Simulating ionospheric scintillation of GPS signals for resilient PNT testing

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This paper discusses a unique approach to simulating ionospheric scintillation scenarios by combining empirical modelling of scintillation strengths for varying elevations with real scintillation signatures extracted from measured Global Positioning System (GPS) signals. This approach to simulating ionospheric scintillation addresses limitations associated with the development of a standardised test framework that is capable of simulating scintillation threats widely applicable to all vulnerable GPS-based systems.

Ionospheric scintillation of GPS signals is the rapid fluctuation of amplitude and/or phase of the carrier signal as it traverses the ionosphere. The highly dynamic nature of ionospheric scintillation, and its dependency on the satellite geometry, result in a given receiver experiencing scintillation effects unique to its time and location. These properties of ionospheric scintillation mean that the combination of real scintillation signatures and empirical data are more likely to represent realistic conditions than the traditional empirical approach on its own. Empirical models used in this study are developed using GPS data from two sites, Cape Verde (equatorial) and Tromso, Norway (high-latitude), and implemented within a Spirent Radio Frequency Constellation Simulator (RFCS). The approach allows the simulation of scintillation scenarios for any given time and place – thus enabling a flexible test framework for ionospheric threats in GPS-based systems. Empirical models developed for different scintillation conditions varying with elevation represent real conditions to a high accuracy, as would be seen by a receiver. Modelling is carried out for all GPS frequencies. Extension of this scintillation simulation capability to other Global Navigation Satellite System (GNSS) signals is planned as a future activity.