Current and Future Generation of Unmanned MCM Integrated Systems

Dr Marc Pinto, ECA Group (pinto.m@ecagroup.com)

Abstract — Current and Future ECA Group Unmanned MCM Integrated Systems (UMIS^{TM}) are discussed. In the current generation of UMIS^{TM}, which is the one selected by the Belgian and Netherlands Navies, the detection and classification is performed with sonars which are forward-deployed on AUVs or towed by USVs. The identification and disposal is performed by ROVs deployed from USVs. It is argued that in the future generation of UMIS^{TM}, the AUVs will also take over the identification task and that this will represent another step change in operational performance.

1 Introduction

The work flow of traditional minehunting systems, based on dedicated manned surface vessels, consists in a first stage of detection and classification (D&C) performed with multi-frequency forward-looking sonar, followed by a second stage of relocation and identification (R&I) of mine-like contacts (MILCOs) performed by ROV or divers, and when needed, a third stage of relocation and neutralisation (R&N) performed by the same means. This third stage is generally distinct from the second one due to pyrotechnic safety requirements. ROV operations, while preferable to divers to reduce risk to personnel, are very time-consuming, manpower intensive, and present many challenges in harsh environments.

UMIS^{TM} is the unmanned MCM system developed by ECA Group, using a collaborative system of air, surface and underwater robots including UAVs for drifting mine detection, AUVs and USV-towed sonars for mine D&C, USV deploying ROVs for mine R&I and R&N, all these systems being integrated in the MCM C2 UMISOFT^{TM} . This reduces risk to personnel, as the manned ship does not have enter into the minefield, and has also proven more efficient and cost-effective than traditional systems. In March 2019 **UMIS^{TM}** was chosen by the Belgian & Netherlands Navies to replace their legacy MCMVs.

In current unmanned MCM systems such as **UMIS^{TM}**, the introduction of AUVs in MCM has impacted only the first stage of D&C, with MILCOs now being found by Interferometric Synthetic Aperture Sonar (InSAS), a very high resolution 3D ground imaging mode, widely adopted in radar, made possible by the side-looking geometry best suited to AUVs or USV- towed sonars. The cross-range resolution offered by a SAS is typically 3cm or less, constant with range. This is better by more than one order of magnitude than the cross-range resolution of the legacy forward-looking classification sonars, of the order of 40cm at their typical classification range of 120m. As shadow classification requires a minimum of 4-6 cross-range pixels on a target, a legacy classification sonar can classify a 0.5mx2m cylindrical target only when the target has a favorable aspect, near broadside. This required the vessel to circumnavigate a detected target in order to have a classification opportunity, increasing time on task. This is no longer necessary with a SAS, which has the ability to easily classify such a target, even at endfire aspects, since the number of cross-range pixels 50/3 is still well above the required value.

SAS leaves no ground mine undetected (except for the fraction μ’ of buried or concealed mines) while maintaining very high area coverage, typically of the order of 0.5 nm^2/h. This very high rate means that the SAS will produce a large number of MILCOs every hour, leading to a bottleneck for subsequent ROV identification missions, which are much slower. Operators today are still left with the difficult task of drastically reducing the number of MILCOs to be handed over to the identification ROV, with increased risk that a mine will be missed. The next generation of AUVs will resolve this problem by taking over the task of automatically collecting identification data (the identification itself can still be done under operator supervision), thus achieving a step change in both operational effectiveness and efficiency, with a simpler, more reliable, and scalable system.

2 Requirements

To meet this goal, the first requirement is for long range (>5m) identification sensors, allowing safe AUV standoff. Examples include chemical sensors able to detect traces in the water of explosive material leaking from the mine case, and long range optical imaging in turbid water using blue-green underwater lidar. Time of flight lidar is a technology which has being received significant attention for both military and commercial applications (Fig.2&3). The principle is that the range gating made possible by the time of flight measurement allows to reduce the optical volume backscatter. As such lidars are offered commercially to do metrology surveys of subsea installations, which indicates a high degree of readiness of the technology, it is anticipated that their introduction in the next generation of UMIS will come rapidly. One obvious limitation of lidar, as for all optical systems, is that they cannot be used to identify buried and concealed mines.

The second requirement is for accurate guidance and navigation, to safely operate all sensors at the correct distance to the seabed, and to relocate MILCOs in all water depths of interest to MCM (5-300m). A SAS-equipped AUV can leverage for this purpose both the SAS imagery and a very high performance aided inertial navigation system. There is significant potential to improve both navigation and guidance performance by either navigating "through the SAS sensor" or designing specific acoustic velocity logs according to a new patented design ([2]).

The third requirement is the artificial intelligence for automatic MILCO extraction. For many years now, deep learning techniques have been receiving a lot of attention, including by the team at the NATO CMRE. While the number of MILCOs extracted by these algorithms still increases significantly with the seabed complexity (roughness, anisotropy, clutter density etc) there is still potential in both algorithmic improvements and sonar designs to reduce the number of MILCOs.

3. Conclusion

Identification is currently the bottleneck for current MCM systems, whether manned or unmanned. The desire to improve identification performance for the current **UMIS^{TM}**, has led to the design of the Seascan reusable inspection vehicle. This remains a lightweight battery operated ROV, like the expendable K-ster, but has much larger endurance, allowing the inspection of multiple MILCOs per mission. It is also equipped with much high performance sensors. However multiplying the number of Seascans deployed simultaneously is difficult as well as manpower intensive. A breakthough in identification performance is expected from AUVs which can also collect identification data autonomously. This will also allow multiple AUVs to be operated in parallel, further increasing efficiency and building redundancy

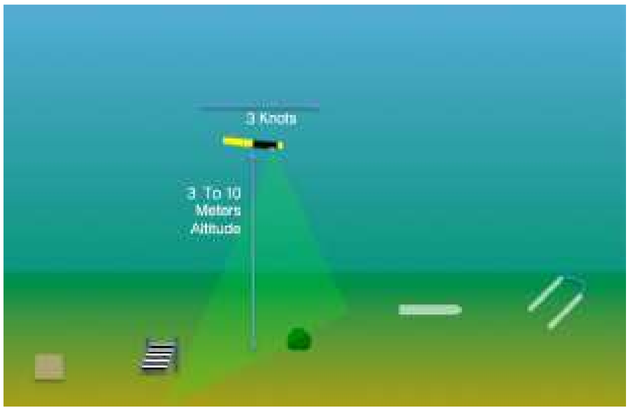

Fig. 1. Across-track scanned TOF lidar (from [1]).

References

[1] Jules Jaffré, personal communication.
[2] M. Pinto, Proc. Oceans 2018

Author/Speaker Biographies

Marc Pinto graduated from the Ecole Nationale des Ponts et Chaussees, Paris in 1983. He received his Ph.D. in Solid State Physics from the University of Paris in 1991. In 1993 he joined Thales Underwater Systems as Head of the Signal Processing Group, specializing in maritime mine countermeasures. From1997 to 2010 he was with the NATO Undersea Research Center, La Spezia, Italy where he served as Head of the Mine Countermeasures Group. He is a recognized expert in Synthetic Aperture Sonar systems for AUV-based minehunting and harbour defence. He served as Chief Technology Officer, Marport Deep Sea Technologies from 2010 till 2014, developing real-time Synthetic Aperture Sonar systems and since March 2013 he is with the ECA Group, where he is currently Scientific Advisor.