IAF SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Advances in Space-based Navigation Systems, Services, and Applications (7)

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NAVIGATION SERVICES FROM LEO CONSTELLATIONS

Abstract

Current generation satellite-based navigation systems have been typically located in Middle Earth Orbit (MEO) to achieve a convenient trade-off between number of spacecraft required for coverage and launch costs and signal power issues. The rapid spread of very large constellations in Low Earth Orbit (LEO), with hundreds or more satellites, is changing this scenario, opening new perspectives especially as far as it concerns the quality of the navigation services. There are certainly the advantages in the number of sources and in their spread all over the field of view, enabling lower constraints to receiver's elevation, improving the GDOP, definitely reducing the outages. Far more important, the distance from the source to the receiver can be reduced to 1/20, with a power available which is ideally going to be 400 times higher. In fact, practical tests already proved that, even taking into account some constraints, a gain in the signal to noise ratio in the order of 30dB could be approached, meaning that indoor navigation could become a chance.

It is important to design and realize effective simulation tools, computing availability, continuity and accuracy attainable by these LEO systems. These tools should be fed in input by the different options relevant to the signal, in such a way to help in the trade-off analysis. As an example, there is the (expensive) chance to accommodate specific navigation payloads, and in such a way the performance could be carefully tailored; on the other hand there is the possibility to simply use the download signal already foreseen for these constellations, without requiring any change, and maybe use the Doppler shift observables. There is the problem of the time synchronization of the signal, with the clear impossibility to use standard atomic clocks partly solved by the availability of new, "rough" chip-scale atomic clocks, already in a space-qualification path. And there is the issue of the location of the sources, to be necessarily obtained with a control segment far different from traditional MEO case and within a more challenging dynamics.

Thanks to a simulation tool, the paper presents an educated analysis of the different possibilities, at a detail level which is enough to understand and identify some guidelines. It is deemed to be of interest due to the expected number of big LEO projects and, indeed, to the effective chance that some - or most - of them could host new powerful navigation services.