# Fully GNSS-Independent Global Localization and Navigation System via Hierarchical Semantic Terrain Matching

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Modern navigation system is highly dependent on GNSS, which is vulnerable to jamming, spoofing, and geopolitical control. Sovereign navigational satellite system can decrease dependency to foreign infrastructure, but is very costly and still exposed to threat of electronic warfare. This project proposes low-cost hierarchical navigation framework to find user's global position without GNSS. This framework integrates solar-referenced initialization, adaptive ground sampling distance estimation, semantic drivable-area extraction, panorama-based local map construction, OpenStreetMap based global localization, UWB based trilateration, and graph-based route planning. Sequential aerial images are converted to semantic drivable-area masks, and stitch masks into panoramic local representation and matched with a global reference map to estimate the drone's location. This estimated value is used as spatial anchor for final user localization after UWB-based trilateration. This proposed system provides low-cost and scalable approach for user position recovery in GNSS-denied environment can be expended to planetary exploration environments.

**Awards Won:**