The optimum assessment of the information systems of shipboard hardware reliability in cloud services

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Abstract. The world wide pandemic situation revealed the problems in all spheres of human life which haven't been faced before. Recently the world has changed greatly as well as the relationship between people and their professional activity. The great bunch of the workload, if basically acceptable, is done with the use of modern innovative technologies. Such problems have not trampled down the sphere of higher education as well. Distance learning, which was previously addressed to only as accompanying possibility of lessons conduct, nowadays is considered to be the only practicable form of conducting lectures, practical lessons, tests, i.e. it has become a usual daily practice for both teachers and students. Among the basic functional requirements to the electronic educational resources in the system of distance learning there are the visualization and interaction principles both when getting familiar with the theoretical material and when completing virtual laboratory and practical tasks. The Microsoft Office documents have become the most widespread elements among the electronic educational resources. That is why there is a pressing need in presenting the electronic MS Excel spreadsheets on the resource web-pages. The simple and convenient way to solve the problem of Excel documents introduction into the electronic resources of the distance learning systems is the use of cloud services. The services help to acquire the access to the information resources of any level and of any capacity with the possibility to allocate the rights of the users belonging to different groups in relation to the resources. For that purpose the availability of the Internet network access and web-browser would be enough [13]. The cloud calculation technologies introduction allows for the use of the programs that do not require special licensing, update versions monitoring and eliminates the need of software technical support as the provider himself exercises control over the functioning, data saving, antivirus protection and possible cyberassaults. The peculiarities of professional training of navigators require the students to acquire the knowledge of professionally-oriented tasks algorithms as well as the knowledge of technologies that can help to implements them. One of the main routines the officer needs to deal with on the navigational bridge is the use of the information systems of shipboard hardware. But before usage he needs to assure of the systems reliability. That is why it is extremely important to gain during the course of professional training the necessary skills of navigation equipment exploitation reliability assessment by means of Microsoft Office documents and cloud services. So the subject matter of the suggested research is the procedure development for the navigation equipment exploitation reliability assessment by means of modern services use in the course of professional training of future seafarers. The aim of the paper is the solution of the problems of optimum assessment of the information systems of shipboard hardware reliability by means of cloud technologies usage. The following tasks are completed in the course of the research: the peculiarities and characteristics of navigational information processed by the shipboard navigation and information system have been analyzed; the results of the information systems of shipboard hardware usage have been studied; the technological diagram of the basic components structuring of the "Information systems of shipboard hardware" complex for the Master's degree training course has been created; the effective technology of the program Excel documents processing has been chosen; the system of access and usage of web-services for calculation tables processing in the system of distance learning has been designed;the process of competency formation which will enable students to use cloud services has been suggested.

Keywords: cloud services, electronic learning, shipboard navigation and information system, probability of navigation equipment failure, service reliability

1. Introduction

Kherson State Maritime Academy (KSMA) is the unique educational establishment which unites the profound technical preparation of students with the professional character of the knowledge received by students by the graduation. For example, the integral components of the curricula for the future navigators training are such subjects as the Technology of the materials, Physics, Theoretical and practical engineering, Information technologies and others without which it is impossible to comprehend such professionally-oriented subjects as Theory and ship construction, Navigation and Pilotage, Cyber security aboard, Information systems of shipboard hardware, Global Maritime Distress and Safety System. It is worth while mentioning that the syllabuses of the technical subjects are developed in compliance with the International Maritime Organization (IMO) standards for the preparation of future seafarers.

The course "Information systems of shipboard hardware" is of high importance for the educational and professional training of future specialists to carry out the professional activity aboard ships, for the formation of students' knowledge as for the current state and problems of the modern ship automatization in accordance with the valid regulatory documentation to enable them to perform their professional duties related to ship navigation at the managerial level. The amount of the information that any student has to acquire while mastering this subject course encompasses the wide range of factors which as a whole comprise the theoretical and practical bundle of knowledge a competitive navigator must possess to withstand the competition at the international employment market. The required pack of knowledge encompasses such elements as the understanding of the unique peculiarities and characteristics of the navigational information which is processed by the shipboard navigation and information system (NIS), the ability to effectively use the communication channels of the automated information systems while keeping the watch on the bridge and communicating with shore services, to assess the probability of shipboard navigation and information system elements failure and their operational reliability. All of the above mentioned is considered to be the basis for the provision of the navigational safety in general, for the protection of the environment and the efficient usage of vessel traffic management system.

The effective work of the shipboard navigation equipment is the guarantee of safe navigation both for the given vessel where it is installed and for the ships in vicinity which must compulsory have information connection with it. Though even the most modern equipment will not be used at the optimum level if the person working with it is not ready for the operational performance. The course "Information systems of shipboard hardware" is taught during the Master course so it is considered to be one of the closing subjects in the curriculum for the navigational training.

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For the maritime industry specialist the process of education for the Master degree is the compulsory step in the career advancement if he wants to obtain the rank of senior officer in navigation to operate a ship at the managerial level. Considering the theoretical and practical bunch of knowledge and training students acquired at the previous levels of education a teacher should at maximum practicable level provide the appropriate level of knowledge on such an important for the maritime industry specialist field as the information systems of shipboard hardware.

The professional training of future seafarers must guarantee the fulfillment of the requirements of the competency standards stipulated by the rules of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers. One of the structural elements of the professional competency is the acquisition of navigation information assessment skills. The information is obtained from all practicable sources including radar, automatic radar plotting aids (ARPA) and electronic complexes of navigation and information systems. The information obtainment and assessment is aimed at decision making for collision avoidance and safe navigation provision.

One of the issues discussed in the suggested course is the assessment of the navigation equipment failure probability and of the operational reliability of the shipboard navigation and information systems components. The reliable operation of the systems provides for the safe vessel operation, full identification of its parameters in comparison with the real condition of a vessel at a specific period of time.

2. Related work

The information provision of vessel traffic control systems and the problems of their reliability have been researched by Vagushchenko [25], Vilskiy [31], Vilsky [32], Vilskyi and Nadych [33]. The subject matter experts stress out that the risks of shipboard emergencies arise from the inaccurate or untimely information and they believe that to solve this problem it is necessary to use the scientific approach which will provide for the well-reasoned technology for the information provision research in the vessel traffic control systems. The complex use of modern information technologies on ships is described in the publications of Voloshynov et al. [34], Zaytseva et al. [35].

The state probability assessment of any technical system in one way or another is connected to the necessity of mathematical grounds comprehension relevant to such research, knowledge of basic provisions of probability theory, the ability to design an adequate mathematical model, which will be relevant to the physical content of the problem. The objects' and systems' reliability research has always been an urgent matter as there are no systems that can function during the unlimited period of time. That is why the issues of basics of the reliability theory, mathematical methods of systems reliability assessment, the usage of probabilistic criterion are discussed by Vasilevskyi and Ignatenko [29]. The basic methods of systems reliability assessment during the sudden or gradual failures, the means of increasing the criterion of objects trouble-free operation are discussed by Shklyar [20]. The reliability theory determines the principles of troubleshooting appearance, system and its elements performance restoration, it also accounts for the influence of both external and internal factors onto the processes inside the system,

enables the determination of the ways to increase system's reliability.

But nowadays it is not enough to be a professional in highly specialized sphere of the professional activity, which is in particular true about seagoing fleet officers who bear the responsibility for the ship, the cargo and the crew. The availability of the expertise knowledge in the world wide trends of digitalization is granted during the period of professional training of future navigator in higher educational establishment. One of such tendencies is the use of cloud technologies in education and, correspondingly, in future professional activity at workplace. Currently this problem is in focus of attention. For example, the publication [6] is aimed at conceptual definitions grounding, determining the principles and methods of cloud-oriented educational and scientific environment formation, electronic resources classification provision, guidelines provision for different types of services usage.

The problems of cloud-based learning tools and especially information subjects teaching are discussed by Balyk et al. [2], Bilousova et al. [3], Fedorenko et al. [7], Glazunova et al. [8], Khmil, Morkvian and Kyselova [9], Kolgatin et al. [10], Korotun, Vakaliuk and Soloviev [12], Lytvynova and Burov [14], Markova, Semerikov and Striuk [16], Markova et al. [17], Oleksiuk and Oleksiuk [18], Osadcha and Osadchyi [19], Spirin et al. [21], Striuk and Rassovytska [22], Symonenko et al. [24], Vakaliuk, Korotun and Semerikov [26], Vakaliuk and Marienko [27], Valko, Kushnir and Osadchyi [28], Velychko et al. [30], the principles of individual work organization by means of cloud services Yandex are described by Aleksanyan [1]. Cloud services provided by the companies Google, Microsoft are described in the works by Bondarchuk, Balakhtar and Balakhtar [4], Bondarenko, Mantulenko and Pikilnyak [5], Korobeinikova et al. [11], Lytvynova, Spirin and Anikina [15], Sultanova et al. [23].

Though the issue of the professional training of a specialist able to adapt to the changing requirements of today in the context of information society globalization, who can freely and effectively use the latest advancements in the sphere of digital technologies, still remains a matter of acute interest.

3. Solving basic problems

The most complicated issue is considered to be the introduction of the described theoretical methods for the practical research conduct in the professionally-oriented direction specific for navigators as compared to the global approach of the analyzed information sources usage there is a very specific peculiarity in the course of the professional maritime training. It is explained by the fact that during the education in higher maritime educational establishment the process of general cycle subjects teaching is organized on the basis of the competency-based approach though anyway it cannot encompass all challenges of such a fundamental science as the theory of information systems reliability.

The result which can prove students' comprehension of the described topic is the creation of data base which is able to optimize the process of operational reliability assessment of shipboard navigation and information system components. It is presupposed that the work with the base is possible in typical office MS Excel program as well as with the use of cloud services. This will enable higher level of convenience and availability to the data base of the users who are granted the access as well as the increase of the mobility level of the user himself.

A Master degree student completes the tasks in electronic MS Excel spreadsheets or in cloud services Google Apps or Microsoft OneDrive. The created data base can be used even during the voyage being aboard ship as the cloud services are available at any place worldwide under the only condition of Internet access.

The task of a teacher here is to develop such subject content and the relevant technology of its realization which will be capable of achieving the main task – future navigator professional training in the sphere of the comprehension of the peculiar features in the course of the information systems of shipboard hardware usage and as a result practical implementation of innovations in the course of professional activity.

A navigator receives the information about ship's position, technical condition of equipment, and its technological characteristics at every specified moment of time exceptionally by means of computers which are installed aboard, i.e. all required data is supplied by the information systems of shipboard hardware. It is clear that a senior deck officer, who is getting a professional training at the Master degree course, must be completely aware of the intended purposes, main functions and operational principle of automated identification system.

The information systems of shipboard hardware in their logical structure use the achievements of modern innovative information technologies such as: microprocessors, logic controllers, which can be programmed, optical electronics and the like. The very use of modern innovative information technologies for the purposes of navigation enables:

- the improvement of shipboard hardware in general;
- the creation of new navigational devices and systems which in turn provided for the increase in accuracy and safety of navigation;
- the development of more effective data sensors showing the information about shipboard technological processes particulars;
- the processing of the navigational information in the real timescale factor;
- the improvement of the quality of ship maneuvering due to the use of more precise information about the navigational process and also due to the fact that the deck officers become less overloaded with the routine operations on information search and processing;
- the improvement of the control over the work of the shipboard hardware and hence increasing the safety of the ship;
- the use in complicated situations of the distant assistance of the qualified shore-based personnel by means of creating the possibility of fast transmissions of large amounts of information which will be displayed ashore and will be used to characterize the development of the situation in the process of ship passage;
- the departure from the traditional rigid organization of ship control systems due to the fact that they now become open because of their integration by means of information channels;
- the fulfillment of automatic completion of a series of "intellectual" tasks connected to ship maneuvering, ship safety provision, technical aids of navigation control and others.

If one gets familiar with the syllabus content of the mentioned course which encompasses such important topics for navigation as "The fundamental concepts of information transmission by means of AIS", or "The effective use of AIS in the "ship-to-ship" and "ship-to-shore" modes, he/she

will at once notice that to study the topic "The possibility of failure and operational reliability of shipboard information and navigation systems components assessment" it is especially crucial to have the profound knowledge both in high mathematics in general and specifically in one of its subdisciplines "The probability theory", on the one hand, and the knowledge of vessel traffic control systems information provision structure, fundamental concepts of reliability theory, on the other hand.

A navigator must be able to classify and cluster maritime data and notices; to research the process of information formation and circulation inside the vessel traffic control systems; to understand cluster – probabilistic methodologies of informational ship movement danger research and the principles of data formation and circulation on the water routes; to perform formalization of navigational field data flows which provide the process of navigation.

Considering all of the above mentioned and own experience, a teacher forms the optimum path of information provision to students and chooses the methods of knowledge reinforcement, using at maximum the potential of modern technologies. In this regard, it is necessary to pay attention to some peculiar features of the education process during the Master degree course, namely the fact that students can enter the course not only after the graduation from Kherson State Maritime Academy but also from any other higher maritime educational establishment in Ukraine as well as abroad. It means that the previous level of professional training (Bachelor degree) can be different but still the curriculum of the Master degree course is the same for everyone.

So, let's move immediately to the failure probability and operational reliability of shipboard information and navigation system components assessment and calculations performance in accordance with the assigned task in electronic MS Excel spreadsheets, in Google Sheets or on OneDrive service.

The overall assessment of shipboard navigation and information system components is based, first of all, on the database creation of the mentioned components with the account of their optimum allocation in the base, all necessary parameters input, which characterize this or that research object; second of all, the creation of calculation framework, which allows for the process of the reliability indices determination to be carried out automatically. Here the crucial for a Master degree student is the ability to use the mathematical apparatus when performing the professionally-oriented calculations; the knowledge of the fundamental principles of the probability theory; the skills of the practical use of vessel traffic control systems. On the other hand, they must learn how to freely use the modern communication means, how to complete common project in collaboration, how to safely use the information space. This is, first of all, the case of the use of cloud technologies, which not only broadens the student's insight of the distant form of education but also makes modern digital technologies an integral part of life-long learning.

A navigator must be able to structure the data received as the readings of devices into the electronic spreadsheets, to create a convenient algorithm of the input data processing, to make a series of calculations according to the formulas given, to obtain and analyze the final result. For example, according to the data about the ship's position (latitude and longitude of the departure) and the port of destination (latitude and longitude of arrival), he must be able to calculate the route the vessel will proceed, the distance between the port of departure and arrival, the best heading of the vessel, under the condition of complications in the form of stormy weather on

the way, supply for stormy weather and many other indices which enable the movement of a ship and the fulfillment of all charter conditions. The knowledge and skills of their practical application provide for the ability of students to comprehend the essence of the problem, to percept any calculation formula as the guideline for actions to be taken, to be able to structure the calculations and to assess the validity of the result obtained. In this respect it is clear that all the calculations are done in electronic spreadsheets because the created beforehand and edited and well-structured calculation framework allows for the substitution of the input data and immediate correct results obtaining.

According to the topic of the research special attention has to be paid to the knowledge from the basic course of the probability theory and especially to the laws of continuous random variables distribution. For example, the probability of trouble-free operation of shipboard automated control systems elements such as magnetic compasses, gyrocompasses, speed logs, echo sounders and the like and the probability of their operational reliability is calculated by means of the exponential distribution law. It must be stated that the reliability theory considers more than ten distribution laws but the demonstrative (exponential) law is used when it is necessary to carry out the general reliability assessment because it complies with the exploitation analysis of complex technical systems in case of sudden serious failures. This distribution law is characterized by the simplicity and allows for the easy calculations of reliability indices which can appear as the result of mistakes while designing, manufacturing and exploitation of elements.

Peculiar features of work on seagoing vessels such as distance from shore require from deck officers the knowledge and skills of system reliability assessment and how to maintain it in operational condition under any circumstances. The reasons for system failure can be storms, magnetic storms, and any other emergency situation which can lead to the failure of the information system of shipboard hardware. That is why it is especially crucial to have the experience in system reliability assessment, in the probability of its failure assessment, in timely recognition of possible damage. For example, if $\lambda(t)dt$ characterizes the probability of the whole system failure or any of its elements in a period of time $(t, t + dt)$ inside the group of elements which remain operational by a specific moment of time t, then it is possible to determine the connection between the probability of trouble-free operation and the intensity of failures:

$$\int_0^t \lambda(x)dx = lnP(t) \tag{1}$$

or

$$P(t) = \exp\left[-\int_0^1 \lambda(x)dx\right] \tag{2}$$

The above mentioned connection in in a general way displays the basic reliability law. If $\lambda(t) = const$, then $P(t) = e^{(-\lambda t)}$ and $a(t) = \lambda e^{(-\lambda t)}$, where $P(t)$ – is the probability of trouble-free operation of the object; $a(t)$ – is the frequency of failures or the frequency time distribution of trouble-free operation, i.e.

$$a(t) = -\frac{dP(t)}{dt} \tag{3}$$

This interpretation is quite often met specifically in practice of information systems of shipboard hardware research and the formula (3) characterizes the exponential time distribution of trouble-free operation. If to construct a function graph $\lambda(t)$, which is called λ – technical systems' characteristics, it will be possible to notice that there is a distribution into three separate areas where the first area located at the interval $(0, t_1)$ – is the great intensity of system's failure provoked by the manufacturing defects; the second area located at the interval (t_1, t_2) – is the interval of stable exploitation, and the last interval (t_2, ∞) – is the area of the fast growth of the failure possibility, i.e. the period which requires great caution (figure 1).
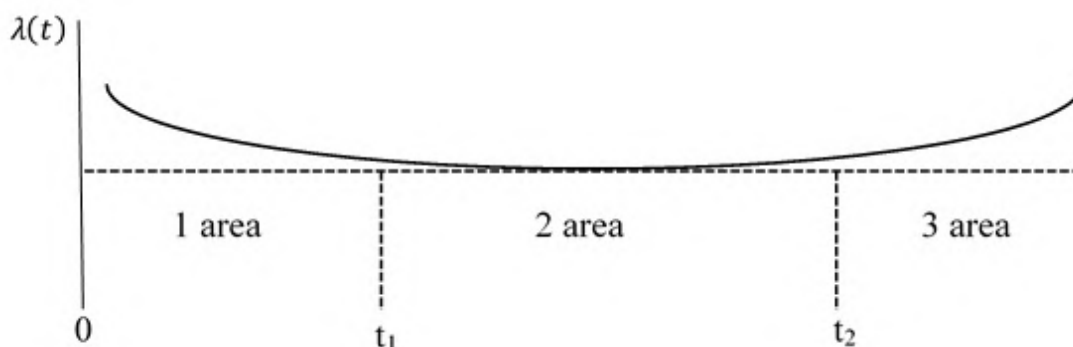

Figure 1: λ-technical system's characteristic.

To effectively assess the systems' reliability it is necessary to clearly comprehend its structural diagram. In that case, first of all, it becomes possible to develop the full value data base with the regard of all associated systems, and, second of all, it enables better understanding of the correlation between its elements, and as a result more effective assessment of system's operational capability in case of one or several elements' failure. The following diagram displays the general appearance of the shipboard automated system which serves as the basis for database structuring (figure 2).

To assess the probability of failures and the operational reliability of shipboard navigation and information system's components in the data base the following calculation formulas will be used:

$$T_{av} = \frac{1}{\lambda}, \tag{4}$$

where T_{av} – the average time of trouble-free operation (according to the documentation); λ – the intensity of failures;

$$P_c(t) = e^{\lambda t}, \tag{5}$$

where $P_c(t)$ – is the possibility of trouble-free operation, t – is the time of exploitation;
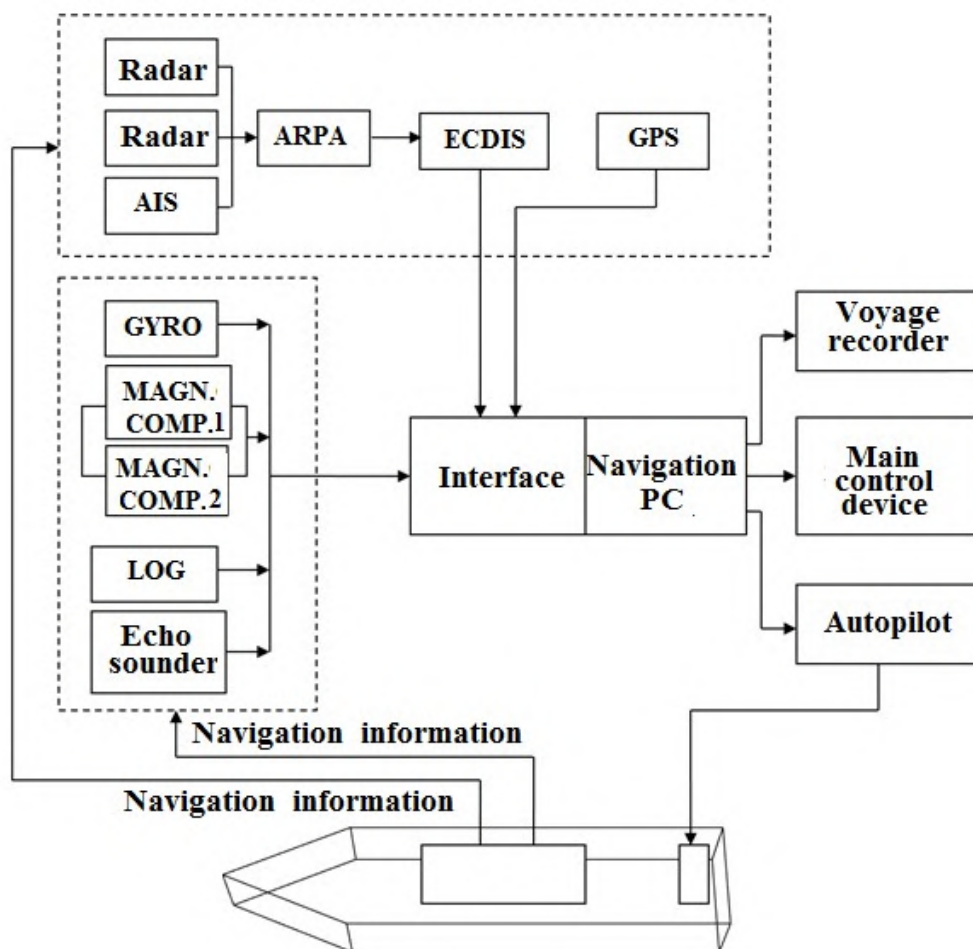
$$F_{av} = \frac{T_{av}}{T_{av} + T_r}, \tag{6}$$

Figure 2: Shipboard automated system structural diagram.

where T_r – is the time of repairs.

Besides, it is necessary to calculate the preventive-maintenance ratio F_{pr} using the formula:

$$F_{pr} = \frac{T_r}{T_{pr} + T_r} \tag{7}$$

Operational reliability is calculated by means of the formula:

$$P_e(t) = F_r \cdot (1 - F_{pr}) \cdot P_c(t) \tag{8}$$

The maintenance of the shipboard navigation and information system operational capability is referred to the competencies of the deck officers. The criteria which helps to assess the competency according to the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers is the professional's profound comprehension of navigation systems operational aspects. But if to consider the professional competency of navigational

officer he must not only comply with all of the stipulated requirements and competencies of his professionally-oriented area solely but also he must be able to freely use modern digital technologies, have adequate skills of standard software use, such as Microsoft Office, and also be familiar and know how to use some specialized programs installed on ship-board computers. Additionally, nowadays the compulsory elements of knowledge, skills and abilities include also the ability to use cloud technologies. This service was created at the end of the last century but the major breakthrough became possible with the development of mobile devices and Internet in general, so now it has occupied an important place in our lives.

Experienced professionals use cloud technologies in the routine operations with the information flows as it economizes the time significantly under the condition of the Internet access. The dynamics of digital technologies is characterized by the high level of interactivity and allows for the collaboration when working upon common projects even if the people engaged in them are at any distance from one another. The specific features of work aboard, i.e. its being away from the standard means of communication, requires from the deck officers, who work with the information systems of shipboard hardware, the availability of the whole new level of competency. So, taking into account all of the above mentioned, it is necessary to design the whole complex of competencies while teaching the topic "The possibility of failure and operational reliability of shipboard information and navigation systems components assessment".

Let's illustrate by means of the example the fulfillment of the computational part of the practical assignment during which the Master degree students of the navigation department so the tasks using standard office programs as well as possibilities of cloud services. This is a useful practical experience for future navigators because it will be in their responsibility to perform the calculations but it is necessary to account for the fact that office programs are not always installed on shipboard computers and cloud technologies allow to work with any kind of documents but only under the condition of the Internet access.

Because the provision of trouble-free operation of shipboard navigation and information systems components and the control over their reliability are the parts of a navigator's professional duties it is suggested to create such a data base which will allow to structure the process the necessary parameters determination in compliance with the chosen navigational technical aid, to add to the program all calculation formulas, to foresee the methods of data and calculation results cross-check, to make graphical display of the trouble-free system operation possibility $P_c(t)$ and the system operational reliability connection $P_e(t)$ to the time automatic.

The following figure (figure 3) displays the fragment of the data base for the parameters determination of the navigation equipment reliability assessment according to the formulas given above. By changing the input data it is possible to receive all the necessary indices of its reliability and the assessment of its trouble-free operation possibility.

As it was stated above the course "Information systems of shipboard hardware" is taught to the Master degree students of specialization 271.01 – Navigation and ship handling. According to the curricular of the Master degree course students must complete their final shipboard practice. But the real period of practice doesn't always coincide with what is planned. This is explained by the great level of competition at the international employment market for seafarers. That is why there is pressing need in creating of such conditions that would enable a Master degree student to have his practice on a seagoing vessel and at the same time to complete successfully the curricular.

Figure 3: The fragment of the data base for the parameters determination of the navigation equipment reliability assessment by means of Google Tables: NE – Navigation Equipment, MTC – Main Technical Characteristics, AU – Average Uptime – According to Documentation, FR – Failure Rate, PTO – Probability of Trouble-free Operation, RT – Repair Time – Appropriate to Maritime Practice, AF – Availability Factor, PF – Prevention Factor, SA – Serviceability.

For that purpose when teaching the mentioned course it was suggested to use the technology of the simultaneous usage of standard software and cloud services. It would provide for the continuous education process of Master degree students and would eliminate the need to master all the specific peculiarities of such complicated subject in a short period of time when they return from their voyages and must get ready to pass credits and exams in a limited period of time. It is worth while mentioning here that before leaving for the voyage a Master degree student consults the teacher on the conditions of cloud services usage aboard.

Modern computerized technologies enable students and teachers to use several devices for communication and cooperative activities: laptops, computers, smartphones, tablets, etc. Cloud services Microsoft, Google Apps are available at different devices so they are considered to be a widely-accessible and universal information technology for the work in the educational environment. To obtain the skills of work with cloud services a cadet, at his discretion, chooses between cloud services Microsoft or Google to fulfill practical tasks assigned (figure 3).

4. Research results

The developed technology was implemented into the education process in 2018–2019 academic year. At that time there was no COVID-19 pandemic situation, but anyway the first results have proved the necessity of such a course introduction. Though starting from the middle

of 2019–2020 academic year the technology became an urgent necessity as the states were closed and, as a results, our students were deprived of the chance to come back home in time according to the terms stated in their employment contracts. The majority of students had to stay aboard and carry out their professional duties until there was a possibility to be repatriated. Thanks to the introduction of cloud services the Master degree students had an opportunity to study the material, fulfill the assignments, to defend the laboratory tasks without leaving their workplaces. The marks they received can be used as the evidence of the fact that hypothesis as for the practicability of the new education technology introduction.

So, the results of the research has proved the following.

The course "Information systems of shipboard hardware" is taught at the Master degree course. Only some part of Master degree students, namely 30%, have the possibility to complete the course off-line visiting the lessons. The other part, approximately 25%, combines the off-line classroom learning with the individual mastering of the information by means of LMS Moodle. The platform allows for the possibility to gain access to all theoretical materials, teachers' instructions to laboratory works and individual assignments, to consult teachers on-line. But the other 45% of Master degree students spend most of the academic year onboard, thus having a possibility only from time to time the address the cloud services. Nevertheless, it appeared to be enough to receive the frameworks and instructions to the assignments, to complete assignments in their free time and send them back to teachers for checking. The researchers, i.e. the authors of the article, collected the data of the statistic monitoring of the academic performance results in three groups of the Master degree courses full time department in a period of 2018–2019, 2019–2020 and 2020–2021 academic years. The average academic performance results are given in table 1.

Table 1
The summary table of academic performance results assessment of Master degree students in different technologies.

Academic Years	Average score					
	First group		Second group		Third group	
	Progress	Knowledge quality	Progress	Knowledge quality	Progress	Knowledge quality
2018–2019	100%	63%	92%	47%	83%	54%
2019–2020	100%	67%	87%	52%	88%	58%
2020–2021	100%	67%	95%	55%	92%	65%
Average	100%	66%	91%	51%	88%	58%

As can be seen from the graph (figure 4), not all of the Master degree students have used the possibility to obtain knowledge by means of standard or cloud technologies though the results of the research prove the fact that the interest of Master degree students towards the new forms of education is growing, especially with the account for the peculiar features of maritime education.
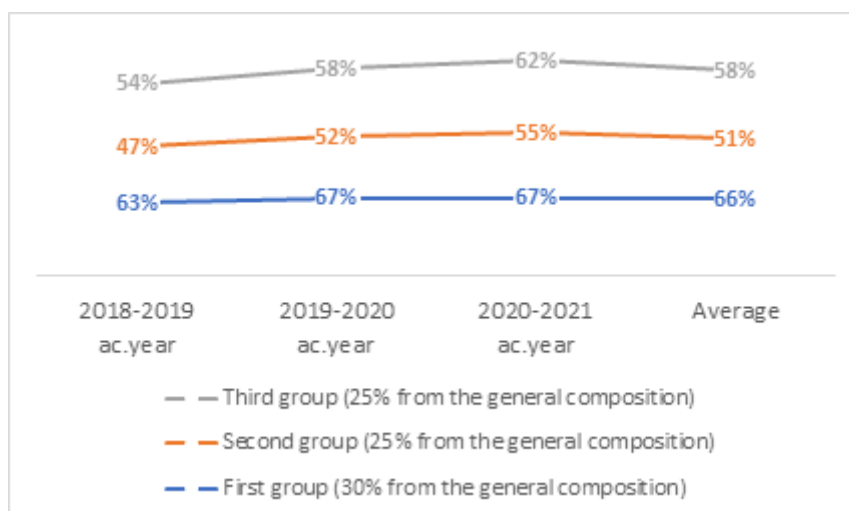
Figure 4: Graphic representation of the academic performance results assessment of Master degree students in different technologies.

5. Conclusions and directions for further research

Every navigational device is provided with the special manufacturer's blank sheet where it is stated how often should a check up of the navigation device should be conducted by the authorized company. As a rule, the check up, conducted once in five years, provides for the reliable operation of the navigation device for the next five years. Many navigators and super-intendants cannot understand why the check up should be conducted namely in 5 years. There are different reasons for that. For example, 5 year exploitation of such device as a magnetic compass it is quite long time because the accuracy of the magnetic compass readings are getting much worse with the time.

Any classification society issues "Type Approval Certificate for Product" for every shipboard device and instrument which is valid for five years, so in five years it is necessary to check and confirm the operable condition and capacity of the device for the next five years by means of check up conducted by the authorized organization. By using the information on the average time of the trouble-free operation of any navigation device, which is calculated based on the maritime practice, a future navigator obtains practical skills of planning the schedule of the most commonly used technical aids to navigation check ups, based on the data as for the trouble-free operation possibility and operational reliability of this navigation equipment, received from the research described in the article.

On the other hand, the requirements to competency formation connected to the use of digital technologies are getting more and more stringent every year. At the same time the funding of the educational sphere doesn't get any better, on the contrary the expenses for the information infrastructure development are becoming less and less. So, one of the effective means to solve the problem is the use of cloud services in the process of education.

Recently the scale rates of cloud technologies implementation are growing rapidly. The single educational information space is being developed with the use of cloud technologies which

are predominantly provided by the Microsoft and Google companies. The organization of the education process with the use of cloud technologies had the following advantages:

- the services work effectively with all types of hardware and software systems;
- there is possibility to apply modern achievements in the sphere of digital technologies;
- there is no need to buy licensed software;
- the access to program apps is granted in any situation (irrespective of students' location, if they visit off-line lessons in the classroom or study individually on-line);
- possibility of cloud services application by students in their future professional activity.

Due to the cloud technologies implementation a Master degree student, while being aboard, can use the created data base for the shipboard information systems reliability assessment by changing the input data in accordance to the shipboard hardware systems parameters of his vessel. The authors of the research believe that the further engagement of Master degree students into the use of modern services can greatly increase the level of their professional training which, for sure, will enable to increase of their competitive abilities at the international employment market for seafarers.

References

[1] Aleksanyan, G., 2012. The use of yandex cloud services in the organization of independent activities of SSE students. *Pedagogy: traditions and innovation.* vol. 2, pp.150–153. Available from: https://moluch.ru/conf/ped/archive/63/2605/.

[2] Balyk, N., Oleksiuk, V., Vasylenko, Y. and Shmyger, G., 2019. Designing of virtual cloud labs for the learning CISCO cybersecurity operations course. *Ceur workshop proceedings*, 2393, pp.960–967.

[3] Bilousova, L.I., Gryzun, L.E., Sherstiuk, D.H. and Shmeltser, E.O., 2019. Cloud-based complex of computer transdisciplinary models in the context of holistic educational approach. *Ceur workshop proceedings*, 2433, pp.336–351.

[4] Bondarchuk, O., Balakhtar, V. and Balakhtar, K., 2020. Monitoring of the quality of the psychological component of teachers' activity of higher education institutions based on Google Forms. *E3s web of conferences*, 166, p.10024. Available from: https://doi.org/10.1051/e3sconf/202016610024.

[5] Bondarenko, O.V., Mantulenko, S.V. and Pikilnyak, A.V., 2018. Google Classroom as a tool of support of blended learning for geography students. *Ceur workshop proceedings*, 2257, pp.182–191.

[6] Demyanenko, V.M., Kovalenko, V.V., Kravchenko, A.O., Nosenko, Y.G., Popel, M.V., Rassovytska, M.V., Striuk, A.M., Shishkina, M.P. and Yatsishin, A.V., 2017. *Methodology of formation of cloud-oriented educational and scientific environment of pedagogical educational institution.* Kyiv: Pedahohichna dumka.

[7] Fedorenko, E.H., Velychko, V.Y., Omelchenko, S.O. and Zaselskiy, V.I., 2020. Learning free software using cloud services. *Ceur workshop proceedings*, 2643, pp.487–499.

[8] Glazunova, O., Voloshyna, T., Korolchuk, V. and Parhomenko, O., 2020. Cloud-oriented environment for flipped learning of the future IT specialists. *E3s web of conferences*, 166, p.10014. Available from: https://doi.org/10.1051/e3sconf/202016610014.

[9] Khmil, N., Morkvian, I. and Kyselova, O., 2020. Creation the site-quest by using the cloud services: From the experience of teaching future teachers. *Ceur workshop proceedings*, 2732, pp.1164–1171.

[10] Kolgatin, O.H., Kolgatina, L.S., Ponomareva, N.S. and Shmeltser, E.O., 2019. Systematicity of students' independent work in cloud learning environment. *Ceur workshop proceedings*, 2433, pp.184–196.

[11] Korobeinikova, T.I., Volkova, N.P., Kozhushko, S.P., Holub, D.O., Zinukova, N.V., Kozhushk-ina, T.L. and Vakarchuk, S.B., 2020. Google cloud services as a way to enhance learning and teaching at university. *Ceur workshop proceedings*, 2643, pp.106–118.

[12] Korotun, O.V., Vakaliuk, T.A. and Soloviev, V.N., 2020. Model of using cloud-based environment in training databases of future IT specialists. *Ceur workshop proceedings*, 2643, pp.281–292. Available from: http://ceur-ws.org/Vol-2643/paper16.pdf.

[13] Kravtsova, L., Kaminska, N. and Kravtsov, H., 2020. Cloud services in the distance learning system for future sailors. *Ceur workshop proceedings*, 2732, pp.1187–1202. Available from: http://ceur-ws.org/Vol-2732/20201187.pdf.

[14] Lytvynova, S. and Burov, O., 2017. Methods, forms and safety of learning in corporate social networks. *Ceur workshop proceedings*, 1844, pp.406–413. Available from: http://ceur-ws.org/Vol-1844/10000406.pdf.

[15] Lytvynova, S.H., Spirin, O.M. and Anikina, L.P., 2015. *Cloud services office 365: Tutorial.* Kyiv: Komprint.

[16] Markova, O.M., Semerikov, S.O. and Striuk, A.M., 2015. The cloud technologies of learning: Origin. *Information technologies and learning tools*, 46(2), pp.29–44. Available from: https://doi.org/10.33407/itlt.v46i2.1234.

[17] Markova, O.M., Semerikov, S.O., Striuk, A.M., Shalatska, H.M., Nechypurenko, P.P. and Tron, V.V., 2019. Implementation of cloud service models in training of future information technology specialists. *Ceur workshop proceedings*, 2433, pp.499–515. Available from: http://ceur-ws.org/Vol-2433/paper34.pdf.

[18] Oleksiuk, V.P. and Oleksiuk, O.R., 2020. Methodology of teaching cloud technologies to future computer science teachers. *Ceur workshop proceedings*, 2643, pp.592–608.

[19] Osadcha, K.P. and Osadchyi, V.V., 2020. The use of cloud computing technology in professional training of future programmers. *Ceur workshop proceedings*, 2879, pp.155–164.

[20] Shklyar, V., 2009. *Reliability of control systems.* Tomsk: Tomsk Polytechnic University Publishing House.

[21] Spirin, O., Oleksiuk, V., Balyk, N., Lytvynova, S. and Sydorenko, S., 2019. The blended methodology of learning computer networks: Cloud-based approach. *Ceur workshop proceedings*, 2393, pp.68–80.

[22] Striuk, A.M. and Rassovytska, M.V., 2014. The system of cloud oriented learning tools as an element of educational and scientific environment of high school. *Information technologies and learning tools*, 42(4), p.150–158. Available from: https://doi.org/10.33407/itlt.v42i4.1087.

[23] Sultanova, L.Y., Tsiuniak, O.P., Milto, L.O., Zheludenko, M.O., Lyktei, L.M., Petrenko, L.M. and Uchitel, A.D., 2020. The potential of Google Classroom web service for lecturers of

higher educational establishments under pandemic conditions. *Ceur workshop proceedings*, 2879, pp.346–365.

[24] Symonenko, S.V., Osadchyi, V.V., Sysoieva, S.O., Osadcha, K.P. and Azaryan, A.A., 2020. Cloud technologies for enhancing communication of IT-professionals. *Ceur workshop proceedings*, 2643, pp.225–236. Available from: http://ceur-ws.org/Vol-2643/paper12.pdf.

[25] Vagushchenko, L., 2004. *Ship navigation information systems*. Odessa: Phoenix.

[26] Vakaliuk, T.A., Korotun, O.V. and Semerikov, S.O., 2020. The selection of cloud services for ER-diagrams construction in IT specialists databases teaching. *Ceur workshop proceedings*, 2879, pp.384–397. Available from: http://ceur-ws.org/Vol-2879/paper21.pdf.

[27] Vakaliuk, T.A. and Marienko, M.V., 2021. Experience of using cloud-oriented open science systems in the process of teaching and professional development of natural and mathematical teachers. *Information technologies and learning tools*, 81(1), p.340–355. Available from: https://doi.org/10.33407/itlt.v81i1.4225.

[28] Valko, N.V., Kushnir, N.O. and Osadchyi, V.V., 2020. Cloud technologies for STEM education. *Ceur workshop proceedings*, 2643, pp.435–447. Available from: http://ceur-ws.org/Vol-2643/paper25.pdf.

[29] Vasilevskyi, O. and Ignatenko, O., 2013. *Standardization of indicators of reliability technical means*. Vinnitsa: VSTU.

[30] Velychko, V.Y., Fedorenko, E.H., Kaidan, N.V., Soloviev, V.N. and Bondarenko, O.V., 2020. The support of the process of training pre-service mathematics teachers by means of cloud services. *Ceur workshop proceedings*, 2879, pp.318–332.

[31] Vilskiy, G.B., 2013. Research of information support for traffic management system of marine vessels. *Ukrainian scientific journal of information security*, 3(19), pp.198–203. Available from: https://doi.org/10.18372/2225-5036.19.5626.

[32] Vilsky, G.B., 2016. Information the risks of navigation in the diagram of Ishikawa. *Scientific bulletin of the ksma*, 1(14), pp.19–25. Available from: http://journals.ksma.ks.ua/nvksma/article/view/731.

[33] Vilskyi, H. and Nadych, M., 2012. *Methodology for probabilistic assessment of the safe parameters of a vessel in conditions of restricted navigation*. Odessa: VydavInform.

[34] Voloshynov, S.A., Zhuravlev, F.M., Riabukha, I.M., Smolets, V.V. and Popova, H.V., 2021. Application of VR technologies in building future maritime specialists' professional competences. *Ceur workshop proceedings*, 2898, pp.68–81. Available from: http://ceur-ws.org/Vol-2898/paper03.pdf.

[35] Zaytseva, T., Kravtsova, L., Tereshchenkova, O. and Yurzhenko, A., 2022. Simulation modeling as a means of solving professionally-oriented problems in maritime industry. In: S. Babichev and V. Lytvynenko, eds. *Lecture notes in computational intelligence and decision making*. Cham: Springer International Publishing, pp.94–106. Available from: https://doi.org/10.1007/978-3-030-82014-5_7.