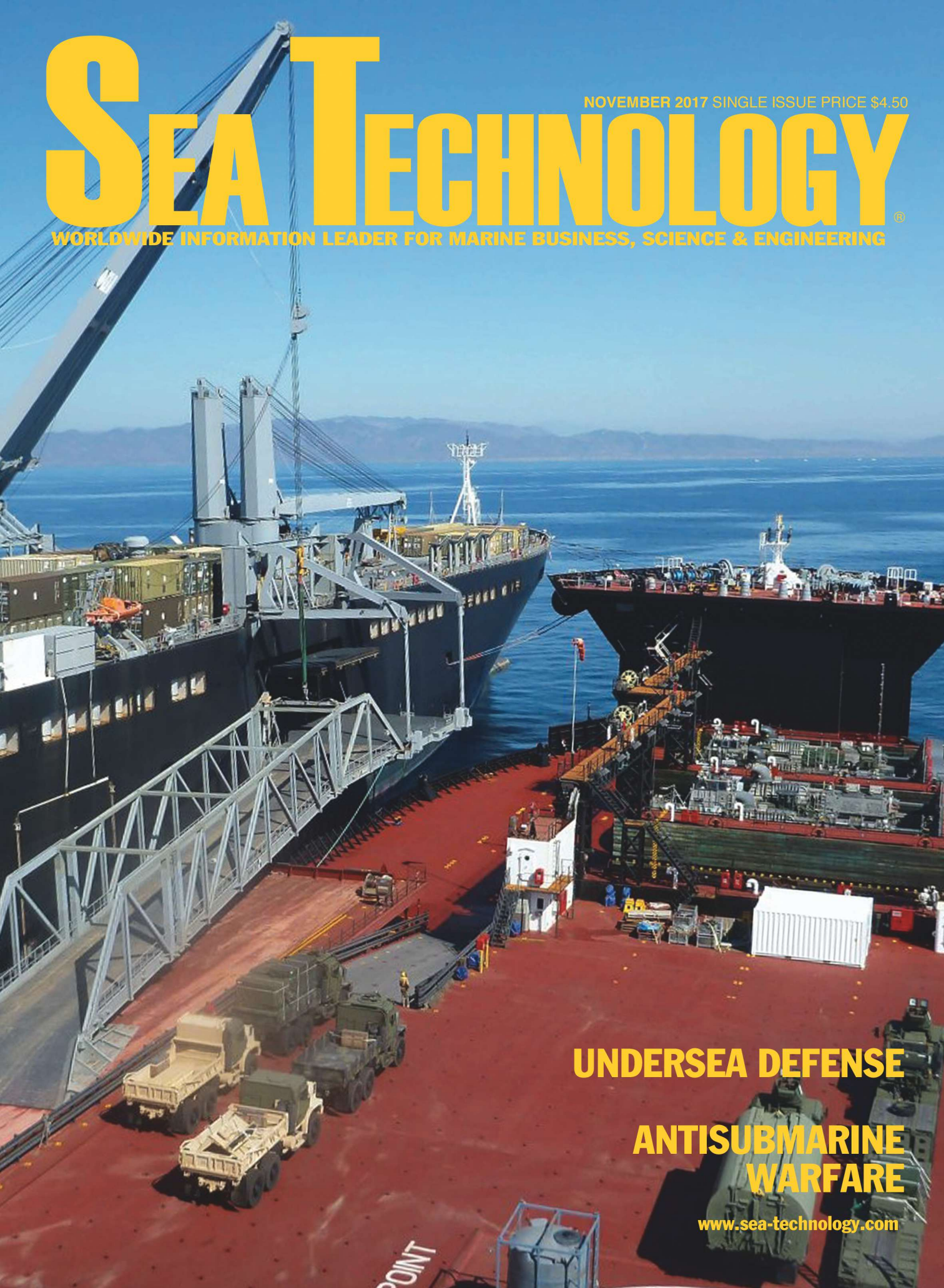


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Multibeam Side Scan For Unmanned MCM

Klein 5900 Performs During Naval Mine Countermeasure Trials

By Giuseppe Di Stefano

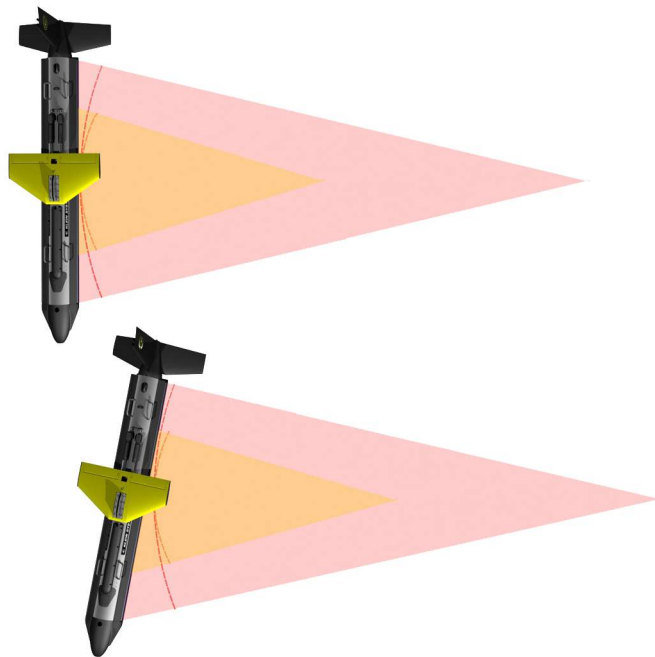
The Belgian Navy and NATO-CMRE hosted the North Sea Unmanned MCM Trials June 2017. This challenge was an assessment of the ability for commercial off-the-shelf (COTS) autonomous systems to perform mine countermeasure tasks. The activities took place in the vicinity of the NB-01 military exercise zone, outside of the Zeebrugge Navy Base.

The trial was open to the participation of COTS autonomous underwater and surface systems (e.g., AUV, USV). All vehicles were required to perform autonomously in a challenging environment populated with realistic mine-like targets including cylindrical, MANTA, ROCKAN and tethered types. Vehicles were assigned 10 hours to complete the mission.

5900 Multibeam Side Scan

Klein Marine Systems participated in this exercise deploying its flagship 5900 high-resolution, high-speed multibeam side scan sonar, specifically designed to obtain high-quality images even in adverse sea conditions. Klein partnered with Elbit Systems, manufacturer of the USV Seagull, a versatile platform for mine hunting and anti-submarine warfare. The Seagull is particularly suited to operate in high sea states and, therefore, an ideal match for the demanding littoral environment of the Belgium and Dutch coast. Elbit has developed for the Klein 5900 an efficient, fully automated launch and recovery system (LARS) particularly suited for operations in high seas.

Klein pioneered the first COTS multibeam side scan sonar. Unlike single-beam side scan sonar systems, whose along-track resolution degrades with increasing range, dynamically focused multibeam side scan systems deliver constant along-track resolution, with 100 percent bottom coverage, at towing speeds that are three to four times higher than possible with single-beam systems. The superior high-resolution and high-speed performance has made the multibeam product line (for example, the 5000 series) extremely successful with many of the world's navies and government organizations for route surveys and detection of mine-like objects (MLOs). The high-resolution multibeam side scan sonar Klein 5900 improves on the performance of



(Top) Klein 5900's 28 segments are electronically delayed to compose synthetic beams focused to the selected range. (Bottom) Synthetic beams created to point orthogonally to course over ground, as opposed to orthogonally to the towfish heading.

its predecessors 5000 and 5000V2 by employing advanced signal-processing techniques and superior acoustic design to improve the overall along-track target resolution by a factor of two. The across-track resolution of the 5900 is maintained at a constant 3.75 cm over all operating ranges.

The Klein 5900, unique in its class, is designed to operate and produce crisp, sharp high-contrast imagery even in adverse operating conditions or in littoral waters where sea waves have a greater effect on the towing vessel.

Dynamic focus and beam steering are two of the signal-processing techniques contributing to the 5900 imaging performance. In the Klein 5900, there are 28 independent



receive subarrays on each side. Each sound sample from each element is recorded and stored in memory. A software process subsequently takes into account position information, motion sensor and user's parameters to retrieve the appropriate sound samples from the sound memory to compose a synthetic image.

Dynamic beam steering image stabilization technique is used to remove artifacts caused by tow vehicle motion that would otherwise blur seabed images, especially at longer range where the effects due to angular perturbations are more pronounced. This is a marked improvement over the 5000 family, which produces successive beams perpendicular to the tow body and is more susceptible to compressed or elongated images due to excessive tow fish yaw. Image stabilization helps to effectively extend the range of the sonar by minimizing this distortion.

By the laws of physics, sonar waves reflected from a target have different radii depending on the distance of the target. When the operator sets the system, for example, on 75 m, the 5900 software delays each sound sample to adapt to the corresponding radius. At 100 m, the software computes a larger radius. The dynamic focusing, i.e., computing the delay of each sound sample, is one of the contributing factors for the 5900 crisp imagery.

The next step in the process of image optimization is to take into account the fluctuations in the heading of the sonar body. Motion sensor information (heading, pitch, roll and yaw) are fed into the 5900 algorithms to create synthetic beams pointing orthogonally to the course over ground, as opposed to orthogonally to the towfish heading which is intrinsically unsteady in operational conditions. The 5900 has several options designed to increase efficiency and ac-



*(Top) Klein 5900 in the automated launch and recovery cradle.
(Bottom) Elbit Seagull with integrated Klein 5900 mobilized at Zeebrugge Naval Base.*

curacy in an MCM environment. Integrated into the Klein 5900 sonar architecture is a swath bathymetric sonar. This sonar uses advanced phase delay signal processing to produce co-registered topography of the seabed out to the full swath extent of the side scan sonar.

Side-looking sonars that do not have the ability to perform bathymetric measurements must assume a locally flat bottom when measuring the location of seabed targets. This can result in target position errors on the order of meters when surveying over sloped bottoms. This added seabed topographic mapping capability is an additional advantage to performing missions involving shallow-water, rapid area assessment.

A great improvement to expedite MCM operations comes from the Klein 5900 fully integrated optional Gap-Filler Sonar (GFS), used to provide high-resolution acoustic imagery across the side scan sonar “nadir gap.” In fact, all side scan sonar systems are incapable of adequately imaging the region directly beneath the sonar tow body. This resulting “nadir gap” region, which can be relatively large depending on the tow body altitude, can only be covered by executing a sonar survey that encompasses 100 percent overlap on reciprocal adjacent survey lines. The Gap-Filler Sonar option can halve the survey time necessary to achieve full bottom coverage. The GFS on the Klein 5900 operates synchronous with the main side scan sonar and covers a sector directly below—and slightly ahead of—the tow body path.

A very important feature is Klein SP-Link, which enables transmission of full-resolution compressed imagery in real time to the command ship or to a base station, either via RF line-of-sight (LOS) or via a satellite communication link. This real-time data collection and transmission software allows MCM missions to be executed and moni-

“The Klein 5900 has specific features designed to make it ideally suited for MCM deployment in an unmanned—and even totally autonomous—scenario.”

tored, which enables, if necessary, making data-based decisions before the vehicle returns to base. Also, the SP-Link allows remote control of standard sonar parameters, such as range, pulse width, etc., as well as remote control of hydrodynamic surfaces—wing and tail fins—for collision avoidance and additional active vehicle stabilization.

MCM Challenge

Many of the features of the 5900 were tested in the difficult conditions of the Mine Countermeasure Challenge in Belgium. In fact, on the day assigned to Elbit/Klein, the sea conditions were less than ideal. During our testing period, a major storm affected the area, but the Klein/Elbit team elect-

ed to demonstrate on the assigned day to prove the superior MCM grade imaging capability of the 5900 side scan sonar even in adverse sea state conditions.

After submitting the results from the survey to CMRE, the Belgian Navy released the actual coordinates of the mine-like objects. By comparing the survey data against the disclosed coordinates, the Klein 5900 was able to detect 100 percent of the ensouffled MLO.

As described, the Klein 5900 has specific features designed to make it ideally suited for MCM deployment in an unmanned—and even totally autonomous—scenario. For MCM operations, its technology overcomes several shortcomings of SAS products. In fact, the resolution of the 5900 in the sonar near field is, by design, superior to any commercial SAS currently in production.

Furthermore, its acoustic and digital processing architectures are optimized for operation in coastal sea conditions, which are typical of MCM scenarios, where there is a considerable risk of SAS inability to generate high-resolution images—particularly in a towed deployment.

The advantages of the 5900 become even more evident when we take into account its cost benefit, particularly when considering the intrinsic high risk of damages to the equipment in unmanned operation.

In conclusion, the North Sea Unmanned MCM Trials in Belgium demonstrated that Klein’s 5900 is the ideal imaging system for unmanned, towed MCM missions. **ST**

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