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ERRORS IN THE PRESENTATION OF THE VESSELS COURSE AND SPEED FOR THE VTS OPERATOR

Abstract This paper presents some results based on the research made in the VTS Gdańsk area.
Conclusions from the experiment shows that errors in the presentation of ships course and speed on the VTS operator console may not allow to VTS operator to react in time to solve the dangerous situation.

INTRODUCTION

Main task of Vessel Traffic Systems is to contribute to improve safety on the sea. New VTS are more efficient than earliest but not always, because there are known ships collisions in the VTS areas. Examination of the VTS Gdańsk showed that there are some critical errors in the data presented by the system.

Information about ships movement is indicated with some delay, this may cause that the operator of the system cannot react effectively. Knowledge about the vector of ship's movement is indispensable for realization of the basic VTS functions such as:

- planning ships safety passage in the VTS area,
- resolving situation dangerous for safe passage of the vessels,
- assisting ship's navigation.

Process of decision making in the VTS system in order to control vessels needs continuous knowledge about ships position and parameters of her movements. Important is estimation of the accuracy of above particulars. Accurate knowledge of the vector of the ship's movement is very important, mainly when ship is sailing on a narrow fairway, where possibility of ships manoeuvre is limited, or when the distance to an obstruction or to other ships is small.

Ships collisions which took place in the VTS areas are the irrefutable argument, that in some situations accuracy of the VTS equipment is not adequate enough to give the VTS operator proper knowledge about collision situation and let him react efficiently.

First modern VTS system on the Bay of Gdańsk was installed in Gdańsk in 1994. This system was based on the Atlas Electronic equipment. Another, new one, installed in 1995 in Gdynia was produced by Norcontrol Norway. Both systems came into force on 9 January 1997 according to Regulation no 1 published by Director of Maritime Office in Gdynia. The area of activity of both systems is presented in Figure 1. This year these two VTS systems are being replaced by very modern, integrated VTS system produced by HITT Holland.

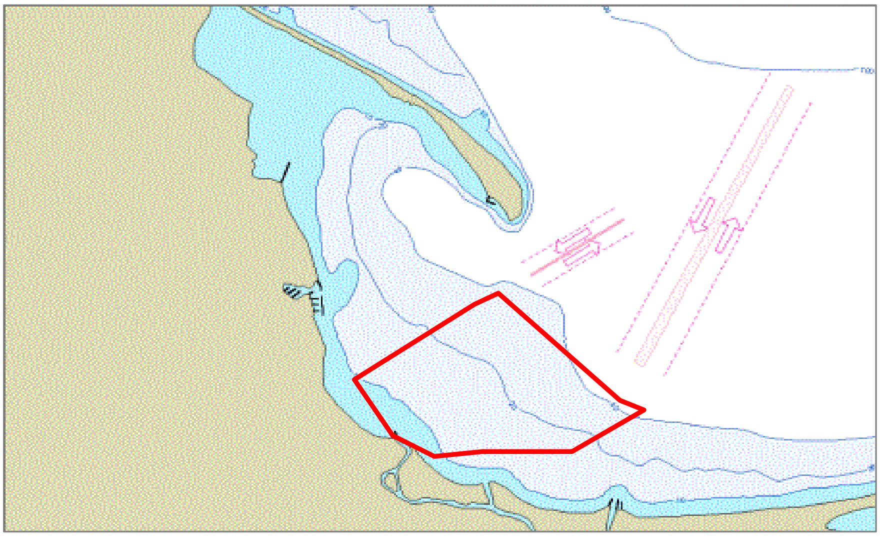

Fig.1. The area of VTS Gdańsk and VTS Gdynia activity

On the VTS console the operator has a possibility to watch ships targets and their movement basing on the radar picture. The system presents, among the others, the following data regarding particular target:

- bearing,
- distance,
- course over ground,
- speed over ground,
- position,
- simulation of course and speed changing.

Information about ships position and parameters of her movement calculated on the basis of the data from radar are presented on the VTS screen also. Having such information VTS operator has a possibility to make his own decision insuring regulation of ships movement and safety of navigation.

For strategic and tactic-planning control of ships movement it is necessary to know some elements such as: safety distance to shallow water, ships domain, safety distance between ships, standard of separation, distance of decision making.

The VTS operator in order to be effective in controlling ships movement in the VTS area, has to know, apart from the above-mentioned elements such information like ships particulars, weather condition, distance of operator's reaction. The VTS operator's decision distance is a ships decision distance increased by the distance where operator is expecting that the vessel should manoeuvre according to the passage plan. VTS operator decision distance is based on the knowledge about ships decision distance. Both decision distances should be increased by safety border.

RESEARCH OF THE SPEED AND COURSE ACCURACY PRESENTED BY VTS GDAŃSK

To gain information about accuracy of the data presented on the VTS Gdańsk operator console research was made.

The research was based on registration of the data of ships course and speed when ship was sailing through the VTS area, including fairway to the Port Północny. The data were registered on the VTS console and on the vessel. The research was made using three vessels sailing in the defined area: the "Horyzont II", the "Zodiak" and the "Tukana". Standard vector was marked from two DGPS receivers installed on bow and stern of the ships but in addition the data from gyro and ship's log were registered. The data from the VTS and the ships were confronted for the same moments.

Tab. 1. Particulas of the ships used in research

ship's name	length [m]	breadth [m]	height [m]	speed [kn]
„Tukana"	17,6	5,7	7	10
„Horyzont II"	56,34	11,36	21,75	12
„Zodiak"	61,3	10,8	18,0	12

The vector of the ship's movement, presented by the VTS system, practically is represented by a line. As this vector is averaged and was counted for the 23-25 seconds time intervals, it does not indicate very small course changes taking place in short time.

Standard vectors, counted every second, from two DGPS receivers present even very small course changing. This scheme is very sensitive and all courses and speed changes are visible. Two diagrams on Figure 2 present differences between course and speed received from standard construction, from registration in VTS system and from ships gyro and log. The course registered by VTS generally is from 1 to 3 degrees different from the standard one. The course from gyro does not differ so much but tendencies to changing are the same like for course from VTS system.

ERRORS IN ESTIMATING FAIRWAY COURSE AND SPEED ON A FAIRWAY APPROACHING PORT PÓŁNOCNY WHILE PERFORMING "ZIG – ZAG" MANOEUVRE

The fairway on approaching Port Północny is 250 m wide and designed for deep – draught vessels (300 m long and of a draught 15 m) calling at the oil terminal. For such vessels this passage is relatively narrow and vessels have to proceed on an exact course. This part of the experiment is supposed to give answer to a question if the VTS operator is able to assist and provide help for a vessel which has problems with keeping course and speed on the fairway and if the VTS operator is able to react soon enough to avoid collision caused by a vessel having altered course and speed on the fairway. In order to find the answer a "zig – zag" manoeuvre was made. The vessel altered course from port to starboard and the wake in the passage covered looked like sinusoid.

The indications of the ship's course made by gyro are about 30 s later than the model ones obtained from satellite equipment but the amplitude of the differences is small and does not exceed 1 degree. The VTS indications of the course appear later than the model ones and the differences are of 20º – 40º when compared to the model ones. see Fig 3.

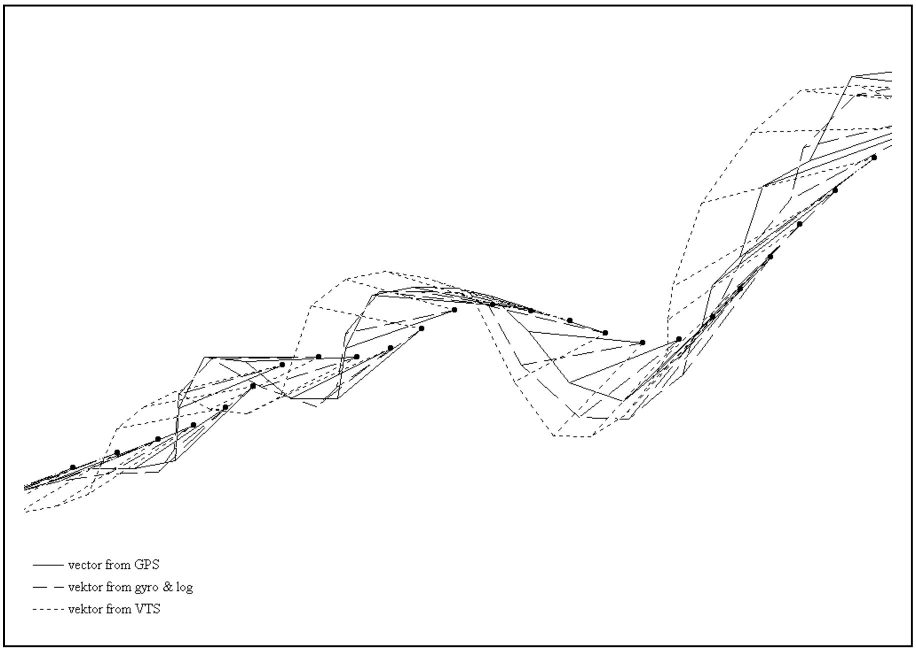

Fig. 3. Differences between course and speed determined by three different methods.

The amplitude of course changes indicated by VTS is several times larger than the amplitude indicated by gyro when compared to the model ones. The tendency of course changes is also untrue, as the vessel is proceeding towards the indication which is a dozen of degrees different from the indications of the VTS system. Because of this the VTS operator is unable to interpret the ship's movement on the fairway properly during difficult hydrometeorological conditions, when she has problems with keeping course on the fairway. This results from the delay of calculations carried out by the system presenting averaged parameters of the vessel's movement. Even slight change in ship's course is detected with more than 1 minute – delay. The speed of the tested vessel remains constant all the time but the change in the course results in resistance of the vessel's movement so consequently first the speed decreases and then increases.

When speed is slow, the possibility to detect such changes by the system increases to such an extent that the log and model readings are the same. The amplitude of changes in speed indicated by the VTS system when compared to the model one is slightly lower. Once the speed has been established by the VTS system, then the system indicates tendency, which is opposite to that before the speed was obtained, this may indicate to the system maladjustment. a single change in vector of ship's movement displayed on the VTS operator's screen does not define the tendency to the ship's movement, only the indications following may let the operator decide that the vessel's course is incorrect and that the vessel is heading in the wrong direction which may finally result in leaving the fairway and grounding. In this way the VTS assistance aimed at directing the vessel on a limited fairway is reduced to minimum and is restricted only to true indications of the vessel's speed especially when she is proceeding at a speed of a few knots. The accuracy of indications of vessel's speed increases with the decrease in vessel's speed. a conclusion may be drawn, that the information regarding the accuracy of detecting the vector if the vessel's movement and the delay of its detection by the VTS system should be used for the vessel's permitted speed calculated for each approach fairway individually.

THE DOMAIN WHERE THE OPERATOR IS UNABLE TO DECIDE

The experiments proved that the operator of the VTS system gets delayed information regarding the vector of the vessel's movement. Such delay depends on technical possibilities of the equipment used, on the system's software, on the vessel's speed and on the possible manoeuvre dynamics. The above mentioned elements cause that the operator gets the untrue information about the vector of the vessel's movement in an area ahead of the vessel. The domain is an area in which the operator cannot make decision as to a possible manoeuvre avoiding collision because he does not know the true parameters regarding the vessel's movement. This domain is proposed to be called the domain where the operator unable to decide (lack of decision). It has been D and represented as a function:

$$D = F(COG, V, \Delta t, ROT, d) \qquad (1)$$

where:

COG	– course made good,
V	– vessel's speed,
$\Delta t - t_1 - t_2$	– the time delay,
t_1	– the time when the manoeuvre was indicated by the system,
t_2	– the time when the operator reacted,
d	– acceleration,
ROT	– Rate Of Turn (the course change within 1 minute).

In the course of experiments it has been noted that the operator obtains the data from VTS system with a delay even up to 8 minutes. That is why there is a need for the analysis of the vessel's movement during such a delay and also when the possibility of imminent collision situation not detected by the operator occurs.

The domain where the operator is unable to decide (DNDO) covers the area of possible vessel's position after Δt time passed.

This domain can be described by means of a sector (sector of a circle) of a "b" chord and radius "a".

Figure 4 presents the area of vessel's domain proceeding at V speed and following course KDd and her possible course change in time unit has the value x°/min.

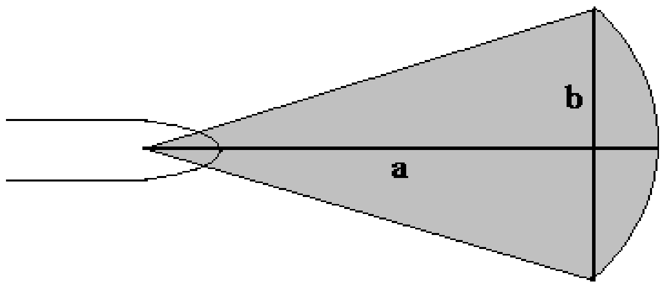

Fig.5. Domain where the operator is unable to make a decision.

The experiments pointed out that:

- radius a [Nm] depends on the vessel's speed V_{st} [knots], on the delay Δt [seconds] and also on changes in vessel's speed ΔV_{st} [knots/sec],
- chord b [Nm] depends on the vessel's speed V_{st} and on ROT (Rate Of Turn).

These correlations are presented by the following function:

$$a = \frac{\Delta V_{st}(\Delta t)^2}{7200} + \frac{V_{st}\Delta t}{3600} \tag{2}$$

$$b = 2\sin\frac{ROT}{2}a \tag{3}$$

CONCLUSIONS

The statistical analysis of the results proved that the vessel's manouvering has significant influence on the GPS and VTS indications being the same; the greater differences occur when the dynamics of manouvering is higher. No statistically significant correlation has been found between the change in speed indicated by GPS and that established by VTS system. There is also no correlation between the dynamics of the change in course by GPS and calculated by VTS.

It has been noted that the first data obtained just after the VTS system operator regained tracing may be marked by greater error, this being more frequent when the vessel alters course or changes the speed. The regression models of the correlation between the speed obtained from GPS and calculated by VTS indicate to significant differences between the values of both variables. The research tests carried out and its analysis point to the influence of the size of the vessel on the accuracy of VTS indications, however further tests taking into consideration the parameter of vessel's size are needed.

The author had no possibility to carry out tests on vessels of heavy displacement and that case requires further investigation. The above mentioned conclusion highlights the fact that the said VTS system provides true data regarding the vector of the vessel's movement only when the speed and course parameters are constant. Such a conclusion does not neglect the opinion of professionals but the scope of errors and delays is surprising and the discussions with VTS operators and port pilots prove that they are unaware of that problem. The results of the research call for the need to verify the opinion on how to use VTS. The greatest problem lies in that the system shows unreliable information, regarding the vector of the vessel's motion when the changes in course and speed take place at the same time. The other problem is the delay with which the system detects the manoeuvers. The results of the research may be very helpful when assessing the reliability and accuracy of the new VTS system for the Gdańska Bay which is just being installed. There is a need to carry out research in order to be able to obtain the information regarding the vessel's movement in the fastest way. The delays in obtaining information as to the vessel's movement by VTS operator and the errors of results cause that it is quite possible that the VTS operator would not be able to react to vessel's manoeuvres due to the lack of information regarding true parameters about her movement.

It is reasonable to carry out further research with might enable the VTS operator to obtain accurate and current information regarding the parameters of the vessel's movement in a continuous manner. In this way both more precise monitoring of the vessel's passage in the area covered by VTS system would be possible and the VTS operator would react to collision situations, when vessels are in a close distance apart. It is not possible nowadays to construct such radars which would provide the operator with information about present vector of the vessel's movement on the operator's console. Work on the change in the calculation algorithms may accelerate the presentation of the information on the operator's console however such information will always be delayed.

The introduction of AIS – Automatic Identification System, the system which presents all current information as to the position and the vector of the vessel's movement among others will contribute to the increase in the accuracy of information on the vector of the vessel's movement obtained by the VTS operator. Nevertheless, even AIS will not solve the problem and further research will be necessary in order to find the correlation between data from AIS and those from radar. It is especially important because the AIS information about the course of the vessel is obtained from gyro. The tests proved that the course indications from this navigational aid are more accurate than those from VTS but still they are marked by some errors. What is more, the VTS system will still make use of radar and the common use of AIS system will also require some verifying devices in case of AIS failure or in situations when the vessels entering area covered by VTS system are not fitted with AIS system.

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