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V.V. Konin, professor
O.S. Pogurelskiy, senior researcher
F.O. Shyshkov, postgraduate student
(National Aviation University, Ukraine, Kyiv)

SIMMULATION OF NAVIGATION SATELLITES AVAILABILITY IN THE NEAR-EARTH SPACE

The problem of GNSS performances in the near-Earth space is considered. The main factor that limits GNSS applying in space is district visibility of navigation satellites. The availability of GNSS satellites required number were checked by using model of satellites motion and data about height of user location.

Introduction

The position determination (positioning) of space vehicle in near space is actual task for missions that is going nowadays and will launched in future. The precise positioning in space is important for docking operations and on-orbit activities such as search and utilization most massive and dangerous elements of space debris.

The satellite navigation is effective technology that could be applied for tasks of positioning in near Earth space. According with Interface Control Documents GPS and GLONASS systems provide continuous navigation field up to height 3000 km and 2000 km respectively [1, 2]. Obviously, the new systems Galileo and Compass will have the several performances [3].

Difficulty of receiving satellite navigation signals in the near Earth space is related with district visibility of satellites. It resulted from directivity pattern shape of the transmitting antenna with beam width ±23º [4].

The availability of satellites only GPS, GLONASS, Galileo or Compass system were researched with the help of model developed in MatLab software. It uses almanac of each system for calculation satellite positions and data about user location (latitude, longitude, height).

Satellite navigation on Low Earth Orbits

Low Earth Orbit (LEO) refers to a satellite which orbits the Earth at altitudes between (very roughly) 200 and 2000 kilometers. Low Earth Orbit has been used for both military and aeronautical purposes.

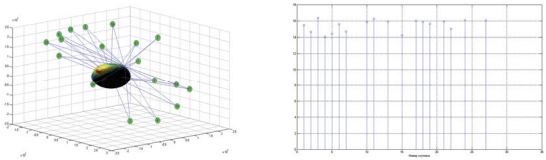

Fig. 1 GPS satellites visibility on height 1000 km

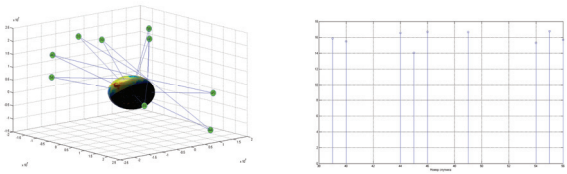

Fig. 2 GLONASS satellites visibility on height 1000 kilometers

The results obtained for height 1000 kilometers confirms that GPS and GLONASS systems could be applied for navigation and number of visible satellites each system varieties between 7 and 16. So, navigation satellites availability on the LEO even better than on the Earth surface. It can be explained by ability to receive signals from satellites located lower plane of horizon and increased beam width compared with the one on the Earth’s surface.

Satellite navigation on Medium Earth Orbits

The heights of MEO satellites range from about 2000 to 24000 kilometers. The most common use for satellites in this region is for navigation, such as the GPS, GLONASS and Galileo constellations. Communications satellites that cover the North and South Pole are also put in MEO.

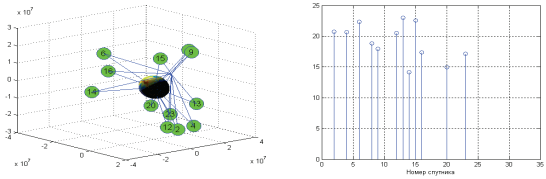

Fig. 3 GPS satellites visibility on height 5000 km

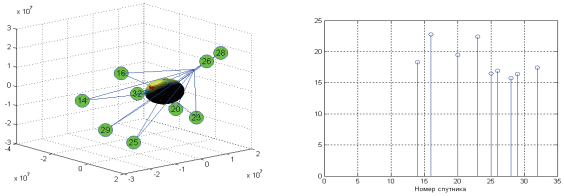

Fig. 4 GPS satellites visibility on height 10000 km

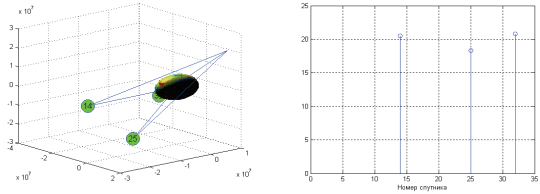

Fig. 5 GPS satellites visibility on height 20000 km

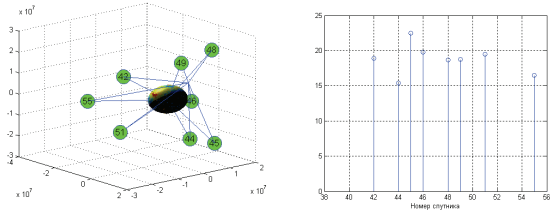

Fig. 6 GLONASS satellites visibility on height 5000 km

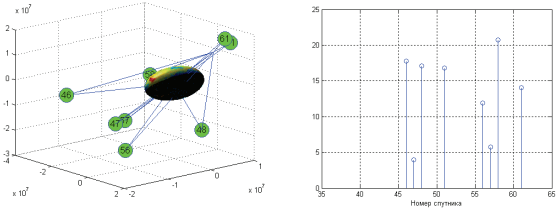

Fig. 7 GLONASS satellites visibility on height 10000 km

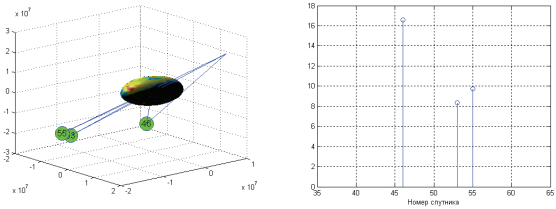

Fig. 8 GLONASS satellites visibility on height 20000 km

The continuity of radio navigation field formed by a single system tends to degrade with increasing height. The significant degradation of GPS is observed from 8000 km, for GLONASS from 6000 km. This problem can be solved by integration of multiple satellite constellations. Currently it is possible only for GPS and GLONASS systems (fig. 9) but in future we expect to add Galileo and Compass (fig. 10).

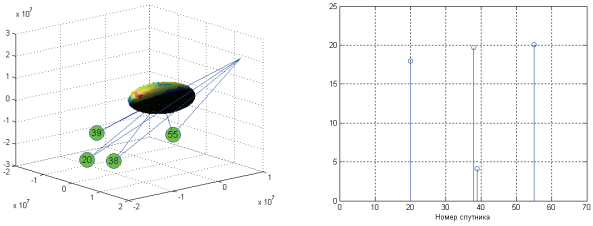

Fig. 9 GPS and GLONASS satellites visibility on height 20000 km

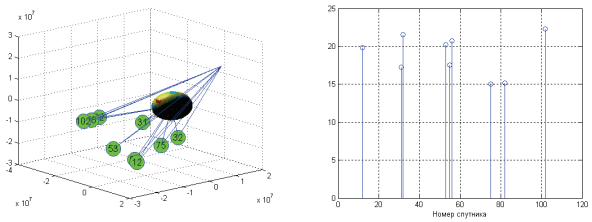

Fig. 10 GPS, GLONASS, Galileo and Compass satellites visibility on height 20000 km

Satellite navigation on Geostationary Orbit

The height of Geostationary orbit is 36 000 km. Navigation with the help of signals of any one system is hard. On average receiver can see 1-2 satellites. The only possible solution is applying data from all available navigation satellite systems (fig. 11).

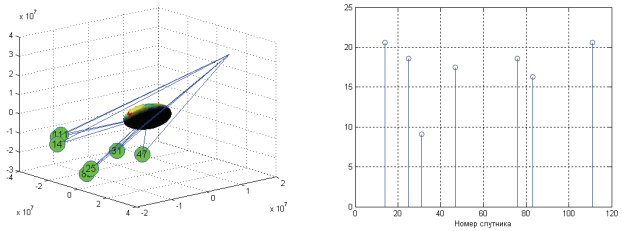

Fig. 11 GPS, GLONASS, Galileo and Compass satellites visibility on height 36000 km

Conclusion

The results of simulation showed theoretical possibility of satellite navigation in near Earth space.

References

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