

APPROACHES TO AUTOMATION CONTROL PROCESSES FOR RESTORATION OF WATER TRANSPORT PROFESSIONALS QUALIFICATION PARAMETERS

V. Ponomaryova, A. Ben, O. Diahyleva, P. Nosov
Kherson State Maritime Academy

Abstract: *The introduction of modern control systems for the formation of crews qualification parameters, directly affects the impact of the human factor on water transport. Given the complexity of such processes parameterization as the behavior and stages of management decisions by water transport officers, there is a need to develop and implement new information and formal means of identifying the status and dynamics of these processes. Therefore, the task of collecting and processing quantitative data for their further integration into knowledge (metadata), with further application in automated control systems of these processes. The paper presents formal and analytical approaches to determine the main factors the process, as well as focuses on use of terminal indicators to restore the qualifications of water transport professionals.*

Keywords: *automated control systems, transport systems, qualification of specialists, identification.*

ПІДХОДИ АВТОМАТИЗАЦІЇ УПРАВЛІННЯ ПРОЦЕСАМИ ВІДНОВЛЕННЯ КВАЛІФІКАЦІЙНИХ ПАРАМЕТРІВ ФАХІВЦІВ ВОДНОГО ТРАНСПОРТУ

В. П. Пономарьова, А. П. Бень, О. С. Дягилева, П. С. Носов
Херсонська державна морська академія

Анотація: *Впровадження сучасних систем керування процесами формування кваліфікаційних параметрів екіпажів, напряму впливає на вплив людського фактору на водному транспорті. Враховуючі складність параметризації таких процесів як поведінка та етапи прийняття управлінських рішень офіцерами водного транспорту, виникає потреба у розробці та впровадженні нових інформаційних та формальних засобів ідентифікації станів та динаміки цих процесів. Отже постає завдання щодо збору та обробці кількісних даних для їх подальшої інтеграції у знання (метадані), з подальших застосуванням у системах автоматизованого керування зазначеними процесами. В роботі наведено формально-аналітичні підходи щодо визначення головних чинників процесів, а також зорієнтовано увагу на застосування термінальних показників для відновлення кваліфікаційних характеристик фахівців водного транспорту.*

Ключові слова: *автоматизовані системи управління, транспортні системи, кваліфікація фахівців, ідентифікація.*

Introduction. Modern trends in the development of organizational and technical systems of water transport are increasingly faced with the risks of reducing the specialists qualification parameters [1–5]. Existing approaches based on cyclic confirmation of qualifications are not an effective enough means to level the negative manifestations of human factor among specialists during the transportation of goods

by water transport [6–9]. All of above requires the development of new automated systems both for identifying and correcting the processes of water transport specialists retraining the qualifications. An important element is the use of a group of time parameters that allow you to customize the system being developed with a sufficient degree of effectiveness [10–13].

Main research material. Thus, the designed system involves the introduction a number of parameters for the process of forming an optimal set qualifications: expected resource costs D_0 and abandonment rate on the part of crewing companies and shipowners ψ_0 .

Then the control of qualification parameters within a discrete cycle θ (stage) assumes the time for the formation of control actions d and failures w , such that: $d = \bar{\theta} D_0$ and $w = \bar{\theta} \psi_0$. Then the average response time of the control action $\bar{t} = \frac{d}{w} = \frac{D_0}{\psi_0}$, at $d > 0$ and $0 < w \leq 1$.

Given that for each globally planned control action $(h)_n > (\bar{\theta}_i)_{\max}$ on a regional scale, it is possible to determine the measure of the impact of the most significant

stages of the type: $\varepsilon = \frac{(\bar{\theta}_i)_{\max}}{(h)_n}$.

Based on the hypothesis that for each time period of the cycle, only one optimal set of control actions is possible due to the characteristics of current conditions $s \in S$ in the maritime industry, requirements and technical conditions, then each of $(\bar{\theta}_i)_{\max(\min)}$, will have a similar structure. Then we represent the structure by the following formal description, of the form:

$$S = \sum_{z=1}^k \begin{pmatrix} z, n_1 \\ s_1 \end{pmatrix} \begin{pmatrix} z, n_2 \\ s_2 \end{pmatrix} \begin{pmatrix} z, n_3 \\ s_3 \end{pmatrix} \begin{pmatrix} z, n_4 \\ s_4 \end{pmatrix} \dots \begin{pmatrix} z, n_i \\ s_i \end{pmatrix} (l+1), k$$

where: s_1 is level of educational qualification; s_2 is current set of valid certificates, courses; s_3 is level of practical qualification (position); s_4 is sea experience; l is criteria for estimating the parameters $s_1 \dots s_4 \dots s_i$.

From the point of view of the terminal distribution of qualification parameters, which are chronologically interrelated, it is convenient to present them in the form of a formal dependence:

$$\begin{aligned} \frac{ds_1}{dt} &= f_1(s_1, s_2), \\ &\dots \\ \frac{ds_4}{dt} &= f_1(s_4, s_{i+1}), \end{aligned}$$

It follows from the presented dependence that the state parameter s_l has the greatest influence on the system, since determines its entire further structure and

priorities relative to l . At the same time, the task of controlling the indicated processes should be considered in the context of control alternatives Y , offered by various maritime companies and forming situations X within t .

In turn $t = \sum t_{org} + \left(\frac{t_p}{c} \right)$, where t_{org} is the time for organizing control actions, t_p is the time of the control period, c is the coefficient of complexity of the impact. Then the effectiveness of the control actions α in general terms t_i for the period will be: $\delta = \Delta t / t_i$ where t_i is the time spent on the voyage by a specialist in the organizational and technical system of water transport.

Then Δ , can be represented depending on the indicator of the possibility of restoring the qualification parameters of a specialist Z , such that: $\Delta = \frac{Q \sqrt{t_{i \min} t_{i \max}}}{t^*}$, where t^* is the average recovery time of a specialist's qualification, and $t_{i \min} t_{i \max}$ is the minimum and maximum travel time of specialists.

Having determined the time intervals, we will form in an analytical form a structure for managing the processes of restoring the qualification parameters of specialists for a period Δt relative to the utility function: $\omega^g : (Y \times S \times X) \rightarrow R^1$, with a transitional control function of the form $q^g(S | S \times Y)$ [14].

The complexity of direct control in the designated formal descriptions lies in the fact that the control alternatives $y_{t_i} \in Y(t)$ depend on the individual states of specialists, which should also be taken into account. It is necessary to know the level of the qualification parameter (LQP) of each specialist in relation to the position held in each discrete time period [15]. Due to the loss of the LQP over time, it is necessary to carry out qualification control, determine the individual dynamics of the transition from $v_{\min} \dots v_{opt} \dots v_{lose}$, as well as probable deviations σ_{lose} :

$$v_{lose} = \frac{\alpha_{lose} - (v_{opt} \alpha_{\min} + v_{\min} \alpha_{opt})}{\alpha_{opt} - \alpha_{\min}}, \quad \sigma_{lose} = \frac{v_{\min} \sigma_{opt} - v_{opt} \sigma_{\min}}{v_{\min} - v_{opt}} + \frac{v_{lose} (\sigma_{\min} - \sigma_{opt})}{v_{\min} - v_{opt}}$$

To improve the reliability of the developed control system, it is necessary to determine the mathematical expectation in time $\alpha_t = (v_{opt} \alpha_{\min} - v_{\min} \alpha_{opt}) / (v_{opt} - v_{\min})$ form the most effective control action.

Having experimentally determined the values for v_i, α_i , it becomes possible to identify the individual time limits of the qualification parameters, when their restoration does not violate the cyclical nature of sea voyages in the required position [16–19].

Thus, having determined an individual time cycle v_n of the control action γ , such that $0 < \gamma < 1$, in the form of an information signal aimed at restoring the LQP, it will be possible to control the stable state of water transport specialists for a long

period of time. Creating a feedback C_u with a corrective function $C_s(w)$, taking into account the correction relative to the structural of each stage, will allow you to determine the dynamically reliable structure of the system, where:

$$C_s(w) = C_s(w) / (1 + C_u \gamma C_s(w))$$

Conclusion. Thus, approaches are proposed in an analytical form to manage the processes restoring qualification parameters of water transport specialists under the conditions of multifactorial processes their restoration. The main control factor in this case is the timing of control action on the water transport specialist. The study examined the structure of four time stages in formation of marine specialists qualification, starting from the educational sector and ending with becoming a position on a sea vessel. In the future, it is required to carry out numerical simulation of indicated processes for a more detailed analysis of control actions influence in mathematical models.

REFERENCES

1. STCW Survey (2020). Nautilus Federation report on the International Maritime Organization's International Convention on Standards of Training Certification and Watchkeeping // https://www.nautilusint.org/globalassets/public-resources/pdfs/stcw_survey_nautilus_report_march_2020.pdf
2. Cabezuelo, Antonio & Caballé, Santi. (2021). A Tool to Manage Educational Activities on a University Campus. https://doi.org/10.1007/978-3-030-61105-7_17.
3. Носов П. С., Тонконогий В. М. 3D оцінювання траєкторії навчання студента // Тр. Одес. політехн. ун-та. – Одеса: ОНПУ, 2007. – Вып. 2 (28). – С. 129–131.
4. Носов П. С., Тонконогий В. М. Використання компонентів мислення експертними системами, як фактору адаптивного впливу в автоматизованих навчальних системах // Тр. Одес. політехн. ун-та. – Одеса: ОНПУ, 2005. – Спецвыпуск. – С. 101–105.
5. Косенко Ю. І., Носов П. С. Механізми ідентифікації та трансформації «знань» суб'єкта критичної інфраструктури // Інформаційні технології в освіті, науці та виробництві. Збірник наукових праць [Текст]. – Вип. 3 (4). – Одеса: Наука і техніка, 2013. – С. 99–104.
6. Nosov P., Ben A., Safonova A., Palamarchuk I. Approaches going to determination periods of the human factor of navigators during supernumerary situations // Radio Electronics, Computer Science, Control. – № 2 (49). – 2019. – Pp. 140–150. Web of Science. <https://doi.org/10.15588/1607-3274-2019-2-15>
7. Nosov, P. S., Ben, A. P., Matejchuk, V. N., & Safonov, M. S. (2019). IDENTIFICATION OF “HUMAN ERROR” NEGATIVE MANIFESTATION IN MARITIME TRANSPORT. Radio Electronics, Computer Science, Control, (4). <https://doi.org/10.15588/1607-3274-2018-4-20>.
8. Nosov P. S., Palamarchuk I. V., Safonov M. S., Novikov V. I. Modeling the manifestations of the human factor of the Maritime crew // Dnipropetrovsk National University of Railway Transport named after Academician V. Lazaryan (Dnipro). – № 5 (77). – 2018. – Pp. 82–92. <https://doi.org/10.15802/stp2018/147937>.
9. 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>

10. Пономарьова В. П., Носов П. С., Дягилева О. С., Прокопчук Ю. О. Особливості розробки автоматизованої системи керування освітньою діяльністю у морському закладі вищої освіти // Сьома міжнародна конференція з адаптивних технологій управління навчанням. АТЛ – 2021. Одеса. 2021. С. 14–16.
11. Nosov P. S., Ponomaryova V. P., Dyagileva O. S. Approches to the automation of maritime educational processes planning system // Сучасні енергетичні установки на транспорті і технології та обладнання для їх обслуговування (СЕУТТО 2021). С. 277–279.
12. 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, 3-4 листопада 2021. С. 154–157.
13. Пономарьова В. П., Дягилева О. С., Носов П. С. Ідентифікація кваліфікаційних параметрів суб'єктів організаційно-технічних систем морського транспорту // Збірник тез за матеріалами ІХ Міжнародної науково-практичної конференції «Філософські обрії сьогодення» / за ред. І. Варнавської. Херсон: ХДАЕУ, 2021. С. 78–79.
14. Баранов В. В. Процессы принятия управляющих решений, мотивированных интересами. – М.: ФИЗМАТЛИТ, 2005. – 296 с. – ISBN 5-9221-0610-4.
15. Pavlo Nosov, Ihor Popovych, Serhii Zinchenko, Vasyl Cherniavskiy, Viktor Plokhikh, Halyna Nosova (2020). The research on anticipation of vessel captains by the space of Kelly's graph. Revista Inclusiones, Vol: 7 num Especial, pp. 90–103.
16. Zinchenko S., Moiseienko V., Tovstokoryi O., Nosov P., Popovych I. (2021) Automatic Beam Aiming of the Laser Optical Reference System at the Center of Reflector to Improve the Accuracy and Reliability of Dynamic Positioning. In: Hu Z., Petoukhov S., Dychka I., He M. (eds) Advances in Computer Science for Engineering and Education IV. ICCSEEA 2021. Lecture Notes on Data Engineering and Communications Technologies, vol 83. Springer, Cham. https://doi.org/10.1007/978-3-030-80472-5_1.
17. 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>.
18. 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.
19. Nosov, P., Zinchenko, S., Ben, A., Prokopchuk, Y., Mamenko, P., Popovych, I., Moiseienko, V., Kruglyj, D. (2021). Navigation safety control system development through navigator action prediction by Data mining means. Eastern-European Journal of Enterprise Technologies, 2 (9 (110)), 55–68. doi: <https://doi.org/10.15587/1729-4061.2021.229237>

Ponomaryova Victoria Postgraduate student, Kherson State Maritime Academy.

Ben Andrii Ph.D., Full Professor, Professor of the Navigation Department, Vice-Rector for Research, Kherson State Maritime Academy.

Diahyleva Olena Ph.D., Associate Professor, Vice-Rector for Educational and Methodological Work, Kherson State Maritime Academy.

Nosov Pavlo Ph.D., Associate Professor, Associate Professor of the Navigation Department, Kherson State Maritime Academy.

