UDC 629.5.066=111(043)

CALCULATION OF THE EFFICIENCY OF AIS FOR CREATION AIS ATON NETWORK ON THE IWW OF UKRAINE

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ABSTRACT

Modernization of ports and fairways, as well as the latest advances in science in the development of new technologies and the growing demand for navigation services make it necessary to dynamically modernize navigation systems. It should be noted that the navigators during navigating in IWW, as a rule, prefer the pilotage as a method of navigation, which does not fully ensure the level of safety of navigation. The most constructive solution of the above mentioned problem is the conversion from the pilotage to the instrumental method of navigation, based on the using of E-navigation, as well as implementation of modern info-communication systems, such as virtual AIS AtoN, which allow to constructively link the structural elements of the transport process with a single architecture. In order to develop the AIS AtoN network, firstly, it is necessary to calculate the effectiveness of AIS, taking into account external circumstances that could meddle with the accuracy of the signal transmission. **Keywords:** effectiveness of AIS, AIS AtoN, IWW.

Defining the general matter

Waterway Administrations in European countries reguire remote monitoring and management of AtoN system to increase accessibility, force response times in dangerous situations, and improve maintenance planning. One of the most effective solutions is to use AIS technology, due to the fact that its equipment is standardized, and the AIS receiver must be established on all ships of the appropriate size. The aim of the research is to improve the safety of navigation by calculating the efficiency of AIS base stations for creation a reliable AIS AtoN network.

Previous researches analysis

A number of works which discuss the subject of increasing safety navigational level on the IWW were considered for the article.

The work [1] considers the prospects for the development of the Ukrainian section of the E-40 shipping route. The findings of the research foreground the necessity to create a common information space which will allow to solve a number of important tasks in the field of navigation in the IWW.

The source [2] describes the creation of the Aton network on critical sections of the Dnieper River, which allows remote monitoring of AIS AtoNs.

The work [3] describes the digital RIS index on the inland waterways of Ukraine in the process of introducing the information portal of the European Union.

The work [4] describes one of the methods of optimization the marine signalling system in the Venetian lagoon. The analysis aims at maximizing the safety level of maritime traffic in dangerous circumstances by development of electronic navigation.

The article [5] formulated the concept of creating a system of guaranteed safety for the control of maritime objects. The main idea is the automation of ship control and information processing.

Using electronic charts in integrated navigation systems in IWW is described in this article [6]. The results show increasing safety navigational level based the European system, where the ENC is, in its turn, based on the Inland ECDIS standard, serves as the source of basic navigation information.

For the development of shipping in IWW of Ukraine and for the high-quality implementation of the above mentioned goal, it is necessary to develop safety using modern technologies; first of all, we need to calculate the efficiency of AIS, which was not done in the above works.

Principal Research Data

AIS shore equipment is designed for monitoring; setting in the area of responsibility the necessary modes of operation of AIS class A, B and navigation equipment (AtoN). AIS of all modifications has access to VDM via FATDMA (Fixed Time Division Multiple Access) and RATDMA (Random Access Time Division Multiple Access) according to the recommendations of ITU-R M.1371-1 [7], IALA A-124 [8] and can work in a dependent (used in the coastal area under the control of the base station) and independent mode (used both on the high seas and in coastal areas), in self-supporting and in a duplicate configuration.

The line of coastal stations is designed in such a way as to ensure maximum coverage of coastal waters, port waters and approaches in working areas. In a particular case, the chain of coastal stations may consist of a single base station, which is installed in a small port located on an undeveloped coast with low intensity of navigation. In most cases, the chain of coastal stations consists of several base stations and repeaters, which cover the working areas of the coast for 60 - 300 miles or more. Let's consider the situation on the Dnieper River.

The table 1 provides information of the location of AIS base stations and their main characteristics on the Dnieper River.

The range of AIS stations can be calculated by the formula (1):

$$R = k \times (\sqrt{h_1} + \sqrt{h_2}) \qquad (1)$$

Where R – the maximum range of radio waves in kilometers (excluding refraction); h_1, h_2 – height above the ground of the receiving and transmitting antenna in meters; k – the coefficient that takes into account the refraction, is taken in the range of 3.6 – 4.2 (when calculating the range of direct visibility, without taking into account the refraction, it is taken equal to 3.57).

The calculation of the efficiency of AIS base stations showed that the obtained data comply with requirements. However, it should be kept in mind that the range of shore stations at the height of the antennas from 100 to 250 meters is 55 – 80 kilometers, which is significantly exceeds the range of ship stations and AIS AtoN transponders. Therefore, vessels and buoys that do not have "radio contact" with each other can fetch the same slots for transmitting their messages within range of the one shore station. Moreover, in areas of intensive shipping when the AIS communication channel is overloaded, the vessel stations transmit part of their messages, where the most remote ship stations also transmit their messages in the slots. In this case, the shore station will receive superimposed messages and some information from the vessels will be lost. The longer the range of the base station and the higher the intensity of navigation, the more probability this situation will occur.

Table 1 – Location of AIS base stations and their main characteristics on the Dnieper River.

Name	**Locality**	**Km**	**Latitude**	**Longitude**	**Antenna height**	**Location height**	**River height**
1	2	3	4	5	6	7	8
BS1	Vyshhorod	871	50°35'22.20"N	030°30'19.80"E	25	100	98/90
BS2	Kaniv	724	49°45'45.00"N	031°27'48.00"E	25	88	87/80
BS3	Svitlovodsk	556	49°40'24.00"N 49°40'23.06"N	033°15'01.02"E 033°15'01.77"E	25	78	77/67
BS4	Kamyanske	434	48°32'49.80"N	034°32'25.20"E	25	67	62/51
BS5	Zaporizhzhia	305	47°51'46.80"N	035°05'24.00"E	25	44	47/13
BS6	Nova Kakhovka	93	46°46'30.00"N	033°22'30.00"E	25	14	13/0
BS01	Kyiv	851	50°23'52.20"N	030°34'24.00"E	34	97	90
BS02	Gnidyn	845	50°19'31.90"N	030°38'46.87"E	30	89	87
BS03	Stables	795	50°05'13.80"N	030°53'19.80"E	55	168	87
BS04	Rzhyshchiv	790	49°57'58.80"N	031°01'32.40"E	63	145	87
BS05	Cibli	710	49°59'16.80"N	031°34'31.20"E	58	113	87
BS06	Bubnivska Slobidka	704	49°43'06.00"N	031°42'06.00"E	50	86	79

Continue of Table 1

1	2	3	4	5	6	7	8
BS07	Svidivok	660	49°31'03.60"N	031°55'28.20"E	46	81	77
BS08	Moskalenki	655	49°26'59.31"N	032°29'42.06"E	42	119	77
BS09	Ratseve	592	49°07'42.60"N	032°44'00.00"E	34	97	77
BS10	Kelebreda	520	48°57'46.80"N	033°42'20.40"E	42	73	62
BS11	Kutsevolivka	505	48°52'09.00"N	033°49'34.80"E	51	77	62
BS12	Prydnipryanske	470	48°46'39.60"N	034°17'43.80"E	42	65	62
BS13	Taromske	410	48°26'46.20"N	034°46'23.40"E	30	161	51
BS14	Dnipro	380	48°26'00.60"N	035°07'31.80"E	56	68	49
BS15	Viyskove	354	48°09'16.20"N	035°10'00.60"E	46	109	47
BS16	Bilenke	270	47°37'25.80"N	035°03'04.80"E	38	28	13
BS17	Energodar	240	47°29'57.00"N	034°39'18.00"E	46	29	13
BS18	Oleksiyivka	209	47°35'30.60"N	034°14'12.60"E	32	27	13
BS19	Zolota Balka	178	47°22'29.40"N	033°57'24.60"E	40	89	13
BS20	Kachkarivka	152	47°05'48.00"N	033°45'03.60"E	35	66	13
BS21	Kairi	118	46°56'40.20"N	033°42'21.00"E	27	65	13
BS22	Poniatinka	65	46°44'58.80"N	032°54'40.20"E	27	39	0
BS23	Kherson	28	46°38'53.40"N	032°37'59.40"E	46	51	0
BS24	Kizomis	0	46°33'40.80"N	032°20'46.20"E	35	11	0

Conclusions and further research prospects

Consequently, it was concluded that in order to develop and implement the AIS Aton network in the Ukrainian IWW, it is necessary to solve the outlined problem. To prevent the loss of information by shore services in congested waters, it is necessary to use the following values or their combinations:

- Limit the range of shore stations by installing antennas at a relatively low altitude;
- Locate coastal stations with a significant (up to 50%) overlap of coverage areas with a corresponding increase in the number of stations;
- Areas of the water area with the most intensive shipping should be overlapped by working areas of 2 – 3 coastal stations at the same time;
- Apply the directed antennas that provide work of stations in the set sector on the section of shore stations;
- Install two base stations operating in adjacent sectors at one facility;
- Use a combination of an increased number of reception-only stations (with a small range or in a given sector) and a smaller number of stations with an extended transmission range.

For a more detailed study in subsequent researches, it is also necessary to calculate the potential efficiency of AIS under conditions of fluctuation noise exposure, as well as under the influence of an obstacle relief.

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