ON THE PROBLEM OF IMPROVING LASER DISTANCE MEASURER LD-2

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ABSTRACT. The question of creation of the mathematical model laser-location station (LLS), which shouldbe take into account of the basic counstituents of the instrumental error of the LLS LD-2 are given. By mean packets of programs "CHECK-GRAFH" we carried out analyse qualitatively seperate bloks and parts of station in the regime of the static distance measurement to a calibre target.

After modernization LD-2, performed together with State Interinstitutional Centre "Orion", the square error measurement of one satellite passage are reduce from $2.5m$ to $0.7 - 0.8m$; mean square error the normal satellite position is of $0.25 - 0.30m$ at then.

Key words: Artificial Satellites.

The first laser observation of satellites in Ukraine occured in 1972 in Uzhgorod (Bratiychuk M.V., 1994). At present on the territory of Ukraine with the participation of several ministries and organizations are working for creating a network of laser - location stations (LLS) in the composition of which there will be two types of stations:

- navigational for the location of low-orbital artificial satellites of the type "Ajisai", "Ers", "Topex";

- geodesic for the location of high-orbital artificial satellites of the type "Lageos", "Etalon". Laser Distance measurer-2 have been used as navigational LLS at the present stage as the most spread on the territory of Ukraine. That is why, the problem of increasing technical characteristics of the given LLS is actual. Exactness of measurements, extreme distance and exploitation indices are to be improved.

At Uzhgorod State University a large experience of the exploitation of the given LLS has been obtained. LD-2 has been used to locate "Ajisai", "Ers", "Topex", "Geos-C", "Geos-A", "Bulgaria 1300", more than 6000 measurements have been carried out.

During the whole period of LLS exploitation work to improve technical characteristics of the given LLS has been carried out at first independently, and then with the State Interinstitutional Centre "Orion" in the town Alchevsk. A number of factors of the permanent and occasional character influence exactness of LD-2 measurements; and eliminating or reducing some of them demanded considerable material and time expenditures, and there was no guarantee of the LLS parametres considerable improvement. That is why we have chose three direction of the work:

- to improve the apparatnes of the receiver-transmitter part of the LD-2;

- to study the experience of the exploitation and improvement of the distance measurers of the first-second generation in the home and foreign publications;

- to create a mathematical model of the LLS, taking into account the basic constitunts of the instrumental error of the LD-2 that would enable to define the the degree of efficienly of the improvement and the choice of directions in these improvements.

When modelling the measurement system of the LD-2 we have use a probability approach to the evaluation of errors. A relativ error E of the N variables function is equal to square root of the squares sums of the partial differentials of the function natural logarithma (Chepurenko V.G. et al. 1978). The limit of the credible interval dY one can define as multiplication of the given limit relatively to error E on arithmetical mean of set of equal point measurements:

$$dY = E * Ya.m. \text{ or } dY = t * G, \qquad (1)$$

where G - is mean square error of a series measurements,

t - coefficient, dependant on the number of observations and trustful variatibility.

For the accepted trustful variatibility at technical measurements $P = 0.9$ this coefficient according to (Novitskij P.V. et al. 1985) is equal to 1.9. All the given results are just for the normal distribution of the system casual errors.

Taking into account this for more graphicality, and for grounding proportions expenses and efforts for improving the apparatus of the receiver-transmitter part of the LD-2 we have chasen an additive manifactoral mathematical model of LLS (Novitskij P.V. et al. 1985) the equation of which has the following form:

$$dY = A_1 * dX_1 + A_2 * dX_2 + ... + A_n * dX_n, \qquad (2)$$

where $dX_1 - dX_n$ - are the reduce errors stipulated by a number of factors influencing exactness of the measuring complex.

$A_1 - A_n$ - are coefficients, taking into account the level of influence of seperate errors upon the error of

the whole measurement ($A_1 - A_n$ may be whole or fractional, positiv or negativ). The model allows to analyse the influenc of errors, provided by seperate parts of LLS upon exactness of distans measuring before and after the modernization. Analysing the equation of the additive model, we come to the conclution that when reducing a seperate error brought by one of the parts of the LD-2, the degree of influence of the other constituents upon the general exactness of measurement will increase. Some factors which provide errors of measurements might be obscure and might be discovered only after long frials or work of LLS. The additive model is very conviment. Computation of the additive model comes to the selection of the most significant factors by defining its most important terms.

On the ground of these exposition, directed by methods of computation, give in (Chepurenko V.G. et al. 1978, Novitskij P.V. et al. 1985) we have worked out algarythms and a packets of programs "CHECK-GRAPH" with the help of a compiler TURBO-BASIC, and it allows to analyze qualitatively seperate bloks and parts of LLS LD-2 in the regime of the static distance measurement to a calibre target. The quality of the given packet is the presence in it the program of support of the very LLS registration system with the computer. The "CHECK-GRAPH" program packet allows:

- to define a mean square error of a series of measuremenst;
- to make direct and indirect computation coefficients of the importance and errors in the equation of the additive model;
- to build histograms of the distribution of the distance measurements results to the target;
- to analyse correlational connection between the results of measurement and definite parametres of seperate blocs of LLS. The packet "CHECK-GRAPH" allowed to work more efficiently upon improving the apparatus part of LLS LD-2. The results of work performed together with "Orion" centre are:

- increase of laser impulse energy of the optical quantum generator LD-2 from $0.3J$ (certificat meaning) to $0.7J$;
- reducing duration of the laser imruls from 50-$70nsec$ (at half attitude) to $20nsec$;
- reducing of mean square error of measurement of one satellite passage from $2.5m$ (sertificate meaning) to $0.7 - 0.8m$; mean square error of the normal satellite position is of $0.25 - 0.30m$ at that. Besides, we have defined further priority ways of improving LLS LD-2. They are:
- choice and optimization of the regimes of photoreseivers of reseiving-optical apparatus of the LD-2;
- time grounding of the distance measurer to the energy centres of reflecting and reflected impulses;
- selection of reflected impulses from "noise" ones by optical and electronic ways.

Preliminary results allow us to hope that in the nearest future we shall increase exactness of distance measurements with the LD-2 for one satellite passage approximately to $0.5m$.

References

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