# RUSSIAN ASTRONOMICAL EPHEMERIS EDITIONS AND SOFTWARE

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## Ephemerides hard copy

Institute of Applied Astronomy of RAS has published "The Astronomical Yearbook" (AY) with 1921, "The Nautical Astronomical Yearbook" (NAY) with 1930, "The Nautical Astronomical Almanac" biennial (NAA-2) with 2001.

Over the last 10 years the resolutions of IAU [1] have essentially changed theoretical basis ephemeris calculations. They were deal with new IAU2006/2000 precession-nutation models of rotation of the Earth and new concept of a sidereal time. The system ICRS was entered, which is based on VLBI observations of extragalactic radio-sources and extended on optical area by catalogues HIPPARCOS and FK6. Relativistic definitions of coordinate systems and time scales were redefined more exactly. However the most significant transformation was replacement the classical conception of system coordinates using equinox to the system CIRS connected to the celestial intermediate pole CIP and the celestial intermediate beginning CIO.

During 2003-2007 according to these resolutions the reform of theoretical and computing base of AY was completed and beginning from the issue AY for 2008, all relevant resolutions of IAU have been implemented in all ephemerides.

Qualitatively new stage of reform became the decision to use the lunar and planetary ephemerides EPM2004 [2, 3] developed in IAA. It should be noted that in 2007 the EPM2004 is accepted as the national standard fundamental ephemerides by the resolution of All-Russian conference "Coordinate, time and navigational support" (CTNS-2007).

At present all ephemerides in AY are referred to the "classical conception of equinox" system. Besides, in accordance with IAU resolutions, the parameters for reduction to new system are also given: the equation of origins Eo, the CIO locator s, parameters X, Y of CIP, the matrix for conversion from GCRS to CIO and to the true equator of date.

Despite of lower accuracy navigation ephemerides (0.1′) for unification of creation of editions NAY is prepared on the same theoretical and technological basis as AY.

For ships at long-run sailing, in IAA new navigating manual (biennial "The Nautical Astronomical Almanac", NAA-2) has worked out. The NAA-2 includes the star charts, examples for the determination of the compass' correction and the position of a ship by the Sun and stars. Fixing position plotter for laying off line of position (L.O.P.) is also given. The NAA-2 contains the explanation both in Russian and English.

A part of published in AY data (the moments of the beginning of seasons, Chebyhev polynomials for lunar ephemerides, lunar phases, planetary configurations and eclipses, ephemerides of the mutual phenomena in system Galilean satellites calculated on the basis of the numerical theory of motion) are located on a site

<http://www.ipa.nw.ru/PAGE/EDITION/RUS/rusnew.htm>.

All calculations are work out on the basis of the multifunctional software system ERA.

**The Astronomical Yearbook (AY, 1921)**

**The Nautical Astronomical Yearbook (NAY, 1930)**

**The Nautical Astronomical Almanac, biennial (NAA, 2002)**

**Publishing systems for hard copy: BookA+PUBLISHER**

**Software package ERA**

**The Shturman (2010)**

**Ephemerides of IAA of RAS**

## The Shturman

Besides system of the removed access the "Shturman" was developed. It intended to solve some the navigating tasks described in the "Nautical Yearbook" (NAY) and biennial "Nautical Almanac" (NAA-2).

The system calculates positions of navigating stars and solves the task of the determination of the position of a ship, and the task of correction of a compass from observations of the Sun and stars. The solving of tasks is carried out in accordance with the accepted in these editions accuracy (0.1′). The system is used for control calculations by examples of explanation of MAA-2 and MAY.

21 examples are accessible to the decision in the Internet' system now. The solution report of task is output, and therefore the system can be considered and as the manual.

The calculations are based on the theory of movement of planets and Moon EPM 2004 and are carried out according to the standards recommended by the resolutions of IAU on 2000-2006.

The system is accessible on a site http://shturman.ipa.nw.ru/ (in Russian).

As an example we will result the decision of a problem of definition of a place of a ship on three stars during three moments.

The panel for input of the observed data and the auxiliary navigating information is shown on fig. 1. The report of the decision of a problem and a fixing position plotter for definition of a place of a ship by a graphic method of lines of position are resulted on fig. 2.

System "Shturman" is applied to control calculations of examples by preparation of edition MAA-2. However the system possesses a number of lacks. It is the fixed accuracy of the decision, a small set of examples (the simplified schemes of the decision 20 problems), dependence on the Internet, etc.
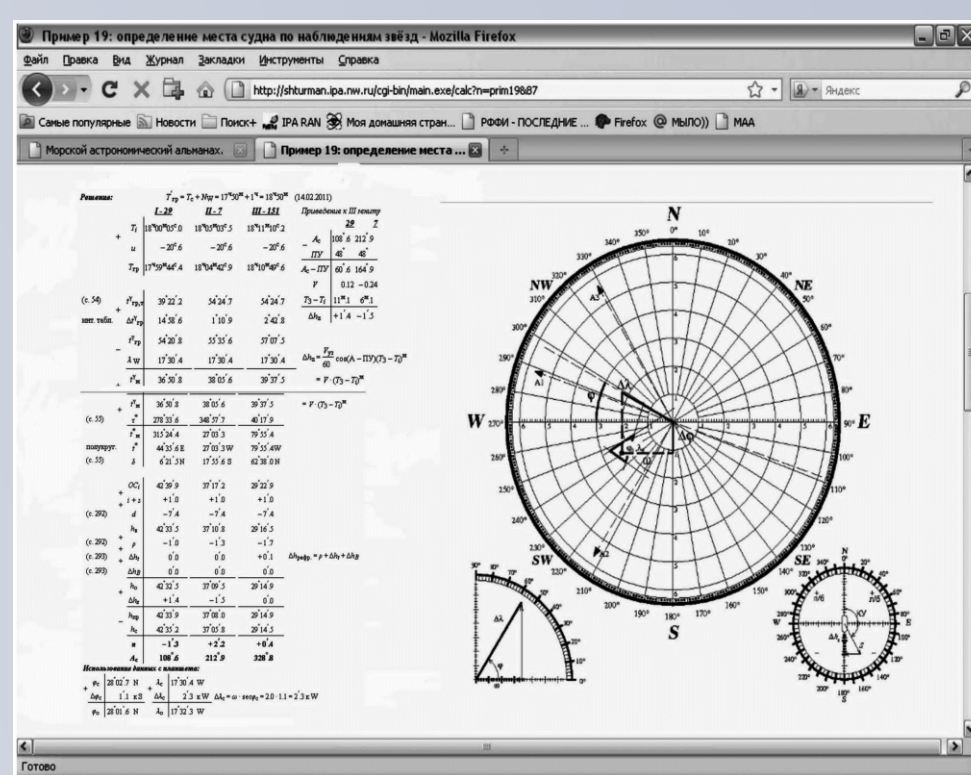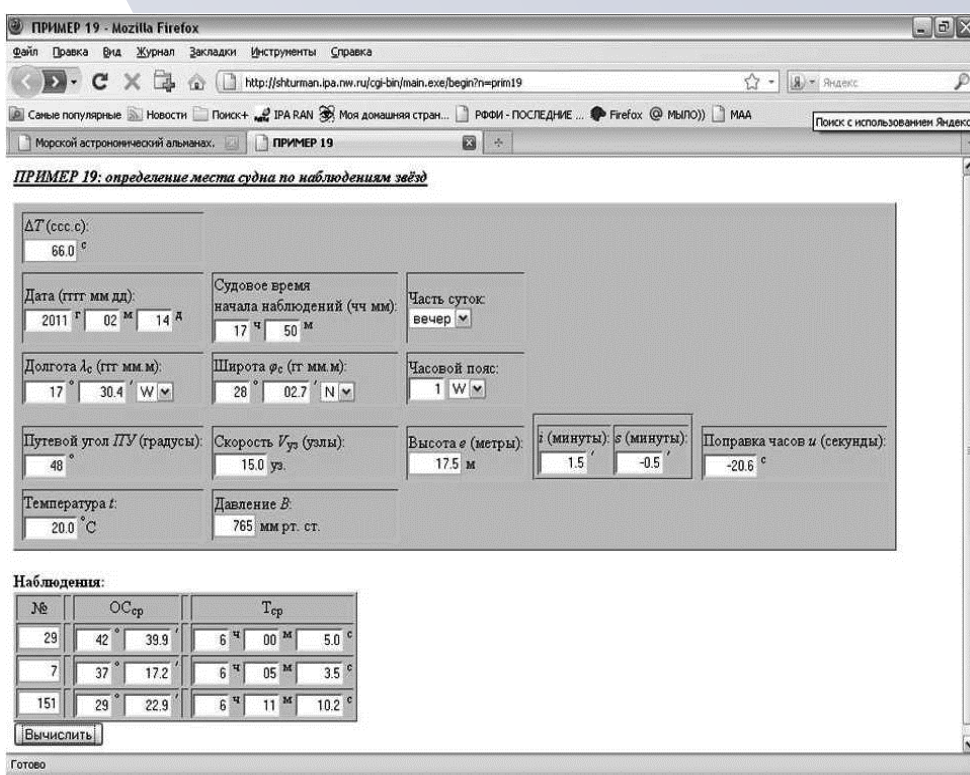
## The PersAY

The electronic versions are developed for two editions. The important stage of reform of AY is creation of "The Personal Astronomical Yearbook" (PersAY).

Program system PersAY covers the basic types ephemerides published in "Astronomical yearbook" and also provides possibility to calculate topocentric ephemerides, which it is necessary for observers. The system enables to calculate the data for four types of tasks (different package sections):

1. Ephemerides – absolute positions of the Sun, the Moon, the major planets and stars and ephemerides for physical observations of the Sun and planets;
2. Astronomical events – solar and lunar eclipses, risings and settings, transits of Mercury and Venus through disk of the Sun;
3. Planetary configurations – geocentric, topocentric and heliocentric phenomena;
4. Daily ephemerides – for the given moment of time the geo- or topocentric coordinates of the Sun, the Moon and all major planets are calculated. Besides in case of topocentric coordinates of observer for given calendar day the moments of the culminations, the moments of risings/settings and the azimuths of points of risings/settings of all objects referred above and stars are calculated.

Calculations in system PersAY are carried out, as well as in AY, with accuracy 0.01" for fundamental ephemerides according to the standards recommended by the resolutions of IAU on 2000-2006. Except EPM2004 in PersAY also it is possible to calculate by means of DE405/LE405 theory to make comparison with others ephemeris editions.

In general it is possible the choice of equatorial, horizontal, ecliptic, apparent and mean coordinates and various types of equinox. As objects it can be chosen the Sun, the Moon, any major planet, star from any catalogue. The set of time scales covers all used in ephemeris.

System PersAY is the important stage in creation of the electronic version of "The Astronomical yearbook" and enables ample opportunities for users. In many respects it is connected to system ERA as the basic software. The important feature of system PersAY is presence of the detailed description of all used algorithms allows receiving objective information about accuracy calculated ephemerides. The system can be considered as electronic version AY.

**The Personal astronomical Yearbook (PersAY, 2010)**

The demo version of system PersAY with interval of ephemerides 2010-2012 is available via FTP from the Internet ftp://quasar.ipa.nw.ru/pub/PERSAY/persay.zip.

The time intervals of validity of the system makes 2010-2015, 2016-2020.

## The Navigator

At present the off-line electronic version of nautical ephemeris software package for the decision of the basic tasks by definition of a place of a ship on observations of celestial bodies is worked out.

The basic requirements to functional filling of system:

**The Navigator**

– The system should not copy only the ephemerides of MAY;
– Period of validity of ephemerides should be at least 5 years;
– Accuracy of ephemerides can be established for choice in 0.1′ or 0.01′;
– The system should provide the decision of following basic astronavigation tasks:

1. Planning and definition of conditions of observation (selection of objects, the moments of rising/setting and the culminations of stars and so on);
2. Equalization and a reduction of the measured heights and azimuths of celestial bodies;
3. Definition of a site of a ship with an estimation of accuracy of the decision on any method of improvement of computed places or direct;
4. Definition of compass correction in the various ways.

– The decision of a problem should be accompanied by the report on standard templates.
– The system should include the graphic means preparation, carrying out and processing of observation;
– The system should contain the help block ("school") and the contextual help;
– The results of calculations should be registered (archive).

Navigation astronomy still keeps the value though against satellite navigation and inertial navigating systems. And the compass correction as total influence of a terrestrial and ship magnetic field on a compass reading is defined while only by astronomical methods.
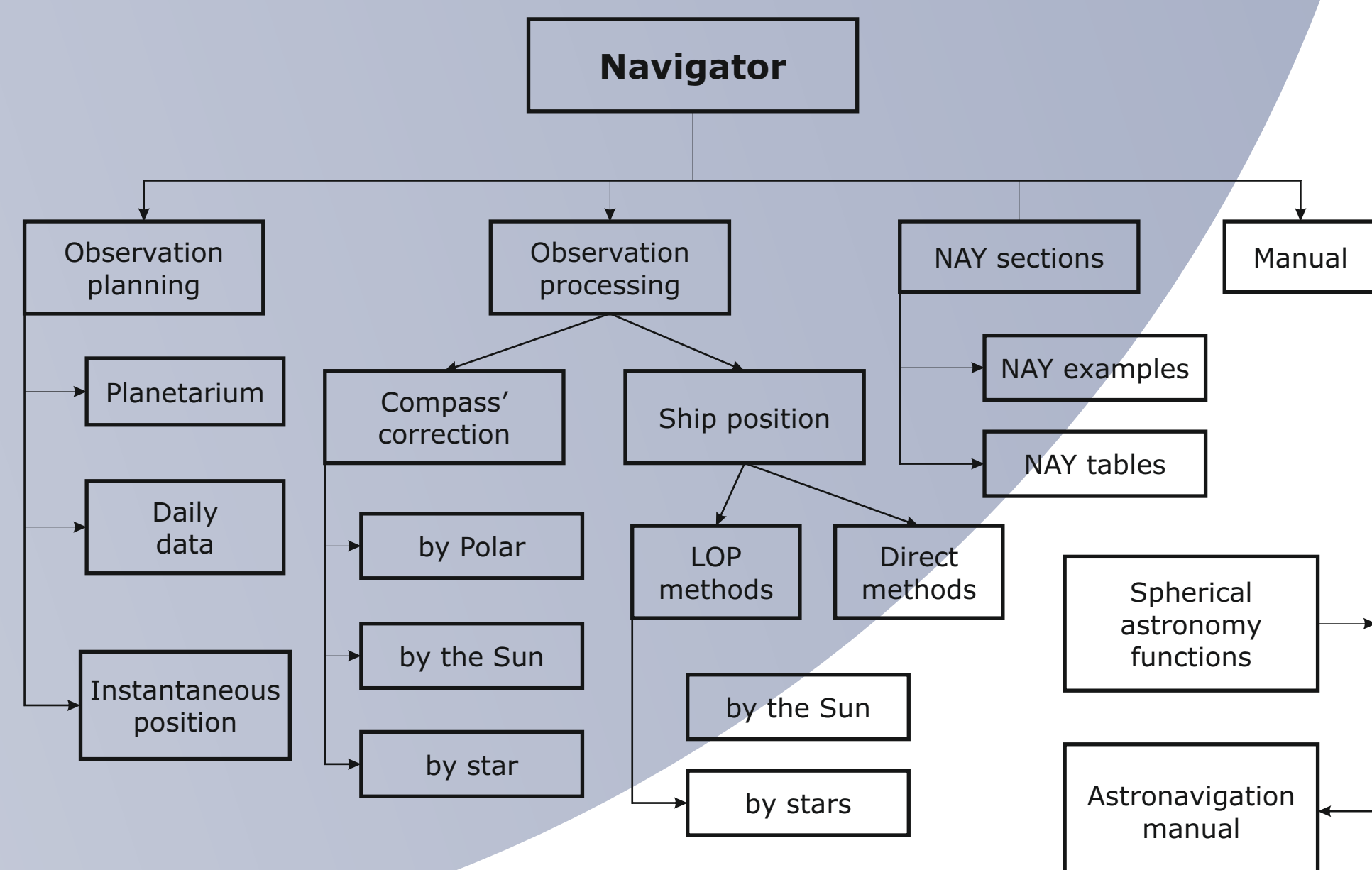






## The Conclusion

1. The reform of ephemeris editions of IAA of RAS has led to complete theoretical identity in Russian astronomical yearbooks and software package, thus providing the ephemeris support of astronomical studies and solution of astronavigation tasks at modern level.

2. Existence of electronic versions of yearbooks does not mean the end of the editions at hard copies. The electronic version should facilitate access to ephemerides, including input data at the computing equipment. The astronavigation software package help to user will help the user to process easier observation of astronavigation bodies.