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## **THE STATE OF NAVIGATION DEVELOPMENT IN POLAND AT THE TURN OF THE 20TH CENTURY**

### **ABSTRACT**

In this paper there are presented the basic and common problems of all kinds of modern navigation, in Poland, on the turn of the 20-th century. The attempt is made to present the basic trends of navigation's development which will still be valid in the first decades of the 21-st century. a special regard has been taken to the Polish Navigational Forum, i.e. to the Polish educational and research institutions and circles professionally engaged in the different kinds and aspects of today's navigation.

### **INTRODUCTION**

Navigation can be considered as a kind of human activity, as a profession, as a branch of learning, and as a branch of applied science.

This kind of human activity consists in "the safe and efficient conducting the craft from one place to another in the proper physical and geographical environment". The term "navigation", considered as a kind of human activity – but in more precise and professional form – is defined as "the process of safe and efficient conducting the craft from one place to another in proper environment".

By the notion "craft" we mean a manned, moving object, such as a ship, submarine, underwater vehicle, airplane, helicopter, space shuttle, land vehicle, etc.

According to the kind of environment, it is accepted to identify the following kinds of navigation:

- sea, i.e. maritime navigation,
- air navigation,
- space navigation, and
- land navigation.

Below, there are discussed only the common problems of all kinds of navigation. The peculiarities and differences, although numerous and important – especially between the land navigation and all other kinds of navigation – due to the lack of space, have been omitted in this paper. However, some special regard is done to the maritime navigation. The last one is still most representative, at least, in our country.

However, one question should be emphasized here. The more and more extended area of human activity is considered as a “navigational activity”, i.e. as a part of maritime navigation. For example, the activity regarding the creation and maintaining the “navigation’s safety”, as well as “ensuring the safety and navigational efficiency of special ships’ tasks”, such as combat, exploring, and exploiting tasks, are also considered now as navigational activity, i.e. as a part of maritime navigation.

The following problems are presented below:

- navigation, its participants, its process and its subprocesses,
- navigation as a profession, as a branch of learning and as a science,
- present-day navigation and main trends of its development,
- cooperation of navigators and geodesists in Poland,
- Polish Navigational Forum and its tasks at the beginning of 21-st century.

### **NAVIGATION, ITS PARTICIPANTS, ITS PROCESS, AND ITS SUBPROCESSES**

The craft, being conducted from one place to another, is not self-dependent. The main participants of craft navigation process, which participate and influence on the craft safety and its conducting’s efficiency, are:

- craft, its crew, and its navigational equipment and systems,
- geographical environment,
- the other craft participating in the traffic,
- navigation safety system.

The main components of the “safety system” of each kind of navigation are:

- navigational infrastructure systems,
- traffic control and management systems,
- standards and procedures regarding all aspects of navigation.

From the operational point of view, the craft navigation process can be divided into the following subprocesses (fig.1):

- collecting and updating the navigational safety information (inf),
- determining the craft trajectory (tra),
- steering the craft in accordance with the chosen trajectory (ste),
- positioning the moving craft (pos),
- correcting the trajectory and vector of craft motion (cor),
- avoiding the collision (col)
- minimizing the influence of adverse environmental conditions (env),
- recording the craft voyage data (rec).

The navigation processes are carried out by the variety of ways and means, beginning with the relatively simple means, and ending with the employing very modern on-board navigational systems, being the parts of the craft operation control system, as well as the parts of craft outside navigation assistance systems.

For example, the space shuttle vehicles use very sophisticated “guidance, navigation and control systems”.

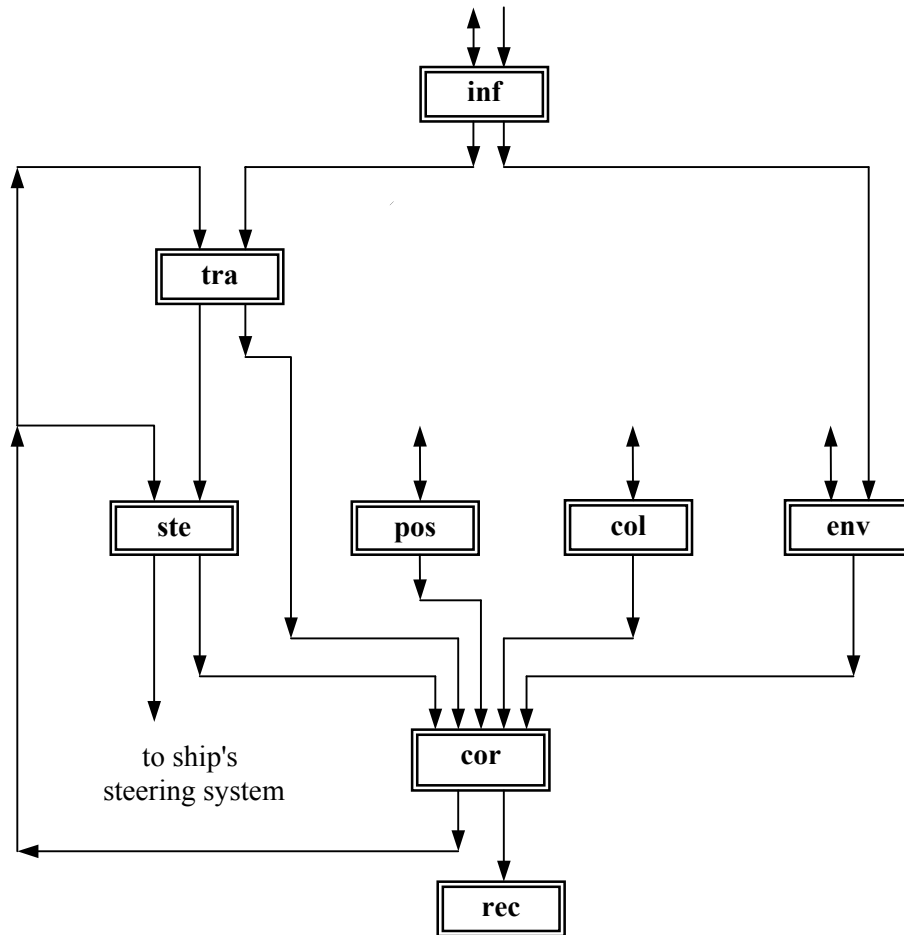


Fig. 1. The subprocesses of the craft navigation process

Notation in Fig. 1

- inf - information flow
- $\longrightarrow$  - craft measurements and observations.
- $\longleftrightarrow$  - name of the craft navigation subprocess. These names are given in the above text



## **NAVIGATION AS A PROFESSION, AS A BRANCH OF LEARNING, AND AS A SCIENCE**

The questions announced by the title of this section are discussed and presented mainly in relation with the maritime navigation.

Each sea craft, i.e. each ship realizes her proper tasks, i.e. her proper operational functions.

The ship's operational function of each ship consists of, at least, three following functions:

- ship's platform control function,
- ship's navigation function,
- ship's main tasks realization function.

The ship's platform control function comprises:

- ship's propulsion and energy supplying,
- ship's internal safety and damage control function.

Ship's main tasks realization functions differ considerably, according to ships' kinds (transporting, fishing, combat, auxiliary, special ships, etc.), and according to ships' classes and types.

The navigational function, always, and two other functions – but only at operational level of responsibility – are performed by two kinds of ships' professionals, i.e.:

- navigation's engineers,
- ship's platform control engineers (marine engineers).

Main form of realization of ship's functions is ship's navigational watch. However, by means of navigational watch not only the navigational function is realized but also, in great measure two other ship's functions.

The general and well known tendency, regarding the realization of the ship's operation function, consists of integration of all ship's functions into only one function, i.e. into the ship's control and management function. That function will be realized in the form of ship's operation control watch whose main part is the function of "safe and efficient conducting the ship at sea".

Taking the above into consideration, the following conclusion, concerning the question of "navigation as a profession", can be stated: the navigational profession remains now the main ship's profession, but in the near future, it will be only-one ship's profession. However, it should be emphasized that the navigational profession should be considered as a profession which enables not only the safe and efficient conducting the ship but also operating all ship's control systems which, in great measure, will be automated. Therefore, the profession of "navigation engineer" may be, and even should be considered, now as "an operator of integrated bridge system", and, in the future, as "an operator of ship's control and management system". However, the last kind of ship's watch regards the highest, i.e. the management level of responsibility.

The term "profession" is understood here as "an occupation requiring advanced, i.e. university or college education and training, and involving the intellectual skill".

The navigational profession is being acquired in Poland as a result of graduation of the “navigational engineering studies”. The curricula of such studies comprise many branches of learning. One, and the most important branch of studying is the branch of navigation’s learning which comprises several navigational subjects. The main field of “navigation engineering studies is defined by a major” of such studies. In this case “the major” is “navigation” or one of its subject.

The notion and contents of term “navigation”, considered as “a branch of learning”, is determined mainly by the being-in-force international requirements, such as Convention 1978/1995 on “Seafarers Training, Certification and Watchkeeping” (STCW). In this Convention, there are presented the required “competencies”, as well as “knowledge, understanding and proficiencies” necessary for performing the duties on ships. There, all the data which should be contained in the curriculum of the whole branch of learning of the navigational subjects are specified.

The main areas of the navigational knowledge needed for safe and efficient conducting the ship can be, approximately, specified as follows:

- physical and geographical characteristics of environment and their influence upon craft motion and craft safety,
- navigational and maneuvering characteristics and properties of the craft,
- aids to navigation and navigational infrastructure,
- navigational safety information system and its use,
- craft navigational equipment and systems,
- methods of trajectory determination and modification,
- methods and procedures of dead-reckoning navigation,
- methods of craft positioning, including the astronomical ones,
- methods of correcting the craft trajectory and craft motion vector,
- procedures of collision avoidance,
- procedures of minimizing the influence of adverse environmental conditions,
- methods and procedures of ensuring the safety of craft, personnel, and environment,
- methods and procedures of use the traffic control and management system, i.e. the craft navigation assistance systems,
- search and rescue methods and procedures,
- craft emergency procedures.

The above list of navigation knowledge’s areas, but without the list of navigation’s proficiencies, can be considered as an exemplary set of the basic navigation knowledge.

The “navigation” is also an applied science, i.e. the branch of applied sciences. The term “branch of applied science” – as opposed to the term “branch of learning”

(branch of study) – means such branch of professional learning which fulfils the following requirements, i.e. which posses:

- specific knowledge domain,
- specific research area,
- specific research methods,
- qualified research personnel,
- internationally recognized research achievements.

The maritime navigation research area, i.e. the maritime navigation research subjects, can be defined as follows:

- process of navigation, i.e. the examination, modification, and adaptation of ship's navigation subprocesses and their components to the being changed traffic conditions – to ensure the proper state on navigation safety,
- maritime navigation safety system, i.e. examination and adaptation of the navigational standards and procedures; navigational infrastructure; and traffic control and management systems, to the being changed traffic conditions – to ensure the proper safety of human activities at sea,
- adaptation of ships' navigation processes to the realizations' requirements of the special tasks, such as combat, research, exploitation and other tasks – to ensure the proper safety and the highest efficiency of realization of these tasks.

The term “the being changed traffic conditions” which is used in the above definitions, should be understood as “the changes of scientific, technological, economical, environmental, legal, social, operational, and political factors which influence the navigation's development and state of navigation safety.

To perform the research in the above research areas, there is also needed the knowledge concerning the proper knowledge's areas of one or some of the following sciences:

- geodesy and sea hydrography,
- arrangement of the navigational infrastructure,
- traffic engineering,
- environmental protection,
- international and national maritime law,
- knowledge regarding ship's special tasks and their realization processes.

Each science uses its own research methods and procedures. Navigation uses mainly the following research methods:

- observation or/and measurements, and methods of their mathematical (and statistical) processing,
- experimentation and testing,
- logic inference,
- mathematical modeling and computer-aided simulation,
- heuristic methods.

Navigation uses also readily the specific research techniques, applied by sciences which are close to navigation or which the navigation “cooperates” with.

## **PRESENT – DAY NAVIGATION AND MAIN TRENDS OF ITS DEVELOPMENT**

The most important influence upon the state and development of navigation, after the Second World War, has exerted and still exerts the following technical sciences:

- electronics,
- computer science,
- space technology.

Unfortunately, there is no place to discuss, even superficially, the influence of the above sciences upon navigation. Nevertheless, one thing is sure. The state of today's navigation would have been not the same if these technical sciences had not existed.

The modern technologies, but especially the space technology, has the special importance for all kinds of navigation. The global positioning systems are the best examples. The GPS, GLONASS, and the differential variants of the GPS have changed radically not only the positioning subprocess of all kinds of navigation but also all other navigation subprocesses. Another huge influence upon navigation has exerted and further exerts the satellite radiocommunication systems, such as INMARSAT and other similar systems. The space navigation would never come into being without satellite radio communication. The last one is of the greatest importance for all kinds of modern navigation. It is enough to mention the Global Maritime Distress and Safety System, and similar systems of air and space navigation. The development of "smart" navigational systems, is the other example of the influence of the scientific and technological achievements upon navigation. Every several years, there are being employed the new generations of more sophisticated and more "intelligent" on-board navigational systems.

The change in the access to the "archival" navigational safety information, and its processing (ECDIS, etc.) are one of several latest technological achievements whose employing is under way.

Let us try to define the main trends of the navigation development in the first decades of the 21-st century. The authors' belief is that the following trends will be continued:

- full employment of the European Geostationary Overleap System (EGOS) and other regional Satellite Based Augmentation System (SBAS), i.e. full employment of GNSS-1,
- full employment, in second decade of 21-st century, the GNSS-2,
- more extensive introduction, especially in maritime navigation, the international traffic control and management systems,
- further "internationalization", except the land navigation, all aspects of navigation, including the language,
- further automation of craft navigation subprocesses, and further integration of the navigation process with other craft on-board processes,

- further implementation of the positioning techniques and technologies to the new areas of human activities, especially to the whole land traffic, including even humans' movement,
- there are coming into being the new specializations of navigation profession, especially, of maritime navigation.

When being asked about the most characteristic trends of navigation development in the first decades of 21-st century, the answer is:

- unprecedented development of land navigation,
- further automation of the craft navigation process and its integration with other craft processes in one craft operation control process,
- the considerable increase of remote control engineering in the craft navigation,
- the beginning of employment, not only in the military forces, the fully automated, i.e. unmanned craft, conducted by on-board computers or from outside.

The above prediction does not take into account the special kinds of navigation, such as "underwater" navigation, etc. This kind of navigation is being progressed by leaps and bounds. It is the result of transferring the sea warfare activities from the sea surface to the subsurface. It takes place in all inshore areas. The nontraditional navigation techniques are here of special value.

The navigation development in the next decades in Poland, especially the development of Poland's navigational infrastructure, as well as the traffic control and management systems, will be greatly influenced also by the political factors, i.e. by the Poland's membership of NATO, and by beginning the admission procedures regarding Poland's access to the European Union. Poland will have to obey and fulfill not only all the navigational requirements issued by International Maritime Organization (IMO) and International Civil Aviation Organization (ICAO) but also much more sharp navigational requirements being in-force in NATO and EU countries.

### **COOPERATION OF BOTH NAVIGATION AND GEODESY COMMUNITIES IN POLAND**

The close cooperation of navigators and geodesists is not only the Polish phenomenon. It is rather the general one. This phenomenon is most noticeable in the post-industrial countries where the new kinds of navigation, i.e. space and land navigation are being developed very rapidly. However, the main reason of this phenomenon is the geodesy's aspiration, eagerness, and also a necessity to extend, and even, to change considerably its present areas of activities. The geodesy is well prepared and ready to undertake these new challenges. The geodesy has at its disposal the workers who possess the highest professional and scientific qualifications. However, there is also the direct reason for such close cooperation between these sciences. The employment of the global positioning systems and their differential variants is the main reason of such close cooperation. Owing to these systems, the positioning accuracy of navigation has considerably



approximated the accuracy of geodetic works. On the other hand, the real-time positioning, which in the past was applied only in navigation, can now be applied also in geodesy, especially in land surveying. There are also all prerequisites to ensure that in the future, because of the predetermined further huge increasing the positioning accuracy, the cooperation between navigation and geodesy will be yet much more wider and closer.

Another area of close cooperation of navigation and geodesy is the chart information, its processing and displaying.

The cooperation of navigators and geodesists in Poland has many forms, including the organizational forms which have also their expression in the structure of Polish science. We think here about the Navigation Section of the Committee of Geodesy of Polish Academy of Sciences.

In Poland, geodesy has its well established position. It possess perfectly educated workers having the highest qualifications and position in science management hierarchy. It possess, well-known in the world, educational and research institutions. However, navigation, considered as a branch of applied science, is comparatively young in Poland. Therefore, it has neither such educated scientific personnel nor such scientific achievements. Consequently, geodesy “holds care” of navigation. This care manifests itself in:

- creation and activity of the Navigation Section of the Committee of Geodesy of Polish Academy of Sciences,
- organizing the common workshops and scientific conferences,
- participation of the geodesy professors in the works of faculty councils of Navigation Faculties in Naval Academy and Air Forces College,
- undertaking and realization of the common research projects.

The navigation in Poland expects that geodesy will help it to gain much more scientific independence. Such independence should manifest itself as follows:

- acquisition by all Poland’s navigation centres the rights to confer the doctoral degree of navigation,
- acquisition by the Polish navigation community the rights to acknowledge the qualification being indispensable for position of “an assistant professor”, i.e. the rights to confer the “higher doctoral degree”.

### **THE POLISH NAVIGATIONAL FORUM AND ITS TASKS AT THE BEGINNING OF 21-<sup>ST</sup> CENTURY**

The navigation in Poland is represented mainly by the maritime navigation and air navigation. There is no reason to assume that the space navigation will become in the nearest future, in our country, the branch of learning, or subject of fundamental researches. The land navigation, being the very different kind of navigation because – apart from common positioning systems, and some other common issues – it has not very much in common with other kinds of navigation. Therefore, the Polish Navigational Forum consists mainly of the navigation teachers and research workers of maritime and air navigation, and of many geodesy teachers

and scientists cooperating closely with navigation and hydrography, being employed in institutions of maritime administration, maritime economy, and maritime industries. To Polish Navigational Forum belong also many other specialists and scientists of other professions interested in developing all kinds of navigation, among them specialists of Polish Space Centre, as well as of sea yachting, etc.

It has been estimated that there are, in Poland, about 250 navigation's teachers and research workers. More than 30 persons of them are full, associate, and assistant professors.

The Navigation Section of the Committee of Geodesy of Polish Academy of Sciences, being the main component of Polish Navigational Forum, comprises more than 100 members.

There are four main navigation's education and research centres in Poland. These are:

- Naval Academy in Gdynia,
- Merchant Marine Academies in Gdynia and Szczecin,
- Air Forces College in Dęblin.

The Aircraft Institute in Warsaw, being the research institution, too.

Apart of the above, navigation is being taught (but not as a major) in the following institutions: Faculty of the Oceanotechnics and Shipbuilding of the Technical University in Gdańsk, Aircraft Faculty of National Defence Academy, Department of Control Systems of the Technical University in Rzeszów, and the Geography Faculties of the Universities in Gdańsk and Warsaw.

The Polish Navigational Forum, besides of this Journal, has at their disposal the following scientific and professional journals and magazines:

- "Geodesy and Cartography" the organ of the Committee of Geodesy, which readily publishes the papers regarding navigation, and until now it also has been the main navigational scientific quarterly,
- "Zeszyty Naukowe" (Research Bulletins), the quarterlies, being issued by Naval Academy, and by both Merchant Marine Academies,
- the following monthlies also readily publish the papers concerning the navigational matters: "Budownictwo Okrętowe i Gospodarka Morska" (Shipbuilding Industry and Maritime Economy); "Przegląd Morski" (Maritime Review); "Przegląd Geodezyjny" (Geodesy Review),
- "Prace Instytutu Lotnictwa" (Proceedings of Aircraft Institute), a journal issued by the Aircraft Institute.

The navigation research activity finds its expression in the scientific conferences and workshops. On an average, every half year, there is carried out a scientific conference or workshop sessions. They are organized, in succession, by the navigation scientific centres, together with the Navigation Section of the Committee of Geodesy of Polish Academy of Sciences. These conferences are being participated by a lot of participants. The amount of participants from abroad is growing permanently.

There is also close cooperation between Polish Navigational Forum with the international organizations and institutions which are in charge of navigation safety and efficiency. The most important of them are:

- International Maritime Organization (IMO),
- International Civil Aviation Organization (ICAO),
- International Hydrographic Organization (IHO),
- International Association of Lighthouse Authorities (IALA),
- International Association of Institutes of Navigation (IAIN),
- Institute of Navigation (ION),
- Royal Institute of Navigation (RIN), and others.

The main kind of Polish Navigational Forum activity is education of navigation engineers, and all other navigation specialists, according to the STCW and other Conventions.

The navigational education realized in three Maritime Academies, and in Air Force College, is carried out at two levels, i.e.:

- “bachelor degree level” of navigation engineer,
- “master degree level” of navigation engineer.

The navigational education in Poland fulfills the requirements of:

- STCW 78/95 Convention,
- Polish Law on University and College Education,
- other relevant laws.

Besides the navigational studies at the above mentioned academies, there are also carried out the following kinds of related studies:

- Naval Academy: bachelor degree level, “hydrography engineer” (sea surveying and arrangement of aids to navigation),
- Merchant Marine Academy in Szczecin: bachelor degree level: 1. “traffic engineering” and 2. “sea fishing procedures and processes”.

Besides of the above studies, there are carried on the different education courses concerning different navigational subjects and levels of responsibility.

The important thing to note is that the process of navigational education is assisted by many very different and very complex simulators. Moreover, the Merchant Marine Academy in Gdynia, in cooperation with the Faculty of Oceanotechnics and Shipbuilding of Technical University in Gdańsk, operates the Manoeuvring Centre of Very Large Vessels in Iława. It is one of the two largest centres in the world. About 80 percent of participants of the courses in that centre are from abroad.

The main research objective of all navigation centres is to improve the safety and efficiency of craft navigation processes.

Secondly, very important research task of Polish navigation centres is to assist the Maritime Administration, Maritime Economy, Naval Forces, as well as Civil Aviation and Air Forces in ensuring the proper navigational conditions in Polish maritime and air zones of responsibility. These centres are carried on many research projects regarding the realization of the above tasks. There is no place to relate more

precisely the research activities of the above navigation centres. We want only to stress the peculiarities of these centres.

- the main areas of research activity of the Institute of Navigation and Hydrography of Naval Academy are: 1. navigational infrastructure, 2. safety and efficiency of the realization of special ships' tasks, such as combat, research and exploitation tasks, 3. special bathymetry and underwater navigation.
- the main areas of research activity of the Institute of Navigation of Merchant Marine Academy in Szczecin are: 1. traffic engineering, 2. weather routing procedures.
- the main areas of research activity of the both Departments of Navigation of Merchant Marine Academy in Gdynia are: 1. traffic control and management systems, 2. safety and economical efficiency of standard navigation process.

One of the most important problem of Polish Navigational Forum is a problem of education of academic teachers and research workers. The amount of persons with doctoral degree is being increased very slowly. Only two academic centres, i.e. the Faculty Councils of Naval Academy, and Merchant Marine Academy in Szczecin are authorized to confer the doctoral degree.

To improve this unfavorable situation, the Navigation Faculty of Naval Academy, with the help of the Physics and Chemistry Faculty of Military Technical Academy, opened in 1996 the postgraduate studies which offer the doctoral degree. There are taught now two classes, each of them has postgraduate students.

Much more unfavorable situation regards the higher doctoral degree, i.e. the qualification needed for the position of assistant professor. Such degree is still required in Poland, according to the Law on University Education, and Law on Scientific Title and Scientific Degrees. Therefore, the task of the Polish Navigational Forum is to be authorized to educate and qualify the persons to the position of "associate professor".

The tasks of Polish Navigational Forum, and tasks of the whole navigational community, result in the following reasons and factors:

- the scientific and technological progress regarding navigation and related areas of human activities,
- the forthcoming economical and social changes in world, our region and our country,
- the political situation, and consequently, military needs and requirements.

One of the most important tasks which should solve the Polish Navigational Forum, in the first decades of 21-st century, is to assist and help Poland's governmental, local, industry, business, and military authorities to fulfill all navigational, and close related requirements of NATO, and of future, most probable Poland's membership of European Union.

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