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ELECTRONIC CHART SYSTEMS WITHIN THE TRANSPORT TELEMATICS' APPLICATIONS – FUNCTIONALITY AND LIMITATIONS

The paper introduces general characteristics of electronic chart systems. Their base functionality and limitations have been described, basing on experience, coming out of implementing of these systems in the sea transport. The undertaking of subject is caused by constantly enhancing usage of navigational systems, basing on GPS and electronic charts, within land transport systems.

SYSTEMY MAP ELEKTRONICZNYCH W APLIKACJACH TELEMATYKI TRANSPORTU – MOŻLIWOŚCI I OGRANICZENIA

W referacie przedstawiono ogólną charakterystykę systemów map elektronicznych. Opisano podstawowe funkcje oraz ograniczenia tych systemów, na bazie doświadczeń związanych z ich eksploatacją w transporcie morskim. Temat podjęto, ponieważ systemy nawigacyjne oparte o GPS i mapy elektroniczne, na coraz szerszą skalę stosowane są również w transporcie lądowym.

1. INTRODUCTION

The launch of Global Positioning System (GPS), resulted with possibility for continuous obtaining of position coordinates. Such a feature was never before available. Thus, the research works on systems, able to present current position onto the chart, were also started. The easiest way to present position obtained from GPS, is to use computer able to display: digitised chart, and position onto it, by retrieving coordinates coming from GPS receiver. System combining electronic chart display capability, and current position presentation onto it possibility, is called the *Electronic Chart System* (or *Charting System*).

Works on such systems were started in the beginning of eighties of the past century [5]. First systems were developed for maritime and air transport, as position determination is one of most important tasks within these modes of transport. The technology is very rapidly expanding - for a few years already it is possible to navigate the ship with the use of electronic chart system, instead of paper chart, which was compulsory for years [5]. Huge advantages of navigating with electronic chart instead of paper chart, resulted with

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implementing the technology also into land modes of transport. Knowledge on experiences of electronic chart systems implementation and usage in the sea transport, allowed herein to specify briefly main subjects connected to navigating on electronic charts – system's functionality, and basic limitations. Features common for all modes of transport have been underlined.

2. ELECTRONIC CHART SYSTEMS AND ELECTRONIC CHARTS

Electronic chart systems are components of navigation systems, working both on transport means, and in transport monitoring centres (see Fig.1). Despite of usage, main task of charting system is presentation of transport mean's current geographical position. The presentation of current position, gives possibilities to realise wide area of applications supporting transport process (described further on).

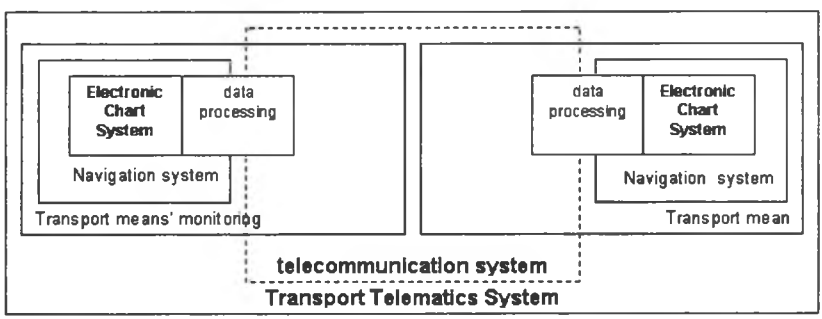

Fig.1. Location of electronic chart systems in the Transport Telematics System [4]

This chapter however, is concentrated on pointing the difference between "electronic chart", and "electronic chart system". Understanding of this fact is important to work with electronic charts, and to develop projects including electronic chart systems.

Electronic chart system is a complex tool, able to perform various functions, helping transport mean's operator to realise transport process, and transport control centre's operator to monitor the transport means fleet. Functionality of charting system determines area of user possibilities to perform different operations.

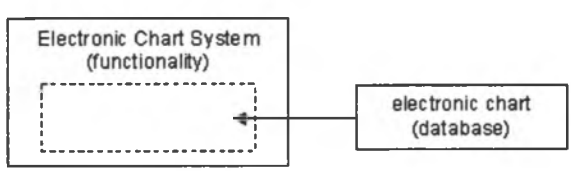

Fig.2. Relations between Electronic Chart System and electronic chart

Electronic chart system itself is not a real component of transport navigation system, until electronic chart is loaded into it (see Fig.2). Electronic chart is a database, letting the system to achieve intended functionality. The System without charts is only set of functions, while the charts themselves also are only a "picture" showing some geographical data. Only the two mentioned components collected together, are giving opportunity to support transport process.

Usually electronic chart systems are coming from different sources than electronic charts. Systems are made by specialists concentrated on developing functionality supporting transport, while charts are made by geodetic companies or institutions, specialised in producing geographical databases. One charting system can work on many different kinds of electronic charts. Different kinds of electronic charts, can give different areas of possibilities, to systems they are working under.

3. ELECTRONIC CHART SYSTEM'S FUNCTIONALITY

As previously mentioned, the core of an electronic chart system is presentation of transport mean's current position onto electronic chart – geographical database. This feature is still the base of each charting system, however systems developed today are much more advanced (see Fig.3) – by both: implementing additional functionality, and giving capability to read data from different devices (external sensors), not only receivers of positioning systems. Wide area of today's systems functionality can be grouped into following main sections:

- route planning,
- route monitoring,
- passage recording.

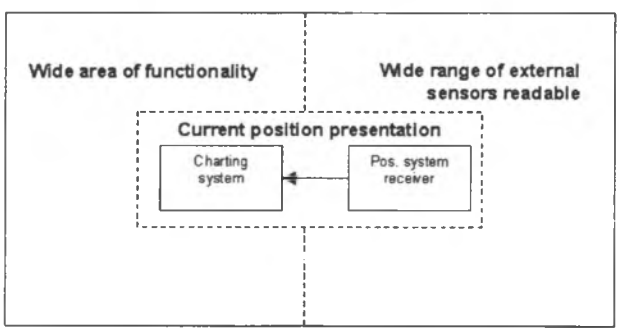

Fig.3. Positioning as a core of electronic charting system

Further fragments of this paper, give more detailed description, of the above mentioned functions.

3.1. ROUTE PLANNING

Route planning is a projecting the transport mean's passage, through the transport system, from departure to a destination point. By use of electronic chart system, the operator can obtain lay-out of his passage plan onto electronic chart. The visual presentation of intended passage, plus current position presentation, lets to control transport mean's movement, along specified plan (see *Route monitoring* section).

Charting systems have also special functions for supporting of route planning process. These functions let automatically take into account the criteria (limitations), set by an operator (passage planner). This important feature of electronic chart systems, helps a lot to specify passage, minimising or maximising important criteria. Fig.4 shows simple route planning for a car: specified destination place, area to be avoided (criterion), and part of passage plan as a result.

Fig.4. Road route planning, taking criteria (i.e. an area to be avoided) into account [6]

3.2. ROUTE MONITORING

Passage realisation according to specified plan, is a condition to achieve declared criteria. Complex of electronic chart system functions, helping operator to move from departure to destination place, is determined as "Route monitoring". Besides following the passage plan, route monitoring functionality is able to monitor different parameters' values, helping to maintain demanded safety level during the passage. Charting system operator can declare set of parameters to be monitored, and their limits, which if exceeded, cause audible and visual alarms. As the electronic chart system is also capable of reading data from different external sensors, it can also check data coming from them, if exceeding limits declared by operator.

Route monitoring functionality can be then divided into three main groups:

- following specified route plan,
- monitoring of parameters, determining safety level,
- monitoring of data coming from external sensors, determining general state of transport mean.

Fig.5 shows example of route monitoring possibilities within a maritime electronic chart system. Left part is introducing following of a route plan. Right part shows special features for monitoring of approaching to dangerous areas (*guard vector* – activates an alarm when "touches" dangerous areas), and dangerous depths (*guard ring* – activates an alarm when "finds" dangerous depth inside it).

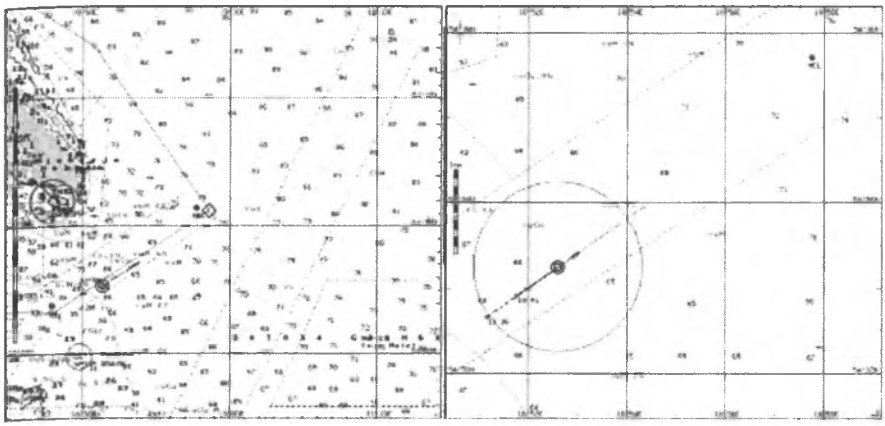

Fig.5. Following a passage plan (left), and monitoring of: *dangerous area* and *dangerous depth* limits (right), by means of a maritime electronic chart system

3.3. PASSAGE RECORDING

As part of each electronic chart system, is a computer software, it is very easy to implement functions for storing important information on passage into system's "memory". Nowadays possibilities, in case of memory capacity for storing data, are practically unlimited. Therefore, charting systems are ideal devices for storing passage data, and its further processing.

Each charting system is performing cycle inputs, of determined set of parameters' values, into its memory. The inputs are done automatically according to system's settings. The settings define when input to memory is to be done. Usually these are situations important from the transport mean's operator point of view, like: crossing not-allowed geographical limit, alarm activation, maximum allowed speed exceeding, entering danger area and so on. Besides automatic inputs, usually systems allow operators to do manual additional inputs.

Electronic chart system's memory is a great tool for investigation on performing of transport process. It can show in deep details the movement of transport means, plus records of different parameters' values, able to show the transport mean's state at any moment of passage. This can be used further, for improving of people work, researches on safety and effectiveness of transport process, and investigations on different accidents causes.

4. ELECTRONIC CHART SYSTEMS' LIMITATIONS

Electronic chart system, like every computer program, besides advantages, has many limitations. System operator's knowledge on this fact, is a condition to achieve enhanced transport process safety and effectiveness. System's disadvantages, when not taken into account, can lead to disaster, instead of safety. There are many of charting systems' limitations, some of them important only for some modes of transport, while following two, seem to appear as very significant, for each transport mode:

- availability of positioning information,
- chart datum.

4.1. AVAILABILITY OF POSITIONING INFORMATION

As the base task of an electronic chart system is presentation of transport mean's current position onto electronic chart, input of current data from positioning sensor is most important condition to obtain proper system's functionality. Lack of position, or wrong position data, make improper charting system functionality, that can lead sometimes to serious danger.

Un-interrupted availability of current position data, is most important condition to ensure proper functionality of navigation system, such as electronic charting system. For the time being, there is no wide range positioning system, which availability would be satisfactory guaranteed by the owners. There is a hope however, this situation will change in a few years, when new positioning systems appear [1].

Besides above mentioned, electronic chart systems can be affected with loss of data on current position, caused by obstructions restricting receiving of satellite signals by the positioning system receiver. This can happen even when positioning system works - delivering non-jammed signals for position determination. Such problems are met, when transport mean is moving i.e. through a tunnel, high trees forest, or between high buildings. For this reason, it is very important to support charting systems with capability to trigger an alarm, when data from positioning system is lost. Situation, when operator does not know positioning signal is lost, can cause serious accident.

It is also very important to ensure back-up positioning system, for the situation when primary positioning system stops sending position data. It is then highly recommended to support electronic chart systems with possibility to read data from minimum two different positioning systems. This gives significant increase of charting system's probability of accessing current position information.

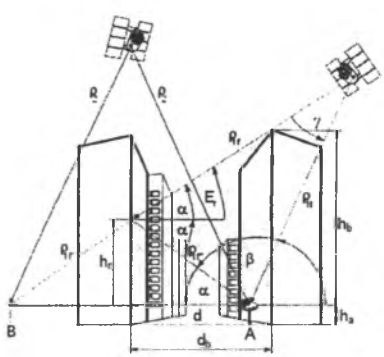

Fig.6. Error of position caused by satellite signals reflection [3]

It must be also pointed - electronic chart systems should be equipped with tools for checking the accuracy of position data, coming from external sensors. In some situations, error of position received from positioning system's receiver, can be reasonably big. Fig.6 shows the example, when positioning system's receiver – located between high buildings,

determines position using reflected signals – error of position can be then even a few hundred meters [3]. If operator does not suspect, error of his position marked on the electronic chart is so big, is not able to fulfil properly his tasks.

4.2. CHART DATUM

It can be easily noticed, there are a lot of efforts put into research works, and technology, aiming to obtain the most accurate position, by the use of positioning systems. It must be clear however, all satellite systems, letting to obtain receiver's geographical position, calculate its coordinates, using some mathematical description of the earth surface. Accuracy of calculated position, is then orientated to the mathematical model of earth surface, used for calculations.

When position is presented onto electronic chart, accuracy of this position presentation is equal to accuracy of positioning system's receiver calculation, only when the chart datum is the same as used for position determination by the receiver. In all other cases, accuracy of position is significantly decreased, by the difference between electronic chart datum, and datum used by positioning system receiver for position coordinates calculation.

Besides efforts put into developing more and more advanced and accurate positioning systems' receivers, the same efforts must be involved into developing of charts – letting to obtain similar position presentation accuracy. This seems to be most important task for railway transport, where accuracy of position presentation, not only position coordinates themselves, must let to locate the train on proper rails [2], while distance between parallel rails is a few meters. To obtain meter or two accuracy from positioning system soon will be not a problem but, to have the same accuracy while presenting the position onto a chart, it is necessary to use also accurate chart – basing on the same datum. Fig.7 shows example of position errors, caused by improper chart datum. Important feature of charting system, which each one should be equipped with, is function indicating current difference, between navigational chart datum, and datum used by positioning system receiver.

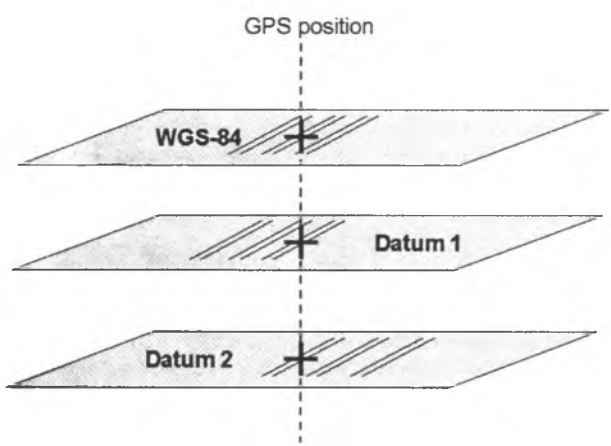

Fig.7. Error of position presentation – the same position presented on different datum charts

5. CONCLUSIONS

Electronic chart systems become popular within land transport applications. Most important fact to remember, when using computer for navigating, is knowledge, its software works strictly according pre-programmed algorithms. As it is impossible, at programming stage, to foresee all possible situations that can happen, computer system is not always reliable device. Operator task is to realise that, and control performance of charting system in all possible ways.

This paper describes main functionality of electronic chart systems, and their limitations. Experience on implementing electronic chart systems in the sea transport, allows to recommend undertaking of research works on performance standards for these systems also for land usage. Each system working on sea-going ship, must fulfil special technical requirements. This is ensuring, charting system is capable of securing proper safety level for ship it is working on. There are also training standards specified, ensuring operators, after training completion, are aware of system's limitations, and trained for effective usage of system's capabilities.

Important functions of each electronic chart system are: route planning, route monitoring, and passage recording. For the route planning and route monitoring, it is very important to take care of proper system settings and configuration. Only system of appropriate configuration, can be a helpful tool, properly taking into account specified criteria. For the passage recording purposes, also proper configuration is needed, letting system storing data, capable of documenting important features of passage.

Electronic chart system, as every computer tool, has also many limitations. Paper describes only some of them, significant for all transport modes. As importance of particular limitations for different modes of transport, can differ each other, there is a necessity for undertaking of research works, aiming to specify charting systems limitations, important for different modes of transport.

BIBLIOGRAPHY

[1] JANUSZEWSKI J., Satellite navigation systems in the new advanced telematics applications, 4th International Conference "Transport Systems Telematics TST'04", Katowice – Ustroń 2004.
[2] LEWIŃSKI A., CHRZAN M., Przykłady zastosowań systemu GPS w transporcie lądowym, Sympozjum „Problemy eksploatacyjne systemu GPS", Gdynia 2004.
[3] NOWAK A., SPECHT C., Wpływ sygnałów odbitych GPS na rozwiązania nawigacyjne, VI Międzynarodowe Sympozjum Nawigacyjne, Gdynia 2005.
[4] WAWRZYŃSKI W., DZIULA P., Information flow modelling within the Transport Telematics' System, 4th International Conference "Transport Systems Telematics TST'04", Katowice – Ustroń 2004.
[5] WEINTRIT A., DZIULA P., MORGAŚ W., Obsługa i wykorzystanie systemu ECDIS, Wydawnictwo Akademii Morskiej w Gdyni, Gdynia 2004.
[6] http://www.garmin.com

Reviewer: Prof. Bernard Wiśniewski