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# USAGE AIS DATA FOR ANALYZING SHIP'S MOTION INTENSITY

**ABSTRACT**

The article is scientific and technological look at AIS implementation trends and development nautical (maritime staff) by telemetric with modern GIS/mapping application. This article also provide what is needed to prepare, made — fuse and display AIS information from radio sources on the nautical/GIS chart with systems in same coordinate and reference. There are some information how to decoding AIS data, how to create SHIPS MOVEMENT intensity DIAGRAMS and how interpret it.

**Keywords:**
AIS, ships motion intensity.

## INTRODUCTION

The state of safety at sea can be rate towards vision range of movement of ships and surface units. All information about the ships movement in dependence of location of sea area is possible to obtain used various methods of observation, with the help of the AIS system. The description of movement of ships, acquisition in the AIS, refer to geographical position, courses, construction parameters of ship as well as kind of transportation, should be presented in figure of simplified diagram: space/time. Diagrams these illustrate ships density of movement under specified sea area, on which they shift ships. Multi-criteria analyzes of such diagrams lets the possibility of improvement of organization human activity at sea which can create threat for ships movement, the human life and sea environment.

## AIS DATA DECODING METHODS

Determined, that in aim of creation of diagrams of ships movement intensity, the AIS data will be converted to files of type: *.mif, *.mid as well as *.txt . The first two files be used become in programme GIS-MapInfo to display position and

information descriptive fixes of monitored ships, however third file — in programme MI Vertical Mapper to transfer in the GRID to describe the spatial expansion of analysed parameter (the intensity of movement of ships).

Realized above mentioned, was worked out specialist software attend to conversion of files from AIS data, which be coded fin accordance ITU-R. M. 1371, to files type: *.mif, *.mid, and *.txt. The decoding and interpreting process compose of three leg:

— transformation in binary chains mark chains, which represent it;
— the organization in packets of message the binary chains peaceably from ITU-R.M. 1371;
— the mapping of organized guided packets of message on suitable information.

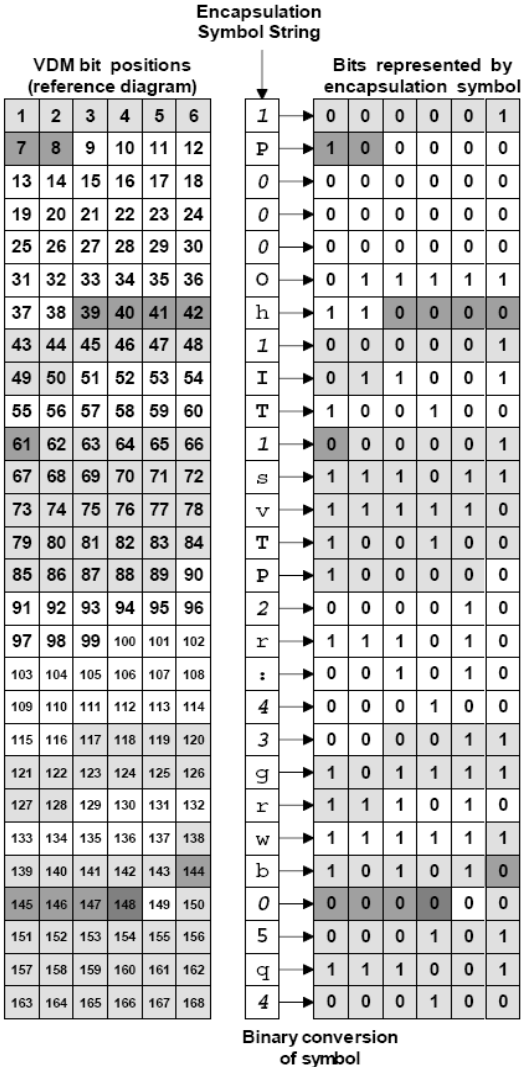
It below example — mark chain and transformed binary chain was presented [1]. Figure this is the visual help, which can facilitate the understanding of process of decoding of AIS message. Line astern on left hand drawing 10 entitled 'Bit positions VDM' is information about accurate position — binary chain of message the information about bit exact position. However line astern after right side entitled 'The binary representation of sign' it motion the information about binary representation of message.

The median line astern contains next the signs of chain of message. Decoding VDM chain has begun for first sign in chain. There in this case sign is '1', and answering him binary chain '000001'. The fix of individual bits of binary chain has been presented on left hand as value since 1 to 6.

Second sign of chain 'P' the binary chain represents '100000'. The fix of individual bits of binary chain has be presented in left line astern as value since 7 to 12. The same the process follows for every sign of chain of message.

Bits 1–6 = Identifier for this message
000001 = **message 1** (Reference Annex E of ITU-R M.1371-1:2000 to interpret following bits 7–168)
Bit 7–8 = Repeat Indicator 2 = **message repeated twice**
Bits 9–38 = MMSI number of broadcasting unit 000000000000000000000001111111 = **127**
Bits 39–42 = Navigational status 0000 = **underway using engine**
Bits 43–50 = Rate of turn (equation used) 00000101 = +**1.1 degrees/minute**
Bits 51–60 = Speed over ground 1001100100 = **61.2 knots**
Bit 61 = Position accuracy 0 = **low (greater than 10 meters)**
Bits 62–89 = Longitude in 1/10000 minutes 000011110111111110010010000 =
= **27 degrees 5 minutes East**
Bits 90–116 = Latitude in 1/10000 minutes 00000101110100010100010000 =
= **5 degrees 5 minutes North**
Bits 117–128 = Course over ground in 1/10 degrees 001110111111 = **95.9 degrees true**

Bits 129–137 = True Heading 101011111 = **351 degrees true**
Bits 138–143 = UTC second when report generated 110101 = **53 seconds past the minute**
Bits 144–147 = Regional Application 0000 = **no regional application**
Bits 148 = Spare
Bit 149 = RAIM Flag 0 = **RAIM not in use**
Bit 150–168 = Communications State 00 = **UTC Direct**
001 = **1 frames remaining until a new slot is selected, UTC hour and minute follow**,
01111001000100 = 01111:0010001 = **15 : 17 UTC**
**Bits 167–168 not used for UTC Sub-message**




| VDM bit positions | | | | | | Encapsulation Symbol String | Bits represented by encapsulation symbol | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 7 | 8 | 9 | 10 | 11 | 12 | p | 1 | 0 | 0 | 0 | 0 | 0 |
| 13 | 14 | 15 | 16 | 17 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | 20 | 21 | 22 | 23 | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 | 26 | 27 | 28 | 29 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31 | 32 | 33 | 34 | 35 | 36 | o | 0 | 1 | 1 | 1 | 1 | 1 |
| 37 | 38 | 39 | 40 | 41 | 42 | h | 1 | 1 | 0 | 0 | 0 | 0 |
| 43 | 44 | 45 | 46 | 47 | 48 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 49 | 50 | 51 | 52 | 53 | 54 | I | 0 | 1 | 1 | 0 | 0 | 1 |
| 55 | 56 | 57 | 58 | 59 | 60 | T | 1 | 0 | 0 | 1 | 0 | 0 |
| 61 | 62 | 63 | 64 | 65 | 66 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 67 | 68 | 69 | 70 | 71 | 72 | s | 1 | 1 | 1 | 0 | 1 | 1 |
| 73 | 74 | 75 | 76 | 77 | 78 | v | 1 | 1 | 1 | 1 | 1 | 0 |
| 79 | 80 | 81 | 82 | 83 | 84 | T | 1 | 0 | 0 | 1 | 0 | 0 |
| 85 | 86 | 87 | 88 | 89 | 90 | p | 1 | 0 | 0 | 0 | 0 | 0 |
| 91 | 92 | 93 | 94 | 95 | 96 | 2 | 0 | 0 | 0 | 0 | 1 | 0 |
| 97 | 98 | 99 | 100 | 101 | 102 | r | 1 | 1 | 1 | 0 | 1 | 0 |
| 103 | 104 | 105 | 106 | 107 | 108 | : | 0 | 0 | 1 | 0 | 1 | 0 |
| 109 | 110 | 111 | 112 | 113 | 114 | 4 | 0 | 0 | 0 | 1 | 0 | 0 |
| 115 | 116 | 117 | 118 | 119 | 120 | 3 | 0 | 0 | 0 | 0 | 1 | 1 |
| 121 | 122 | 123 | 124 | 125 | 126 | g | 1 | 0 | 1 | 1 | 1 | 1 |
| 127 | 128 | 129 | 130 | 131 | 132 | r | 1 | 1 | 1 | 0 | 1 | 0 |
| 133 | 134 | 135 | 136 | 137 | 138 | w | 1 | 1 | 1 | 1 | 1 | 1 |
| 139 | 140 | 141 | 142 | 143 | 144 | b | 1 | 0 | 1 | 0 | 1 | 0 |
| 145 | 146 | 147 | 148 | 149 | 150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 151 | 152 | 153 | 154 | 155 | 156 | 5 | 0 | 0 | 0 | 1 | 0 | 1 |
| 157 | 158 | 159 | 160 | 161 | 162 | q | 1 | 1 | 1 | 0 | 0 | 1 |
| 163 | 164 | 165 | 166 | 167 | 168 | 4 | 0 | 0 | 0 | 1 | 0 | 0 |

Messages 1, 2, and 3 (position reports) [2]

| Parameter | Number of bits | Description |
|---|---|---|
| Message ID | 6 | Identifier for this message 1, 2 or 3 |
| Repeat Indicator | 2 | Used by the repeater to indicate how many times a message has been repeated. Refer to § 4.6.1; 0–3; default = 0; 3 = do not repeat any more |
| User ID | 30 | MMSI number |
| Navigational status | 4 | 0 = under way using engine<br>1 = at anchor<br>2 = not under command<br>3 = restricted manoeuvrability<br>4 = Constrained by her draught<br>5 = Moored<br>6 = Aground<br>7 = Engaged in Fishing<br>8 = Under way sailing<br>9 = reserved for future amendment of Navigational Status for HSC<br>10 = reserved for future amendment of Navigational Status for WIG<br>11–14 = reserved for future use<br>15 = not defined = default |
| Rate of turn ROT[AIS] | 8 | ±127 (–128 (80 hex) indicates not available, which should be the default). Coded by ROT[AIS] = 4.733 SQRT(ROT[IND]) degrees/min ROT[IND] is the Rate of Turn (720 degrees per minute), as indicated by an external sensor.<br>+127 = turning right at 720 degrees per minute or higher;<br>–127 = turning left at 720 degrees per minute or higher |
| SOG | 10 | Speed over ground in 1/10 knot steps (0–102.2 knots) 1023 = not available, 1022 = 102.2 knots or higher |
| Position accuracy | 1 | 1 = high (< 10 m; Differential Mode of e.g. DGNSS receiver);<br>0 = low (> 10 m; Autonomous Mode of e.g. GNSS receiver or of other Electronic Position Fixing Device);<br>default = 0 |
| Longitude | 28 | Longitude in 1/10 000 min (±180 deg, East = positive, West = negative);<br>181 degrees (6791AC0 hex) = not available = default) |

| | | |
|---|---|---|
| Latitude | 27 | Latitude in 1/10 000 min (±90 degrees, North = positive, South = negative);<br>91 degrees (3412140 hex) = not available = default) |
| COG | 12 | Course over ground in 1/10° (0-3599). 3600 (E10 hex) = not available = default;<br>3601–4095 should not be used |
| True Heading | 9 | Degrees (0–359) (511 indicates not available = default) |
| Time stamp | 6 | UTC second when the report was generated (0–59, or 60 if time stamp is not available, which should also be the default value, or 62 if Electronic Position Fixing System operates in estimated (dead reckoning) mode, or 61 if positioning system is in manual input mode or 63 if the positioning system is inoperative) |
| Reserved for regional applications | 4 | Reserved for definition by a competent regional authority. Should be set to zero, if not used for any regional application. Regional applications should not use zero |
| Spare | 1 | Not used. Should be set to zero |
| RAIM-Flag | 1 | RAIM (Receiver Autonomous Integrity Monitoring) flag of Electronic Position Fixing Device;<br>0 = RAIM not in use = default;<br>1 = RAIM in use) |
| Communication State | 19 | |
| Total number of bits | 168 | |

## PRINCIPLE OF THE SHIPS MOVEMENT INTENSITY DIAGRAMS CREATION

In programme implemented the algorithms to determination of number of ships spending in sub-area (formed with division of inspected area on smaller fragments — point of grid net) in time definite slice. Parameter this be described as value definite in node of GRID net. It was determined in result of analysis of mutual location next intervals of ships cruses and intervals limiting the individual point of GRID net. Processed application possesses following main window (cardinal port).

In figure 1 PC window the strainer cores (filters) are to sharp-tuning of individual's selection ships as well as the editorial ports (window) fixable to the parameters of net GRID. Strainer cores permit on of individual's selection ships according to:

— MMSI number;
— type;
— dimensions;
— the velocity of motion (speed);
— draught,

giving in this the way the possibility of constructing the GRID net with expansions of intensity of movement chosen group of individuals ships. The size and resolution of net be established in window 'the parameters of GRID net'. It influences on resolution, appointive from grid in programme VerticalMapper, isoline of analysed parameter and the same on quality their display in programme MapInfo.


Fig. 1. Main window — programme cardinal port

It below represented the example — file of *.txt type with calculated value of node GRID net.

```
ncols 10
nrows 10
xllcorner 18.00000000
yllcorner 54.00000000
Cellsize 0.00027778
NODATA_value 0
0 0 0 0 2 0 0 0 0 0
0 0 0 0 0 1 0 0 0 0
0 0 0 0 1 0 0 1 0 0
0 0 0 0 0 0 0 2 0 0
0 0 0 0 0 3 0 0 0 0
0 0 0 2 0 0 1 0 0 0
0 0 0 2 0 0 1 0 0 0
0 0 2 0 0 0 1 0 0 0
0 0 2 0 0 0 0 1 0 0
2 2 0 0 0 0 0 1 0 0
0 0 0 0 0 0 0 0 1 0
```

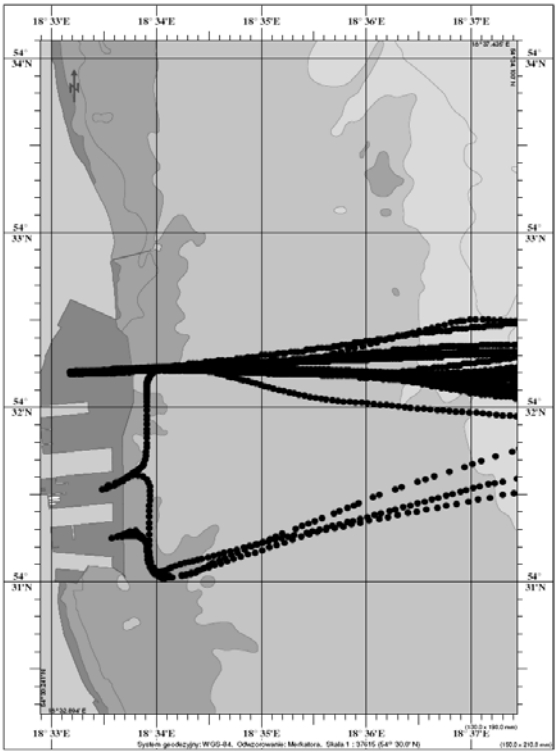



Fig. 2. The trajectories of passenger ships in one week period

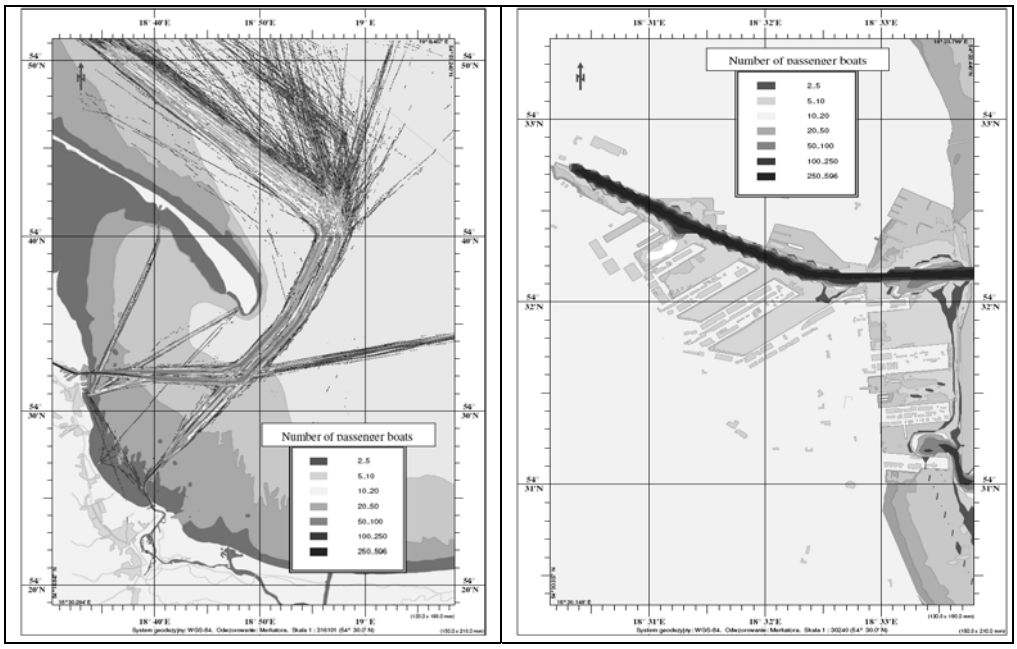



Fig. 3. The analysis of passenger ships movement intensity with speed above two knots (kn) from 24 IV 2006 to 06 IX 2006

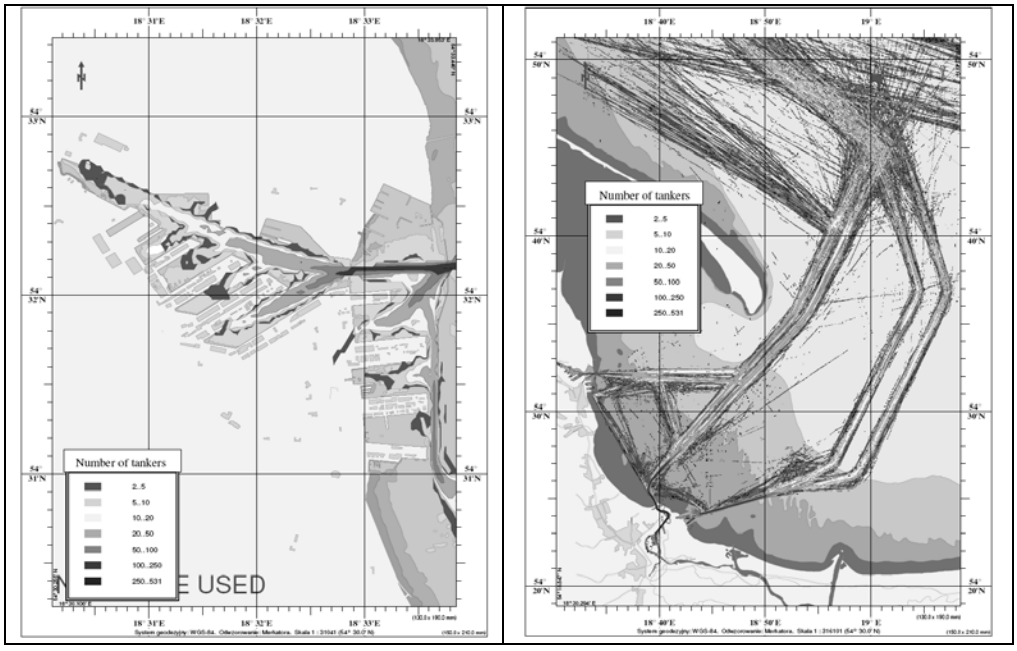



Fig. 4. The analysis of tankers movement intensity with speed above two knots (kn) from 24 IV 2006 to 06 IX 2006

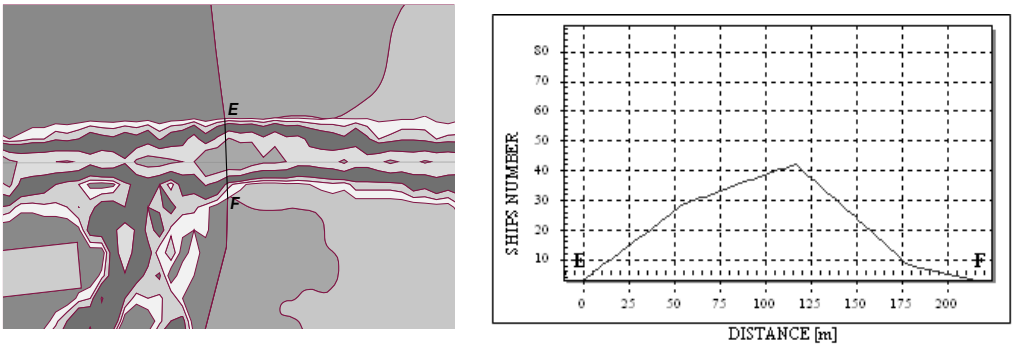



Fig. 5. The analysis of ships movement intensity on $\overline{\mathbf{EF}}$ section from 24 IV 2006 to 06 IX 2006

## CONCLUSIONS

The safety at sea describes the state of sea environments, objects in movement as well as the organization and principle of realization of human activity at sea. The diagrams of ships movement intensity should permit on quantitative qualification of security — safety level, connected directly with kind of area as well as exploited thereon with types of ships at sea. It should facilitate the guidance of tests the relating of local regulation, among other things: the principles of ships movement, especially determination of ships distances, principle of passing and crossing each other on the NavArea fairways.

## REFERENCES

[1] IEC, Maritime navigation and radiocommunication equipment and systems — Digital interfaces, Part 100: Single talker and multiple listeners, Extra requirements to IEC 61162-1 for the UAIS, 2002.

[2] ITU, Technical characteristics for a universal shipborne automatic identification system using time division multiple access in the VHF maritime mobile band — M.1371, 2001.

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