Information Support for Navigator Providing Maritime Safety

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ABSTRACT

Introduction of information technologies into maritime safety improvement process makes maritime universities face the problem of training navigators for competent information usage. The present paper focuses on the main trends in solving this task.

1. Introduction

Training specialists in maritime academies and advanced training aims at improvement of maritime safety by making the most efficient use of the information available aboard. Constantly growing number of information sources, increasing requirements to its trustworthiness and accuracy requires changes in maritime training quality. The leading role here is played by the ability to correctly evaluate information and to make up the optimal decision. Presently training process in maritime academies and skill improvement courses for navigators incorporates certain innovations. They are: elaboration of automated information systems based on satellite navigation, automated radar plotting systems and radio transponders. All the information sources go with capacities of electronic cartographic systems.

2. Requirements to navigation accuracy

Wide usage of GPS Global Navigation Satellite System (GNSS) gives the possibilities of high accuracy navigation in all the areas of the World Ocean. According to IMO Resolution A.529 (13) 1983 ship's position is to be known with radial error of $R < 4$ miles ($M_0 < 2$ miles) and probability of $P = 0.95$. The above requirement concerns the areas where ship's manoeuvring is not restricted. For narrow waters, passages and port waters according to Global Radio navigation System requirements adopted in 1995 on the 19th IMO Assembly ship's position error should not exceed 10 meters with probability of $P = 0.95$ ($M < 5$m). IMO resolution A.860 (20) of November 27, 1997 confirmed the ship's position accuracy requirements regarding future Global Navigation Satellite System.

Presently the problem of high accuracy navigation has been solved both for coastal and deep sea voyages. However it should be mentioned that there exist certain factors which do not depend on position accuracy but nevertheless influence navigation safety. For instance, surf beat unknown not shown in navigation guidebooks or insufficient information on tide phenomena.

While plotting not far from navigation dangers, if necessary, the observations should be of high accuracy (M_0 = 2-5 m). At differential GNSS operation variants cartography errors should be also considered. Thus, average square errors in nodal point position on cartographic graticule (intersection point) do not exceed 0.2 mm in the map scale. Mark stations are mapped with the same accuracy. However, due to the paper deformation in reprints map frame dimensions may differ in 1-2 mm. Analysis of different maps showed that outline points position on the cartographic map is characterized by average square errors of 1.0 mm. Mapping of other points no sea maps is carried out with less accuracy, mainly due to cartographic generalization.

It should be also mentioned, that until recently accuracy of depths mapping on sea maps produced in this country is evaluated by average square error of ± 1.5 mm in the map scale, and isobathes are drawn by limited number of depth, their pattern serving as usual for better visual perception of underwater landscape. Taking into account both depth errors and depth mapping errors we can speak of total limited error in mapped depth of 4-6% of actual depth.

3. Factors influencing maritime safety

The main factor influencing maritime safety in coastal and narrow waters is that on the maps of some countries actual depth may prove to be less than mapped depth. Thus, on the USA Atlantic coast and Central America maps, where low water level is accepted as datum in 50% cases heading level may be lower than datum. In some areas (Alaska, Mexico, USA Pacific coast, the Philippines and the Hawaiians) heading depth is lower than datum in 25% cases.

Another important problem of high accuracy navigation is so called "coordinate problem".

For instance, in Russia state coordinate system was adopted in 1942 (CK-42). This system includes topographic sea gravitation maps and other guides. GLONASS (Global Navigation Satellite System) uses universal geocentrical coordinate system П3-90, which served as basis for modernization of state geodesic net CK-2 and for reference coordinate system 1995 (CK-95).

In order to introduce П3-90 into operation all over Russia, CIS countries and world community it should be given national status, parameters of correlation with other coordinate systems should be published, including correlation with WGS-84.

Presently in different countries various regional and local national coordinate systems are used in marine cartography, with data coming from GNSS indicators and shore based RNS. Their lists and WGS-84 conversion formulas are given in International Hydrographic Organization guidance S-60. Data on П3-90 and CK-42 are not listed therein. Guidance formulas are approximated, and resulted error in coordinate conversion can be as high as 25 m or even more. Today there exists neither international standard which would predetermine obligatory S-60 application nor acceptable coordinate systems which would provide necessary accuracy and recommended conversation formulas.

During IMO Maritime Safety Subcommittee meeting in 1997 International Electric Engineering Commission introduced NAV 43/7/4 of April 17, 1997, where the problem of different coordinate systems usage in ocean navigation was thoroughly investigated. Analysis of the document shows that NAVSTAR indicator-receivers give observation readings in WGS-84. Conversions in П3-90 and CK-42 and not carried out as there are no conversion formulas approved by respective Russian and USA bodies. As a result, data obtained on equipment in different coordinate systems may considerably vary and may not meet IMO and IKAO requirements.

The problem of agreement between coordinate systems became still more urgent due to wide application of maps based on ECDIS in navigation. Up-to-date ECDIS combine maps of different brands. One and the same ECDIS for sailing in different World Ocean areas may combine charts based on different coordinate systems. Navigator should be ready to act under such circumstances and to correctly evaluate accuracy of obtained information.

Globalization of navigation systems raised the problem of determination of correlation between П3-90 and WGS-84, prevention of errors connected with the systems application to different cartographic projections, and training navigators with respect to obtained information analysis.

However, together with technical problems in coordination of information received from different positioning systems there are difficulties caused by maritime specialists competency level.

Under present navigation conditions navigators has to deal with navigational information received from different systems operated according to different physical principles and, therefore, having errors of different origin. Ship's speed can be measured in respect to water – by patent, dynamic pressure, induction or other log, or in respect to bottom – by Dopler acoustic log. With implementation of GNSS operated in differential mode navigator got one more way to calculate ship's course and speed values in respect to ground. Thus, at navigator's disposal there is a large set of values of one and the same ship's parameter, and actual value selection is carried out by navigator based on his own knowledge and experience. The same situation can be observed with other ship's parameters, such as coordinates and course.

Training navigators for operations with large volume of various information is the main task for maritime educational institutions. This problem becomes more important with implementation of information transfer systems – radio transponders – into everyday use.

In 1998 Maritime Safety Committee adopted MSC.74(69) recommendation proposed by Maritime Safety Subcommittee and operation requirements to ship transponders. In October 1998 M.1371 Guidance was issued containing main principles of AIS structure and operation. In accordance with the latest edition of SOLAS Convention, Chapter V, adopted by Maritime Safety Subcommittee NAV-45 in September 1999, additional paragraph 1.5 was incorporated into Rule 19, which determines requirements to AIS installation terms depending on vessel type.

Optimization of the message format if transmitted via transponder will allow determination of information which is of vital importance for safe navigation excluding unnecessary and complicated information which distracts navigator from his main task. Continuous automatic identification of the vessel under control excludes the necessity to use expensive and ineffective VHF-radio direction finders.

Due to exchange of ships' coordinates determined at high accuracy (by global differential navigation satellite system – 5-10 m) and information exchange on current route we can increase accuracy of passing parameters determination and, therefore, provide safe passing at sea.

It is proposed to transmit via transponder the following three types of information:

1. Static:
   - IMO number (if any)
   - Call sign and name
   - Ship's length and width
   - Type of vessel
   - Location of sip position determination antenna on board (aft, stern part, starboard, portside)
2. Dynamic:
   - Ship's position (indicating system accuracy and integrity)
   - UTC
   - Course in respect to ground
   - Speed in respect to ground
   - Own-ship course
   - Navigation status (anchored, steered etc.) – set by hand
   - Angular speed (if possible)
   - Angle of heel (if possible)
   - Angle of roll and pitch (if possible)
3. Voyage information:
   - Draft
   - Dangerous cargo (type)
   - Port of destination and ETA (under Master's order)
   - Voyage plan (main points)

Besides there may be short messages on ship's safety.

However, in this situation information about oncoming vessel will increase the possibility of correct decision, but at the same time the information can make navigator trust the data without checking it. This can be clearly seen during transmission of information on navigational situation from shore based maritime safety systems. This information is of obligatory type, i.e. it is considered as immediate guidance on board. However, if high accuracy position determination system is installed onboard and if it is possible to evaluate navigational situation in a certain moment, navigator is to make independent decision using positive maritime experience as a guidance. In order to make the decision navigator should not only possess navigation experience, but also psychological strength, confidence and deep knowledge. All the above qualities can be acquired on board during voyages but there is no doubt that much cheaper and safer way of gaining knowledge is during simulation training.

4. Conclusion

In the course of high accuracy navigation and electronic cartography systems development another problems may arise, which can change navigator'' work. Still, maritime safety is one of the most important issues. Presently we can draw to the following conclusion: simulation testing should be obligatory for maritime universities graduates, just like regular control testing using conning bridge simulator should be obligatory for competent navigators. The testing will allow utilization of the whole scope of information which navigator receives during voyage, assistance of experienced instructors, evaluation of competency in information analysis and navigational decision making. Such testing should be necessary step for navigator before he takes his place on conning bridge.