Rapid Adjustment of Large Antenna Surfaces Using Modern Laser Systems

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Abstract. It is presented the new method of large antenna surfaces geometric control as the example of the elements radial position measurements for RATAN-600 variable profile antenna. The method is based on the modern high-precision laser systems usage. The results of radial position measurements for the South telescope sector are presented. The adjustments for separate element groups of the Flat reflector have been made.

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1 Introduction

The RATAN-600 radio telescope of the Special Astrophysical Observatory of RAS (Esepkina et al. 1973) is a variable profile ring antenna 600 m in diameter. The variable profile antenna is one of the alternative decisions for achieving a large geometric area and a high angular resolution and it solves the problem of impact the weight constructional deformations of the telescope main mirror (Khaikin & Kaidanovskii 1959; Khaikin 1960).

RATAN-600 is an open access instrument which realizes the scientific observing programs in the daily operations of Northern, Southern, Western sectors and Flat reflector simultaneously. A multi elements construction and the large geometric area demand a systematic control the surface accuracy and its operative correction. The high time spent for antenna adjustment leads to the ineffective telescope using. The telescope must be always ready for solving the actual scientific goals including urgent ones. The new method of the geometric control and radial position measurements antenna elements is presented. The method is based on the modern high-precision laser systems usage.

2 Ratan Main Mirror

The RATAN-600 surface is a variable profile antenna which is formed by separate mechanically independent reflective elements fitted in an arc of a given radius. The main task of a geodetic adjustment is installation of elements in the design position. In this position elements stand vertically on the circle 288 m in the radius. The precise determination of reflective element positions is an important task for the following installation of the antenna in the calculated position.

Before the antenna adjustment was carried out by geodetic methods with accuracy up to 0.2-0.3 mm. All measurements were made from a special representative sites (points) on the elements which are located in one plane, the normal of which should be directed to the center of the circle during the adjusting. The question about a consistency of the representative sites plane and the reflective surface plane is opened and requires a detailed research. That is why the radio technical or autocollimation adjusting is carried out after the geodetic one.

Currently we have a possibility to develop methods of geometrical control of the large antenna surfaces with help of the modern laser measurement systems by Leica Geosystems company, specifically the precision total station Leica TDRA6000.

The usage of this device, Leica TDRA6000, allowed to speed up significantly the South sector adjustment measurements. An approximate estimate of the measurement duration is about 2 hours per antenna part, which includes one station of the total station. There are 2 stop stations shown on the Fig 1. These measurements took 4 full working days in the past, which means 2 weeks per antenna sector. After the improvement of the measurement technique, especially using the different types and numbers of the reflectors, the measurement of the whole sector can be done in less than a working day using the coordinate measurement system based on the total station Leica TDRA6000. The speed of the preparatory work is increased as well, specifically the measurements of the planned reference radio telescope network (Fig 2). Before that we spent around two weeks for the network measurement. To measure the network marks on the South sector it was required to provide a direct visibility of the radio telescope geometrical centre, and, in addition, to set several antenna elements on a given angle, which means spending the observation time. Currently, with the help of the selection and measurement of the separate reflectors characteristics which are used for the adjustment process, the preparatory work time is reduced significantly, and it is no longer required to allocate an antenna time for that. Practically, the measurements of a part of the network used for binding during the South sector adjustment can be done in 3 hours in a good weather conditions. Before it was required to set the equipment on the every mark and

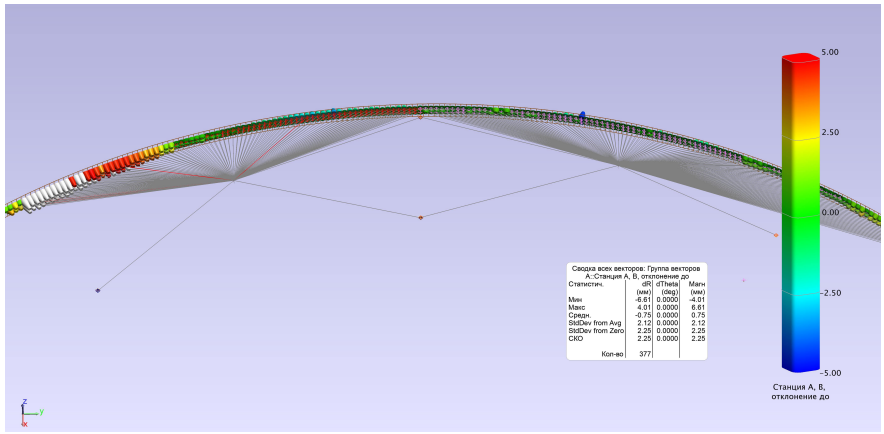

Fig. 1. The general measurements scheme for the South sector elements

make a series of the measurements with a subsequent data reduction, now it is enough just two stop stations to measure all network marks. Measurements of the geodetic reference system (GRS) can be made from single stop station and repeat measurements are carried out for minimization of their errors. Due to the software of Spatial Analyzer (SA) by New River Kinematics for the total station control the data processing takes a minimum of time.

The method let us obviate the need the center GRS mark aiming, exclude accumulation of errors and it makes possible to carry out the adjustment both single elements and the group of one's independently, using geodetic points. The method is important for the South RATAN-600 sector because of the absence of visibility to the radio telescope center and the visual tube adjustment is possible with the Flat reflector lying on the ground only. It is difficult for its following adjustment that is why the development of large geometric surfaces control methods is a key point for round-the-clock telescope operating. Usage the received zero positions together with kinematic corrections (Zharov & Sotnikova 2017) increases the elements position accuracy significantly.

3 The Flat Reflector Adjustment

The plan position of separate Flat reflector elements measurements have been carried out usage the high precision total station TDRA6000. On the center elements part measurements were carried out with four sites in order to obtain a full picture of their positions. As the results the values of positions deviations were obtained and the correction of the worst elements position has been

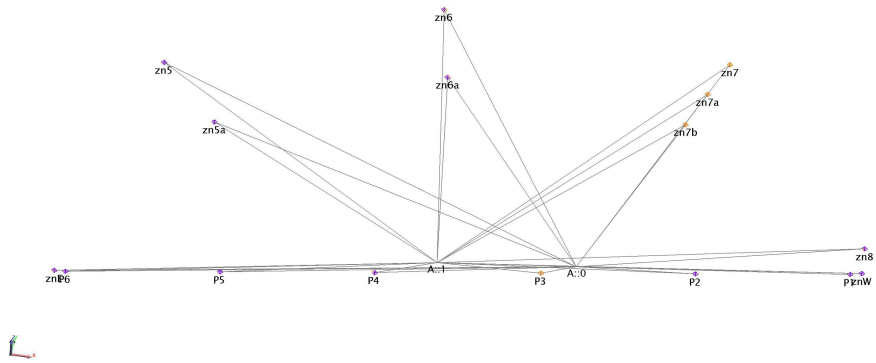

Fig. 2. The geodetic network measurement scheme

done. The main conclusions are following: (i) - plan position of the Flat reflector elements measurements can be done in a short time (1-2 days); (2) design position correction of the Flat reflector elements is possible to be made without significant antenna time costs, after necessary preparatory work.

4 Development Prospects

At present we are planning to raise the accuracy measurements methods using the total station Leica TDRA6000. This includes the reflective element measurements from several stop station and a following equalization of measurements usage the software Spatial Analyzer by the New River Kinematics. Additional we carry out the position reflecting surface determination relative to the representative sites of each element. Carrying out these measurements will allow us improve the position accuracy of the variable profile antenna significantly.

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Zharov, V. I. & Sotnikova, Y. V. 2017, Astrophysical Bulletin, 72, 480