GNSS Jamming Mitigation for Large-Scale Airborne Wind Energy Systems Using Cable Measurements

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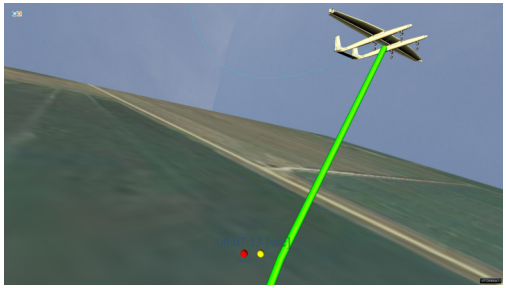
This research presents a method for mitigating the effect of GNSS jamming on large-scale airborne wind energy systems. Onboard navigation systems for airborne wind energy systems typically utilize a combination of inertial measurement unit (IMU) and Global Navigation Satellite System (GNSS) measurements, fused together via a Kalman filter. To keep the cost of the total system low, system designers are forced to utilize lower grade IMUs compared to what would normally be used in commercial aviation. However, this renders the system susceptible to GNSS outages, either malicious or accidental. The risk is compounded by the widespread availability of jammers in recent years [1].

When operated in an autonomous mode, the ensuing navigation drift can quickly result in system divergence and crash. This research investigates methods of mitigating such GNSS outages by using measurements that are already available for use by other functions, such as: 1) Static pressure, 2) Tether length, 3) Tether reel-speed, 4) Tether tension, 5) Wind speed, and 6) Cable direction. Static pressure provides a very effective way of constraining altitude drift, and has been used for this purpose in aircraft navigation systems for several decades. However, the use of tether length/speed/tension/direction is application-specific and requires additional processing before the data can be used by the onboard systems. This research investigates alternative implementations of the fusion of these measurements using a sparse quadrature Kalman filter in combination with a cable model that accounts for sag as a function of tether tension and predicted drag.



Simulation of predicted cable shape used as a measurement model inside of a Kalman filter.

References:

[1] Rugamer, A., Kolwalewski, D.: Jamming and Spoofing of GNSS Signals – An Underestimated Risk!?, FIG Working Week 2015, Sofia, Bulgaria, 17-21 May 2015.