Title: Selection and Pathways to Next Generation Innovations of Speed Over Ground (SOG) Measurement Technologies to Overcome Harsh Conditions and Technological Limitations: A Review.

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Abstract: Determining speed over ground (SOG) with high precision is a critical challenge for marine and aerial vehicles due to various harsh conditions and technological limitations. Here, we review and evaluate current SOG measurement technologies, such as water speed sensor, air speed sensor, global navigation satellite system (GNSS), underwater acoustic positioning system (UAPS), Doppler velocity log (DVL), Doppler navigation system (DNS), simultaneous localization and mapping (SLAM), conventional inertial navigation system (INS), and their performance amidst harsh condition and technological limitations. It reveals the vulnerabilities, and noting their limitations when faced with stressors and technological challenges, thus highlighting the urgent need for resilient and innovative SOG measurement solutions. A substantial focus is placed on emerging sensor technologies, including cold atom inertial sensor (CAIS), micro-opto-electro-mechanical systems (MOEMS) inertial sensor, and particle imaging velocimetry (PIV) inertial sensor. Each of them presents a new frontier in navigational sciences, offering the potential for improved precision and robustness against harsh conditions that traditionally hamper SOG measurement accuracy. However, they still suffer from technological limitations like integration error over time. The Galilean projectile model-based SOG Sensor is spotlighted for its potential to provide a contactless, environment-independent SOG measurement, which is less prone to both harsh conditions and technological limitations like integration error over time. As such, this article outlines a pathway toward selecting the best SOG sensor based on harsh conditions and technological limitations for particular applications, as well as future research direction that could significantly enhance the reliability and accuracy of SOG measurements, ensuring safer and efficient navigation.

Keyword: Accelerometer, Air Speed, Ground Speed, Inertial Measurement Unit (IMU), Inertial Navigation System (INS), Speed Over Ground (SOG), Speed Through Water (STW), Speedometer.

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