Conception of EGNOS Integrity Data Utilization in ENC Systems

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ABSTRACT: The paper presents the processing of EGNOS integrity data received either directly from the satellite network or the Sisnet internet relay. Relationship between the individual frames in EGNOS messages has been described. Usefulness of these data was indicated by the three examples. In the first example data form EGNOS was used to compare integrity parameters and the calculated position error. In further examples the simulated position with error and calculated integrity parameters were implemented together. The results were presented in two ways: with use of dedicated program which presents only ship contours (the one not covering GNSS uncertainty and the one covering this uncertainty called Marine Vessel Protection Area) and as a layer in existing ECDIS.

1 INTRODUCTION

Over-confidence in the modern positioning systems (especially GNSS) can lead to dangerous situations which in turn can lead to accidents. For this reason it is worth to have a tool to determine the accuracy and integrity of positioning data, in addition to the raw point-based position. Satellite-based augmentation systems (SBAS) such as the European Geostationary Navigation Overlay Service (EGNOS) provide ranging signals transmitted by geostationary satellites. Wide area differential corrections and additional parameters aim to guarantee the integrity of the GNSS. Data from EGNOS can be obtained either via the satellite link, or from ground systems propagating these data online via Internet, such as Sisnet [7]. This allows almost anyone to access these data without sophisticated equipment.

2 PARSING OF THE EGNOS MESSAGESS

The process of EGNOS messages parsing consists of several stages. Data block format of the EGNOS message frame is presented in the Figure 1 [1].

The beginning of the message frames received from the satellite can be recognized by the cyclic prefix: 53(16), 9A(16) and C6(16), but when data are received as .ems file (in post processing) each frame is preceded by an additional satellite number, date and time of registration [7].
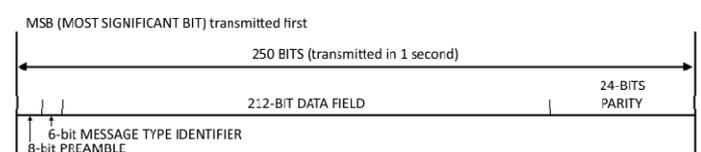

Figure 1. EGNOS data block format

After receiving a frame the checksum calculated by CRC-24Q algorithm should be checked. CRC-24Q is

Cyclic Redundancy Check parity in the 24 bit version developed by Qualcomm Corporation. After calculating the checksum, quick method based on the hash table can be used [8]. In the case of an invalid checksum message is rejected. In the next stage it is checked whether messages necessary to parse according to the tree presented in the Figure 2 were previously received.

The arrows in the Figure 2 indicate the flow of information. Messages required are connected by the continuous lines and the messages preferred to parse are connected by the dashed lines.

The data is then stored in a database to enable intuitive access. Separate process was designed for reading from this database and checking if data were obtained correctly and their ages are valid.
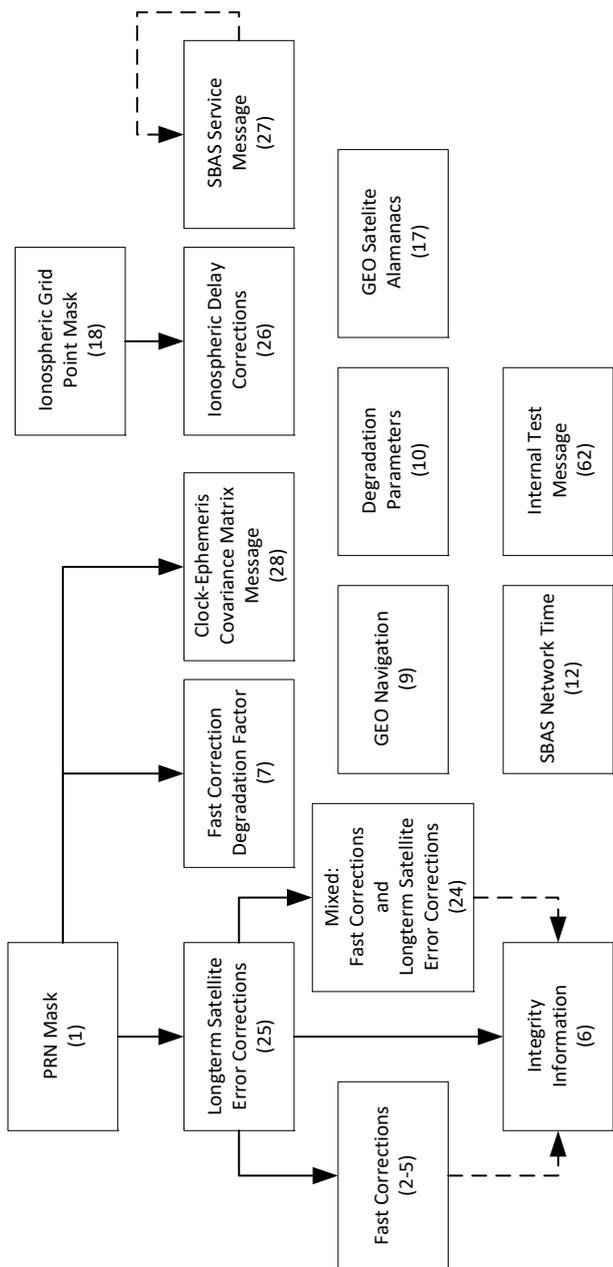
are grouped into classes by this program and stored. Figure 3 shows the relationship between these classes.

3 COMPARISON OF INTEGRITY PARAMETERS AND THE CALCULATED POSITION ERROR

The data was collected during real experiment carried out on board of the vessel. The position error was calculated as a difference between obtained positions from GNSS and RTK, which was treated as a reference position. Integrity parameters were gathered from the Sisnet database for the corresponding period. The results of the comparison are presented in the Figure 4 which shows slightly correlation.
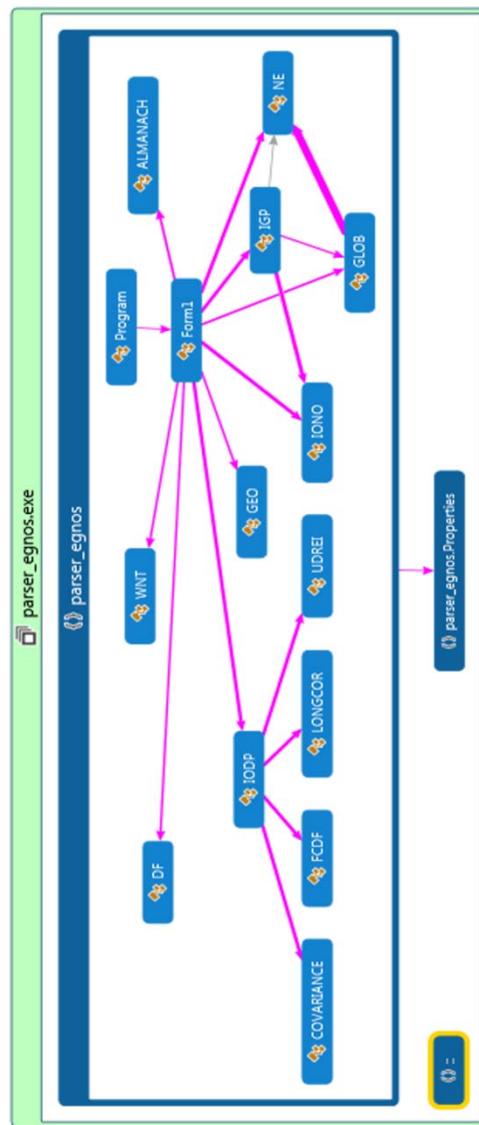

Figure 3. Codemap of "parser_egnos"

Figure 2. Relationship between message types in EGNOS

To extract specific data from .ems files the dedicated program "parser_egnos" was written in C# on the .Net platform 4.5. The individual data series
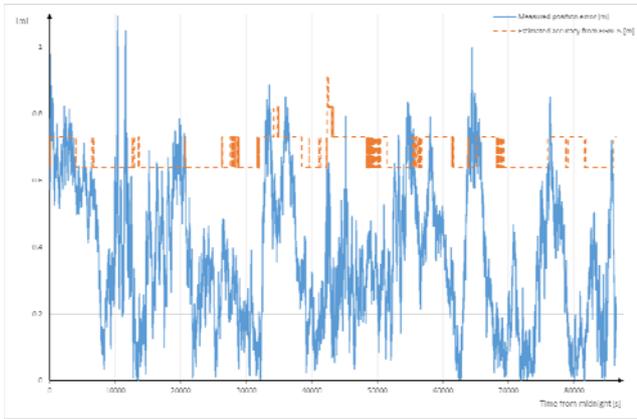
Figure 4. Example of integrity data usage. Estimated accuracy from EGNOS (σ_{GIVE}) and measured position error (difference between GNSS and RTK positions) in one day

4 DETERMINING THE MVPA

The concept of Marine Vessel Protection Area (MVPA) determination with EGNOS augmented GPS as positioning source is based on the assumption that the vessel is a 2-dimensional (2D) spatial object and as such is presented in electronic chart system (ECDIS) integrated into Full Mission Bridge Simulator (FMBS). The navigator has to monitor the position of the vessel contour relative to the declared safety isobaths (navigation dangers). As a result, the vessel position cannot be treated as a point [6]. The error in antenna position will propagate to the final MVPA according to the Gauss's Error Propagation Law. The statistical evaluation of this propagation effect has been presented in [3] and fully elaborated in [4].

For each waterline point the uncertainty ellipse was determined taking into account:
– variance of GNSS position in the East direction,
– variance of GNSS position in the North direction,
– GNSS position East-North covariance,
– variances of waterline points relative to antenna (in ship's body fixed coordinate frame),
– variance of ship's heading,
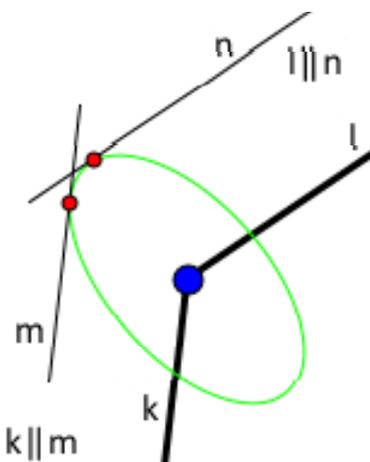– coverage *k*-factor corresponding to the expected confidence level.

Figure 5. Selection of the two MVPA points (red colour) from the error ellipse attached to the original point of waterline (blue color).

Estimated error of each ship's contour point involves the errors of two jointly distributed variables of x_N and y_E coordinates. From every ellipse formed this way the two points are selected to create an MVPA polyline in order to maximize the possible surface area. Method of determining these points is shown on the Figure 5. More details about determining MVPA presented in [5,6].

5 GRAPHICAL INTERPRETATION OF MVPA

Figure 6 shows the developed application which presents actual shape and position of MVPA with reference to the ship's waterline without uncertainty / integrity data included in ship's body fixed coordinate system. In NMEA standard the position in navigation systems is transmitted every two seconds. Buttons 'slower' and 'faster', in section A, allows to increase and decrease frequency of generated simulated position and calculated MVPA, shown in section H. Section B is used to switch between two types of imaging. Mode 1 is semi-transparent history of simulated position, MVPA and solid waterline (Figure 7). Mode 2 is solid representation of these three polylines (Figure 6). Section C contains three checkboxes to select the displayed polylines. Coverage factor (*k*) is presented in section D, and it can be changed in section G. Sections E and F present heading and position: original (real) and simulated respectively. Impact of the coverage factor value is presented in the Figures 8a and 8b.
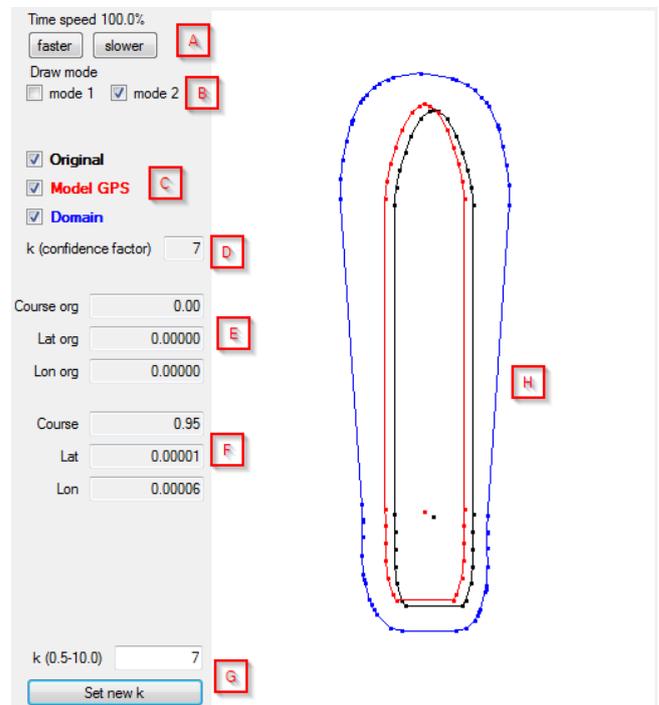

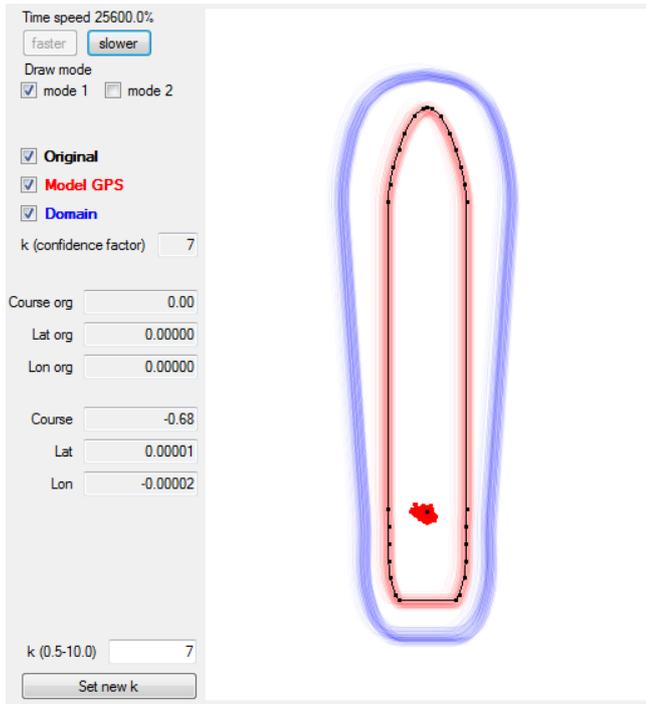Figure 6. The interface of application illustrating the waterlines and MVPA
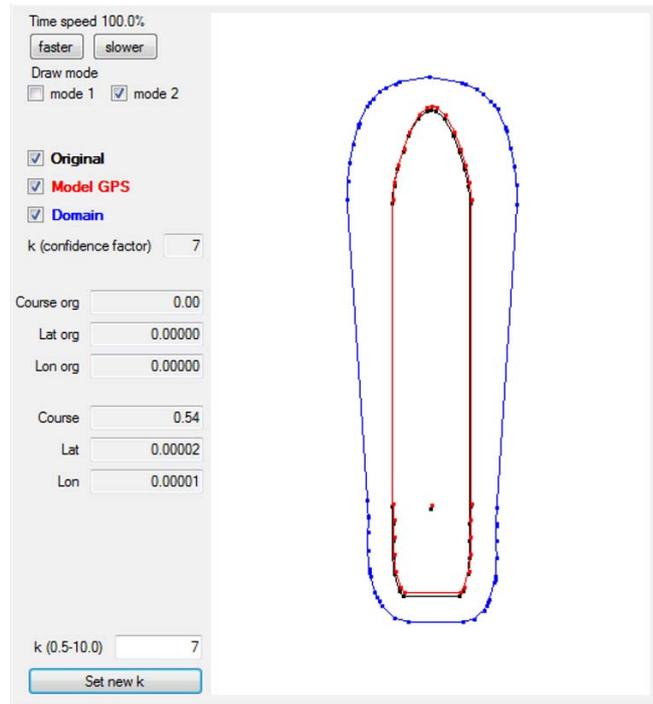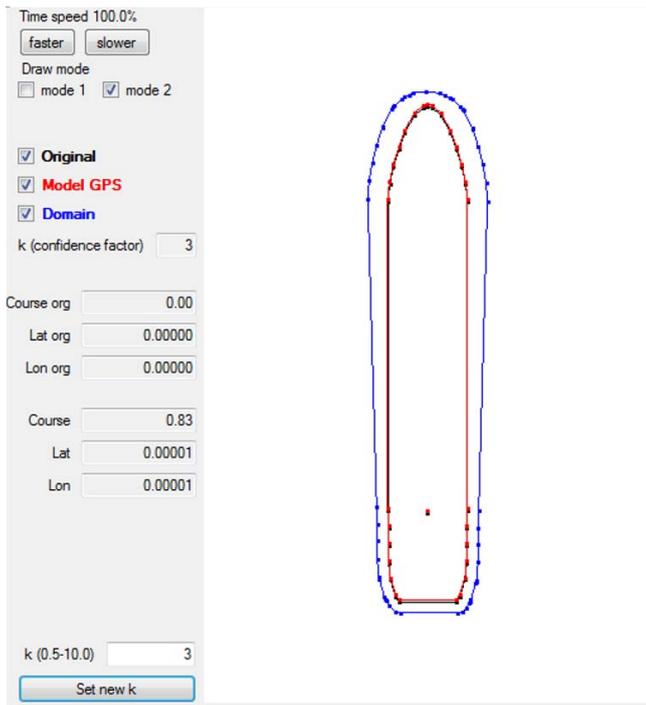
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Figure 7. The interface of application illustrating the drawing mode

b)

Figure 8. Application screenshots illustrating the waterlines and MVPA for two values of the parameter k.

a)

6 THE LAYER OF MVPA APPLIED IN ECDIS

The ECDIS graphical user interface (presented in Fig. 9) is made up of six main components: the chart area, menu bar, status panel, function buttons, alphanumeric panel and information panel. The chart area presents the ENC chart in a way the user chose it according to his requirements. Menu bar contains a few panels where application settings could be changed by user. The first one called "Settings" allows to choose the way the application is exchanging data with other devices. It can be realized via appointed COM port or via net by choosing the one of two available protocols, UDP and TCP/IP. Panel "Ship" defines the position system antenna coordinates and shows the vessel's general particulars. Panel "Charts" presents the list of actually installed ENC charts with its status. The last "Navigation" panel contains the list of custom layer which can be switched on and off. The status panel shows the information regarding current scale and cursor geographical coordinates. Information panel shows the data depending on mode the ECDIS is working in particular moment. It could be information regarding ENC chart, symbols, route, waypoint, MOB, and the EGNOS data.

During the tests the calculated ship's waterline was added to ECDIS - this is shown in Fig 10. ECDIS interface was also enriched by three alarms: HAL Exceeded, TAL Exceeded and MVPA Trespassed. HAL (Horizontal Alarm Limit) Exceeded is activated if circular protection level HPL (derived solely from GNSS / SBAS) exceeds the Horizontal Alert Limit HAL set for a specific marine area and operation. Time Alarm Limit (TAL) establish maximum age of the message in the EGNOS system, above which an TAL Exceeded alarm is activated. MVPA Trespassed

is an alarm that is activated when another object will appear inside the MVPA.
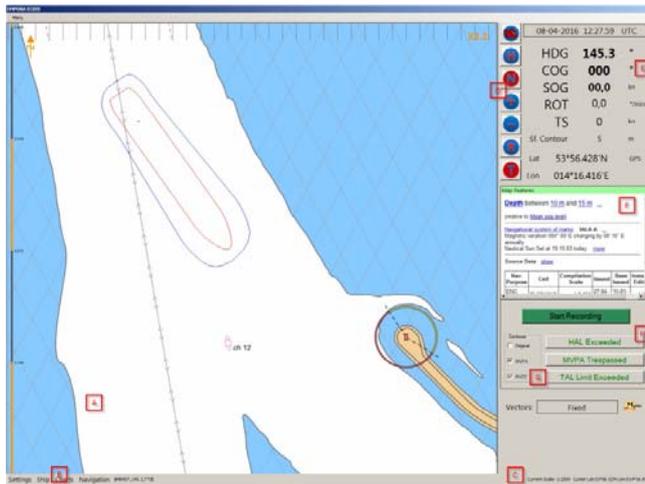

Figure 9. ECDIS interface with MVPA and EGNOS integrity layer (A - chart area, B - menu bar, C - status panel, D - function buttons, E - alphanumeric panel, F - information panel, G – layer selection, H – alarm panel)
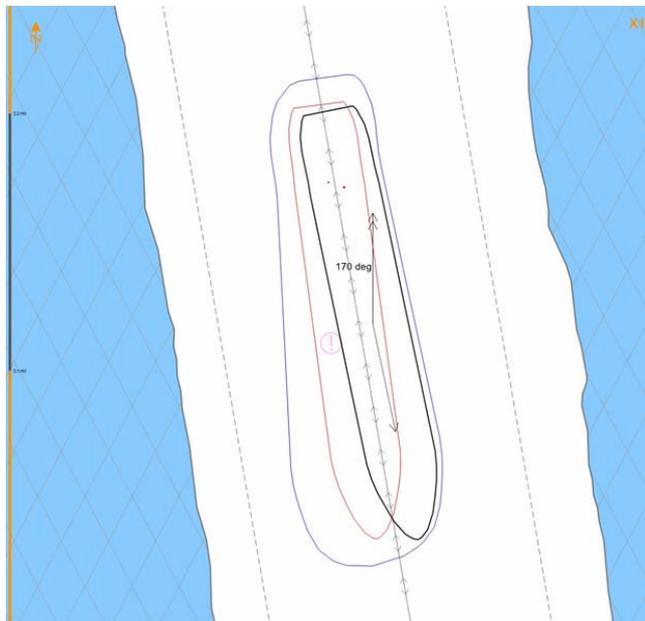

Figure 10. ECDIS with simulated waterline (red), original waterline (black) and MVPA (blue)

7   CONCLUSIONS

Results of the comparison of selected EGNOS integrity parameter (ionospheric propagation variance) and the calculated position error didn't prove the correlation between them, but it proved that the model proposed in [6] should not consider σ_{GIVE} as the most significant integrity parameter. Generally the mathematical model of Marine Vessel Protection Area (MVPA) based on EGNOS provided integrity data is an innovative solution of marine navigation safety evaluation. The display of MVPA on the ECDIS should make it easier and safer to maneuver the ship. Expansion of the waterline can be particularly suitable in the ports. It should illustrate navigators how uncertain may be the data presented by GNSS devices. It shows also that in proximity of other ships or objects, special attention should be paid to visual or radar observations and that you cannot absolutely trust ECDIS presentation based solely on GNSS.

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