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Experimental research and modeling of the parameters of the Quasi-Zenith Satellite System in Ukraine

The results of experimental studies and modeling of the orbital motion of QZSS geosynchronous satellites are presented. The possibility of forecasting the availability of satellites using almanac data obtained from the QZSS system and so on is shown.

The satellite navigation system QZSS is operated by Japan. Geostationary and geosynchronous satellites QZSS operates in conjunction with GPS. In Ukraine, QZSS satellites are available in a limited time interval and at the greatest distance. Nevertheless, the characteristics of Quasi-Zenith Satellites are of scientific and practical interest. For a preliminary assessment of the characteristics of satellites using the OEM 719 navigation receiver from Novatel, one of them received data of the signal characteristics at two frequencies, quasi-range, and ephemeris. To process the data obtained, mathematical models were developed to assess the availability of satellites and distortion of pseudo-range.

Consider experimental information. Fig. 1 shows the monitor in the signal-receiving mode. The investigated satellite has an identifier 195 placed in a triangle.
Total of 32 satellites take part in solving the navigation problem. Their numbers and belonging to systems are indicated in Fig. 1. The signal-to-noise ratio at the current time is shown in Fig. 2. The satellite transmits a signal at two frequencies. The magnitude of the signal is admissible for participation in solving the navigation problem. The pseudo-ranges for the two frequencies are shown in Fig. 3 and are more than 43,000 km. The data presented above for subsequent processing were recorded at a time interval of about 4000 sec.

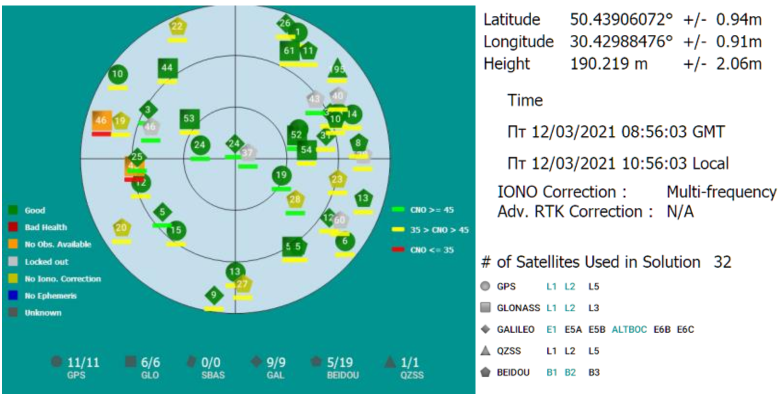


Fig. 1

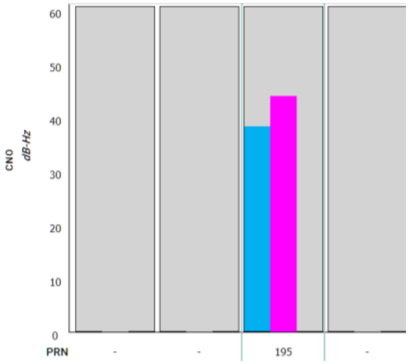


Fig. 2

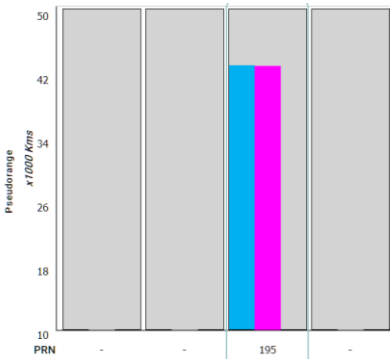


Fig. 3

Table 1

**** Week 2150 almaNAU for PRN-195 **********
ID: 195
Health: 000
Eccentricity: 0.74498233795E-01
Time of Applicability(s): 0.0000
Orbital Incluation(rad): 0.7128396737
Rate of Right Ascen(r/s): -0.23772418788E-08
SQRT(A) (m^1/2): 6493.1997070
Right Ascen at Week(rad): -0.29792270040E+01
Argument of Perigee(rad): -1.5713303738
Mean Anom(rad): 0.70116928569E+00
Af0(s): -0.19073486328E-05
Af1(s/s): 0.00000000000E+00
week: 2150

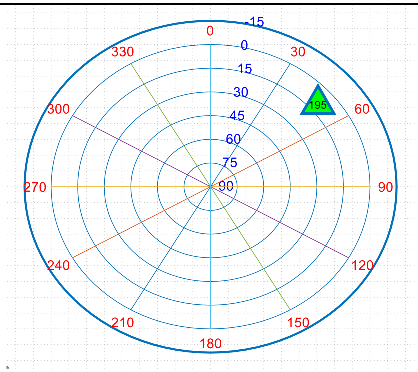


Fig. 4

The QZSS satellite, marked as 195, transmits ephemeris related only to it. The same satellite transmits almanac data for all four spacecraft of the Quasi-Zenith group. These data were recorded in binary form, converted into YUMA format and used by us in the model of the satellite's orbital motion. Satellite almanac 195 data are given in Table 1. Fig. 4 shows a diagram of the visibility of satellite 195 obtained by modeling from almanac data. The simulation results are consistent with the data in Fig. 1. The position of satellite 195 in space and the orbits of four QZSS satellites are shown in Fig. 5 and Fig. 6 respectively.

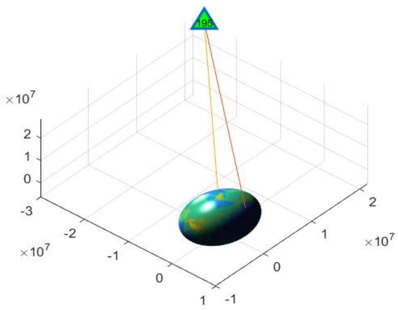


Fig. 5

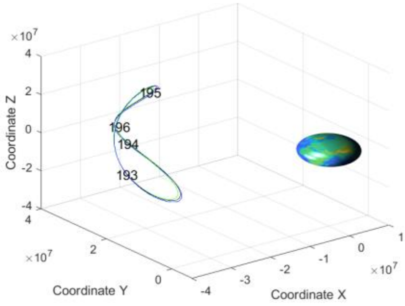
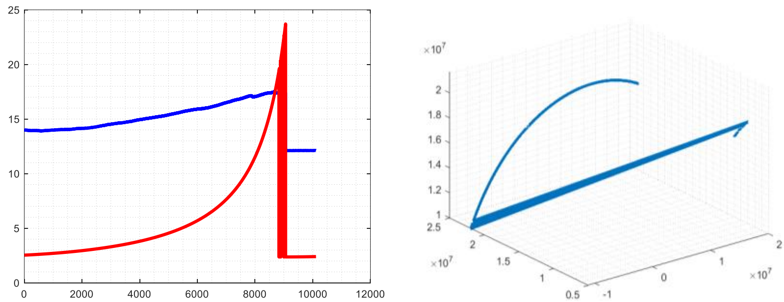


Fig. 6

As follows from Fig. 6 orbits of all four satellites are geosynchronous. The data obtained makes it possible to predict the availability of QZSS satellites.

The study recorded a message containing the ephemeris of satellite 195, ionospheric, tropospheric and temporal corrections. These messages were decoded and processed by specially designed programs. Some results are presented below in graphical form.



a b

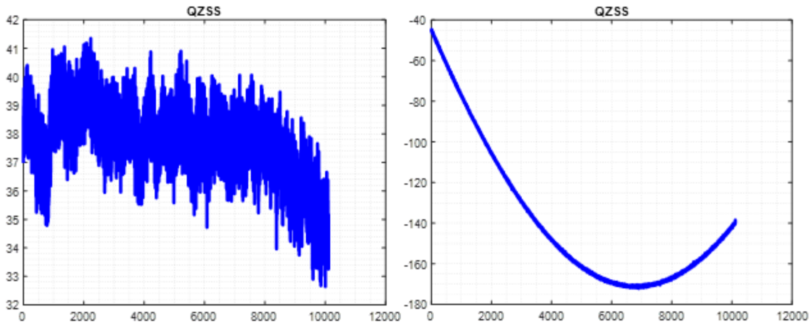
Fig. 7

The nature of the change in ionospheric and tropospheric corrections (Fig. 7, a) is typical for satellite systems, despite the fact that the distance to the satellite is more than 40,000 km. Temporary corrections are not given, as they were absent in this measurement session. Fig. 7, b shows a fragment of the trajectory of the satellite.

The "gap" of the trajectory is due to the peculiarities of the calculation program. This can be taken into account in a software way.

The next step in our work was to study the pseudoranges to navigation satellites. Pseudorange is one of the main parameters for solving the navigation task. The smoothing operation is performed on raw measurements using filters with a final pulse response.

This report provides a method for smoothing the pseudorange to the QZSS navigation satellite. The method is based on the approximation of the measured pseudorange by a polynomial and the subsequent replacement of the measured approximate pseudorange. Processed data at intervals of more than 10,000 s. shown in Fig. 8 and Fig. 9. Fig. 10 shows the differences between the pseudoranges approximated by the polynomial (ADRP / PSRP) and the measured pseudoranges (ADR / PSR). ADR - phase, PSR - code pseudorange. We also note that in Fig. 9, 10 on the vertical axis meters are set aside, seconds marked on the horizontal axis. The degree of the approximating polynom is 6, larger values did not lead to improvement.



PRN 195 signal-to-noise PRN 195 Doppler frequency

Fig. 8

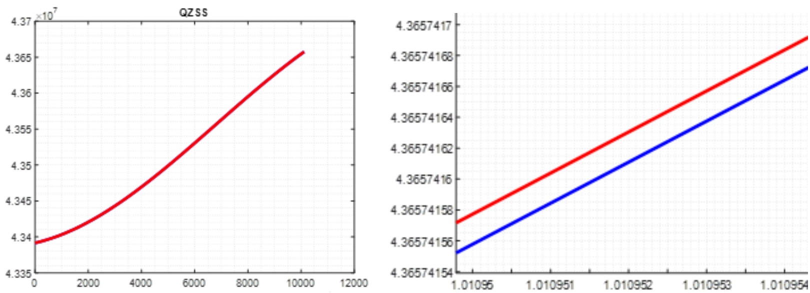


Fig. 9 PRN 195 Range: red-code, blue-phase

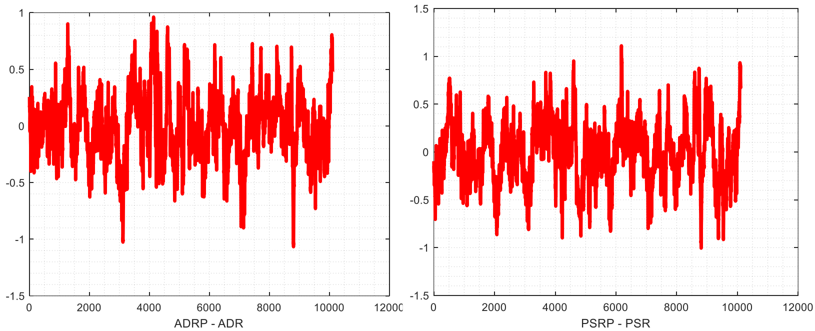


Fig. 10

Conclusion

During our research, we investigated Quasi-Zenith satellite system. In particular, satellite 195. The signals characteristics were obtained at two frequencies, quasi-distance, and ephemeris. To process the results, mathematical models were produced to test satellite availability and pseudo-range distortion. The origin of changes in ionospheric and tropospheric corrections was investigated in this work. We explored the method of smoothing the pseudorange to the navigation satellite QZSS, which is based on the approximation of the measured pseudorange by a polynom. The project was performed in the satellite navigation laboratory of NAU within the discipline "Global Navigation Satellite Systems"

References

1. Системы спутниковой радионавигации / В.В. Конин, В.П. Харченко; Национальный авиационный университет. – К.:Холтех, 2010. – 520 с.