NEAR-EARTH SPACE NAVIGATION USING OVER-THE-HORIZON SATELLITES

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The given work is devoted to the idea of the near-Earth navigation in space using the active satellite constellations by applying the over-the-horizon satellites, which provides a relatively simple solution with the usage of sensitive navigation satellite receiver.

Introduction

Ever since the launch of Sputnik, humankind has been propelling objects into Earth's orbit and it is starting to add up. We are not only talking about rocket ships, but hundreds - even thousands - of satellites.

Determination of the coordinates of spacecraft in near-Earth space is required when executing a number of tasks that are relevant in the present time (docking, movement to desired orbit), or that would be relevant in the near future (with the removal of large orbit space debris). Satellite navigation systems are most effective on the Earth's surface so far. According to the interface control documents for GPS and GLONASS these navigation systems provide reliable navigation to the heights of 3000 and 2000 km respectively. It is natural to expect that new Galileo and Compass systems when entered in operation would work in the same range.

The usage of over-the-horizon satellites may significantly increase the limits.

Physical restrictions

For satellites above the horizon plane beam width is set in the range ± 23 °, for satellites below the horizon plane (the back side of the Earth), the radiation pattern in the range of ± 13,8 ° to ± 23 °.

The radiating patterns of satellite antenna systems form radio navigation field in the limits of main lobe. The measured radiation pattern of the GPS satellite is shown on fig. 1 [1].

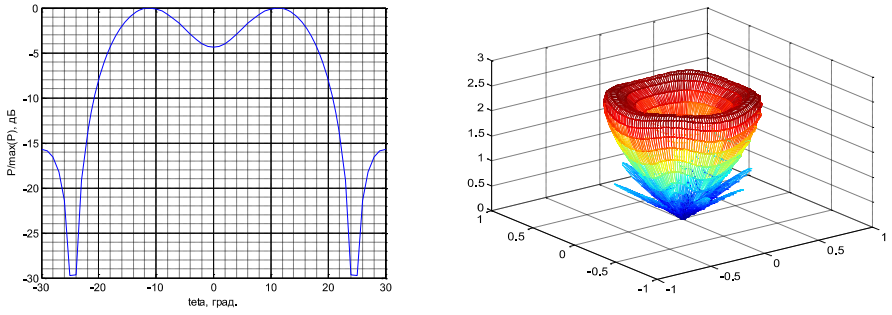

Fig. 1 – Radiating pattern of GPS satellite

The axis of radiating pattern passes through the phase center of antenna and is directed into the center of mass of Earth. In the center of radiating pattern there exists a specially formed “gap”, which is used to align the field on Earth’s surface.

If the distance of the object from the Earth's surface is over 2000 km to GLONASS and 3000 km to GPS, we can talk about unstable radio navigation field, which means that we can not simultaneously receive signals from four satellites of one navigation system.

The radio navigation field is superposition of electromagnetic waves emitted by all navigation satellites within the main lobe of the satellite antenna

pattern. The structure of the radio navigation field formation can be seen on fig 2.

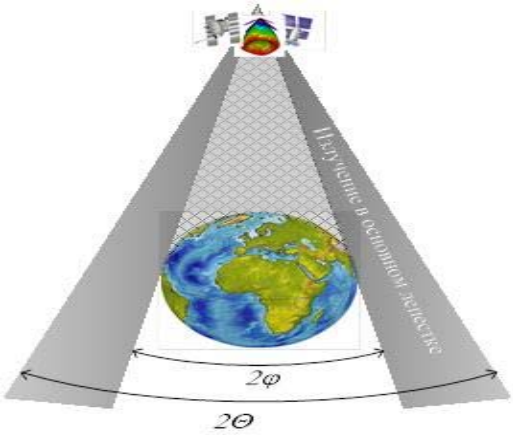

Fig. 2 – Radio navigation field formation

Experimental data

Based on the restrictions, a model has been built. The model allows analyzing the availability of the navigation satellites in space.

An example output of 10000km for GPS constellation only can be seen on fig 3.

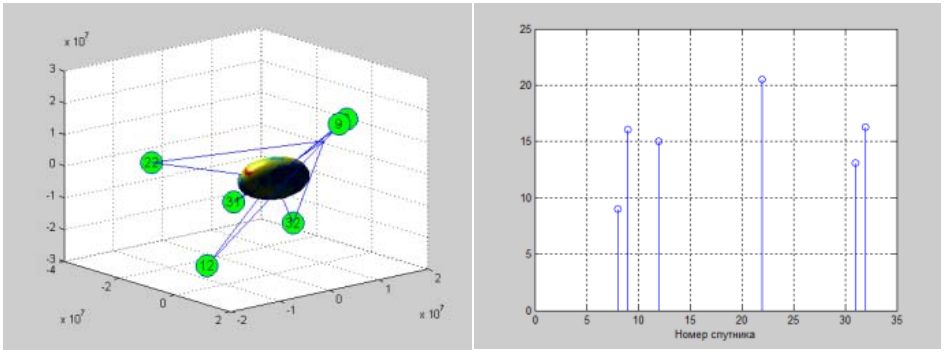

Fig.3 –Visibility of GPS satellites on the height of 10000km and their elevation angle

An example output of 20000km for GPS + GLONASS constellation only can be seen on fig 4.

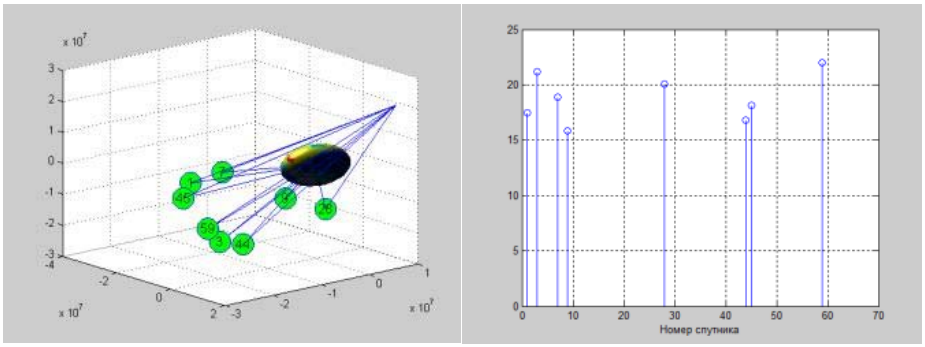

Fig.4 - Visibility of GPS + GLONASS satellites on the height of 20000km and their elevation angle

Conclusion

The possibility of usage of the over-the-horizon satellites provides us with a relatively cheap and realistic solution to the question of near-Earth orbit space navigation. The pursue of reliable space navigation method forces us to find the best solution, thus this question requires even more research.

References

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