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The reliability of compass information at navigational safety

Wiarygodność informacji kompasowej w bezpieczeństwie nawigacji

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Abstract
The problem of routine control of true courses from gyrocompass and from magnetic compass is presented. It is shown, that contemporary method of monitoring is not agree to science methods and is not agree to the intention of navigation safety. The reasons of this situation in aspect of history are analysed. The role of education at solution of this problem is exhibited. The problem is analysed at technical aspect, low aspect, moral aspect. The methods and means of resolving of the problem are presented.

Słowa kluczowe: dokładność, kompas magnetyczny, żyrokompas, niezawodność, bezpieczeństwo nawigacji

Abstrakt
W artykule jest zaprezentowany problem codziennej rutynowej kontroli porównawczej kursów rzeczywistych z żyrokompasu i kompasu magnetycznego. Pokazano, że istniejąca metoda kontroli znajduje się w sprzeczności z zasadami naukowymi i nie odpowiada głównemu celowi bezpieczeństwa nawigacji. Przeanalizowano przyczyny takiego stanu w aspekcie historycznym. Odzwierciadlano rolę edukacji morskiej w rozwiązaniu tego problemu. Kwestię przeanalizowano pod kątem technicznym, prawnym, moralnym, etycznym. Pokazano sposoby rozwiązania tego problemu.

Introduction

Every master mariner remembers his first days in the watch life as a watch officer Navigator. The author of this article is no exception in this matter.

This watch in July 1961 on m/v "Cola" (Murmansk shipping company Arctic Sea State) immediately evoked feelings that, were caused by divergence of pure science and practice. True courses from gyrocompass do not agree with the real courses obtained using the magnetic compass, but in the logbook, after the watch, these courses must be completed every hour.

After the Leningrad Marine College author was not ready to operate in engineers categories and there was nobody to help him in this matter. The most logical to me at that time was to fit the less accurate readings of magnetic compass for more accurate readings of gyrocompass, eliminating this way the difference of true courses. Author is thinking that he was not the only one who went to the same position exactly. Having crossed this Rubicon once, he didn't put himself more of these issues, even at highest professional, educational, and scientific qualifications.

However, as it is known from the philosophy, that life is cyclical. It has to return to old issues, but at a higher level. This article just reaffirms the classical philosophical position.

In the history of navigation crashes caused by low accuracy or failure of compass are known. The accuracy of the gyrocompass is much greater than the accuracy of magnetic compasses, however, their reliability is less than reliability of magnetic compasses.

From this reason at all ships of gross tonnage 500 t and more there are requirements to have a gyrocompass and compensated magnetic compass, as well as a spare magnetic compass.

At normal situation the gyrocompass is used for navigation from point of high accuracy. If the gyrocompass has refusal, the magnetic compass is used for navigation. So, the magnetic compass is realized its advantage in reliability. Not found or detected late failure of gyrocompass often led and leads to accidents.

The accident of 20th century in this sense was the death of the super tanker "Torrey Canyon" on the rocks of Scilly in 1967. As a result rocks broke the ship apart into three parts and 130 000 tons of spilled oil caused exceptional damage to the southern coast of England.

Fig. 1. Crash of super tanker "Torrey Canyon" at the English channel because of undetected failure gyrocompass
Rys. 1. Śmierć supertankowca „Torrey Canyon" w kanale La Manche z powodu niewykrytego uszkodzenia żyrokompasu

The cause of accident was a gyrocompass refusal in fog. There were many such accidents, smaller-scale, in the history of navigation and they continue to take place now.

The modern practice of using a gyrocompass and magnetic compasses

The regulation of navigational watch requires to write in logbook the courses and amendments of gyrocompass and magnetic compass by every hours. At hypothetically perfect devices and observer the true courses of gyrocompass and true courses of magnetic compass must be the same. The systematic errors and the random errors of equipment and also the errors of observer are the reason of differences of true courses from gyrocompass and magnetic compass.

Now, it is possible to use the machine for compare courses from gyrocompass and from magnetic compass, but the vast majority of the civilian ships does not have the such machine.

The true courses found by gyrocompass, as well as by magnetic compass will always differ one from the other. The reason of this is that in nature there are no ideal observers, perfect equipment, and conditions of observation, especially during stormy weather.

The accuracy of gyrocompass correction is depending from the following factors:

- accuracy of information about ship's speed, accuracy of counteracting tidal stream and counteracting leeway;
- inertial errors at manoeuvring;
- roll errors;
- technical inaccuracies of course.

The accuracy of magnetic compass is depending from the following factors:

- inaccuracy of calculating the magnetic declination;
- inaccuracy of calculating the deviation of magnetic compass;
- instability of deviation, especially coefficients B and C;
- inaccuracy of stagnation;
- inaccuracy from deviation of heel;
- inaccuracy from technical transfer course;
- inaccuracy of observer.

Systematic errors of measurement can be compensated, but not completely. Random errors are not compensable by definition.

The middle difference m of the true course of the magnetic compass from the true course of gyrocompass is determined by the expression:

$$m = \sqrt{m_{GK}^2 + m_{MK}^2 + m_O^2} \qquad (1)$$

where:

m_{GK} – mean square error of gyrocompass;
m_{MK} – mean square error of magnetic compass;
m_O – mean square error of observer.

The expression (1) can be rewritten to a more detailed view:

$$m = \sqrt{m_{KK_{GK}}^2 + m_{\Delta_{GK}}^2 + m_{KK_{MK}}^2 + m_d^2 + m_\delta^2 + m_O^2} \qquad (2)$$

where:

$m_{KK_{GK}}$ – mean square error of gyrocompass course;
$m_{\Delta_{GK}}$ – mean square error of gyrocompass correction;
$m_{KK_{MK}}$ – mean square error of compass course from magnetic compass;

m_d – mean square error in counting the declination of magnetic compass;

m_δ – mean square error in counting of deviation of magnetic compass.

The mean square difference of courses M at the level of reliability P(95%) can be represented by the expression:

$$M = 2\sqrt{m_{KK_{GK}}^2 + m_{\Delta_{GK}}^2 + m_{KK_{MK}}^2 + m_d^2 + m_\delta^2 + m_O^2} \quad (3)$$

The same, more or less, must be the objective difference between the true courses of logbook records. The value of the standard difference of the true courses m for modern model gyrocompass and magnetic compasses [1, 2, 3, 4] is 2.4°.

The difference R at the limitation $-2.4° \leq R \leq 2.4°$ take place at the level of probability $P = 68.3\%$. If the difference $R = 2.4°$ is installed as criteria at automat of comparison, the probability of alarm signal is equal 31.7%. This situation cannot be evaluated as normal situation. From this reason as a rule the criteria of comparison is usually $R = M(0.95) = 5°$.

It should be noted that although the machines of courses comparison are simple and not very expensive. However, the most of ships is unequipped by this machines.

The regulation of filling in logbook

The logbooks of all country of the world have position for writing the gyrocompass course, compass course and amendments of these compasses.

The ship's logbook is considered as one of the most truthful documents maintained by human beings on Earth. Information from the logbook must allow maximum precision recovery action when ship in flight at all times. This documentary information allows an objective assessment of the actions of the ship if necessary.

The navigators teach the students for years that no ambiguities, inaccuracy, the more falsehoods, are allowed in the ship's logbook. In short we can say that in a normal environment the ship's logbook can be discribed as "Holy of Holies".

On this score at navigation folklore there are sayings like "what I see is what I write, what I don't see is that not written".

At complete objectivity of ship's logbook in accordance of scientific knowledge, differences of the true course of the gyrocompass and magnetic compasses must be detected.

The practice of comparison of the courses on the vessels and its analysis

The statistical analysis of information from ships' logbooks about comparison of courses on the ships of world fleet was made in Szczecin Maritime University.

The results of the statistical analysis is absolutely unnerving. As a strict rule, true courses from gyrocompass and true courses from the magnetic compass according of logbook records are coinciding with absolute precision.

The result of such oobservations was copied from logbooks of vessels under the flag of Poland, Greece, Russia, Norway, Denmark, Sweden, Germany, England, Spain, Barbados, Antigua.

These hourly observations from gyrocompass and magnetic compass in number of 1558 were presented by author and by K. Pleskacz, Master Mariner MSc.

All 100% of true courses from gyrocompass and true courses from magnetic compass are characterized by an absolute coincidence.

Scientific knowledge precludes such a systematic coincidence. Inevitably the question arises, what means this disparity between well-known scientific fact and reality.

To answer this question a detailed analysis of any questions is required. It is necessary to analyse the current practice of logbook, the requirements to navigator in this part, the program of maritime education and attitudes.

From collected statistics should match that coinciding of true course from gyrocompass and from magnetic compass is qualified in mentality of navigator as quite natural coincidence.

Apparently, two different true courses of a ship is complication of issue for navigator. In the routine of daily life the master avoids unnecessary complications. And that's OK.

However, at the same time the positive action can be dropped. In that situation, avoiding of complications is not hard and sometime even tempting.

"A little is enough" to fit the true course from less precise magnetic compass by more accurate counting of true course from gyrocompass. The tedious problem of systematic calculation of magnetic compass correction at this decision disappears by itself.

Apparently, this fitting is "appointment" of such correction of the magnetic compass, which would provide the same true course as the true course obtained from gyrocompass.

However, the correction of magnetic compass is not an arbitrary value that can be assigned to any

extraneous considerations. The correction of magnetic compass is strictly scientific category and it is calculated as the sum of the declination and deviation. If the correction of magnetic compass every time conscientiously evaluated (as taught in schools), there would never have been the ideal matches of true courses from gyrocompass and magnetic compass.

The difference of true courses from gyrocompass and from magnetic compass would judge about the credibility of compasses. Adapted (selected) true courses from gyrocompass and magnetic compass can not guarantee of navigational reliability. If the compass error is appointed, but not evaluated, that products any questions (about the deviation of magnetic compass, declination and correction of magnetic compass).

This situation shows utter disregard for the practical work of modern navigators, knowledge and skills acquired in education.

Does this mean that all navigators are intentional or deliberate falsification? It is obvious that such a judgement would be excessive.

In this view such position at recording of logbook is "the line of least resistance", which has long been a practice in the popular consciousness of navigators. It allows to reduce and to simplify a daily routine work.

After all, the main objective of supervision is the failure detection of one compass by means of not valid large variation of one compass indication from the other.

Goes like this will simplify your daily routine work any way prohibited even diluted the original purpose of the control.

The question of gyrocompass accuracy and accuracy of magnetic compass on a real ship (not school class) generally considered to be of purely academic. It is the main reason of disagreement of science knowledge and maritime reality.

It should not be embarrassed about it, because true courses from gyrocompass and from a magnetic compass when took place objective observation (without adjustment) are different. That is the way it should be in real life, and concern should arise only when the difference is outside the range, indicating that there may be a refusal of one of the compasses. Moreover, an objective registration of those courses that are observed eliminates the need for the "chemical combination" of fitting one course to another, facilitating the conscience of the observer and shortens the time monitoring.

Because this *problem exists all over the world* must be rooted short-sighted position of navigators throughout the world to eradicate, by all available means. Truth, even if it is less intelligence, convenient and pleasant always is more appropriate, expedient, reasonable and ethical than a beautiful lie. This is all the more so that it is not only and not so much about the moral and ethical categories, as technical categories related to the safety of navigation.

Analysis of the causes of malpractice

The main reason for the existence of the problem of biased writing courses in ships' logbooks in author's opinion is a superficial look at the problem of precision of compasses.

The more precise measuring instruments, the less important and noticeable difference in their testimony, and this difference are of less interest to the observer, especially when performing routine measurements.

If the navigatortor shall designate and take the course of the ship with discreteness in one degree (both accepted and legitimized by normative documents), 0.1° usually does not pose any practical interest. This is especially true when it comes to daily routine operations of the ship.

Pursuit of simplicity (simplifications) is understandable desire to reduce the amount of unnecessary work.

However, the transition from simplifications to the fitting results is no longer harmless and it is essentially a criminal operation.

In this case, the "crime" can be even not comprehension, but in sense of the consequences of this changes nothing. For the merits of the case does not matter what was the reason of grounding of the vessel – recognized error or not recognized.

When hundreds of thousands of navigators systematically make the same error it gets a lot of questions. Why is happening? What does the help this? What are the roots of evil? In such cases, you should check the underlying concepts and principles articulated in regulations for training of navigators. One of the fundamental principles is the principle of maximum objectivity reflect events in the logbook.

Even at the first navigational practice the cadets are studying to write in logbook only what do you see and what is not in doubt". In this training are used even crudes slogans like "see-what I write, what I don't see is that not written".

Any person, as a subject, distortes information in varying degrees, even do not wishing that, but in the main it has acted in accordance with the principles and concepts obtained when training a specialty.

In this case, the problem is that the system of special maritime education in the world has not seen the flagrant violation of the fundamental principle of truthfulness of entries in the log-book.

The custom to adapt results rather than analyze the actual state of affairs is in complete contradiction to the primary goal of monitoring. If an unacceptably high misalignment at compasses, the navigator used to the routine adjustment of results, does not parse the critical gaze of the actual disagreement. He much longer does not detect an emergency and would be less willing to respond adequately and in a timely manner, adopt appropriate measures.

Thus, this seemingly simple question has many interrelated aspects – the scientific aspect, technical aspect, aspect of legal, moral aspect. Radical fight against unacceptable practice should start already in educational institutions at studying of navigation and navigation safety.

In the years of logbooks on ships' board of the world fleet there is a flagrant violation of the principles of navigation safety and the principles of the true reflection of production information.

Trendy fit of true courses from gyrocompass and magnetic compass, occurring in ships' logbook, is hurting the navigation safety, eviscerate the essence of objective monitoring, breaking the principle of objectivity of a ship's logbook with all the ensuing consequences.

Such practices should be universally eradicated. It is necessary to end the practice of fitting records courses from gyrocompass and magnetic compass under the one true course. Writing courses should reflect what really navigator sees at compasses.

Distinguish the true course of gyrocompass and of magnetic compass should not embarrass or frighten the navigator as long as it is within an acceptable range.

The difference of true courses provides a rationale for an adequate assessment of the compasses and, if necessary, to take appropriate measures to ensure the navigation safety.

Elimination of falsifications of ship observations should start first of all with appropriate training in maritime educational establishments.

The most radical solution to this issue can be automatic registration of gyrocompass courses and of a magnetic compass at their auto-sensing amendments. In this case, clearly there will be no permanent match of true courses of compasses.

When implementing such a registration comparing the true courses of both compasses, evaluation of compasses reliability and where appropriate marking of unacceptably large disjunctions among shall be carried out.

Conclusions

Liquidation of the *bad seaman ship* in part of monitoring compasses will allow:

– an objective assessment of the actual reliability of compasses,
– an objective assessment of deviation changes of magnetic compass,
– to increase the navigation reliability,
– to improve the reliability analysis of navigational accidents and incidents,
– to eliminate constant self-deception of navigators at conducting of ship's logbook.

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