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Zdzisław Kopacz
Wacław Morgaś
Józef Urbański

The Institute of Navigation and Hydrography
The Naval Academy
(81-919 Gdynia, Śmidowicza St. 69)

The navigational and hydrographical provisionof ships' special tasks. Its state and development tendencies

In this paper, there are presented the main principles of the navigational and hydrographical provision of ships' special tasks. There are specified the types of ships' tasks, but especially, ships' special tasks. There is discussed the ship's navigation process as the function of the type of the ships tasks. There is also presented the substance of the navigational and hydrographical provision of the ships' special tasks, as well as the development trends of this provision.

INTRODUCTION

There is a lot of ships' tasks, besides the ships' tasks, which realization effectively, or even the realization possibility, depends upon the navigational and hydrographical provision. We assume, according to the Webster's New Word Dictionary, that the term "provision" means a preparatory arrangement of measures taken in advance for meeting some future needs". In this paper, the term "navigational and hydrographical provision", means the carrying out the set of navigational and hydrographical activities for creating and maintaining the necessary navigational and hydrographical conditions which enable the realization of ships' special tasks, i.e. such ships' tasks as "mine warfare tasks"and other similar ships' tasks.

In this paper, there are discussed the ships' tasks which need such navigational and hydrographical provision. There are also discussed the means and ways of the navigational and hydrographical provision, as well as prospective changes of this provision.

In the not very distant past, the main reasons for organizing and realizing the navigational and hydrographical provision was mainly, and almost exclusively, the insufficient positioning accuracy provided by the commonly available positioning systems. Therefore, it was necessary for example, for "mine sweeping"and in other similar cases, to ensure the higher positioning accuracy than this which was commonly available for ships at sea. This end was achieved thanks to additional navigational and hydrographical activities performed before and during realization of the ships' special tasks. These additional activities contained usually the creation of special additional local navigational infrastructure which insured the higher positioning accuracy, as well as preparation, usually by the Hydrographical Office, the additional great –scale charts, with drown position – lines nets, in order to increase the position – fixing frequency, i.e. in order to use properly and entirely the provided positioning accuracy. But now (2000), the problem of positioning has been considerable changed. The Differential Global

Positioning Systems (DGPSs) are widely used. They ensure the accuracy of 3-8 m with 95% probability, i.e. with position accuracy expressed by the two distance root-mean-square errors (2 drms). This accuracy is sufficient for the realization of the most traditional ships' special tasks. However, besides the traditional ships' special tasks, there have been arisen and are further arising the new ships special tasks. The permanently growing the exploration and exploitation of the sea-bottom resources, as well as, being-in-progress, the process of transition of the naval warfare activities from the sea surface to the sea-subsurface, and to sea bottom, results in the permanent increasing the demand for organization and realization of the navigational and hydrographical provision of ships' special tasks. Therefore, now, there is needed not only the accuracy of 1-5 m (2 drms), and in many cases much more higher, but there is also needed the additional new kinds of underwater information, particularly, the hydrographical one.

The main reasons for organizing and realizing the navigational and hydrographical provision of ships' special tasks are:

- the huge demand for comprehensive underwater information, especially for sea-bottom information, including not only sea-bottom-sediment information but also information regarding hydroacoustical, hydromecanical, and other kinds of sea – bottom properties,
- the increased demand for precise conducting the ships along the planned tracks, or for maintaining by them the fixed positions, while performing their special tasks,
- the necessity to satisfy very high accuracy requirements for manned and unmanned underwater vessels and their activities.

In the last 20 years, the huge progress took place in the development of the electronic position-fixing systems, especially their differential variants; in the development of the echosounders and soners; and in the automation and computerization of the ships' navigation systems and their integration with other ships systems, particularly, with ships tasks realization's systems.

The above mentioned progress influenced also in very high degree the means and ways of navigational and hydrographical provision of ships' special tasks.

Below, there are discussed the following issues of navigational and hydrographical provision of ships special tasks:

- the types of ships tasks and definition of ships' special tasks,
- the ship's navigation process as the function of the type of ships tasks,
- the substance and definition of the navigational and hydrographical provision of the ships' special tasks
- the realization's possibilities of the carrying on the navigational and hydrographical provision of ships' special tasks,
- the development trends of navigational and hydrographical provision of ships' special tasks.

1. *The types of ships tasks and the definition of ships special tasks*

Each ship, both combat and non-combat, is built, equipped and trained to fulfil one or several tasks. Many ships, such as transporting, fishing, hydrographic, etc. Are one-purpose ships. Now, there are also developed the new kinds of one-purpose ships for new kinds of human activities at sea, particularly, for exploration and exploitation of the sea-bottom

resources. However, the combat ships are, as a rule, the multi-purpose ships. This principle is being strengthened and deepened. The idea of building "the arsenal ships" and many similar events, corroborate this principle. Besides the above ships, there are also developed and deployed the new and new kinds of manned and unmanned underwater vessels, chiefly for waging special warfare activities in coastal waters, in harbours, etc., and for technical supervising and maintaining the facilities of the sea-bottom-exploitation industries.

The tasks of all ships can be divided into three following groups:

- transporting tasks,
- sea-surface tasks,
- underwater tasks.

The main criteria of such division of ships' tasks are the following ones:

- where is situated the object of ship's tasks,
- what kind of additional information is needed for realization of this kind of ship's tasks,
- how the standard navigation subprocess should be modified to realize this kind of ships' tasks.

To the group of ships' transporting tasks can be included the following tasks:

- transport of goods and persons,
- sea-tourism,
- yachting and boating (rowing, sailing and cruising), and many other similar tasks.

This group of tasks is being characterized by the following facts:

- the object of ship's tasks is located on board of own ship,
- there is not needed any other additional environmental information, apart from information which is needed for safe and efficient conducting the ships at sea, i.e. for realization of the ships' standard navigation process,
- there is not needed any modification of ship's standard navigation subprocess (cf. Fig.2).

To the group of the ships' sea-surface tasks can be included the following tasks:

- anti-air warfare tasks,
- anti-surface warfare tasks,
- strike warfare tasks,
- electronic warfare tasks,
- sea-logistic tasks,
- ensuring the "maritime safety" tasks (maintaining the operation of navigational infrastructure; operating the ships navigation assistance service; operating search and rescue service; operating the marine environment protection service, and others),
- maritime law enforcement tasks (interdiction of smuggling and drug trafficking, prevention of illegal immigration, enforcement of fishing control regulations, protection of off-shore resources, etc.).

This group of tasks is being characterized by the following facts:

- the object of ships' tasks is located outside the ship, at the sea surface or above it,
- there is needed more comprehensive hydrometeorological information,
- there is needed the modification of the ship's standard navigation subprocess, i.e. "the ships maneuvering and handling subprocess" (cf. Fig. 3).

To the group of the ships' underwater tasks can be included the following ones:

- anti-submarine warfare tasks,
- mine warfare tasks (mine laying and carrying on the mine countermeasures),

- special warfare tasks,
- the amphibious warfare tasks,
- hydrographic surveying,
- establishing the floating aids to navigation,
- oceanographic investigations,
- geophysical surveying,
- geotechnical investigation and well drilling,
- setting up the off-shore platform construction,
- pipe and cable laying,
- off-shore structures monitoring,
- dredging,
- searching and removing the underwater obstacles,
- underwater archeology searching, and many other tasks.

This kind of tasks can be characterized by the following facts:

- the objects of the ships' tasks are situated outside the ships and under the water,
- there is needed more exact and more comprehensive underwater information, i.e. oceanographic, hydrographic, and very often, the geophysical information,
- there is needed the modification of these ship's standard navigation subprocesses which unable the accurate conducting the ships along planned tracks, or maintaining them over fixed positions, while performing their special tasks (cf. Fig. 4).

However, the ships' underwater tasks are not homogenous. They can be divided into the main subgroups:

- the ships underwater tasks whose tasks' objects are situated below the sea-surface, but they are not durably connected with the fixed positions of the sea bottom,
- the ships' underwater tasks whose tasks' objects are situated under the sea-surface and they are constantly connected with the fixed positions of the sea bottom.

To the first subgroup of the ships' underwater tasks belong such tasks as:

- submarine warfare tasks,
- oceanographic investigation tasks,
- sea fishing tasks and other similar tasks.

The navigational and hydrographical provision of the above subgroup of the underwater ships' tasks is similar the navigational and hydrographical provision of ships' sea-surface tasks, and, therefore, they are not subject of further considerations.

To the second subgroup of the ships underwater tasks belong all other underwater tasks, i.e.:

- mine warfare tasks (mine laying, mine sweeping, mine hunting, mine demolishing),
- special warfare tasks,
- amphibious warfare tasks,
- hydrographic surveying,
- establishing floating aids to navigation,
- geophysical surveying,
- geotechnical investigation and well drilling,
- off-shore platform constructing,
- pipe and cable laying,
- dredging,

- searching and removing the underwater obstacles,
- underwater-archeology searching and others.

Only the second subgroup of the ships underwater tasks are considered as the ship's special tasks and so they are understood in this article.

2. *The ship's navigation process as the function of the type of the ships tasks*

The ship can be considered as a super system composed of the four systems each of which realizes the proper ship's process, i.e. (Fig. 1) [8]:

- ship's command and control process,
- ship's propulsion and energy supplying process,
- ship's navigation process,
- ship's tasks realization process.

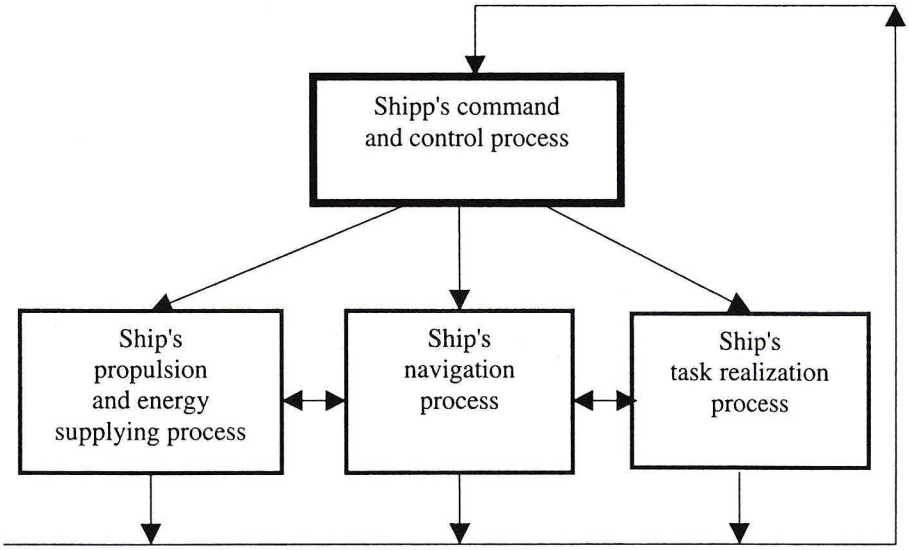


Fig.1. The ship's navigation process as the constituting part of the ship's assignment process

It is obvious that the ship's navigation process must be adapted to the types of ship's tasks.

In the Table 1, there are shown the main features of the ship's navigation process, being the function of the type of ships' tasks.

In the Fig. 2, there is shown the ship's standard navigation process and its subprocess.

In the Fig. 3, there is shown the ship's expanded navigation process, i.e. the modified ship's standard navigation process for realization of the ships' sea-surface tasks.

In the Fig. 4, there is shown the ship's standard navigation process adapted for realization of the ship's special tasks.

T a b l e 1. The main features of ship's navigation process as a function of the type of the ships' tasks.

Kind of ships' tasks	Ships'	Ships'	Ships'
Main features of ship's navigation process	transporting tasks	sea-surface tasks	special tasks
Name of ship's navigation process	Ship's standard navigation process	Ship's expanded navigation process	Ship's special navigation process
Main objective of ship's navigation procsess	Safe and efficient conducting the ship from one place to another	Safe and efficient conducting the ship from one place to another and facilitating realization of her sea-surface tasks	Safe and efficient conducting the ship from one place to another and enabling realization of her special tasks
Main modification of the ship's navigation process	Not any modification of the standard ship's navigation process	Modification of subprocess: inf = information acquisition, ... etc., man = maneuvering and handling the ship,	Further modification of the subprocess: inf = information, etc. and modification of subprocess; pln = voyage planning, etc. pos = ship's positioning
Number of figure illustrating the ship's navigation process	Fig. No 2	Fig. No 3	Fig. No 4

3. *The substance of the navigational and hydrographical provision of the ships' special tasks*

Before defining the purpose, objectives and substance of the navigational and hydrographical activities constituting the navigational and hydrographical provision of ships special tasks, several remarks should be done to confine the subject of the further considerations:

- the activities of the navigational and hydrographical provision of ship's special tasks do not include the activities whose objective is only "the safe and efficient conducting the ship at sea from one place to another" i.e. the activities which comprise the standard navigation process, but only these additional activities which enable and ensure the realization of ship's special tasks (cf. Fig. 2 and 4),
- the ship's navigation process of the ships carrying on their special tasks is being realized now by the means of the special navigation systems, i.e. by the systems which realize the ship's special navigation process, at it is shown in Fig. 4 [8],

- the main objective of the activities constituting the navigational and hydrographical provision of ships special tasks is to create and maintain such additional conditions which make possible for the ships to perform their special tasks.

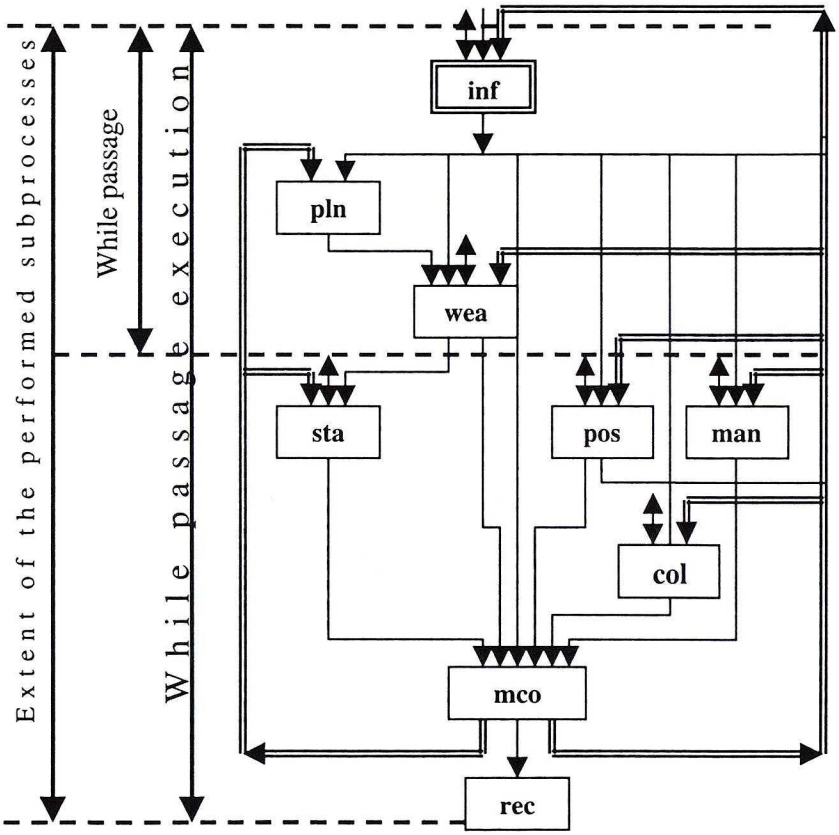


Fig. 2. The (standard) ship's navigation process and its subprocesses

- name of the ship's navigation subprocess. The names of the subprocesses are given in the text,
- received and own information,
- ship's measurements and observation,
- feedback and control information

inf = information acquisition and storing, pln = voyage planning, wea = weather - damage minimizing, sta = stabilizing ship's course or track, pos = ship's positioning, man = ship's maneuvering and handling, col = collision avoidancse, mco = monitoring and controlling ship's navigation process, rec = ship-voyage-data recording

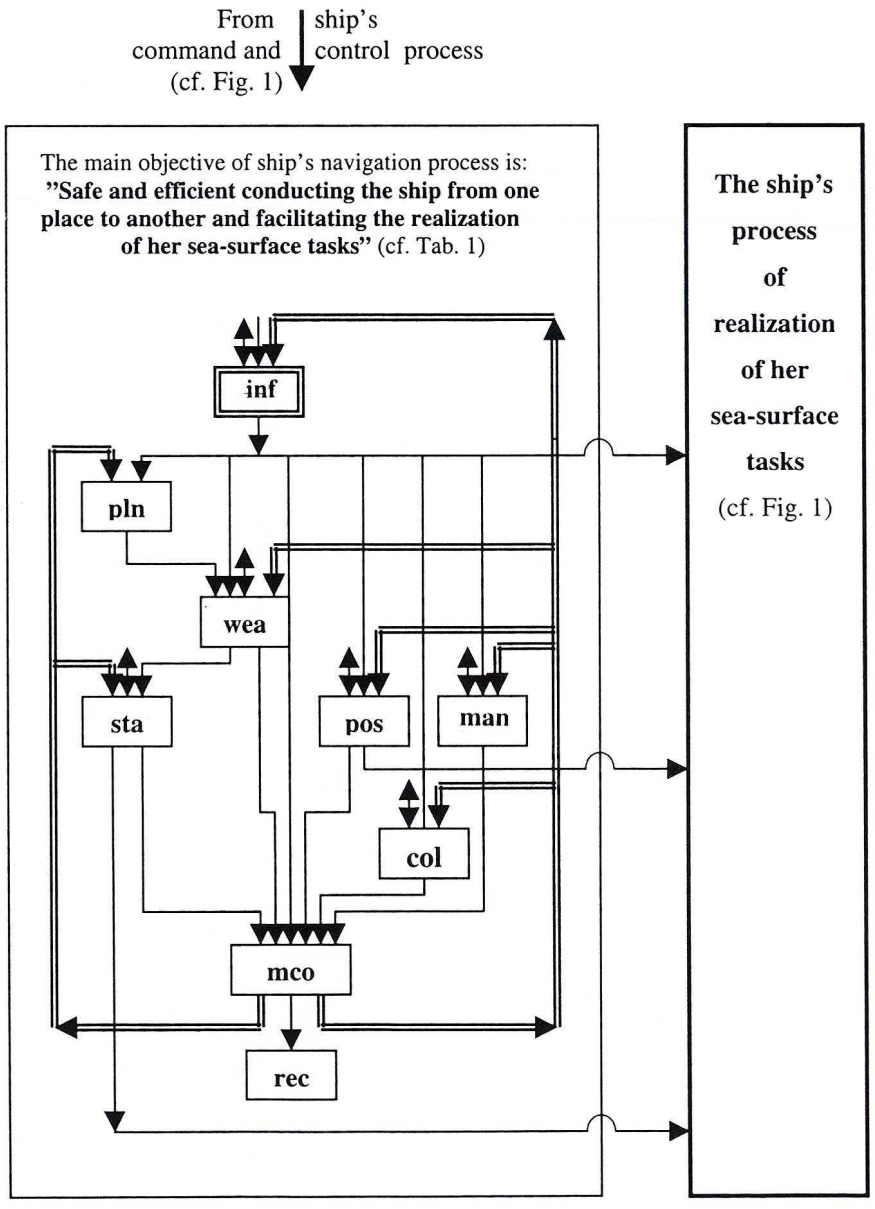


Fig. 3. The ship's navigation process adapted for realization of ship's sea-surface tasks. (cf. also Fig. 2);

pos - standard navigation subprocess

inf - modified navigation subprocess,

↔ - measurements and observations

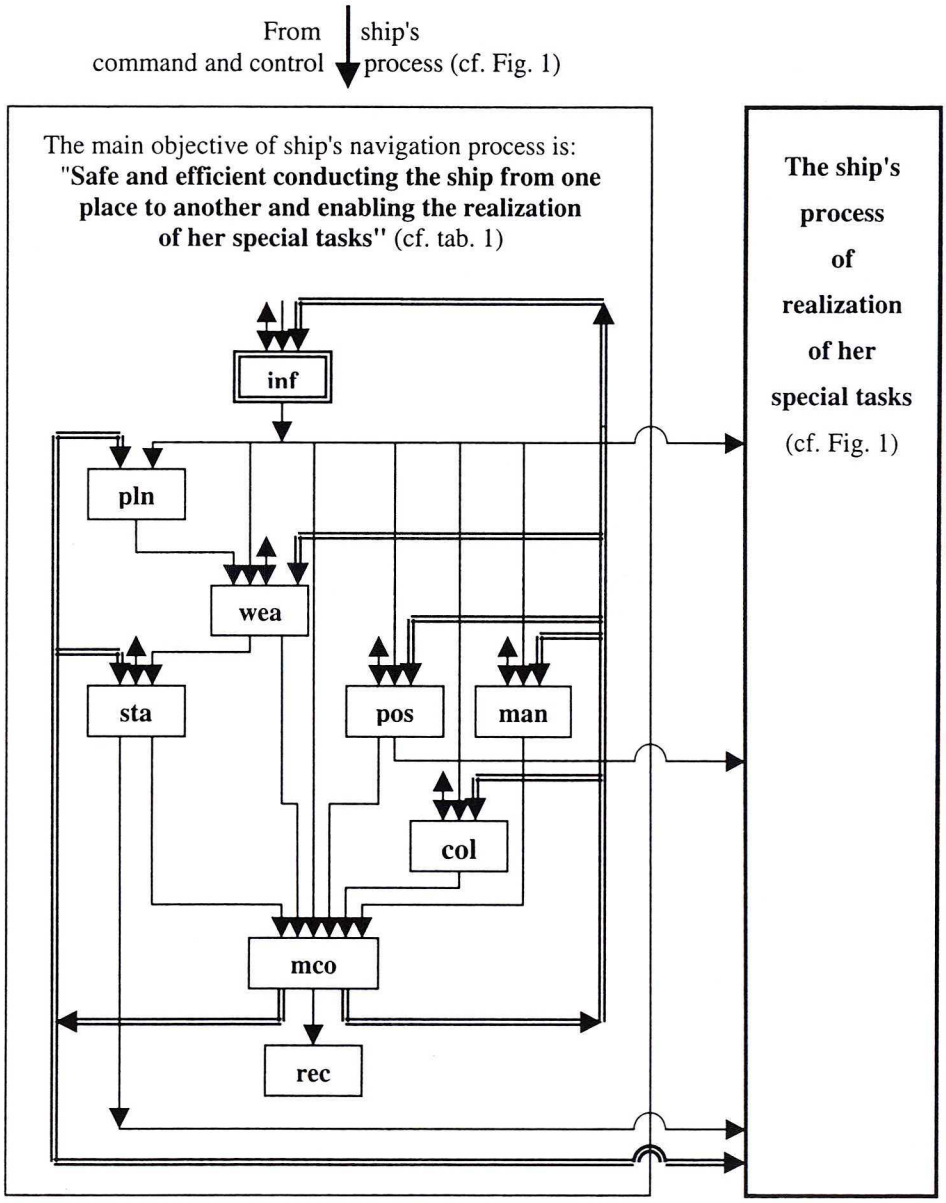
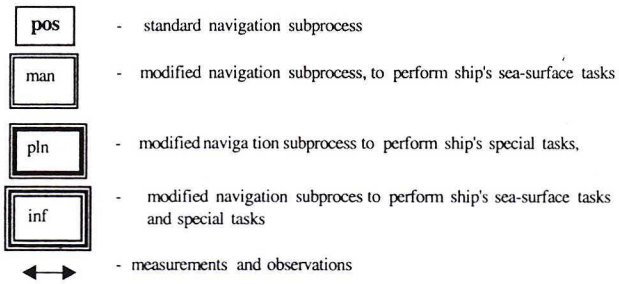


Fig. 4. The ship's navigation process adapted for realization of ship's special tasks



The additional navigational and hydrographical activities which should be done to enable the ships to perform their special tasks comprise two kinds of activities:

- first kinds of navigational and hydrographical activities constitute these activities whose main objective is supplying the ships with additional underwater information, particularly, with the additional hydrographical information necessary for carrying out their special tasks. The most suited presentation form of such information are the charts (paper and digital), usually in very great scale, presenting the needed kinds and form of presentation of sea-bottom information of the areas where the special tasks are going to be performed.
- the second kinds of additional navigational and hydrographical activities constitute these activities whose main objective is to increase the ships positioning accuracy to the necessary level for ensuring the realization of the ship's special tasks. These activities comprise usually the establishing the additional aids to navigation, including special electronic position-fixing systems.

However, the above remarks call for additional explanations:

- the today's navigational activities constituting the navigational and hydrographical provision of ships special tasks are composed of the activities which almost do not belong to the standard ship's navigation process. They create only the necessary conditions outside the ships, i.e. they create the additional sources of the underwater information, particularly, the sources of the hydrographical information. They also create the additional elements of the navigational infrastructure, which enable the ships to be conducted along the planned tracks with needed accuracy, or to be maintained in the fixed positions. It should also be mentioned that in the not very distant past, i.e. even then when the electronic position-fixing systems were not yet fully automated, it was necessary to provide many additional procedures to ship's navigation process (prepare special plotting sheets, plot manually the planned ship's track, etc).

Taking into account the above considerations, the main objectives of the navigational and hydrographical provision of the ships' special tasks can be defined as follows:

"The main objective of the navigational and hydrographical provision of the ships' special tasks is to create and maintain the necessary additional navigational and hydrographical conditions which enable the ships to perform their special tasks".

The main substance of the navigational and hydrographical provision of the ships' special tasks constitute the activities belonging to two main kinds of navigational activities, i.e.:

- the activities dealing with gathering and suplying the ships with additional kinds of hydrographic information necessary for realization of the ships special tasks,
- the activities dealing with improving the local navigational infrastructure to ensure the conditions for conducting the ships along planned tracks or maintaining them in the fixed positions with the required accuracy.

4. *The realization possibilities of the navigational and hydrographical provision of ship's special tasks*

It can be assumed as a dogma that the realization of the ships' special tasks needs the preparation and carrying on the navigational and hydrographical provision of the ships' special tasks (cf. section 2 and Fig. 4).

The second dogma is that the navigational and hydrographical provision of ships special tasks comprise always the following activities of the navigational support, i.e.:

- supplying the ships with the proper additional hydrographic information, particularly, with bathymetric data, which include also the hydroacustical and hydromechanical properties of bottom – sediments strata,
- establishing the additional proper electronic position-fixing systems ensuring the required positioning accuracy for ships carrying on their special tasks,
- fitting the ships with the proper additional shipborne navigational systems enabling the ships to be conducted along the planned tracks or maintained at the fixed positions with required accuracy, and enabling proper cooperation with ships special tasks realization systems (cf. Fig.1 and 4).

Although the navigational and hydrographical provision of ships special tasks always comprise all the above activities, there is a lot of differences in preparation and realization even of similar ships special tasks. These differences depend upon many reasons, but mainly on:

- the kind of the realized ships' special tasks, i.e. technology of carrying on this kind of special tasks (dredging, pipe lying, mine sweeping, mine hunting, etc.),
- location of the areas where this kind of special tasks is to be performed,
- the experience regarding the realization of navigational and hydrographical provision of this kind of special tasks (whether this special tasks is realized first time or it is a common special task).

However, the most important factor influencing the quality of preparation and realization of navigational and hydrographical provision is the possibility of procuring and therefore, having for disposal the modern means of the navigational and hydrographical provision of ship's special tasks. The degree of the up-to-dateness of being to disposal of the technical equipment and systems of navigational and hydrographical provision is the main factor deciding upon the navigational activities to be performed while preparation and realization's phases of the navigational and hydrographical provision of ships' special tasks. The range of the possible solutions is really very broad (e.g. paper charts, and plotting sheets or ECDIS).

For sea bottom examination and, therefore, for supplying the ships, realizing special tasks, such as pipe laying, dredging, searching the wrecks, etc. – with the necessary hydrographical information, can be applied a lot of various types of sea-bottom-examination systems. The technological progress in this area is tremendous, especially during the last 20 years. The following types of echosounders and sonars are most representative [11]:

- monochromatic one beam echosounders,
- monochromatic multibeam echosounders,
- side-scan sonars and side-looking sonar's (towfish sonar's),
- search sonars,
- mixed echosounders (one beam echosounder and side-looking echosounder),
- two and more frequency echosounders,
- parametric echosounders,
- "chirp" sonar's and others.

For example, there is a broad variety of multi-beam echosounders. They can incorporate from 2 to 180 beams which are transmitted from one or two transducer arrays. The angular coverage sectors, i.e. the beam sector, are contained within the sector range from about 60° to 160°. The sounding systems provide high precision mapping with 100 percent coverage. The wide of swath can reach 8 depths. They allow also 3-D presentation. These systems are now most modern. But they are yet very expensive. However, they are expected to be commonly used in several years. The horizontal scanning sonar's (search sonar's) are now highly accurate

survey tools. They can easily locate even 2-inch wire at 40 m distance. For investigation and classification of sea-bottom sediments, there are applied two and more frequency echosounders, "chirp" sonars and others.

T a b l e 2. Marine surveying accuracy requirements for several kinds of ship's special tasks.

Kind of ship's special tasks	Accuracy (2 drms)
Charting – harbours and warfs	1-2 m
– roadsteads and anchorages	5-10 m
– coastal waters	10-25 m
Sea Floor Mapping EEZ (200 N.M.)	66 m
Establishing navigational aids in restricted waters	3 m
Defining territorial boundary (12 N.M.)	10 m
3-D seismic survey	10 m
Pipe laying	2-20 m
Site survey recovery and reentry	10-20 m
Construction works	1-2 m
Dredging	2-10 m
Mine hunting	2-5 m
Future 3-D seismic survey	25 cm
Offshore structure monitoring (static)	cm – level

T a b l e 3. The available accuracies for navigational and hydrographical provision of ship's special tasks and adequate electronic position fixing systems [2], [5], [9], [14]

Level of available (2 drms)	Kinds of Electronic Position-Fixing Systems	Range (NM)	Remarks
5–25 m	2 MHz Phase Comparison Systems (Radist, Hyperfix, etc.)	100–180	
5–10 m	Differential Global Positioning Systems	150–200	
1–5 m	Microwave Direct Range Systems (Trisponder, Syledis, Artemis, etc.)	horizontal (20-25)	
	European Geostationary Overlay System (EGNOS)	regional	by 2003
	Modified GPS System	global	
	GALILEO System	global	by 2008 by 2009
0.5-1 m	Microwave Phase Comparison Systems (Tellurometer, etc.), and Laser Systems	horizontal	
cm-level	After implementing technology using the GPS Differential Carrier Phase Techniques		The search and tests proved the possibility of centimeter level real-time positioning

For the navigational and hydrographical provision of ships' special tasks, there are used very different electronic position fixing system. In the Table 2, there are shown the marine surveying accuracy requirements for several ships' special tasks.

In table 3, there are shown the available levels of accuracy for navigational and hydrographical provision of ships' special tasks and adequate land and space-based electronic position-fixing systems.

The data presented in this section corroborate the truth that there exists now a wide variety of means for carrying on the navigational and hydrographical provision of ship's special tasks, particularly for navigational support of special tasks performed by the combat ships.

5. *The development trends of the navigational and hydrographical provision of ships special tasks*

The development trends of naval warfare activities, as well as development of the other kinds of human activities at sea indicate explicitly that more and more human activities are performed under the sea surface, in the vicinity of the bottom, on sea bottom, in bottom sediments, and even beneath the sea bottom. There are also more and more manned and unmanned underwater vessels not only for special warfare activities and mine warfare activities but also for new and new kinds of underwater industrial activities, such as assembling, supervising, and maintaining the operation of the underwater exploitation infrastructure, etc.

The above mentioned situation results in coming into being the new or the higher requirements for the means of navigational and hydrographical provision of ships special tasks, but especially for:

- higher and higher positioning accuracy,
- new kinds of bathymetric and geophysical information including the information regarding the hydroacustical and hydromecanical sea-bottom sediments,
- further perfection of navigation systems of ships realizing the special tasks.

It is obvious that the permanent development of science and technology in our "information age" will be able to satisfy all the new and higher requirements for navigational and hydrographical provision of ships' special tasks.

Below, there are presented the most probable development trends of the navigational support of ships' special tasks.

The first trend consists in the development of the ships organic possibilities of permanent carrying on the navigational and hydrographical provision of ships' special tasks by the ships themselves. Almost all combat ships are getting more and more multi-purpose ships. For example, each combat ship should be also able, in the near future, to carry on some mine countermeasures activities (e.g. mine avoiding, mine hunting, mine demolishing). Therefore, the combat ships are getting also to be so equipped that they will be able to carry on permanently their special tasks. The above possibility is of most importance for all mine-warfare ships.

The ensuring the organic possibilities of carrying on the navigational and hydrographical provision of ships' special tasks by the ships themselves means that that the following requirements must be fulfilled:

- there must be available the space and/or coastal electronic position-fixing systems ensuring permanently the required positioning accuracy,

- the ships must be permanently supplied with the necessary underwater information [3],
- the ships navigation systems, being the constituting parts of the integrated ship's operation control systems, should realize the navigation process proper for ships performing the special tasks (cf. Fig. 4)

It is obvious that the organic possibilities of navigational support of ships' special tasks will be also developed by the one-purpose ships realizing the navigational activities belonging to the navigational and hydrographical provision activities (hydrographic and geophysic survey, establishing and maintaining floating aids to navigation, and others).

The second trend of the navigational and hydrographical provision of ships special tasks consists in the development of dedicated means and tools of navigational and hydrographical provision of ships' special tasks. There are created and maintained the special integrated navigational and hydrographical provision's services.They comprise, besides the classical navigational and hydrographical services, also the geophisical and geodesical services. They are composed of special built and equipped ships and underwater vessels and also own coastal electronic position-fixing systems. This trend regards mainly the marine industries exploring the resources, building the infrastructure and exploiting crude oil, gas and other sea-bottom deposits [4]. It means that the big sea-bottom resource-exploitation companies create their own services of navigational and hydrographical provision of the activities of these companies. These services comprise mainly the means of navigation and hydrogeodesic service. It is worth to emphasize here that more and more geodesic methods are becoming gradually the navigational methods. It is the result of that the real-time positioning are methods are approaching the accuracies comparable with the accuracies of geodesic methods (cf. Table 3).

However, besides the two above mentioned development trends of the navigational and hydrographical provision some ships' special tasks will remain outside the two main development trends. Moreover, there are coming into being the new ships' special tasks. Therefore, the classical methods of navigational and hydrographical provision, organised and maintained, when and where necessary, by the navigational and hydrographical services of the navies or other maritime institutions, will be further maintained and perfected. Nevertheless, the old means and tools of the navigational and hydrographical provision will be permanently changed, i.e. replaced be the more and more new means and tools of the navigational and hydrographical provision of ships' special tasks.

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Zdzisław Kopacz
Wacław Morgaś
Józef Urbański

Nawigacyjne i hydrograficzne zabezpieczenie zadań specjalnych okrętu. Stan i tendencje rozwoju

Streszczenie

W artykule przedstawiono podstawowe zasady nawigacyjnego i hydrograficznego zabezpieczenia zadań specjalnych okrętu. Wyspecyfikowano rodzaje zadań a w szczególności zadań specjalnych. Scharakteryzowany został proces nawigacji okrętu w funkcji jego zadań. Przedstawiono także zakres nawigacyjnego i hydrograficznego zabezpieczenia zadań specjalnych okrętu oraz tendencje jego rozwoju.

Здислав Копач
Вацлав Моргась
Юзеф Урданьски

Навигационные и гидрографические обеспечение специалных задач кораблей. Состаяание и пути развития

Резюме

В статье представлено основные виды навигационного и гидрографического обеспечения специальных задач корабля. Формулируются виды задач корабля, а особенно специальных задач кораблей. Расматривается тоже содержание навигационного и гидрографического обеспечения специальных задач кораблей, в том числе пути развития их обеспечения.