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Necessity for a change to the control procedures for merchant vessel course indicators

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Abstract

The author presents a new perspective on the process of controlling course indicators, to fit with the modern equipment of present day ships, in line with current trends and prospects for its development. The newly proposed measures and methods in this research must address the following issues: the improvement of safety, reduction in routine work and improvement of the navigation services on a ship. This article includes an analysis of requirements and also test results relating to compliance with respect to the course indicators used on commercial vessels. The author presents and justifies the need to introduce changes to the procedures and practices of conduct, updating the current actual situation. The proposed new procedures should have a direct impact on the security of navigation.

Introduction

An object contained in the marine environment is constantly subjected to variable forces that determine its position in space.

The 21st century has witnessed a rapid, almost revolutionary advancement in ship-borne equipment, in line with the development of modern navigational systems as well as broadly understood control systems. However, this author claims that despite this technological progress, the compasses – magnetic and gyro – still remain the most important elements of a ship's navigation equipment. Those compasses are used to maintain the vessel at a given course.

The introduction of the concept of an "integrated bridge", implementing among others: ARPA – Automatic Radar Plotting Aid, ECDIS – Electronic Chart Display and Information System, AIS – Automatic Identification System, VTS – Vessel Traffic Service systems and modern means of communication and transmission of information, have significantly changed the procedure for watch keeping. The pace of change in fleets in recent years has been so high that the required modifications to the procedures and principles of the operation of ships, has not kept pace with the technological advancement. The economic factor is also very important. Certain functions previously performed by humans have been taken over by automated systems. This has led to a reduction in the crew number to the minimum for which the applied equipment and regulations allow.

The progress made in recent years in the field of the gyro and magnetic compasses is incomparably smaller than the progress in other areas of navigation. The increase in accuracy and reliability of the course indicators has changed by about a few percent, while at the same time the accuracy and reliability of other systems have increased more than a dozen times, as in the case of positioning systems.

The author presents a new perspective on the process of controlling course indicators, to fit with modern ship-borne equipment, in line with current trends and prospects for its development. The newly proposed measures and methods in this research must ensure the improvement of safety, reduction in

routine work and improvement of the navigation services on a ship.

The requirements for course indicators in ship's equipment

The modern science of course determination of a vessel uses different laws of physics, in conjunction with information from gyro, magnetic and satellite compasses. Current rules allow, or even require, the use of only two types of compasses: gyro and magnetic. They provide information to maintain the ship's course, in addition to the positioning and collision avoidance systems.

According to the requirements of SOLAS (International Convention for the Safety of Life at Sea), chapter V, for ship's navigation systems and equipment, all ships, irrespective of size, shall have:

- a properly adjusted standard magnetic compass, or other means, independent of any power supply, to determine the ship's heading and display the reading at the main steering position;
- a means of correcting heading and bearings to true at all times;
- all ships of 500 gross tonnage and upwards shall be fitted with a gyrocompass, or other means, to determine and display their heading by ship-borne nonmagnetic means and to transmit heading information for input to the radars, automatic identification systems or automatic tracking systems.

Resolution A.382(X) requires that each magnetic compass is properly compensated and its table of curve of residual deviations is available on board in the vicinity of the compass at all times.

Meanwhile the convention STCW (International Convention on Standards of Training, Certification and Watchkeeping), requires that relieving officers shall personally satisfy themselves regarding the errors of gyro and magnetic compasses.

All these rules and requirements have led to the development of recommendations on the use of magnetic compasses and gyrocompasses included in the collections of the implementing rules. A magnetic compass' error should be determined at least once a watch while the vessel is at sea and, when possible, after any major alteration of course. The observed error should be recorded in the logbook. Checking the compass deviation regularly may reveal the need for repair, testing or adjustment. In addition, compasses should be inspected occasionally by a competent officer or compass adjuster.

The situation in modern fleets is such that, on the one hand, there are very high expectations in relation to the methods and quality of course control indicators on vessels in operating conditions, while on the other hand, there is a limited number of crew with excess duties, and an inadequacy in the existing procedures with respect to modern marine equipment.

Thus occurred a problem of effective use of integrated bridge systems, combining in one, among other things: GPS – Global Positioning System, ARPA or ECDIS. The information obtained from these devices should be used to reduce routine work associated with the current course control indicators but in reality causes deviations from the compliance with the provisions.

This has created a duality: on the one hand, there is a sense of duty and a need to respect these provisions, especially under the pressure of numerous inspections, while on the other hand, the hierarchy of importance of actions causes psychological discomfort for navigators.

This asymmetry in the development of the most important navigation devices does not allow effective optimization of the navigation process, both in terms of economy as well as the safety of navigation.

The activities of the IMO, tightening requirements for course control indicators

The above problems have been noticed very quickly by the IMO MSC – International Maritime Organization Maritime Safety Committee, and measures were taken to counter the effects of automation (Pleskacz, 2011).

"Guidelines on ergonomic criteria for bridge equipment and layout" was developed and published in 2000 (IMO MSC/Circ. 982, 2000), and "Guidance for the operational use of integrated bridge system" (IMO MSC/Circ. 1061, 2003) and "Issues to be considered when introducing new technology on board ship" (IMO MSC/Circ. 1091, 2003).

The results of an analysis of accidents and incidents at sea and in ports were presented at the meetings of the subcommittees of the IMO. As a result of this research, a set of recommendations that should limit the negative impact of automation on safety of navigation was developed (IMO MSC/Circ. 82/15/2, 2006).

The effectiveness of the course control indicators

The author has been studying the extent of the efficiency of modern means and methods of controlling the accuracy and reliability of course

indicators on modern ships, and what are the possibilities to increase this efficiency?

In order to obtain data on the practices employed when checking the quality of work of course indicators, a questionnaire was used, the purpose of which was to answer questions regarding the practical and compliance requirements related to the use of magnetic and gyro compasses.

Questions were directed to 212 respondents taking part in various courses conducted by the Maritime University in Szczecin (Łusznikow & Pleskacz, 2012).

Among the respondents were managers with years of experience at sea; the persons directly responsible for organizing work on vessels in the navigation section, and even lead supervision over lower-level officers. The average length of marine service of the surveyed individuals was 17 years.

Individual affirmative answers are:

- 63% – regularly set gyro corrections at any time;
- 45% – set gyro corrections once a watch;
- 53% – set magnetic compass corrections once a watch.

An important element of the operation of the magnetic compass is to compensate for the errors that arise during its use. The respondents were asked about a person of deviator, compensation and about the current deviation, which is crucial and necessary for the proper use of a magnetic compass.

When asked, "When the respondents had last witnessed conduct of a magnetic compass deviation be the deviator on the ship?" 16% answered "never" and only 39% "over the last year".

While answering the question "When was the last deviation compensation carried out on the ship?", the responses were as follows: 23% "never", and 42% "over the last year".

The analysis results show that only 28% of the respondents set gyros in accordance with good sea practice and regulations, at least once a watch. Given this and the fact that 56% determine corrections of the magnetic compass by comparing the gyrocompass, it can be concluded that only about 20% of the officers act in accordance with the regulations surrounding proper control of the magnetic compass.

All the above mentioned errors in the control of magnetic compass deviations and gyro corrections indicate that the proper and regular inspection of these two devices on board is neglected (Łusznikow & Pleskacz, 2014a).

Uncompensated or not included systematic and random errors cause divergence of true courses determined from the gyro and the magnetic compass. The reason for the differences is that in real life there are no perfect observations or ideal means of observation, and also the conditions of observation can be variable and/or poor, especially in heavy seas.

In addition, the total error of gyrocompass indication depends on a number of other factors (Adamowicz & Łusznikow, 1998; Jagniszczak & Łusznikow, 2010):

- accuracy of speed deviation, depending on the accuracy of information regarding ship speed, drift and leeway;
- maneuvering or inertial errors;
- errors due to ship motion;
- technical errors in settings and the translation of the course to repeaters.

The magnetic compass error, in turn, depends on such factors as:

- calculating the variation error;
- deviation error;
- deviation instability error, separate for coefficients B and C;
- insensitivity zone error (dry friction);
- error due to motion;
- technical errors in course translation.

For proper control of the course indicators, in present day, it is possible to automatically compare the parameters of the gyro and magnetic compasses. However, the vast majority of civil ships are not equipped with such devices. Nonetheless, it is still a comparison of two sources of information. Keep in mind that the comparison of the two sources of information provides the ability to control the item with the comparatively lower level of accuracy; usually the magnetic compass.

Systematic errors can be compensated for, but not completely excluded. Random errors, by definition, cannot be compensated for.

A mean error (m) of true course difference obtained from a magnetic compass and gyrocompass can be calculated from the formula (Łusznikow & Pleskacz, 2014b):

$$m = \sqrt{m_M^2 + m_V^2 + m_D^2 + m_G^2 + m_{GE}^2} \qquad (1)$$

where:

m_M – the mean error of the magnetic compass;
m_V – the mean error of the variation;
m_D – the mean error of the deviation;
m_G – the mean error of the gyrocompass;
m_{GE} – the mean error of the gyrocompass correction.

Analyzing this formula, we see that logbooks must contain a difference between true courses from the gyrocompass and those from the magnetic compass.

Under ideal conditions, using hypothetically perfect devices, actual courses obtained from both devices must be the same. Because there is no such situation in reality, the difference between true courses obtained from a gyro and a magnetic compass is usually not equal to zero. Modern statistical analyses of gyro and magnetic compass indications show that the value of the difference (m) of true courses for modern compasses equals ±2.4°.

It follows that the discrepancy of courses in every second observation should be a minimum of ±1.5°. In every third observation, that difference should not exceed ±2.5°, and for every fourth observation, ±3° or more (Adamowicz & Łusznikow, 1998).

In addition, storm weather must be taken into account. The real gyro-compasses at stormy condition has a deviation from 1.5° to 2.5° (Smirnow, Jalowenko & Woronow, 1996). During orbital motions, ship's centre of gravity moves in the plane of wave propagation, along an elliptical track, or spherical track in a particular case. The phenomenon was investigated and described in detail by A.N. Krylov, who did research onboard the cruiser "Petropavlovsk" (Krylov, 1958).

These are the values that a careful observer will not overlook. However, real life has shown a completely different image of practices on navigation bridges on the ships analyzed. It looks as if the navigation rules are governed by different laws than the rules of the generally accepted procedures in accordance with good sea practice.

To know the actual state of the course control indicators on the ships of the world fleet, records of 37 log books from 17 different countries in the world were analyzed (Łusznikow & Pleskacz, 2014b).

Copies of the logbooks were delivered by captains of ships calling at Szczecin.

All the vessels from which information has been obtained were merchant ships flying different flags and manned by crews from different countries. Randomly selected entries were chosen from five consecutive days when the ship was in operation on the open sea or on the approach to the port. A total of 2631 individual entries in these logbooks were examined. The term "single entry" means records relating to a single, specific hour of observation, which is a single line entry in the log book.

Statistical processing of data from the logbooks led to surprising results. It was found that 100% of true courses obtained from a gyrocompass and a magnetic compass written down in the examined logbooks had exactly the same values.

The results of analysis of the logbooks were compared with the results of actual tests conducted on 35 ships navigating the mouth of the Oder. As a result of the implementation of the cognitive objective, an experiment was conducted reading values of courses in operating conditions when the helmsman steered exactly in the line of leading. It was found that the mean square deviation of the difference between the true course specified using a magnetic and gyro compass for the statistically average vessel is: $m_{\Delta KR} = \pm 2.0°$ instead of zero, as always entered in the logbooks (Łusznikow & Pleskacz, 2014b).

The practice of filling in logbooks on the modern ships of the world fleet does not correspond to the rules of safety of navigation relating to the control of course indicators, and does not reflect the information necessary for the conduct of safe navigation. Adjusting the actual true course obtained from a magnetic compass to the actual gyro true course, detected on ships of the world fleet, is a crime that eliminates the main purpose of compasses crosschecking.

The improper conduct of seafarers on all ships in the world fleet, surrounding the routine improper procedures relating to the issue of control indicators should be stigmatized and eliminated. The main agents for this should be: universities, academies and all kinds of maritime schools.

In this situation, the question inevitably arises as to what are the causes of this state of affairs?

In order to understand and respond to such questions, a detailed analysis of the actual practices of filling in logbooks as compared to the stipulated requirements for the officers of the watch, and the content of training and negative stereotypes affecting good sea practice should be made.

The gathered statistical data implies that equal values of true course obtained from a gyrocompass and a magnetic compass is an ordinary occurrence for deck officers. An analysis of the difference in true courses for one ship steering a specific course, shows that it is considered by navigators to be an artificial problem, which they know how to avoid. All they do is "slightly adjust" the readout from the less accurate magnetic compass to align with the more accurate true course produced by the gyrocompass. Thus, mandatory routine calculations of magnetic compass corrections are neglected. Naturally, such "adjustment" of magnetic compass correction does not have much to do with reality. Magnetic compass correction cannot be carried out accurately using a randomly estimated value; it is a scientific concept, a sum of declinations and deviations. If ships' compass corrections were determined in accordance with

procedures taught at training institutions, then true courses obtained from a gyrocompass and a magnetic compass would not be equal, and the value of the calculated difference between the true courses would allow estimation of how reliable the indicators are (Pleskacz, 2011).

Everything points to the fact that a modern navigator ignores his knowledge during routine daily work, and very importantly, good sea practice, which he learnt in the educational process.

Conclusions

Does the situation mean that today's navigators deliberately falsify data essential for navigational safety? An affirmative answer would require taking on great responsibility. In reality, we can assume that navigators' behaviors and attitudes represent a wide spectrum. Some probably do not understand or appreciate the problem, while others consciously eliminate certain things to gain temporary benefits. This author believes that navigators in all parts of the world take an easy way out that has long been nested in navigators' minds as a method of simplifying daily routine, even at the cost of forgery.

In an age in which GPS position is continuously displayed, navigators seem to lack motivation to strive for extra accuracy that can be provided by magnetic compasses. After all, the main aim of simultaneous monitoring of two independent compasses is to know whether we should give up relying on one of them when the indication difference becomes unacceptably large. In an attempt to facilitate their daily work, navigators have lost sight of the original objective of comparative monitoring of two compasses.

The issue of gyrocompass and magnetic compass accuracy assessment in real onboard conditions is considered by navigators as a purely academic issue. That is why they abstain from a real assessment of the differences and prefer to fiddle with observation results.

The problem is that the creators and executors of maritime education systems around the world do not suspect that basic principles of recording navigation data in logbooks are routinely violated by saving only the information that is deemed correct.

Becoming accustomed to simply adjusting the results and not analyzing the actual state of the compass is definitely not compatible with the main objective of controlling the course indicators. In the event of excessive discrepancies in compass indications, navigators who are accustomed to the routine adjustment of these results (without adequate analysis) will eventually cause a dangerous situation after a significant length of time. Thus, they will not be ready at the right time to react properly to the resulting risk.

Only a real monitoring of the difference between true courses obtained from a gyrocompass and a magnetic compass creates grounds for the sufficient assessment of the reliability of a ship's course-control system.

Therefore the author proposes an additional navigation safety criterion, namely that the difference between the true courses determined by using a magnetic compass and gyro must be clearly highlighted. Navigation classes should emphasize that there is nothing wrong with the fact that the difference is not zero. A large value or rapid change in the difference between the true courses determined by using the gyro and magnetic compass is a threat.

A column to determine the actual true courses determined separately by two compasses should be added to ships' logbooks.

Only regularly kept records will turn the attention of navigators to the proper control of course indicators and alert them when the safe limits of excess values are reached.

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References

1. Adamowicz, M. & Łuszникow, E. (1998) *Rola wskaźników kursu w bezpieczeństwie żeglugi morskiej*. Materiały Międzynarodowej Konferencji „KDS-98", Maritime University of Szczecin, pp. 129–134.
2. IMO MSC 82\15\2 (2006) Research into interaction with automated systems, IMO.
3. IMO MSC/Circ.1091 (2003) Issues to be considered when introducing new technology on board ship, IMO.
4. IMO MSC/Circ.982 (2000) Guidelines on ergonomic criteria for bridge equipment and layout, IMO.
5. IMO MSC/Circ/1061 (2003) Guidance for the operational use of integrated bridge system (IBS), IMO.
6. Jagniszczak, I. & Łuszникow, E. (2010) *Bezpieczeństwo nawigacji*. Gdańsk: Fundacja Promocji Przemysłu Okrętowego i Gospodarki Morskiej.

7. Krylov, A.N. (1958) Election Publication. Science Academy of USSR.
8. Łusznikow, E. & Pleskacz, K. (2012) Analysis of problems related to the use of ship's course indicators. *Scientific Journals, Maritime University of Szczecin* 29 (101). pp. 122–126.
9. Łusznikow, E. & Pleskacz, K. (2014a) Analiza stanu kontroli dokładności i niezawodność wskaźników kursu jako czynnik bezpieczeństwa nawigacji. *Logistyka* 4. pp. 764–769.
10. Łusznikow, E. & Pleskacz, K. (2014b) Prezentacja wyników badań rzeczywistej dokładności żyrokompasów i kompasów magnetycznych. *Logistyka* 4. pp. 770–776.
11. Pleskacz, K. (2011) Impact of automation on ship's safety. *Scientific Journals, Maritime University of Szczecin* 26 (98). pp. 88–91.
12. Smirnow, E.L., Jalowenko, A.A. & Woronow, V.V. (1996) Electro navigational equipment. Sankt-Petersburg: ELMOR.