performance of the watch keeping service. It should be noted that for a more visual representation of the situations under study, it is necessary to build a mathematical model for the interaction of team members in terms of set theory, group theory, game theory and the theory of formal systems [6, 7].

In the conditions of watch keeping, especially when practicing maneuvers in relation to locations, the decision to manage the ship is influenced by several members of the watch keeping duty. In some cases, when it's required by the changes in the situation, the captain gives the command to immediately strengthen the watch on the bridge. Typically, this decision is affected by: visibility, weather and sea conditions, the intensity of navigation and other features of the navigation situation. At the same time, the number of members of the watch keeping duty is increasing, which also contributes a factor capable of adversely affecting the decision of the navigator. To construct a formal model, consider the following scheme for the interaction of watch members. During the maneuvers, the naval officer requests the watch personnel to specify the indications of navigational instruments and other parameters necessary for steering the vessel.

In this case, local interactions occur short-term in time between the members of the watch and the deck officer (captain).

We will assume that two subjects are involved in the interaction: W is a deck officer or a captain and M is a member of the personnel on duty. In this example, the captain instructs before the start of the passage of the location, and immediately at the time the first mate takes command. Thus, the participant at number 1 (the captain) does not participate in team interaction, but can prompt the first mate. Each watch interaction solves the micro-task of steering the vessel at the current moment.

During the transition, the command performs a different kinds of tasks n consisting of a finite sequence of operations depending on the complexity $u_i, i = 1,...,n$. Members of the watch keeping duty W and M are divided into interacting groups $W_1,...,W_{\overline{Q}}$ and $M_1,...,M_{\overline{S}}$ depending on the level of qualification and experience. This leads to the formation of groups W_R, M_S for completing the tasks n and accomplishing the result C_i^R, $\overline{C}_i^S$.

To describe the model, let us set: the set of I different groups of interaction between the watch keeping members; the numbers N^Q, $Q \in I$ of these groups; the set $H = \{\psi\}$ of possible interaction types, where $\psi = \langle Q(1,\psi),...,Q(m(\psi),\psi)\rangle$, $m(\psi)$ – the number of interactions participants ψ, $Q(i,\psi) \in I$ is the group to which the participant with the number i belongs; function $\vartheta(\psi)$, indicating for $\psi \in H$, the performance value of the micro-tasks, united into interaction ψ.

Let us denote the type of interaction corresponding to the individual member of the watch Q, who is not united with anyone using $\langle Q\rangle$.

At the same time he can be a deck officer with high experience, who ignores the watch keeping members or an unclaimed watch keeping member due to low qualification, then $\forall Q \in I \langle Q\rangle \in H$, $\vartheta(\langle Q\rangle) = 0$.

In this situation the following condition will be true: $H = \{\langle Q\rangle, Q \in I\} \cup \cup \{\langle W_R, M_S\rangle, R = 1,...,\overline{Q}, S = 1,...,\overline{S}\}$, when $I = \{W_1,...,W_{\overline{Q}}, M_1,...,M_{\overline{S}}\}$.

Proceeding from the desire of watch members to maximize the vessel controllability, it is natural to assume that when the participants from the groups W_R, M_S unite, they will give the following result (1):

$$i \to \max_{j=1,...,n}\left(u_j - C_j^R - \overline{C}_j^S\right) \textit{i.e. } \vartheta(\langle W_R, M_S\rangle). \quad (1)$$

The situation when (Q) is a deck officer is fully justified in the conditions of passages with minimal risk, however, in the conditions of complex maneuvering this can lead to serious negative consequences. The case when (Q) is a member of the personnel on duty, whose skills are not trusted by the captain, is unlikely.

The reduction in the safety level can be preceded by the duplication of the functions of the watch keeping personnel by the watch officer. Even in situations when the maneuver was carried out successfully, the loss of experience by the personnel on duty due to inaction will subsequently lead to negative consequences.

This is justified in cases when the watch officer needs the support of a more experienced navigator, and the acting member of the watch keeping service does not cope with the task in the allotted time. In such cases, there are unforeseen collisions in the source information for decision-making, uncoordinated actions are possible and as a consequence, the safety level decrease.

We describe the interaction of team members formally. Then, N_Q when $Q = 1,...,\bar{Q}$ and $\tilde{N}_S$ when $S = 1,...,\bar{S}$ – we will take as the numbers of interaction groups of the personnel on duty with varying qualification in order if its descent.

But the transition from dynamic positioning to manual vessel control may cause inadequate response of specialists if the team is not ready. Testing of such events were conducted on the navigation simulator NTPRO 5000 and confirmed our fears. The experiment showed that the actions of navigators with the loss of control over the vessel cause spontaneous movements on the bridge.

At a certain point in time, the watch keeping begins to independently make decisions from the whole team; this can be seen in the chronology of events (Fig. 1).

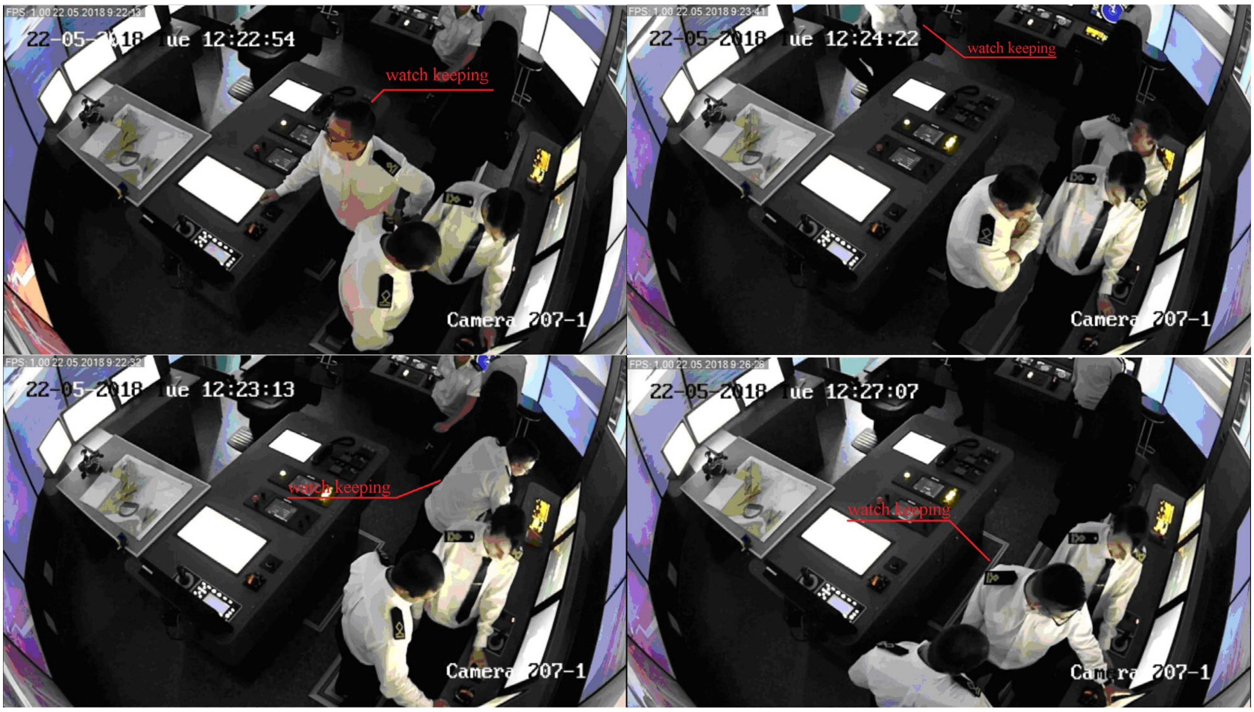

Fig. 1 – Interference with the navigation watch

A study of the trajectory of the control vessel confirmed the fact of loss of control. A computer program was developed to analyze the vessel's control path. The graph shows that loss of control occurs soon after turning off the dynamic positioning due to the human factor (Fig. 2).

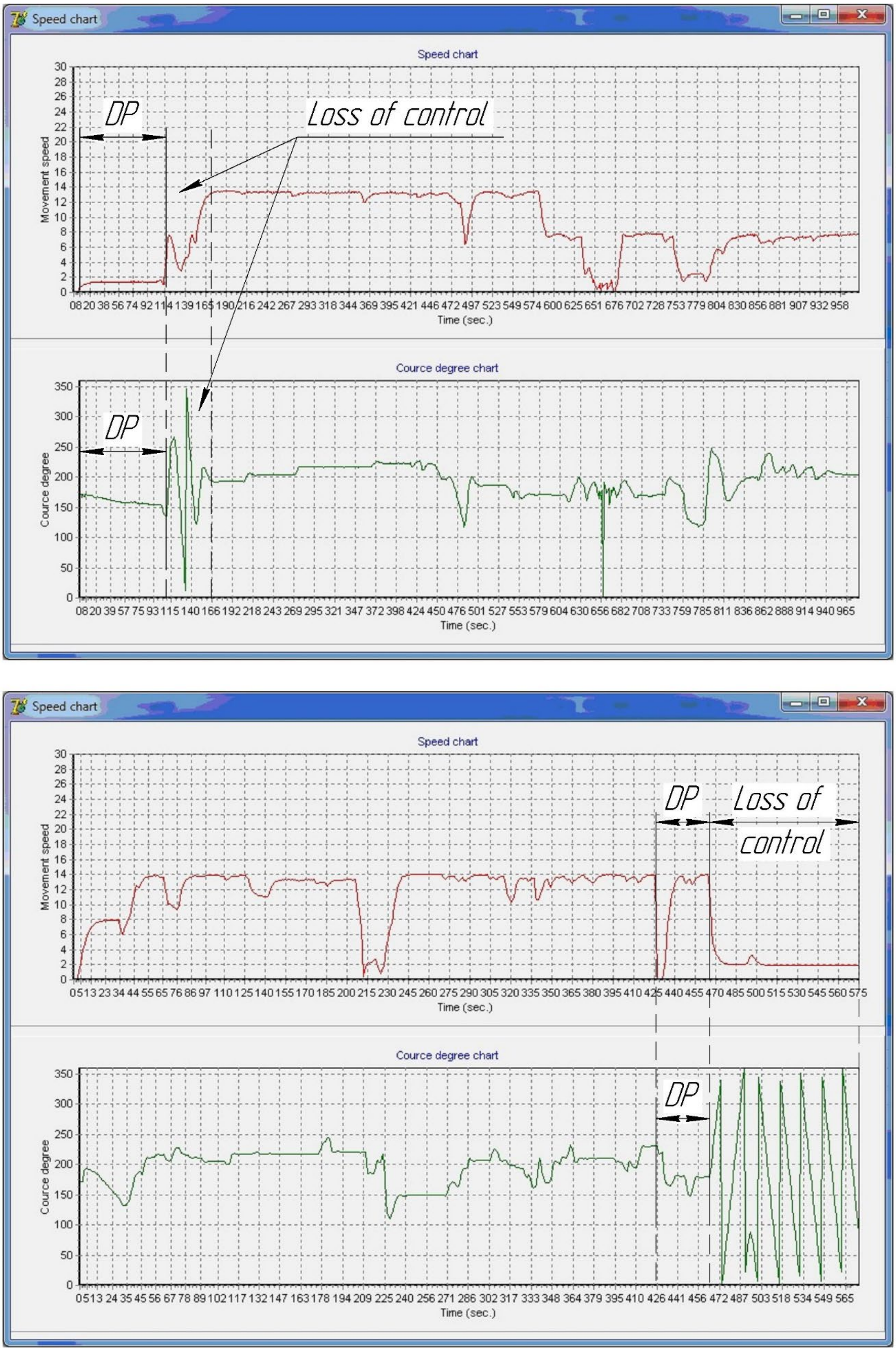

Fig. 2 – Periods of loss of control due to the fault of the human factor

There is a direct relationship between the spontaneous behavior of the watch crew and the loss of control over the vessel. Therefore, it is important to track the movements of the watch crew on the bridge using software tools.

A special program is installed on the server, which registers the movements of all team members with the connected sensors. All their parameters (coordinates, heart rate and temperature) are stored every few seconds in the database. It is possible to view all movements of team members for the purpose of conducting behavioral analysis.

The software and hardware complex allows to identify not only the location of members of the watch keeping service, but also physiological characteristics, such as heart rate and body temperature. These characteristics may indicate the level of stress and mental state of navigators (Fig. 3).

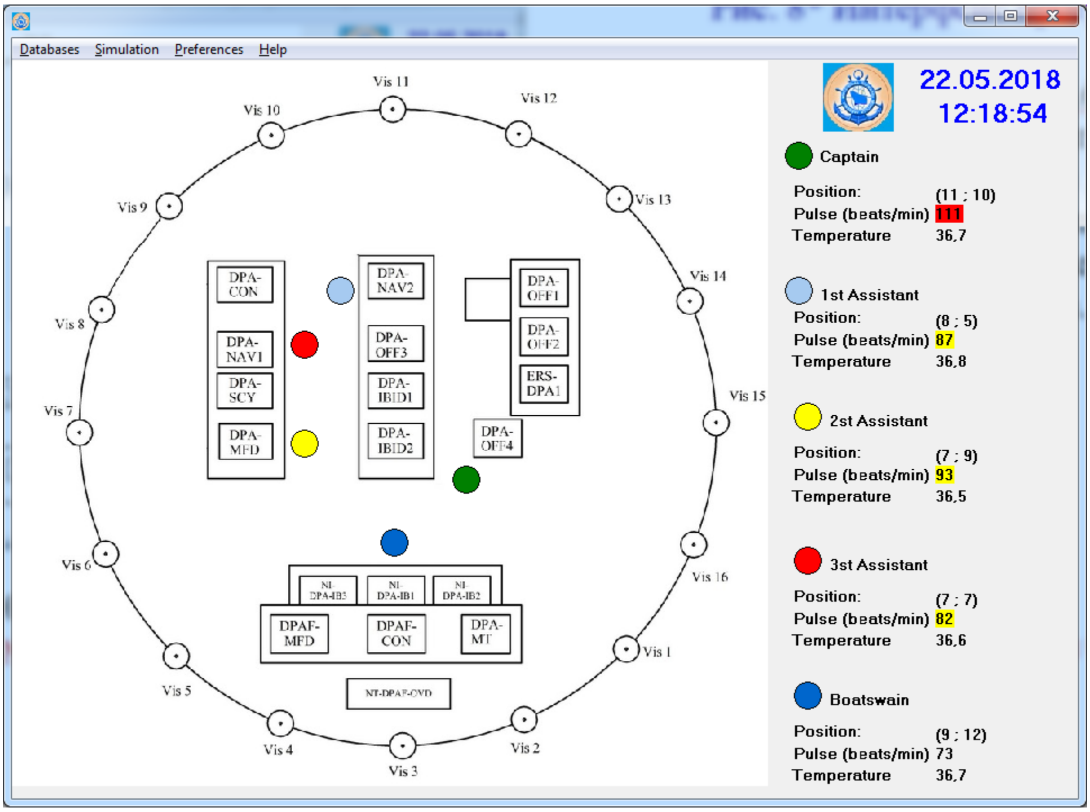

Fig. 3 – Program interface to analyze the behavior of the watch crew

Conclusions. The authors for the first time developed soft-ware and hardware for analyzing the movements of members of the watchkeeping service, allowing to identify violations of safety regulations. As a re-sult, a hardware-software complex for identifying the location and psychophysiological parameters of navigators was developed. Exceeding the temperature and pulse of navigators, as well as fast moving of individual members of the watchkeeping service to the positions of other team members, testifies to the violation of watchkeeping instructions. The automatic identification of these manifestations will prevent the negative manifestations of the human factor of the team, both in the course of simulator practice, and in the real situation. The developed software system will prevent unwanted behavior of the watch crew during the transition from the vessel's dynamic positioning mode.

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