KVH

Case Study

Collegiate Engineering Team, Desert WAVE, Sets New Standard in Underwater Navigation Challenge with Precision KVH Sensors

Introduction

Accurate and reliable navigation is one of the greatest challenges facing autonomous vehicles whether on land, in the air, or at sea. That challenge becomes even more extreme when dealing with navigation and positioning in the subsea environment. While autonomous and unmanned aerial and ground platforms can use satellite-based data to aid navigation, obtaining navigation data from the Global Navigation Satellite Systems (GNSS) is not an option for underwater vehicles as seawater is opaque to electromagnetic signals. This means other methods of gathering navigation data are used, including north-seeking systems and dead reckoning.

Naval submarines and very large work-class remotely operated vehicles (ROVs) use heavy, costly north-seeking navigation systems, which are not an option for smaller research and inspection autonomous underwater vehicles (AUVs) and ROVs. Therefore, smaller platforms typically use dead reckoning for navigation, employing a Doppler Velocity Log (DVL) and a GPS on the surface for a heading reference. Dead reckoning, which estimates the vehicle position based on its known previous position, or fix, and its course and speed over a known time period, is subject to errors since both speed and direction have to be known at all times for an accurate position fix. In addition, subsea applications face challenges that don't exist on land or in the air. These include current-induced movement and heave.

Applications for subsea navigation range greatly – from diver-held guidance systems to large AUVs conducting high-accuracy surveys over vast distances. For example, AUVs are used to survey the ocean floor to look for pipeline leaks or corrosion, to conduct infrastructure inspections in busy ports, or to carry out underwater inspections of vessel hulls. The sophisticated technology of the AUV is often used in tasks considered too dangerous for humans, providing benefits of both safety and project cost savings.

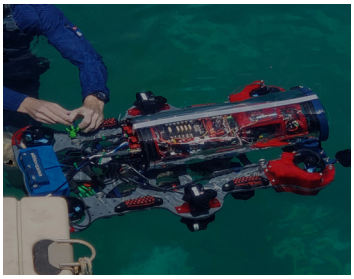
The Desert WAVE team has 14 members, and is primarily comprised of freshmen women studying engineering at Arizona State University. Formed to support and encourage women to study engineering and robotics, most of the team members had no experience in robotics before the RoboSub competition.

Desert WAVE team checks on the progress of their robotic sub, Phoenix, during testing.

The Challenge

Teams of engineers throughout the world are researching and developing new undersea designs to tackle issues of accurate geolocation and navigation underwater. Colleges are high-profile contributors to this research, and RoboSub 2019, the annual AUV competition held for over two decades and co-sponsored by Autonomous and Unmanned Vehicles Systems International (AUVSI) and the Office of Naval Research (ONR), highlights the extensive international AUV work of student engineers.

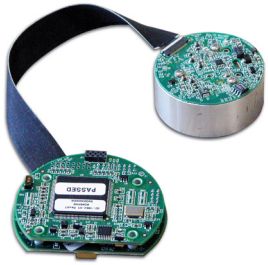
This year's goal for the RoboSub competition is for an AUV to demonstrate its autonomy by completing various underwater tasks such as navigation, manipulation of the environment (picking up, dropping, and shooting objects), identification of figures, and maneuverability. As the competition progressed, all eyes were on the all-female rookie engineering sensations from Arizona State University and the Si Se Puede Foundation, aptly named Desert WAVE (Women in Autonomous Vehicle Engineering).



Lowering Phoenix into the test pool in preparation for one of its runs during the RoboSub competition.

Desert WAVE's competition strategy was to be selective, realizing early on that it would not be possible for their AUV, named Phoenix, to function at a high level for all RoboSub 2019 tasks. Consequently, Desert WAVE took the approach of doing a few tasks really well to receive high-value points.

"The ability to drive in an absolute straight line was considered a highly critical task," explained Faridodin 'Fredi' Lajvardi, Vice President of STEM Initiatives for Si Se Puede Foundation and Desert WAVE team mentor. "If this task could be accomplished, higher level tasks involving more complicated maneuvering and navigating would become significantly more conquerable."

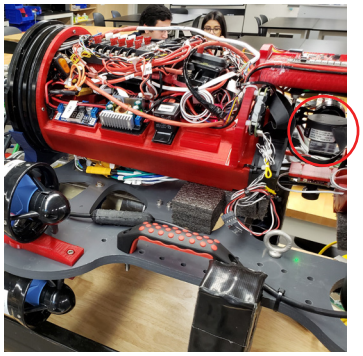


The super-compact and flexible design of the KVH DSP-1750 makes the FOG easy to integrate into platforms where space, payload weight, and high performance are at a premium.

The Solution

Desert WAVE decided to use dead reckoning, utilizing Google Earth to generate longitude and latitude waypoint coordinates to complete tasks. The accuracy of this method was significantly improved with the use of a high-performance FOG and a DVL. Desert WAVE avoided the errors that typically occur when using dead reckoning with DVL and surface GPS, as they had the advantage of a FOG to provide accurate positioning data.

Early in the design process, Desert WAVE was the recipient of an essential donation – a KVH DSP-1750 FOG – to meet the team's goals of maneuvering Phoenix in a straight line, and accurately navigating on a determined route. The capability of the KVH FOG to provide accurate positioning data, when combined with the DVL, also eliminated the team's need to explore and build additional navigation solutions such as a vision-based system; an integral part of their strategy to minimize manufacturing time and maximize testing time.



The KVH DSP-1750 single axis gyro is visible in Phoenix on the right. It is sitting on the gimbal that keeps the fiber optic gyro level with the Earth when turned on.

"Phoenix was built primarily with commercial-off-the-shelf components, including the DSP-1750 FOG," explained Fredi. "This method of fabrication greatly simplified the AUV construction since no members held manufacturing experience prior to joining the team. In addition, the team knew that a well-designed and successful navigation system built around a high-performance FOG would eliminate the need for an in-depth computer vision system underwater, which was one less obstacle to conquer in the AUV design process."

The DSP-1750 was easy to integrate into the Phoenix and the completed AUV was equipped with 10 thrusters, a passive sonar, DVL, and two cameras in addition to the KVH FOG. "The FOG was critical for Phoenix's localization to make sure that it was always aware of the RoboSub's location and heading at all times," added Fredi.

Desert WAVE team member guides Phoenix into position for another run.

The Results

"The DSP-1750 FOG was outstanding in action for Desert WAVE's RoboSub, with virtually no drift, and enabled the Phoenix to maintain its heading under water," said Fredi. "For example, a significant number of points were awarded if an AUV accomplished the task of surfacing in a PVC-constructed octagon eight feet in diameter at the furthest point from its starting position. Despite the established difficulty of this task, Desert Wave's RoboSub was repeatedly able to find the octagon, surface, and complete the task."

When the DSP-1750 FOG was paired with the DVL, distances and headings were found with great accuracy, allowing Desert WAVE to be among the most consistent teams at the competition, placing third internationally, and first among the U.S. teams – a huge accomplishment for any RoboSub team, never mind a first-time entrant.

Navigating the underwater course as quickly and accurately as Phoenix was a difficult challenge for many other teams. "Desert WAVE believes they have set a new standard at the competition for navigation," concluded Fredi.

KVH's 1750 IMU is a versatile, highly accurate inertial measurement unit that's ideal for navigation and dead reckoning in GNSS-denied environments. KVH donated one of these units to the Desert WAVE team for its next competition.

There was an additional bonus as well. The ability of Desert WAVE's AUV to be consistent and precise in its underwater navigation and maneuvering allowed the team to focus on meeting a final goal – collecting data and developing skills necessary to form the foundation of a competitive team next year and beyond. KVH will remain an avid team supporter, donating its 1750 IMU inertial measurement unit (IMU) to further enhance AUV navigation, guidance, stabilization, and pointing abilities. Desert WAVE looks to be a formidable opponent in RoboSub 2020.

About Desert WAVE

Desert WAVE was formed through a partnership between the Si Se Puede Foundation and Arizona State University. KVH supports team-based modes of learning in undergraduate education as a way to encourage collaboration and prepare students for the workforce.

About KVH Industries

KVH Industries, Inc., is a premier manufacturer of high performance sensors and integrated inertial systems for defense and commercial guidance and stabilization applications. KVH is also a leading manufacturer of solutions that provide global high-speed Internet, television and voice services via satellite to mobile users at sea, on land, and in the air. An ISO 9001-certified company, KVH is based in Middletown, Rhode Island, U.S.A., with facilities in Illinois, Denmark, Norway, and Singapore.

Learn more at KVH.com/FOGs

Have a question or want to discuss how KVH FOGs and inertial systems can help you overcome your engineering challenges? Contact:

North America

Sean McCormack
Sr. Director, Global Inertial Systems Sales
Inertial Navigation Group
Direct Tel: +1 401-845-2413
Email: smccormack@kvh.com

Europe

Alessandro Rossi
FOG & OEM European Business Development & Sales Manager
Inertial Navigation Group
Direct Tel: +39 328-4557397
Email: alessandro.rossi@kvh.com

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