TRANSNAV International Journal on Marine Navigation and Safety of Sea Transportation
Volume 6 Number 4 December 2012

About Effectiveness of Complex Using of Satellite and Geoinformation Technologies on the Ship of Compound 'River-Sea' Type

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ABSTRACT: The problem of obtaining complete and accurate information for the skipper is crucial in making the right decisions to ensure safe navigation. Subject of study in this paper is the effectiveness of incurring way navigational watch with a wide variety of navigation equipment at the bridge. The authors demonstrate the benefits of integrated use of satellite & GIS technologies on ships to various options of using other electronic navigation systems.

SECTION I

Navigation security of navigation depend most on the opportuneness and basis of administrative solutions, which captain and his watch officer made during navigation watch, based on operative receipt complete and trustworthy information. However lack or abundance of such information in the extreme situations leads to the wrong actions with negative consequences.

The situation of the indefinity turned out in the case of information lack. That does not assist to acceptance of the correct decision.

In the case of the surplus of the information the situation is characterized that navigator can very difficulty detached main characteristic, to separate unessential, to reveal major correlations and make appropriate decision.

Thus contradictions arise between quantity and quality of the receipt information, ways of its remaking, reflection, keeping and using in the interests of navigation security. Producing contradictions provoke necessity of conducting special researches, which can make optimal decision through number and measure.

In accord to our opinion, that problem could be solved with the aid of complex using of new technologies in navigation: satellite system of different appointment and means of reflection of the heterogeneous information on the basis of geoinformation systems (GIS) which mean combination of computer equipment, program provision, geographical data and arbitrary project by user for accumulation, keeping, modification, processing, analysis and visualization of all forms of information.

It is a well know fact that digital map is a basis of any geographical information system.

Geoinformation system gives an opportunity to create maps in different scales and projections with different colouration, to define spatial links between maps objects, that is to create any necessary geographical maps which satisfied consumer's requests. In this way, the main appointment of GIS is an efficient presentation of reliable and processing space-dispersed information to the user which is necessary to solve administrative problems. It makes

it irreplaceable analytical tool in daily and especially in extreme conditionals.

Success of GIS makes conditional on maintenance of the following main requests.

GIS must be:
- complete, that is inclusive all parties of information, program and technological provision which meet in the process of the system exploitation;
- complex, to give an opportunity of joint analysis of the large group of parameters in its correlation;
- open, to provide easiness of modification and resetting to maintain its on the level of contemporaneity, which is necessary as for providing evolutionary, so for solution of different tasks;
- covered, to provide protection of information which is intend for different administration levels.

GIS must provide solution of the following tasks:
- creation and conducting of the base space-dispersed data;
- creation and editing of digital maps in the different projections and scales;
- reflection of the different data in the form of maps, graphs, diagrams;
- analysis of mapping data;
- fathoming of geometrical characteristic of natural objects, distance from geographical points to the areas with either conditions;
- change of scales of reflection, forms and aspect of the presentation of graphic and maps information;
- binding to the information from data bases to geographical objects on the digital maps;
- interpolation and construction of vectorial and scalar fields on the information from data bases;
- fulfillment of inquiries on the different samples from data bases;
- on the reflection and spatial analysis of the maps data (on parameters, periods of time, regions, etc.);
- documentation of information production;
- application of supplement for carrying out special kinds of processing, keeping information, etc.

One of the complicated problems of the GIS-technology are the efficient gathering and keeping of initial data, which survey is the most labor-intensive and expensive process. Nowadays traditional sea and river paper navigation maps become the most widespread as the basis for creation of the digital maps. However in the case of the maps lack or necessity to get operative information of the large spatial inclusion using the distance means is the most expedient. The satellite information of the GIS has the special importance here. In the GIS the results of the distance investigation of the Earth surface (ocean) from the space are regularly renovative source of the data, which is necessary to form the information layers of the electronic maps in the large scales spectrum (from 1:10000 to 1:10000000). Information from the distance means of survey gives an opportunity not only to estimate efficiently, but mostly to renovate and correct using geographical stratum with exact arrangement of objects on them to geographical system of coordinate.

Including aforesaid, complex information from following satellite systems could be useful for forming geographical stratum:
- navigation (GLONASS, GPS, Gallileo, GLONASS+ GPS+ Gallileo);
- survey of situation;
- oceanographic;
- meteorological;
- geodesic.

Using of satellite – relay assists realization of connection between ships and command of different levels.

Integration of complex satellite information and GIS reveals new opportunities for providing navigation security of the navigation. New technology has following advantages which make it leader at the cost of:
- complex of information;
- operation of its receipt and presentation in compact form;
- graphic presentation;
- opportunity of analysis of joint heterogeneous information and production of well-founded administrative decisions.

To prove advantages of GIS before existing programmes of providing navigation security of sailing, based on using only electronic map and satellite navigation system could be possible using in the article new method of comparative estimate of effectiveness.

We could detached the following standard conditions of sailing and describe them briefly. According to the world practice regions of sailing separate on:
- oceanic where sailing accomplished behind boundary of the continent shelf or on the distance of more than 50 area miles from land or another obstacle;
- coastal where sailing accomplished in the boundaries of 50 sea miles from land or in the boundaries of external border of coastal bank or another dangers or in the area where sailing limited;
- ways to the harbours and sailing there, where sailing accomplished in the waters situated between land and area of the coastal sailing. Those regions are determined separately for each water way in the practice of navigation;
- internal water ways where sailing accomplished in limited areas, resemble with sailing in harbours or on the ways to its.

Therefore it is necessary to distinguish only 3 areas: oceanic, coastal and reduced sailing.

SECTION II

We could compare new technology with other approaches for comparative estimate of its effectiveness:

- without using of electronic maps;
- using electronic cartographical navigation-information systems for reflection of the definite itinerary of movement and reflection of necessary information for provision security of sailing.

As a criterion for comparing systems, we take the probability of obtaining reliable information for management decision $P_{ДОСТ}$ - multiplicative indicator species [4]

$$P_{НБП} = \prod_{i=1}^{n} P_i \qquad (1)$$

where:

P_i – private dimensions (i=1,5);

P1 – accuracy rate sailing ship at any time;

P2 – measure the speed of information (РОП)- the probability of obtaining the necessary information in a specified time or in real time;

P3 – measure the validity of the information (РОБ) - the probability of obtaining the information that is adequate to the situation in which the vessel is located. Calculated using mathematical modeling;

P4– measure the influence of the external environment (РГМО) - the probability of hydrometeorological information in real time, which affects the safety of navigation of the ship;

P5 – measure the influence of human factors on safety of navigation (РЧФ) - the probability of making correct management decisions in the light of human qualities and professional experience.

The primary means of determining the place of the ship are now satellite navigation systems are the second generation: GPS (U.S.) and GLONASS (Russia) and their functional additions.

Private index P1 is calculated as the probability of hitting a ship in a circle given radius or a strip of given width, respectively [5]

$$P_к = 1 - \exp(-r/M)^2, \qquad (2)$$

$$P_П = \Phi\left(\frac{Ш_П}{M\sqrt{2}}\right) \qquad (3)$$

where

r - given radius;

M - experimental standard deviation determine of the position;

$\Phi = \frac{2}{\sqrt{2\pi}} \int_0^x e^{-\frac{t^2}{2}} dt$ - Laplace function.

For the calculation of other partial indicators of efficiency can be used depending on the analytical or probabilistic estimates, which are an expert way [6,7].

Comparative analysis of the effectiveness of the proposed method is carried out for three options:

- option 1 - for the existing equipment from the navigating bridge
  SNA receivers, but without the electronic cards;
- option 2 - for navigating bridge with the receivers of the SNA and electronic charts;
- option 3 - for navigating bridge with the receivers of various satellite systems and GIS-technologies.

The results of calculations by formula (1) are given in Tables 1-3.

Based on the outcome $P_{ДОСТ}$ taken from the tables, the graphs for the studied variants of the way and watch.

Table 1

Existing equipment navigation bridge with the receivers of the SNA, but without the electronic cards

Watch	Navigation zones		
	Oceanic	Coastwise	Cramped conditions and GDP
Captain	$P_{опер}$=0,75 $P_{чф}$ =0,97 $P_т$ = 1,0 $P_{гмо}$=0,7 $P_{об}$ =0,75 **$P_{дост}$=0,38**	$P_{опер}$= 0,8 $P_{чф}$ =0,95 $P_т$ = 1,0 $P_{гмо}$=0,75 $P_{об}$ = 0,75 **$P_{нбп}$=0,43**	$P_{опер}$= 0,9 $P_{чф}$ = 0,9 $P_т$ = 1,0 $P_{гмо}$=0,85 $P_{об}$ = 0,75 **$P_{нбп}$=0,52**
Senior Assistant	$P_{опер}$= 0,75 $P_{чф}$ =0,9 $P_т$ = 1,0 $P_{гмо}$=0,7 $P_{об}$ =0,7 **$P_{дост}$=0,33**	$P_{опер}$= 0,8 $P_{чф}$ =0,85 $P_т$ = 1,0 $P_{гмо}$=0,75 $P_{об}$ =0,7 **$P_{дост}$=0,36**	$P_{опер}$= 0,9 $P_{чф}$ =0,8 $P_т$ = 1,0 $P_{гмо}$=0,85 $P_{об}$ =0,7 **$P_{дост}$=0,43**
Second Assistant	$P_{опер}$= 0,75 $P_{чф}$ =0,8 $P_т$ = 1,0 $P_{гмо}$=0,7 $P_{об}$ =0,65 **$P_{дост}$=0,27**	$P_{опер}$= 0,8 $P_{чф}$ =0,75 $P_т$ = 1,0 $P_{гмо}$=0,75 $P_{об}$ =0,6 **$P_{дост}$=0,27**	$P_{опер}$= 0,9 $P_{чф}$ =0,7 $P_т$ = 1,0 $P_{гмо}$=0,85 $P_{об}$ =0,6 **$P_{дост}$=0,32**
Third Assistant	$P_{опер}$= 0,75 $P_{чф}$ =0,7 $P_т$ = 1,0 $P_{гмо}$=0,7 $P_{об}$ =0,6 **$P_{дост}$=0,22**	$P_{опер}$=0,8 $P_{чф}$ =0,7 $P_т$ = 1,0 $P_{гмо}$=0,75 $P_{об}$ =0,55 **$P_{дост}$=0,23**	$P_{опер}$= 0,9 $P_{чф}$ =0,65 $P_т$ = 1,0 $P_{гмо}$=0,85 $P_{об}$ =0,55 **$P_{дост}$=0,27**

Table 2

Existing equipment navigation bridge with the receivers of the SNA and ECNIS

Watch	Navigation zones		
	Oceanic	Coastwise	Cramped conditions and GDP
Captain	$P_{опер}$=0,75 $P_{чф}$ =0,97 $P_{т}$ = 1,0 $P_{гмо}$=0,7 $P_{об}$ =0,8 **$P_{дост}$=0,41**	$P_{опер}$= 0,85 $P_{чф}$ =0,95 $P_{т}$ = 1,0 $P_{гмо}$=0,75 $P_{об}$ = 0,82 **$P_{нбп}$=0,50**	$P_{опер}$= 0,9 $P_{чф}$ = 0,9 $P_{т}$ = 1,0 $P_{гмо}$=0,85 $P_{об}$ = 0,85 **$P_{нбп}$=0,58**
Senior Assistant	$P_{опер}$= 0,75 $P_{чф}$ =0,9 $P_{т}$ = 1,0 $P_{гмо}$=0,7 $P_{об}$ =0,75 **$P_{дост}$=0,35**	$P_{опер}$= 0,85 $P_{чф}$ =0,85 $P_{т}$ = 1,0 $P_{гмо}$=0,75 $P_{об}$ =0,77 **$P_{дост}$=0,42**	$P_{опер}$= 0,9 $P_{чф}$ =0,8 $P_{т}$ = 1,0 $P_{гмо}$=0,85 $P_{об}$ =0,82 **$P_{дост}$=0,50**
Second Assistant	$P_{опер}$= 0,75 $P_{чф}$ =0,8 $P_{т}$ = 1,0 $P_{гмо}$=0,7 $P_{об}$ =0,7 **$P_{дост}$=0,29**	$P_{опер}$= 0,85 $P_{чф}$ =0,75 $P_{т}$ = 1,0 $P_{гмо}$=0,75 $P_{об}$ =0,72 **$P_{дост}$=0,34**	$P_{опер}$= 0,9 $P_{чф}$ =0,7 $P_{т}$ = 1,0 $P_{гмо}$=0,85 $P_{об}$ =0,75 **$P_{дост}$=0,40**
Third Assistant	$P_{опер}$= 0,75 $P_{чф}$ =0,7 $P_{т}$ = 1,0 $P_{гмо}$=0,7 $P_{об}$ =0,65 **$P_{дост}$=0,24**	$P_{опер}$=0,85 $P_{чф}$ =0,7 $P_{т}$ = 1,0 $P_{гмо}$=0,75 $P_{об}$ =0,67 **$P_{дост}$=0,30**	$P_{опер}$= 0,9 $P_{чф}$ =0,65 $P_{т}$ = 1,0 $P_{гмо}$=0,85 $P_{об}$ =0,70 **$P_{дост}$=0,35**

Table 3

Suspension bridge with the receivers of different Satellite Systems and GIS technologies

Watch	Navigation zones		
	Oceanic	Coastwise	Cramped conditions and GDP
Captain	$P_{опер}$=0,85 $P_{чф}$ =0,97 $P_{т}$ = 1,0 $P_{гмо}$=0,9 $P_{об}$ =0,9 **$P_{дост}$=0,67**	$P_{опер}$= 0,9 $P_{чф}$ =0,95 $P_{т}$ = 1,0 $P_{гмо}$=0,95 $P_{об}$ = 0,92 **$P_{дост}$=0,75**	$P_{опер}$= 0,95 $P_{чф}$ = 0,9 $P_{т}$ = 1,0 $P_{гмо}$=0,97 $P_{об}$ = 0,95 **$P_{дост}$=0,79**
Senior Assistant	$P_{опер}$= 0,85 $P_{чф}$ =0,9 $P_{т}$ = 1,0 $P_{гмо}$=0,9 $P_{об}$ =0,9 **$P_{дост}$=0,62**	$P_{опер}$= 0,9 $P_{чф}$=0 ,85 $P_{т}$ = 1,0 $P_{гмо}$=0,95 $P_{об}$ =0,92 **$P_{дост}$=0,67**	$P_{опер}$= 0,95 $P_{чф}$ =0,8 $P_{т}$ = 1,0 $P_{гмо}$=0,97 $P_{об}$ =0,95 **$P_{дост}$=0,70**
Second Assistant	$P_{опер}$= 0,85 $P_{чф}$ =0,8 $P_{т}$ = 1,0 $P_{гмо}$=0,9 $P_{об}$ =0,9 **$P_{дост}$=0,55**	$P_{опер}$= 0,9 $P_{чф}$ =0,75 $P_{т}$ = 1,0 $P_{гмо}$=0,95 $P_{об}$ =0,92 **$P_{дост}$=0,59**	$P_{опер}$= 0,95 $P_{чф}$ =0,7 $P_{т}$ = 1,0 $P_{гмо}$=0,97 $P_{об}$ =0,95 **$P_{дост}$=0,61**
Third Assistant	$P_{опер}$= 0,85 $P_{чф}$ =0,7 $P_{т}$ = 1,0 $P_{гмо}$=0,9 $P_{об}$ =0,9 **$P_{дост}$=0,48**	$P_{опер}$=0,9 $P_{чф}$ =0,7 $P_{т}$ = 1,0 $P_{гмо}$=0,95 $P_{об}$ =0,92 **$P_{дост}$=0,55**	$P_{опер}$= 0,95 $P_{чф}$ =0,65 $P_{т}$ = 1,0 $P_{гмо}$=0,97 $P_{об}$ =0,95 **$P_{дост}$=0,57**

CONCLUSION

1 Common to all three cases is that the likelihood of obtaining reliable information increases for all members of the bridge watch on the transition from the oceanic area to the navigation of a ship sailing in cramped conditions and the GDP.

2 Using only SNA + ECNIS slightly increases the likelihood of obtaining reliable information $P_{ДОСТ}$. Sharp rise in $P_{ДОСТ}$ provides comprehensive use of heterogeneous satellite data and GIS technologies.

3 Under the first option (in the absence of electronic cartography and mapping of the external environment) there is the advantage of capital over other members of the bridge watch, especially in the area of constrained navigation. This advantages are:
- from 1.15 times to 1.21 times over the senior assistant, respectively, in the ocean swimming area and swim in cramped conditions;
- from 1.41 to 1.62 times over the second mate;
- from 1.73 to 1.92 times over the third assistant

4 Under the second option (subject to availability of electronic means of cartography and mapping of the external environment) the advantage of capital over the rest of the way down to watch some of the same conditions and sailing is as follows:
- from 1.17 to 1.16 times for the senior assistant;
- from 1.41 to 1.45 times for the second assistant;
- from 1.71 to 1.66 times for the third assistant.

In this case, the greatest effect the introduction of electronic cartography and mapping of the external environment is achieved when navigating in the coastal zone.

5 Under the third option (subject to availability of information from different satellite systems and applications of GIS) is a significant reduction in the superiority of capital over the rest of the way the watch. In this case, the advantage of 1.1 times remains almost constant for all zones of navigation on the senior assistant, rising marginally from 1.22 times to 1.3 times for the considered zones of navigation on the second assistant, and slightly decreases from 1.4 times to 1.38 times over a third assistant to the same conditions of navigation.

6 When comparing the values РДОСТ between variants may be noted

7 The biggest advantage of the integrated use of heterogeneous satellite data and GIS-technologies

received the third mate in the area of coastal vessels.

The smallest advantage of this complex technology to access capital when navigating in restricted conditions.

8 Application of satellite and GIS technologies, to some extent negates the professional experience and expertise of the bridge watch (Роб). Thereby reducing the risk of human factors on the wrong decision and created considerable promise for automating the navigation process.

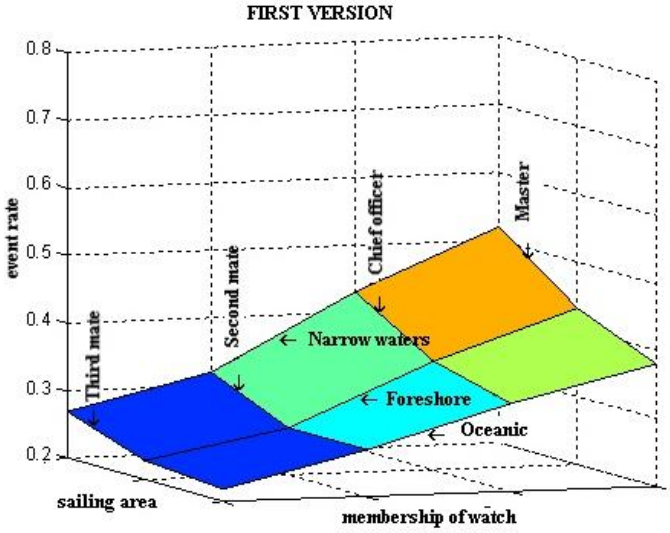

Figure 1. Comparative analysis of effectiveness ($P_{дост}$) Watch for various sailing conditions for a hardware version of the navigation bridge

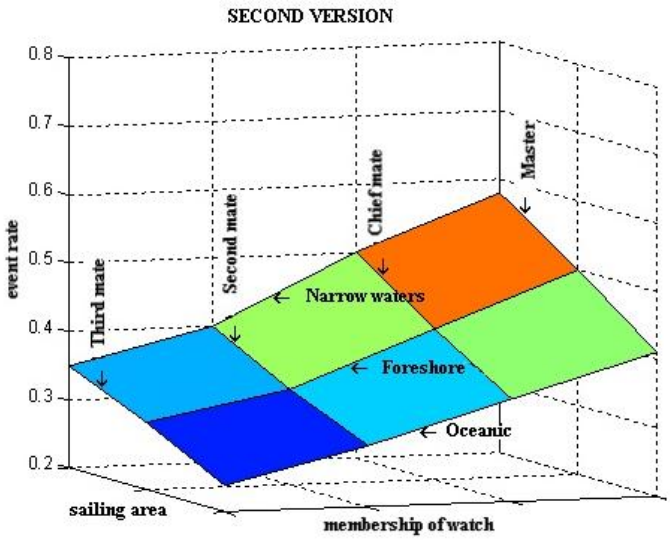

Figure 2. Comparative analysis of effectiveness ($P_{дост}$) watches in different sailing conditions for the 2 variants of the navigation bridge equipment

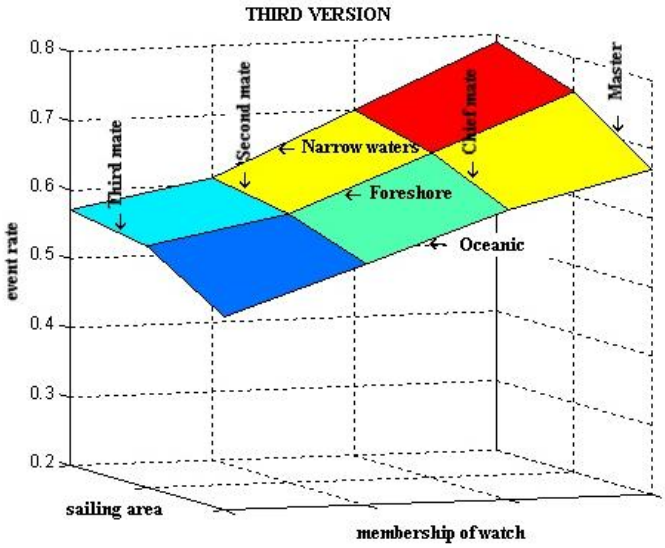

Figure 3. Comparative analysis of effectiveness ($P_{дост}$) watches in different sailing conditions for the 3 types of equipment navigating bridge

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