Object Detection Using the HydroPACT 440 System

Unlike magnetometers – traditionally used for subsea UXO detection – the HydroPACT 440 detection system uses the principle of pulse induction to detect the presence of any electrically conductive materials. It is not limited to the detection of ferrous metals, and will reveal the presence of brass, bronze, aluminium and light alloys, that a magnetometer will not recognise.

Being able to detect a much wider range of targets means that the HydroPACT 440 (and its predecessor, the 340) is a powerful tool for use in general subsea metal detection tasks, such as ordnance salvage and marine archaeology. Its use for similar applications such as Mine Countermeasures (MCM) and Unexploded Ordnance (UXO) detection is less common but it remains a viable option. This technical paper addresses questions that may arise from those seeking to use it in this role.

DEPLOYING THE SYSTEM

The design of the HydroPACT 440 system makes it flexible and easy to install on a variety of subsea vehicles. Typical support vehicles include:

- Remotely Operated Vehicles (ROVs)
- Tracked vehicle or crawler
- Towed sled

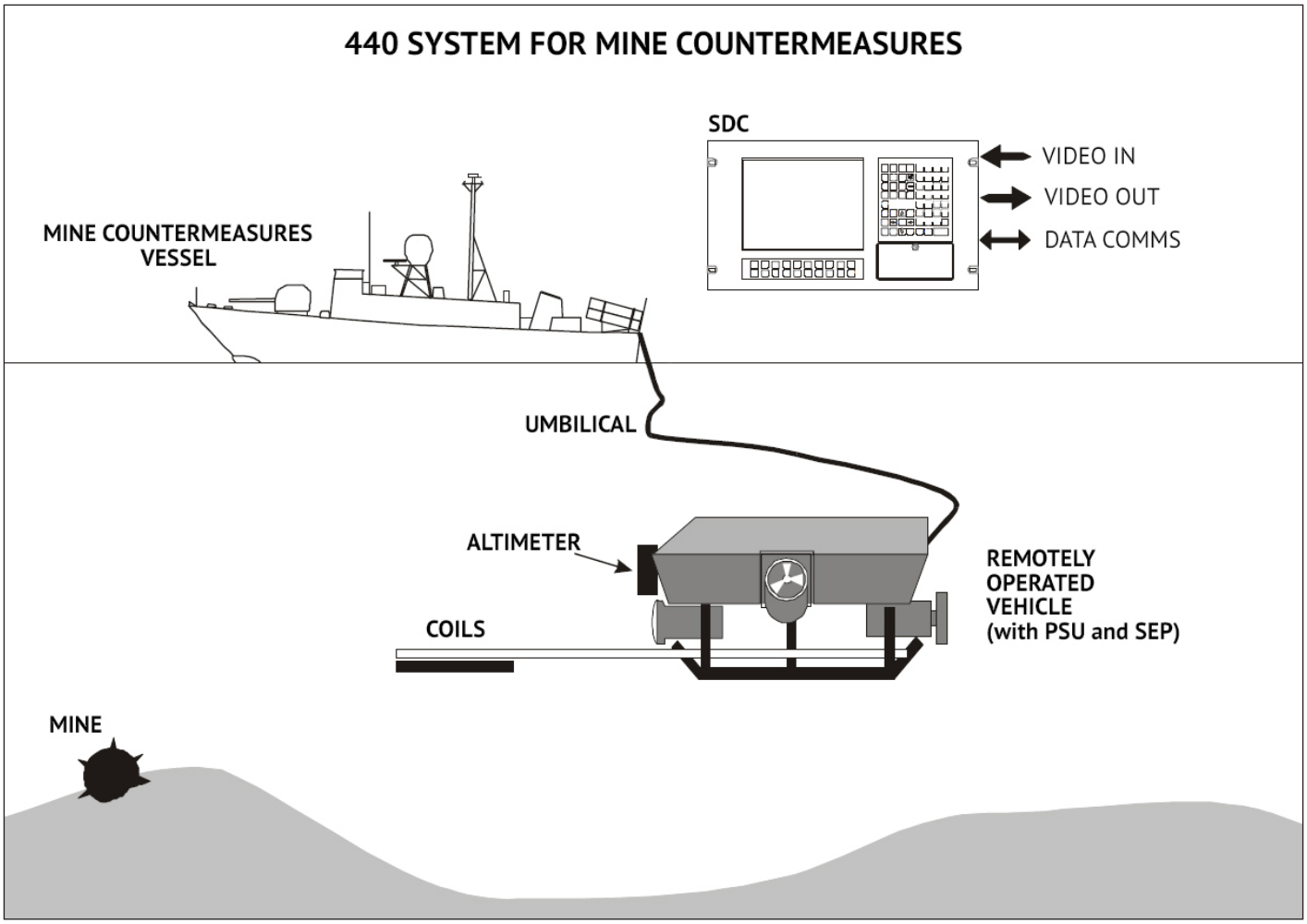
Larger vehicles, which tend to be the most stable platforms, are preferable. Work class ROVs have proved to be ideal deployment platforms.

The highly sensitive HydroPACT 440 coil array, that detects the conductive materials, must be mounted out in front of the ROV (recommended 75cm – 1.25m). As the system is no longer being used to provide accurate depth of burial information, alternate coil arrangements may be employed, meaning the 440 does not require the standard, overlapped coil arrangement. The coils can be placed adjacent to give better coverage, or spaced slightly to improve coverage further but users should note that excessive spacing of the coils will carry the risk of missing small objects between the coils. The end-user should determine the acceptable number of survey lines, expected size and depth of objects and ROV handling abilities to determine the optimal coil arrangement for the survey.

The effective range of the 440 system depends only upon the size and conductivity of the target, not its state of burial.

Typical range of the system is as follows:

Target	**Esitmated Detection Range**
Oil drum (0.75m diameter)	2.4 metres
Torpedo (light alloy, 0.5m diameter)	2.4 metres
Ground mine	1.5 metres
Anti-personnel mine (0.2m diameter)	1.2 metres



Key of the HydroPACT 440 for UXO and MCM applications:

1. Detection of any type of conductive material – including non-ferrous metals which magnetometers cannot identify.
2. Insensitivity to DC magnetic fields, including terrestrial magnetism and magnetized objects.
3. Detection is focused on the area under the coils, allowing for precise locations of objects of interest.
4. Simple deployment and operation.
5. Flexible coil arrangement

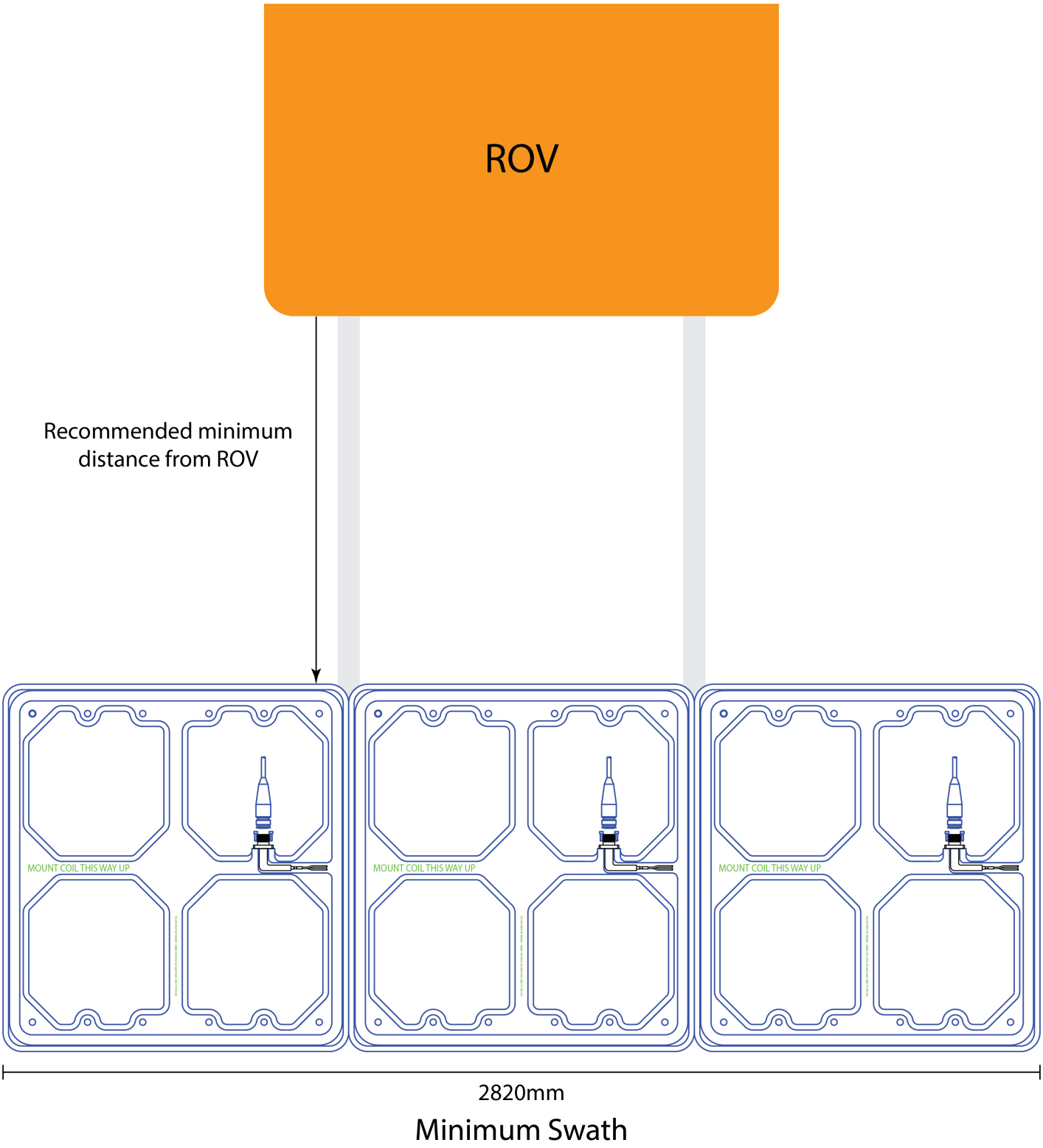
Key limitations of the HydroPACT 440 for UXO and MCM applications:

1. Limited detection range.
2. When detecting unknown objects, the target-scaling factor is indeterminate. The 440 system is not able to give range or size for any detection objects – it simply identifies an object's existence in the surveyed area.
3. Survey of large areas may require many passes – the system coils must be passed over the area to be surveyed.

RECOMMENDATIONS FOR EFFECTIVE DEPLOYMENT

The The DeepView topside software is designed to support cable and pipeline tracking only, which are known dimensions, so LAT (Lateral Range to Target) and VRT (Vertical Range to Target) should be ignored. The only parameter of interest for end-users surveying for UXO is the coil voltages, with elevated values indicating the proximity to conductive material.

The survey region or route should be identified and divided into survey lines spaced accordingly to the width of the coil array. Data logging equipment must be configured to record early and standard coil voltages, and ROV position. All data should be appropriately geotagged in to allow cross-referencing to produce a mosaic grid to identify objects of interest.



As the diagram above shows, the minimum swath for the coil arrangement is 2820mm wide as the coils are installed edge to edge. The recommended distance out in front of the ROV for coil installation is between a minimum of 750mm to a maximum of 1250mm to eliminate background noise from the vehicle. The maximum coil swath is only limited by the length of cable that can be supplied. TSS can supply cable up to a maximum of 10m in length.

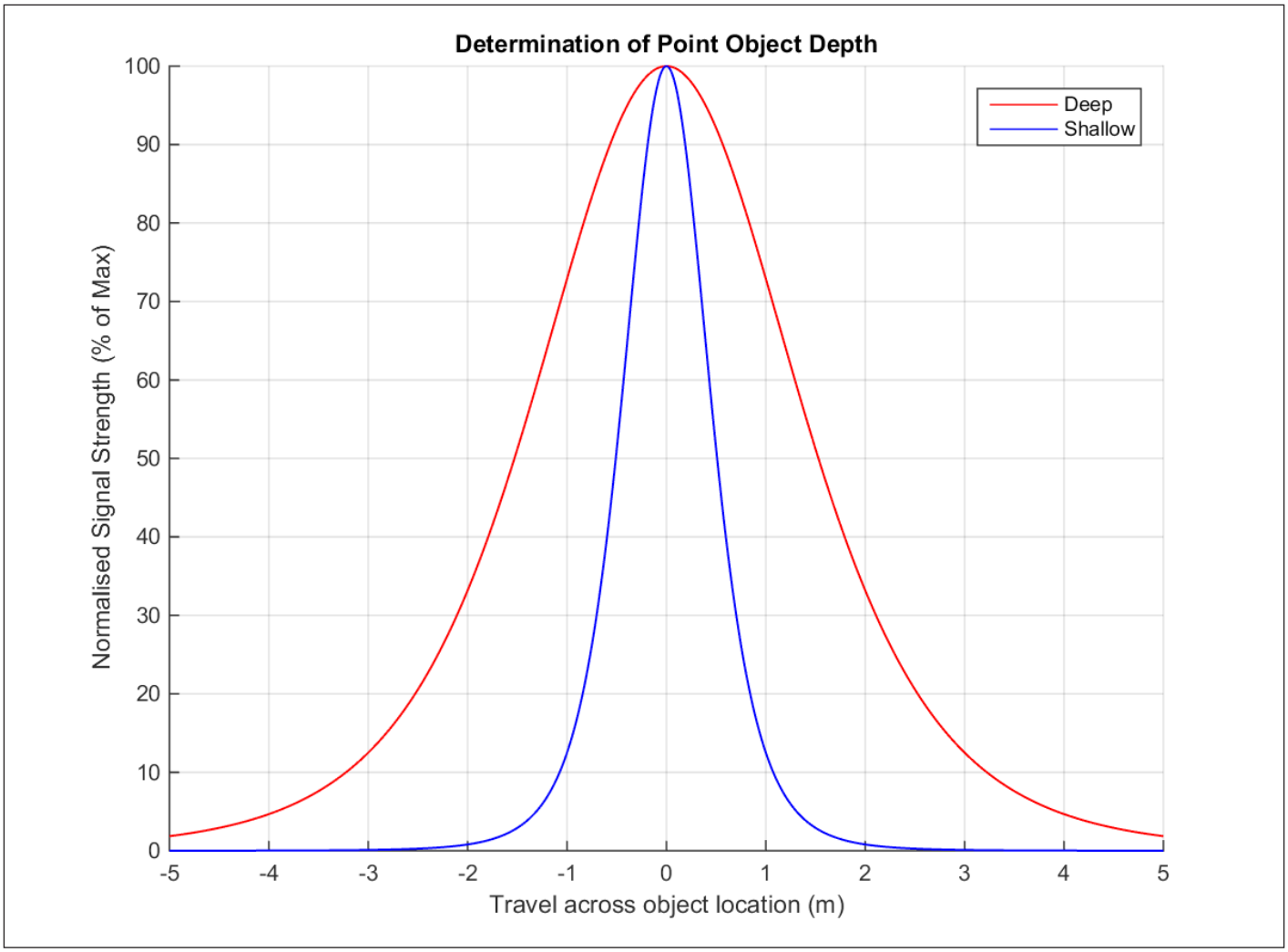
The optimal range to target is a maximum of 3m which may vary considerably with the physical characteristics and electrical properties of the target itself. The coil voltages are strongly dependent upon range (following an approximate sixth power relationship).

If the grid approach is not acceptable and steerage of the ROV by coil voltages is required, the unnecessary features (waterfall plot and coordinates) can be turned off in the DeepView overlay settings. Teledyne TSS recommends display of coil voltages only in this scenario.

Sample of DeepView overlay display showing coil voltages only

DATA PROCESSING AND INFERENCE OF OBJECT DEPTH

An indication of the range to an object can be estimated using the width of the signal peak along the direction of travel, with deeper objects tending to give a broader peak. The figure below illustrates this relationship for two objects, using peaks that have been normalised to give the same magnitude when directly over the object.



A A key limitation of this approach is object shape. The model above is created using a point source; real-world objects may be large, elongated or irregular giving rise to broadening of the peak width. It is not realistic to establish a reliable burial depth but this method may be useful to determine which objects require further investigation.

OPERATIONAL CONSIDERATIONS

Arguably, the most significant contribution of the HydroPACT 440 system in the MCM arena is its ability to help classify mine-like sonar contacts. If a sonar contact is classified as a mine, the 440 system provides an additional classification tool available to the MCMV (Mine Countermeasures Vessel) before carrying out time-consuming neutralisation procedures. If a sonar-classified mine is also electronically conductive, or if it contains conductive material, then confidence would be very high in its classification status.

WARNING! Unexploded ordnance (UXO) may take many forms including, but not limited to, unexploded bombs, shells, rockets and missiles, grenades, land mines, naval mines, and cluster munitions that did not explode when they were employed, and still pose a risk of detonation. The unknown state of these items may mean that they become unstable with the passage of time and may be sensitive to transient electrical energies. Teledyne Technologies Incorporated and its subsidiaries, including Teledyne TSS – a division of Teledyne Limited – accept no responsibility whatsoever for the premature triggering or firing of UXO whilst employing this apparatus to detect the presence of such devices.

CASE STUDIES

ROV

Teledyne TSS has designed the 440 system to be compatible with most standard ROVs.

The two electronics pods accept electrical power form the ROV, and communicate with the surface installation through dedicated wire pairs in the vehicle umbilical. The array of three search-coils extends ahead of the ROV. The SDC (topside computer), located in the ROV control room, displays measurements made by the system using clear graphical and numerical readouts.

Case Study 1:

A first generation TSS pulse induction system performed an operation for a defence organisation to assess its ability to detect buried light-alloy targets on a torpedo test-range in Canada. A SORD ROV supported the detection system, together with various recovery tools and jetting equipment.

The SORD was not a conventional ROV because is used kedge wires to aid its guidance. Despite this, installing and commissioning the detection system was still completed within a few hours. It then successfully located not only the test target but also two sonarbuoys buried more than a 1.5 metres beneath the seabed of which both had been lost for several months.

Tracked Vehicle or Crawler

This mode of deployment is ideal for operations on beaches, in marshland, and in very shallow water (up to 10m).

A tracked vehicle is very similar to a ROV, with the 440 installed in exactly the same way. The crucial difference is that the tracked vehicle or crawler does not free swim but runs along the seabed on its tracks. It is possible to operate this type of vehicle from land, for example to direct it along the surf zone of a beach.

Case Study 2:

Trials performed by a UK based survey company included a first generation system installed upon their 'Navtrax' vehicle. Operating on a gently sloping beach five miles north of Aberdeen, Scotland, the vehicle was directed into and out of the sea.

The operation required the detection system to continuously track and follow a partially buried test-cable over terrain ranging from the dry beach to a seawater depth of 10 metres. It completed this task successfully while simultaneously locating several dummy targets (oil drums) buried along the route.

Towed Sled

Several marine salvage contractors and offshore companies have pioneered the use of a towed sled to support a TSS detection system. This is also an interesting and available option for MCM operations, with the search-coils installed on a rugged sled towed astern of a vessel.

The operation requires the vessel to tow the sled along the seabed, following a pre-planned search pattern. Alternatively, the vessel can tow the sled to the position of an acoustic contact identified previously by sonar and standard acoustic navigation systems.

Case Study 3:

A German survey company pioneered the use of a towed sled a number of years ago while they performed an operation off the coast of Bremerhaven for the German Federal Government. The operation was to recover a large quantity of ordnance dumped in the area during World War II.

The original contract to recover the ordnance and clear the area specified the use of side-scan sonar and standard proton magnetometer. After a demonstration of the effectiveness of the TSS detection system in accurately detecting and locating small items of test ordnance, the specification changed to include TSS detection equipment in preference of traditional methods

The German survey company manufactured their own sled and fitted the detection system to it, successfully completing their operation ahead of schedule.

Since then, a number of companies have used this technique successfully in diverse applications.

SUMMARY

It is a technical reality that high-frequency mine-hunting sonar, scanning sonar or side-scan sonar cannot distinguish reliably between metals and non-metals. Neither can these types of systems detect buried or partially buried targets. The HydroPACT 440 system provides the ability to fill this gap in the capabilities of acoustic technology.

The Teledyne TSS technology has proven itself in the commercial sector on closely related applications, and has the potential to radically improve the effectiveness of MCM or UXO operations.