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**MODELING OF CONTROL ACTIONS IN THE PROCESSES  
OF RESTORATION OF QUALIFICATION PARAMETERS  
OF MARITIME TRANSPORT SPECIALISTS**

Ponomaryova V.P., Ben A.P., Diahyleva O.S., Nosov P.S.

*Kherson State Maritime Academy*

**Introduction.** The development and trends in the transformation of organizational and technical systems of maritime transport directly depend on the preservation of specialist subjects qualification parameters [1-5]. Dynamic processes affect the integrity of the maritime transport specialists qualifications, which negatively affects the level of their performance of their functional duties [6-8]. The amount of loss from the human factor can be fatal and irreversible [9-12]. This implies, on the part of scientific world, the development of control systems that allow identifying the state of qualification parameters, both as a private subject of the system, and in field of maritime transport as a whole [13-15].

There is a need to identify and restore the qualification parameters of specialists, predict risks and prevent catastrophic consequences [16-18]. For this, one of important components of solving the problem posed is formal definition of control recovery signal to maintain a sufficient level of qualification parameters for maritime transport specialists.

**Main research material.** To solve the indicated problem, it should also be taken into account that in addition to determining the individual settings for the supply of a control signal in time, it is necessary to take into account the amount of information sufficient both to restore the level of qualification parameters (QP) and not exceeding the ability of a specialist to fully perceive it  $P$ .

In this case, it is necessary to observe the accuracy of information signal normalization in time  $x(t^*)$  using a correction factor  $\tau$  depending on the complexity of perceived information (individual indicator).

In this form  $\tau$ , it allows to normalize the flow of information, providing sufficient bandwidth of perceived control signal, which is described by the condition:  $F[R_x(0), R_x(\tau)] \geq P$ , at  $(R_x(\tau)/R_x(0)) \geq P$ ,  $(0 < P < 1)$ .

Due to heterogeneity of information signal between indicators  $R_x(0)$  and  $R_x(\tau)$ , peculiarities of individual perception of information by a specialist, the occurrence of uncertainty, parameter  $\tau$  will change cyclically, which does not allow the formation of a long-term plan of control actions [19]. In this case, it is necessary, in each the predetermined discrete cycles, to take into account the mean square error of signal adjustment  $L_\tau$ , both in total time  $t$  and in  $\tau$ , of form:

$$L_\tau = \sqrt{M[x(t^* + \tau) - x(t^*)]^2}, \text{ then } R_x(0) = M[x^2(t^* + \tau)], \text{ a } R_x(\tau) = M[x(t^*)x(t^* + \tau)]$$

From the above, it follows that in order to increase the effectiveness of QP recovery, it is necessary to generate a control signal according to criterion of individual information susceptibility [20]. This approach involves the introduction of signal quantization process  $\delta_s$  according to the criterion of conscious perception volume of information  $R$  within  $(a_i)$ , by a maritime transport specialist, [21,22] such that:

$$R = \frac{S}{\tau} \log_2 \left( \frac{2a}{\delta_s} + (R_x(\tau)/R_x(0)) \right).$$

Then, the level higher of signal quantization, the indicator higher of volume of information conscious perception by a maritime transport specialist.

Given that the recovery signal QP is  $X_i$  directed to impact of parameters  $s_1 \dots s_4 \dots s_i$ , then there are individually oriented limits on volume of such impact  $A'_i$  and  $A''_i$ , at  $X_{ires} - A'_i < X_i < X_{ires} + A''_i$ .

Based on indicated parameters, we will simulate the volumes of nformation perception i to restore QP for each  $S_i$  ( $s_1$  is the level of educational qualification;  $s_2$  is the current set of valid certificates, courses;  $s_3$  is the level of practical qualification (position);  $s_4$  - long-term sea experience).

The main components that allow approximating the studied processes in the form of surface graphs will be: correction factor  $\tau$ ; recovery time of a specialist's qualification  $t^*$ ; the intensity of control action  $\gamma$ .

For example, for  $s_1$ , with an increase in  $\gamma$  (0.3; 0.5; 0.7), the effectiveness of information perception increases significantly without additional correction, which indicates the age and sensitive characteristics of this specialists category (applicants for higher education) (Fig. 1).

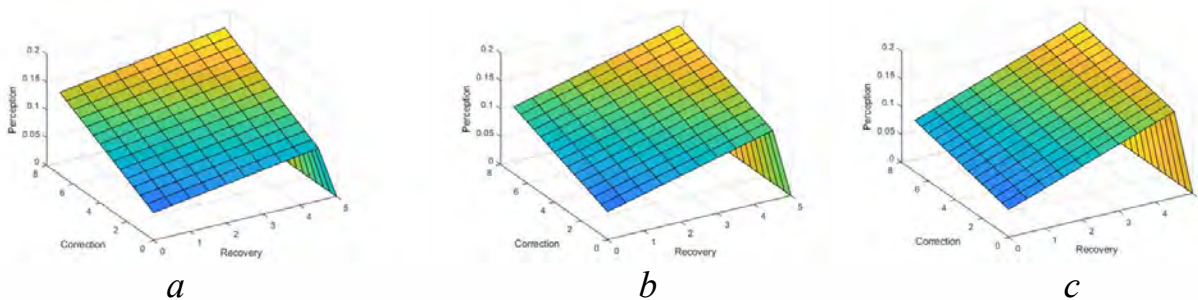


Fig. 1. Graphs-surfaces of information perception processes by maritime transport specialists  $s_1$ :  $a - \gamma = 0,3$ ;  $b - \gamma = 0,5$ ;  $c - \gamma = 0,7$

The data obtained indicate that the process is stable and does not require high intensity. The graphs (Fig. 1 a, b, c) show that it is possible to achieve the maximum effectiveness of qualification restoration for  $s_1$  without significant indicators  $\gamma$ , varying only by the submission of information and additional correction in time.

In turn, for the group of specialists  $s_2$ , when comparing the level of qualification the primary and "refreshing" for each of qualification courses, there is a

tendency to lose the effectiveness the perception volume of information for restoring qualifications in the second cycle (Fig. 2).

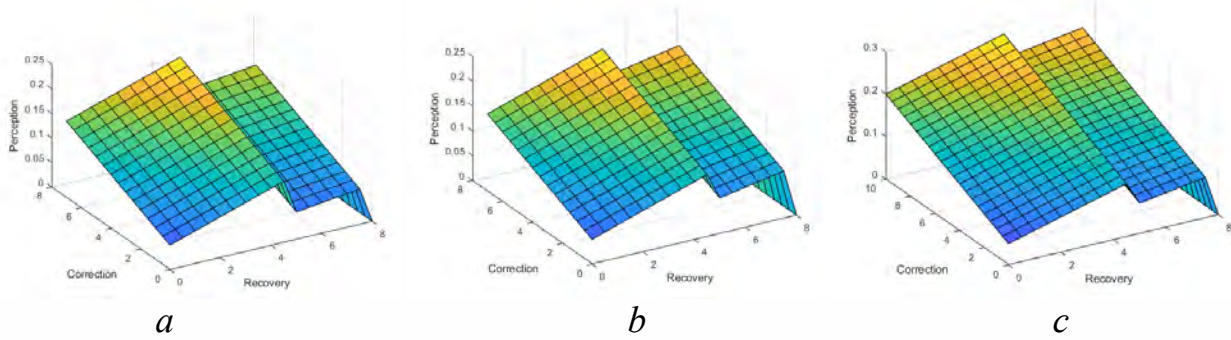


Fig. 2 Graphs-surfaces of information perception processes by maritime transport specialists  $s_2$ :  $a - \gamma = 0,3$ ;  $b - \gamma = 0,5$ ;  $c - \gamma = 0,7$

In the case for  $s_2$ , increasing the amount of perceived information by specialists, it is necessary to increase  $\gamma$ , so in the case of  $\gamma = 0,7$ , it is possible to get almost the same high result with “refreshing” as with “basic”. Thus, taking into account the track record of a specialist, it is possible to determine the control action for each individual with the maximization of the result. At the same time, an effect is observed when an excessive increase in volume of information-signal of control action can cause a sharp decrease in the efficiency of qualification restoration. It can also be caused  $T_{lose}$  when the optimal time for effective impacts is lost to restore the qualifications of specialists [23,24].

When moving to a new position, when the set of course certificates changes and it is necessary to ensure a qualitative transition to a new level of marine specialist qualification, it is necessary to significantly increase the intensity of control actions  $\gamma$  in addition, to balance the corrective function  $K_s(q)$ .

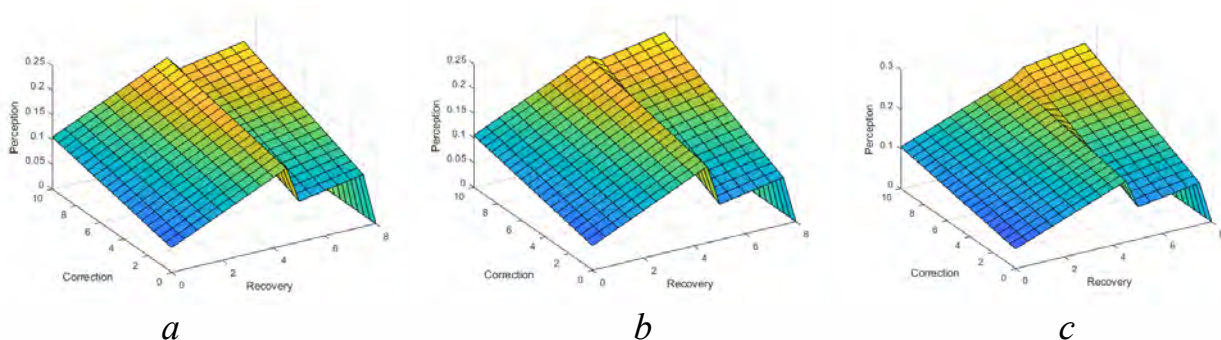


Fig. 2 Graphs-surfaces of information perception processes by maritime transport specialists  $s_3$ :  $a - \gamma = 0,3$ ;  $b - \gamma = 0,5$ ;  $c - \gamma = 0,7$ , when balancing  $K_s(q)$

The data obtained for  $s_4$  show that, at a certain age, maritime transport specialists lose the ability to progress when their qualifications are restored and are

based on previously acquired qualification levels. This fact indicates the risk of working in leadership positions for a long time.

And there is also the effect of a sharp decrease in efficiency with increasing load. Under the conditions of long-term modeling for  $s_4$ , there is a decay in the effectiveness of information perception even in the conditions of introducing corrective actions into the process (Fig. 4).

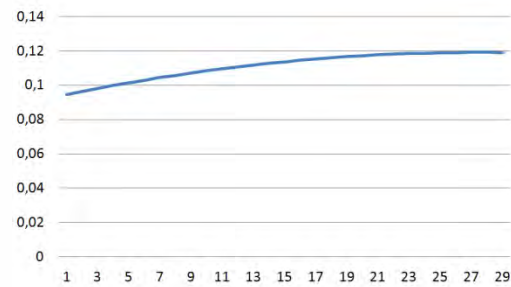


Fig. 4. Efficiency of recovery of qualification for  $s_4$

There is also an increased risk of control by these specialists over specialists who have an updated level of qualification for their position.

**Conclusion.** The obtained formal and analytical data indicate that the problem area of research under consideration requires in-depth study and application of innovative approaches in the framework of automating the management of processes and complex multi-parameter objects of organizational and technical systems of maritime transport.

From the formal description and subsequent modeling, it became clear that the main factor for managing the processes of forming identification and restoring the qualification parameters of maritime transport specialists are terminal ones. The management of such parameters in a time context involves the use of not only linear models, but also fuzzy systems that can identify the state of processes and fine-tune the control system to reduce risk factors due to the human factor in water transport.

### References:

1. Nosov, P.S., Cherniavskiy, V.V., Zinchenko, S.M., Popovych, I.S., Nahrybelnyi, Y.A., & Nosova, H.V. (2021). Identification of marine emergency response of electronic navigation operator. *Radio Electronics, Computer Science, Control*, (1), 208–223. <https://doi.org/10.15588/1607-3274-2021-1-20>
2. Nosov P., Cherniavskiy V., Zinchenko S., Popovych I., Prokopchuk Y., Safonov M. Identification of distortion of the navigator's time in model experiment // *Bulletin of University of Karaganda. Instrument and experimental techniques*, 2020. - № 4(100). P. 57-70. <https://doi.org/10.31489/2020Ph4/57-70>
3. Plokhikh, V., Popovych, I., Zavatska, N., Losiyevska, O., Zinchenko, S., Nosov, P., & Aleksieieva, M. (2021). Time Synthesis in Organization of Sensorimotor Action. *BRAIN. Broad Research in Artificial Intelligence and Neuroscience*, 12(4), 164-188. <https://doi.org/10.18662/brain/12.4/243>
4. Nosov P.S., Zinchenko S.M., Ben A.P., Nahrybelnyi Ya. A., Dudchenko O.M. Models of decision making by a navigator with implicit agreement of the COLREG rules // *Науковий вісник Херсонської державної морської академії : науковий журнал. – Херсон : Херсонська державна морська академія*, 2019. – № 1 (20). – С. 31-38

5. Popovych Ihor, Blynova Olena, Nosov Pavlo, Zinchenko Serhii, Kononenko Oksana. Psychological factors of competitiveness of women's youth handball team. *Journal of Physical Education and Sport*, 21(1), 227 - 235. <https://doi.org/10.7752/jpes.2021.01030>

6. Ponomaryova V.P., Ben A.P., Dyagileva O.S., Nosov P.S. Approches to the automation of maritime educational processes plannings system // Сучасні енергетичні установки на транспорті і технології та обладнання для їх обслуговування (СЕУТТО 2021). С. 277-279.

7. Ponomaryova V.P., Nosov P.S., Dyagileva O.S. Personnel qualification management approaches in marine organizational and technical systems // Матеріали І міжнародної науково - практичної конференції "Проблеми сталого розвитку морської галузі (PSDMI-2021), Херсон: ХДМА, 03-04 листопада 2021. С. 154-157.

8. Пономарьова В.П. Дягилева О.С., Носов П.С., Ідентифікація кваліфікаційних параметрів суб'єктів організаційно-технічних систем морської транспорту // Збірник тез за матеріалами ІХ Міжнародної науково-практичної конференції «Філософські обрії сьогодення»/ за ред. І.Варнавської. Херсон: ХДАЕУ, 2021. С. 78-79.

9. Mamenko P., Zinchenko S., Kobets V., Nosov P., Popovych I. (2022) Solution of the Problem of Optimizing Route with Using the Risk Criterion. In: Babichev S., Lytvynenko V. (eds) *Lecture Notes in Computational Intelligence and Decision Making. ISDMCI 2021. Lecture Notes on Data Engineering and Communications Technologies*, vol 77. Springer, Cham. [https://doi.org/10.1007/978-3-030-82014-5\\_17](https://doi.org/10.1007/978-3-030-82014-5_17).

10. Zinchenko Serhii, Mateichuk Vadym, Nosov Pavlo, Popovych Ihor, Solovey Oleksandr, Mamenko Pavlo and Grosheva Olga. "Use of Simulator Equipment for the Development and Testing of Vessel Control Systems" *Electrical, Control and Communication Engineering*, vol.16, no.2, 2020, pp.58-64. <https://doi.org/10.2478/ecce-2020-0009>

11. Zinchenko S.M., Mateichuk V.M., Nosov P.S., Popovych I.S., Appazov E.S. Improving the accuracy of automatic control with mathematical meter model in on-board controller // *Radio Electronics, Computer Science, Control*, 2020. - № 4. – P. 197-207. <https://doi.org/10.15588/1607-3274-2020-4-19>

12. Zinchenko S., Ben A., Nosov P., Popovych I., Mateichuk V., Hrosheva O. The vessel movement optimisation with excessive control // *Bulletin of University of Karaganda. Technical Physics*, 2020. - № 3(99). P. 86-96. <https://doi.org/10.31489/2020Ph3/86-96>.

13. Зинченко С.Н., Носов П.С., Грошева О.А., Маменко П.П., Матейчук В.Н. Управление судном в условиях внешних воздействий. *Materials of the XI "Modern information technologies in transport, MINTT-2019"* May 28-30, 2019 Kherson, Ukraine. С 177-178.

14. Зинченко С.Н., Носов П.С., Грошева О.А., Маменко П.П., Матейчук В.Н. Избыточность по управлению как количественная мера маневренности судна. *Materials of the XI "Modern information technologies in transport, MINTT-2019"* May 28-30, 2019 Kherson, Ukraine. С 97-99.

15. Zinchenko S., Tovstokoryi O., Ben A., Nosov P., Popovych I., Nahrybelnyi Y. (2022) Automatic Optimal Control of a Vessel with Redundant Structure of Executive Devices. In: Babichev S., Lytvynenko V. (eds) Lecture Notes in Computational Intelligence and Decision Making. ISDMCI 2021. Lecture Notes on Data Engineering and Communications Technologies, vol 77. Springer, Cham. [https://doi.org/10.1007/978-3-030-82014-5\\_18](https://doi.org/10.1007/978-3-030-82014-5_18).
16. Longino, John. (2020). Navigating the Ship of Theseus from typology to cartography. *Megataxa*. 1. 43-45. <https://doi.org/10.11646/megataxa.1.1.8>.
17. Lisaj, Andrzej. (2019). Implementation of e-Navigation Strategies for RIS Centres Supporting Inland Navigation. *TransNav, the International Journal on Marine Navigation and Safety of Sea Transportation*. 13. 145-149. <https://doi.org/10.12716/1001.13.01.14>.
18. Rudolf, DI & Triyanti, Vivi. (2020). Designing a Device for Measuring Human Reaction Time. *IOP Conference Series: Materials Science and Engineering*. 847. 012051. <https://doi.org/10.1088/1757-899X/847/1/012051>.
19. Wróbel, Krzysztof & Gil, Mateusz & Chae, Chong. (2021). On the Influence of Human Factors on Safety of Remotely-Controlled Merchant Vessels. *Applied Sciences*. 11. <https://doi.org/10.3390/app11031145>.
20. Sun, Qingquan & Ma, Rui & Hao, Qi & Hu, Fei. (2013). Space encoding based human activity modeling and situation perception. 183-186. <https://doi.org/10.1109/CogSIMA.2013.6523845>.
21. Sheroziya, G. & Sheroziya, Maxim. (2020). CALCULATING THE AMOUNT OF INFORMATION CONTAINED IN A CONTINUOUS SIGNAL. *Vestnik of Ryazan State Radio Engineering University*. 73. 59-70. <https://doi.org/10.21667/1995-4565-2020-73-59-70>.
22. Ereshko, Felix & Gorelov, Mikhail. (2021). Hierarchical games with restrictions on the amount of information transmitted. 1-5. <https://doi.org/10.1109/MLSD52249.2021.9600193>.
23. Solovey, O., Ben, A., Dudchenko, S., Nosov, P. (2020). Development of control model for loading operations on Heavy Lift vessels based on inverse algorithm. *Eastern European Journal of Enterprise Technologies*, 5/2 (107), 48–56. <https://doi.org/10.15587/1729-4061.2020.214856>
24. Liu, Yan. (2020). Survey of Intelligent Recommendation of Academic Information in University Libraries Based on Situational Perception Method. *Journal of Education and Learning*. 9. 197. [10.5539/jel.v9n2p197](https://doi.org/10.5539/jel.v9n2p197).