Laser Lights to Define a Safe Course

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ABSTRACT

Usage of lasers as sources of light narrow-beams in beacons considerably increases of detectable distances in area of large optical thickness in dense atmospheric smokes, when traditional lights are not visible. On the one hand, it is reached due to a high directivity of the laser beams, and with other - high spectral brightness and concerning high output power of used lasers. Besides, usage a small optical diameter of the laser beam allows creating the one position range. This circumstance in a number of cases is the key to solve the problem. In the paper the items of information on domestic laser aids to navigation (AtoN) types are resulted. The features are considered from the comparison positions. Results of field tests are considered and the problems of operational use and the further development perspectives and usages are considered.

1.0 INTRODUCTION

In spite of the progress of radio-electronic systems, the importance of visual aids to navigation (AtoN) in the field of safety and regularity of navigation in a coastal zone constantly grows. Moreover, there is an imperative need of constant perfection and creation essentially new visual AtoN. First of all, it is connected with complex navigating conditions in seaports, in connection with growth of terrorist threats. For these conditions navigators require the simple and clear navigating information, which does not demand special preliminary preparation.

These changes require to improve AtoN both for increasing visibility range and conspicuous light sources, increase in service life and reduction of expenses at operation, and for creation of essentially new kinds of AtoN, more effective AtoN.

Now the direction is set to a vessel by navigational range, which has luminous head, and rear range, and accuracy of orientation increases with increase in distance between them. The range sets a line, which shows a safe route of movement to a mooring.

In conditions of sharply crossed coastal zone, for example, at presence of mountainous coasts and a narrow way in the channel, there is no opportunity to carry head and back ranges at necessary distance. Besides, front and rear ranges can be strongly carried by height. In these conditions to take a direction with necessary accuracy is difficult enough. The situation even more becomes complicated at reduction of visibility in the atmosphere.

At the present time the unique decision of similar problems of coastal navigation is connected with the development of laser technologies. It is recognized by the marine community that is confirmed with many publications including XIVth and XVth IALA Conferences, 1998, 2002 where to this problem was devoted US, Japan, Canada Coast Guards and Russia reports [1,2,3,4,5,6,7,8].

2.0 ADVANTAGES OF THE LASER TECHNOLOGIES USE

As it has already been marked, the given technology allows creating the one position AtoN. It is essentially important where it is impossible to expose or the construction back range is difficult where the minimal territory is necessary for expansion of AtoN. For example, in conditions of mountainous coast, this technology is effective, and in some cases, it is unique. The technology provides better visibility of the range and conspicuous of fire against a complex lighting background so that it can be quickly identified [9,10,11]. Besides the application of laser technologies allows to create visual AtoN, having even more, than Light Emitted Diodes (LEDs) technologies profitability.

That is why such activity is observed in the field of research and development of laser visual AtoN, especially during last 10 years. This activity can even be compared to a boom, characteristic now for LEDs technology.

First of all, it is connected with occurrence during these years of highly effective diode lasers with power consumption of unit watt and with a time between failures exceeding 50 000 hours. By this time the parameters of classical He-Ne, Ion laser and Diode-Pumped Solid State Lasers, which spectrum of radiation is shown in the Figure 1 also have been improved.

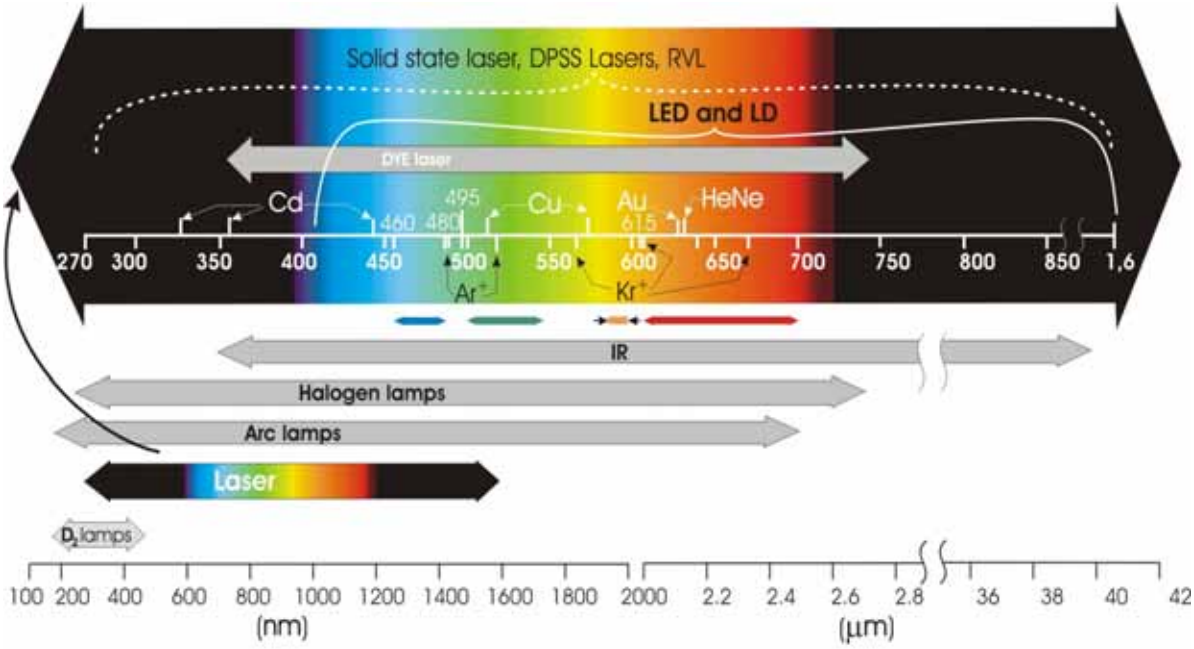

Figure 1: Available light sources.

All this means, that the market of essentially new, economic visual AtoN with service of one time in 7 years in the near future will be open, that sharply reduces operational expenses [12]. These are essentially new kinds of AtoN. Therefore, the marine community pays much attention to laser technologies.

3.0 OUR APPROACH

Our approach is based on scanning of a laser beam into an orientation zone with the divergence of radiation equal to several angular minutes. It allows increasing in comparison with known decisions and traditional visual AtoN the detectable distance at least on 25 - 30 %. Distinctions even more grow at reduction of visibility in the atmosphere. In twilight, the limiting visibility range always two and more times is larger, than at regular fires at equal power consumption. It is actual for Russia at maintenance of navigation in the Arctic Seas where twilight are long, especially during the spring and autumn periods. Besides, narrow laser beams allow one to use simple and cheap methods to carry out redistribution of light energy in a zone of orientation, increasing thus detectable distance.

4.0 DEVELOPMENT OF LASER AtoNs

At the end of 80's and the beginning of 90's years a number R&D organizations of Russia has been developed domestic samples of laser visual AtoN, the majority of which should be attributed to laser leading beacons. Their features are given in the Table.

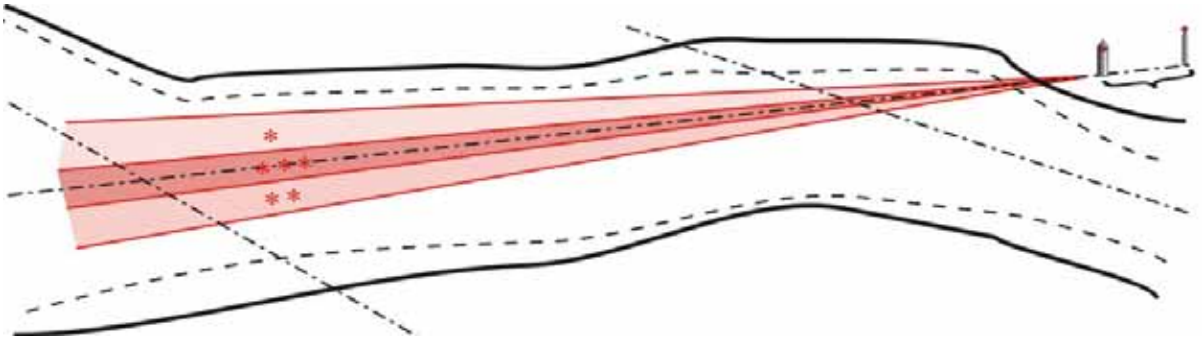

Figure 2: Nizhneudinskii laser leading beacon.

In the majority of our decisions, the laser beacon has one position site. For some cases where visibility of Front Range is limited by irrational port building, two position laser leading beacons are developed. Some pre-production models of one position laser leading beacon, fulfilled by the order of the Ministries for Transport custom-made the Hydrographic Enterprise, have been established in ports Dudinka and Providence Bay.

The typical location plan of the given beacon in rivers mouth of the Siberian Rivers is given in Figure 2 for a mouth of the river Ob'. Conditions of navigation here are the following: extended up to 15 and more miles and narrow channels are available. Navigating maintenance of such channels with visual means in some cases is complicated due to a complex relief of land. Therefore the equipment of the given waterways one position laser leading beacons is the single decision.

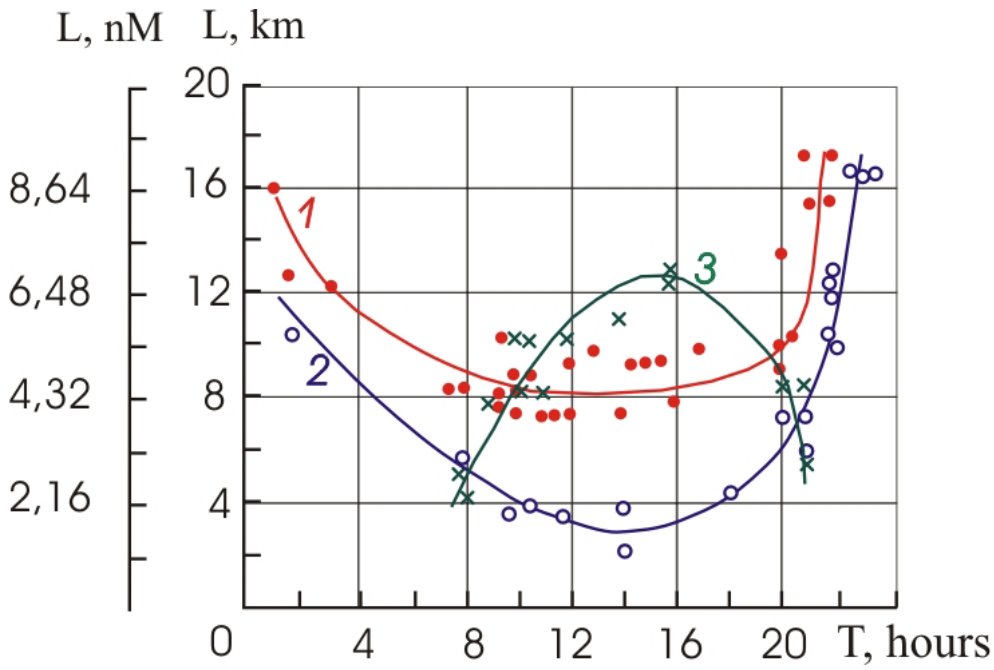

Figure 3: The data of field observations of the one position laser leading beacon (1), regular marine lights (2) and unlit marks (3) as the function of the day time (unaided eye).

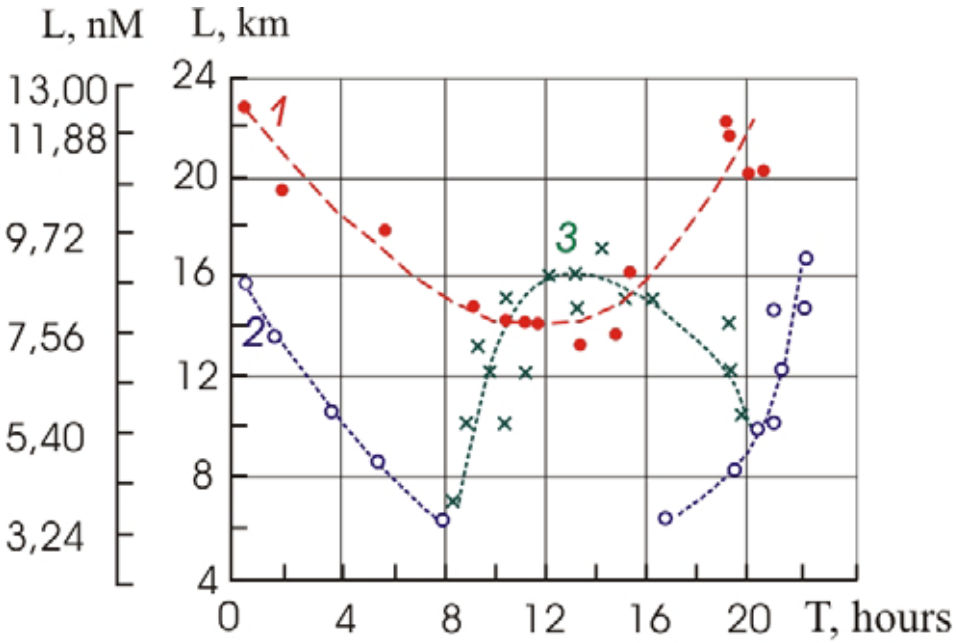

Figure 4: The data of field observations of the one position laser leading beacon (1), regular marine lights (2) and unlit marks (3) as the function of the day time (binoculars observations).

Table: Specification of the Laser Leading Beacons

The name of characteristics	Two position	One position	*One position two colour*
Character of navigation information	Flash, 0.2 - 0.7 Hz; pause-1-3 s. One colour	Flash, with pause 1-10 s. One colour	*Flash, with* pause 1-10 s
Quantity of sectors	One	Three	*Three*
Adjustment angle in zones, degree	Azimuth - 0.5-5 Angle of elevation 0.5 - 3	Azimuth – 0.1-1.2; 0.1-3; Angle of elevation 0.5-5.	Azimuth:10 Angle min. lateral-0.1-3.5. Angle of elevation 0.5-5
Radiation wavelength, μ m	0.63	0.63	*0.61-0.66;* 0.46-0.52
Output power, mW	4-10	15-25	*45*
Range of visibility: day, night	1 Sm*), 2 Sm	1.5 Sm, 2.5 Sm	1.5 Sm, 2.5 Sm
Accuracy of pilotage, angle minute	3-7	1 near a channel edge at the 3σ	1 near a channel edge at the 3σ
Power consup., watt	550	Average - 30	1500
Environmental, deg.C	40; - 40	35; - 50	40; - 50
Lifetime, hours	5000	3000	5000
Mass, kg	76 - one position	180	---

*) Sm – meteorological range of visibility.

The laser leading beacon have operated more than 6 years in difficult climatic conditions, however, now due to the limited opportunities of the consumer there are no means for the further service. Figure 3, 4 shows essentially major detectable distances of the laser leading beacon in comparison with standard navigational range [13, 14]. This field measurement data received at Sm ≈ 8 km.

In Figure 5 the appearance of the beacon without mantle and ready-assembled is shown.

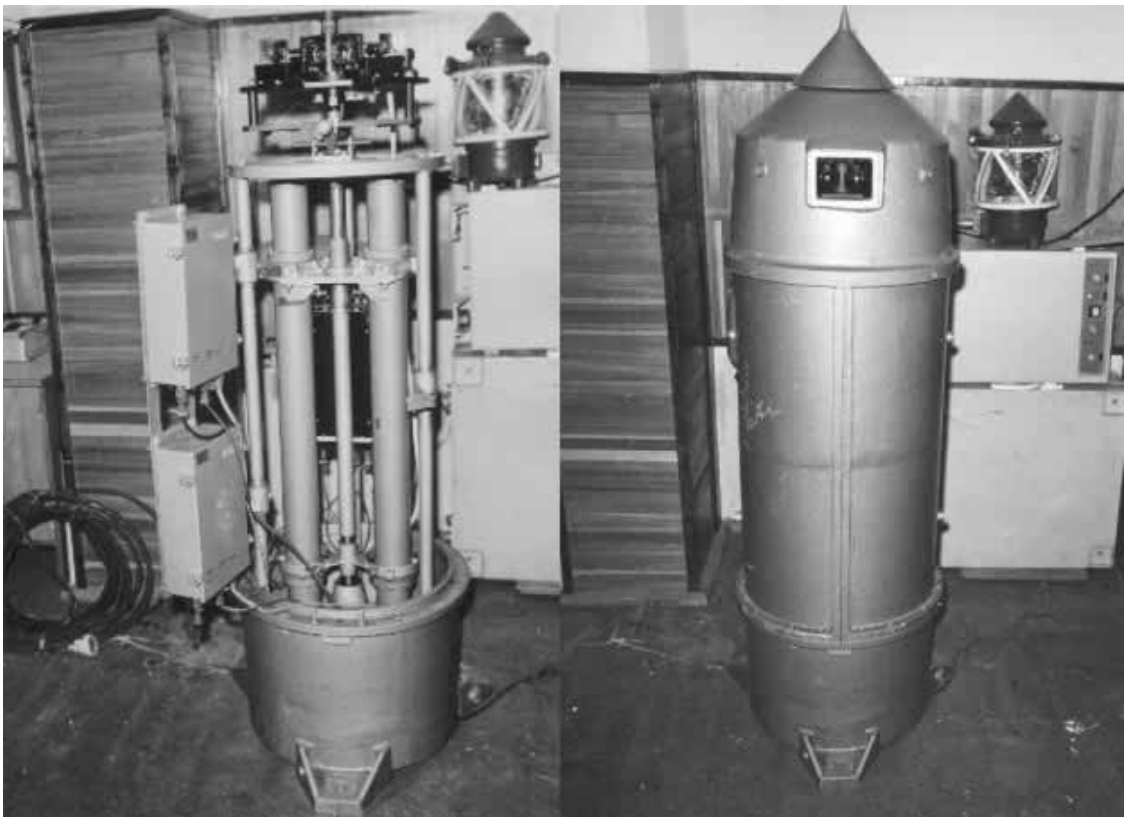

Figure 5: One colour, one position laser leading beacon: left - without mantle, right – ready-assembled.

Figure 6: The laser leading beacon collocation on the front structure of the Lihachyvskii leading range of Providence Bay

One of the laser leading beacon placing sites on Northern Sea Way is shown in Figure 6 where it is resulted one-colour one-structure laser leading beacon established on the front structure of the Lihachyvskii leading range of Providence Bay. Here at the left the beacon is located, the front lantern of the regular leading range MS-210 is on the right.
At the same time here it is necessary to note, that the rear lantern of the regular leading range is located on distance about 1 kilometer. To place on the greater distance the rear lantern of the leading range for increasing an accuracy of the center line design the relief does not allow. The laser leading beacon solves this problem. For its accommodation needs the minimal area. Thus, high accuracy of the center line design is provided. The detection distance always on 25 - 30 % is more, and power consumption is less, than at the regular leading range.

One of latest domestic developments is the experimental sample of laser multi-colour leading beacon based on the use of semi-conductor lasers with electronic excitation, which allow refusing electromechanical scanners [15,16,17,18]. Another basic difference is the opportunity of obtaining practically any flashing characteristic. Principle of work the given laser range is based on the power transformation of an electronic stream to a semi-conductor monocrystal in optical radiation.
The location plan of Scanning Semi-Conductor Laser Range with Electronic Pump (SSCLEP) on coast and principle actions is similar two position laser leading beacon (Figure 7).

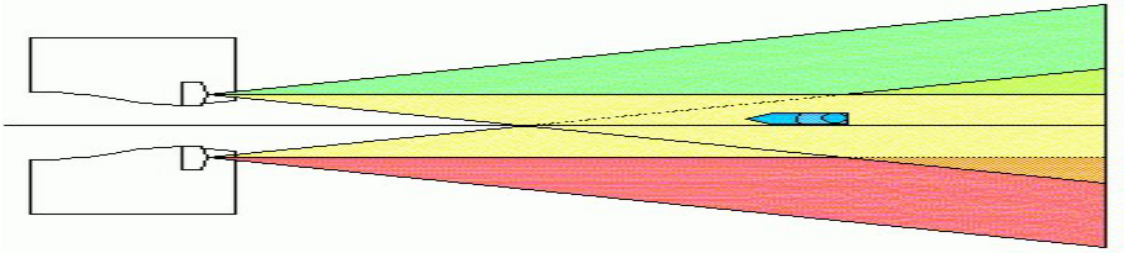

Figure 7: The operation principle of the semiconductor two position laser leading beacon

The appearance of one post of laser beacon and the tube is given in and Figure 8.

Figure 7: The one post beacon exterior (left) and tube (right).

5.0 RESULTS OF PRACTICAL APLICATION

Numerous and long-term sea tests, pre-production operation and the comparative analysis of characteristics of the Table shows the following:

- In the common opinion, the installation of laser leading beacons considerably improves the conditions of navigation on range especially at the lowered visibility and in twilight when conditions of natural light exposure are adverse for supervision of fires and marks.
- Light characteristics of zones are distinguished precisely and the side of evasion from a conducting zone is determined confidently.
- In twilight the detectable distance of a laser light source is much higher, than regular fires and marks under any conditions of visibility. This circumstance is especially important for navigation in the Arctic seas where the twilight is long especially during the autumn and spring periods.
- The exit on conducting zone in a distant part of the laser range at transition from one to another does not cause difficulties.
- As a whole, the laser light source on the spectral intensity of radiation considerably surpasses other known light sources. However doubtless optimism causes that the time between failures of lasers, suitable for use in AtoN, constantly grows. Now it exceeds 50 thousand hours. Among other things, it gives significant economy on operating expenses.
- It should be noted especially that all the domestic samples of laser beacons satisfy the National Safety Standards for Laser Products, which do not contradict the European Standards.

6.0 SUMMARY

By present time the extensive nomenclature of methods is developed, the various kinds of laser aids to navigation are tested, allowing to solve those or other problems at the navigating equipment of waterways.

The question on expediency of application of AtoN should be solved proceeding from concrete conditions of navigation and its maintenance of safety, at the all-round account of technical opportunities and economic efficiency of all AtoN.

In some cases the greatest effect from laser leading beacons will be achieved at simultaneous their use with other kinds of AtoN.

One position laser range is expedient for establishing in those places where:

- the construction of back range is complicated or is impossible;
- for maintenance of the approach to moorages at performance of hydraulic engineering, and
- dredging works;
- at a lining of cables;
- at exhibiting a protection to channels and waterways;
- borders or local points is necessary;
- in all other cases when high accuracy range guideline or fixations on a water table of lines.

7.0 REFERENCES

[1] A.V. Arecehi, L.R. Lomer. (1975). *Single station. Laser range light*, USA IX Intern. Conf. on lighthouse and other aids to navigation, Ottawa.

[2] Zuev V.E., Kaloshin G.A., Peresipkin V.I., et al. (1985). *Laser devices for providing coastal navigation*. Science, Novosibirsk, 127 p.

[3] P.F. Jacobs, T.S. Winslow, J.D. Campbell, and L. Reynolds. (1985). *Design, development, and testing of two prototype maritime laser aids to navigation*. Proc. Soc. Photo-Opt. Instrum. Eng., V. 540, p. 555-559.

[4] L. Mehrkam, M.J. Baca, "J. Walters. (1994). *New Range Lights*. Proc. XIIIth Conf. of the IALA, Hawaii.

[5] ChateauvertA., Taillon Y. (1998). *Laser Technology and the Modernization of Marine AtoN*. Proc.XIVth Conf. of the IALA.

[6] R. Silberhorn, A. Chateauvert. (2002). *The Use Laser Technology in Aids to Navigation service*. Proc. XVth Conf. of the IALA, p. 63 - 72.

[7] A. I. Gordienko, G. A. Kaloshin. (2002). *Laser Leading Beacons: Summaries and Perspectives*. Proc. XVth Conf. of the IALA, p. 150-158.

[8] T. Nitta. (2002). *Development of New Aids to Navigation System by Laser.* Proc. XVth Conf. of the IALA, p. 19-25.

[9] Kaloshin G.A. (1995). *Time and energy characteristics of emission in signal zone of laser beacon*. Proc. of III Inter. Conf. "Atomic and Molecular Pulsed Lasers", Proc. of SPIE, V. 4071, p. 253-258.

[10] Kaloshin G.A., Miheev Y.S. (1992). *The Energy radiation structure in orientation bands LND*. J. Opt, Tech., No. 10, p. 3-6.

[11] Kaloshin G.A. (1997). *Investigation of the impurity effect of optical surfaces on the accuracy and the reliability of a laser beacon operation.* J. Opt. Tech., V. 64. No. 12, p. 89-92.

[12] G.A. Kaloshin, A.N. Maltsev. (2001). *New Light Sources for Visual Aids to Navigation*. J. Navigation and Hidrography, No13, p. 100-109.

[13] G.A. Kaloshin, S.A. Shishkin. (2004). *Methodical Problems of calculating the Detectable Distance for New Light-Optical Systems of Visual Aids to Navigation*. J. Navigation and Hydrography, № 18, p. 34-43.

[14] J. Piazzola, G. Kaloshin, G. De Leeuw, A. Van Eijk. (2004). *Aerosol extinction in coastal Zone.* Proceeding of the 11th SPIE International Symposium "Remote Sensing", V.5572, p. 94 -100.

[15] I. Olihov, L. Kosovskii. (1999). *A mobile laser tree chromatic navigational.* Reliability in extreme situations. Electronics: science, technology, business, 3, May - June.

[16] Kaloshin G.A. (2003). *Advanced Navigation System (Russia)*. IALA Bulletin, **2**, p. 38.

[17] Kaloshin G.A., Gordienko A.I. (2003). *Laser Aids to Navigation (methods).* IALA Bulletin, **3**, p. 46 – 51.

[18] Kaloshin G.A., Gordienko A.I. (2004). *Laser Aids to Navigation (technologies).* IALA Bulletin, **1**, p. 30 – 39.