The Potential of LEO Mega-Constellations in Aiding GNSS to Enable Positioning in Challenging Environments

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SUMMARY

In this work, we will discuss the potential of employing signals from the emerging Low Earth Orbit (LEO) satellites from mega-constellations that are primarily used for internet broadcast, such as Starlink (Space X), OneWeb, Iridium etc., also known as "signals of opportunity" (SOP), for aiding positioning in surveying applications. These LEO satellites are approximately 20 times closer to Earth compared with GNSS medium-earth orbit (MEO) satellites – with 800-1500km altitudes, and 100-120 minutes orbital periods. Hence, providing a new navigation space infrastructure with much stronger signal power than GNSS signals, which allow them to penetrate buildings. This makes these LEO signals more resilient to interference and available in deep attenuation settings. In challenging environments, with limited GNSS observations that may not allow positioning, such as in urban canyons, bushland, or bottom of mining pits, integrating LEO signals with the available GNSS observations can enable positioning. Moreover, the low altitude and the corresponding high speed of LEO satellites enable a much faster satellite geometry change, and hereby significantly shortens the convergence time in the precise point positioning (PPP). Such potential for a combined LEO and GNSS for Surveying operations will be overviewed and discussed.

For positioning of LEO+GNSS, the ranging concept of LEO Doppler shift time variation will be presented and the main models of combined GNSS and LEO observations will be discussed. Some challenges in positioning using LEO will be addressed. For instance, the positions (orbits) of LEO satellites and their clock behaviour must be known. We will present suggested solutions to the estimation and prediction of these orbits. In addition, unlike GNSS satellites, LEO satellites are not equipped with atomic clocks, and typically use oven-controlled crystal oscillators (OCXOs), nor are they tightly time-synchronised with each other. This issue will also be discussed. Some preliminary results will be presented.