

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE  
RESEARCH INSTITUTE “NIKOLAEV ASTRONOMICAL OBSERVATORY”

**METHODS AND INSTRUMENTS  
IN ASTRONOMY: FROM GALILEO  
TELESCOPES TO SPACE PROJECTS**

International Workshop

**ABSTRACT BOOK**

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- 1) AZT-8 (*NSFCTC*), 0.7/2.8 m, FLI PL09000 stare,  $3056 \times 3056$ ,  $45' \times 45'$ ,  $12 \times 12 \mu\text{m}$ ,  $0.9''/\text{pix}$ ,  $20^{\text{m}}$ ,  $0.05'' \div 0.15''$ ;
- 2) FRT (*NAO*), 0.3/1.5 m, Alta U9000 stare and drift-scan,  $3056 \times 3056$ ,  $1^{\circ}24' \times 1^{\circ}24'$ ,  $12 \times 12 \mu\text{m}$ ,  $1.6''/\text{pix}$ ,  $18^{\text{m}}$ ,  $0.15'' \div 0.40''$ ;
- 3) MobiTel-0.5 (*NAO*), 0.5/3.0 m, Alta U9000 stare and drift-scan,  $3056 \times 3056$ ,  $42' \times 42'$ ,  $12 \times 12 \mu\text{m}$ ,  $0.8''/\text{pix}$ ,  $19^{\text{m}}$ ,  $0.05'' \div 0.15''$ ;
- 4) MobiTel-0.3 (*NAO*), 0.3/0.75 m, Alta U9000 stare and drift-scan,  $3056 \times 3056$ ,  $2^{\circ}48' \times 2^{\circ}48'$ ,  $12 \times 12 \mu\text{m}$ ,  $3.2''/\text{pix}$ ,  $18^{\text{m}}$ ,  $0.20'' \div 0.45''$ .

The telescopes are actively used for control of the near-Earth space as well as for the solution of problems connected with the potentially hazardous asteroids and comets approaching the Earth.

Combination of classical and original methods of observations allows us to carry out virtually any observing programme.

Considering objects at geostationary orbits and at highly elliptical orbits, we are able to carry out the following types of observations: massive – survey, boundary – search, high accuracy – single object.

To solve the problems connected with the potentially hazardous asteroids and comets approaching the Earth, we are able to observe faint objects located in the asteroid belt as well as objects approaching the Earth at the distance less than 0.1 a.u. and with elongation angle up to  $130^{\circ}$ .

## FIRST RESULTS OF FUNCTIONING OF THE UKRAINE-CHINA TELESCOPE NETWORK ON SPACE DEBRIS OBSERVATIONS

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Substantial growth of space debris (SD) on the near-Earth orbits is caused by increasing launch number of the Earth artificial satellites

(EAS). Leading space countries assign considerable efforts and contributions for creation, maintenance and development of space control systems (SCS). Effective work of SCS is achieved by usage of radio and optical means based both on the ground and space.

Control system of space environment (CSSE) developed by National Space Agency is working in Ukraine. CSSE provides space tracking of up to 300 objects and supplies information about them to customers. Usage of optical telescopes belonging to Ukrainian research institutes and universities of Ministry of Education and Science (MES) is a prospective way to enlarge number of information sources about the SD at low orbits (less than 2500 km) for CSSE. The network of the MES telescopes has a perspective in international cooperation in particular with People's Republic of China. Ukraine and China are members of the Interagency Coordinating Committee on Space Debris; and in accordance with the resolution of the United Nations General Assembly #61/11, they are responsible for collection and distribution of data on SD.

This project is directed towards creation of the first Ukrainian-Chinese network of optical telescopes for observations of the SD on the low orbits. The telescopes are equipped with the short focus objectives and sensitive TV CCD Watec cameras. A list of telescope features, such as an institution name, telescope abbreviation, focal length, f-number, field of view are given below:

- 1) RI NAO, FRT, 85 mm, 1.8,  $4.2^\circ \times 3.2^\circ$ ;
- 2) RI AOONU, KT-50, 250 mm, 2.5,  $1.5^\circ \times 1.1^\circ$ ;
- 3) AOLNU, TPL1M, 250 mm, 2.5,  $1.5^\circ \times 1.1^\circ$ ;
- 4) LSRUNU, TPL1M, 85 mm, 1.5,  $4.2^\circ \times 3.2^\circ$ ;
- 5) ShAO, TV, 85 mm, 1.8,  $4.2^\circ \times 3.2^\circ$ .

An original method of TV observations of the low orbit objects with a static telescope was tested at all the telescopes. This method was developed and successfully used in RI NAO in the last years. The observations have shown that used equipment allows us to observe objects with reflective square of  $0.1 \text{ m}^2$  and mass of 50 kg. Orbit modelling of the EAS taken from the USSTRATCOM catalogue in observation zone of the network has shown that up to 1000 from 10500 objects may be tracked with a period of data update not more than 10 days. It allows us to obtain a forecast accuracy that is not worth than in the USSTRATCOM catalogue.

During the first observational campaign, measurements were carried out by two methods: along all visible orbit arc, in the limited sky zone with the largest density of objects. The first method is aimed at obtaining of maximum data volume to estimate the highest possible accuracy of orbit determination. The second method is designated to estimate a possibility of catalogue maintenance and enlargement for observations with several static telescopes. A quality of measurements for orbit improvement and a forecast accuracy were estimated for each method.

## **CATALOGUE OF POSITIONS AND ORBITAL ELEMENTS OF EARTH'S ARTIFICIAL SATELLITES AS A PART OF VIRTUAL OBSERVATORY**

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Regularly updated catalogue of positions and orbital elements of Earth's artificial satellites (EAS) are presented at the RI NAO website since 2005. The orbital elements are freely available. Information about the positions is provided on request by e-mail.

The catalogue contains data for the following orbit types of the EAS:

- geosynchronous and geotransitional orbits;
- low orbits;
- highly elliptical orbit.

Catalogue data is arranged by observation date and numbers of the EAS. The numbers correspond to the numbers of the NORAD catalogue. The catalogue is compiled using observations made in RI NAO. The observations are carried out by a combined method with the Fast Robotic Telescope. The orbital elements are calculated using Adams method of fifth order and data obtained during two or more nights. 105 geosynchronous and geotransitional satellites, 48 low orbit satellites, 1 highly elliptical orbit satellite are included in the catalogue now. Moreover, the internal accuracy of observations for reference stars and the EAS are given in the catalogue in a graphical format.