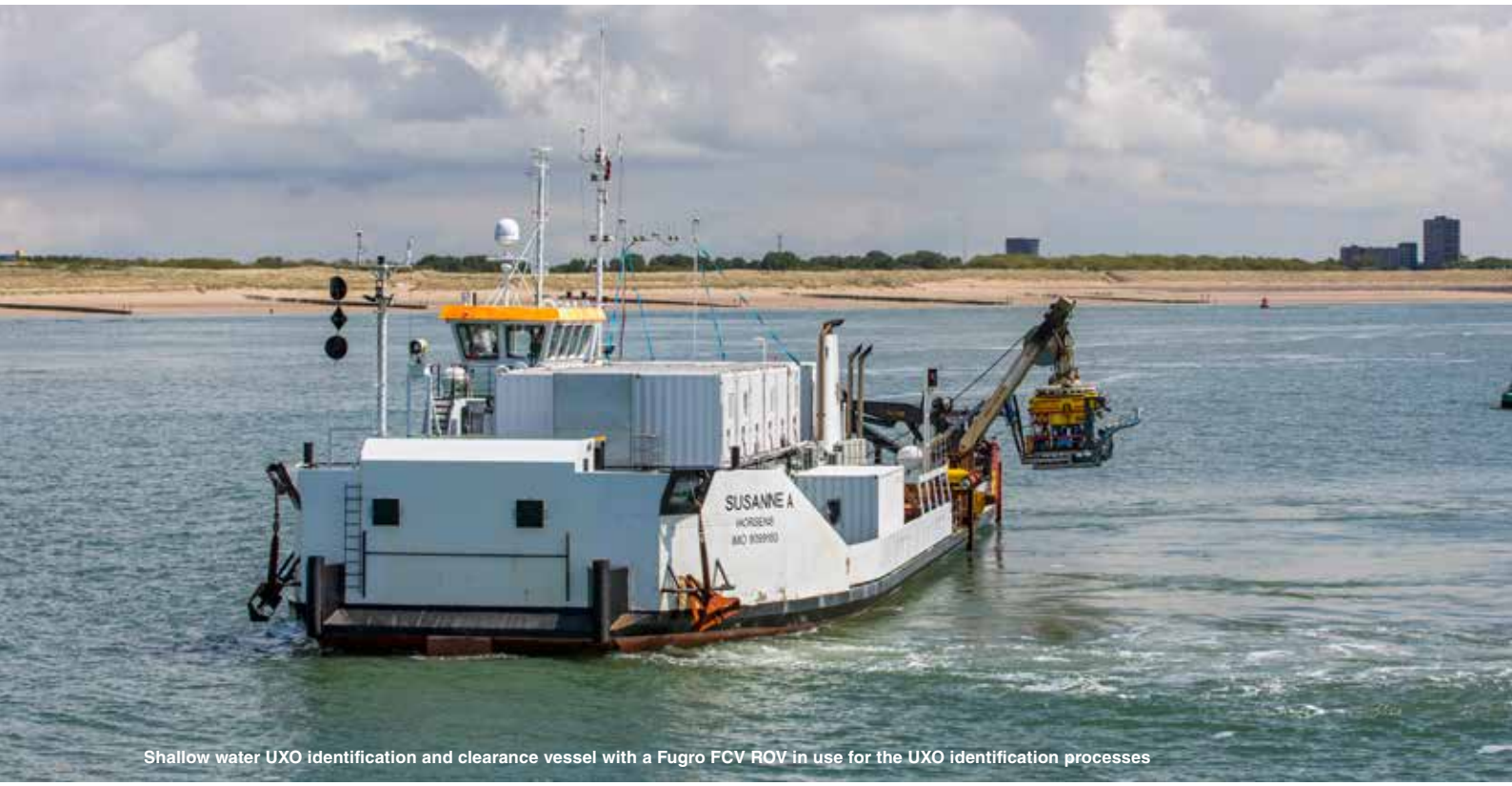
UXO

Risk mitigation tools and techniques

Unexploded ordnance (UXO) represents substantial risk and cost for the rapidly growing global offshore wind industry when planning new large-scale wind farm including cable routing and other activities in the marine environment. Offshore Wind spoke with Fugro Project Director Marco Gilissen, who leads an expanding subsea geo-intelligence group specialized in the full spectrum of UXO risk management services.

Fugro's Atlantis Dweller, a dedicated UXO identification vessel


FUGRO

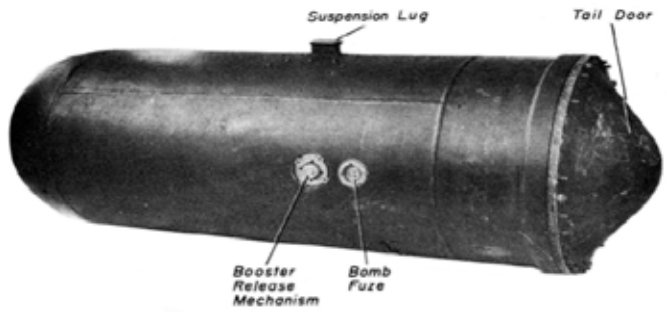


Shallow water UXO identification and clearance vessel with a Fugro FCV ROV in use for the UXO identification processes

Offshore wind farm construction is at full swing and accelerating across Europe and several emerging markets, such as the USA and Asia-Pacific regions (e.g. Taiwan, Japan and Vietnam). This in turn increases demand for professional certified UXO target detection and identification, and clearance services before starting construction or other marine activities.

Key topic

UXO (see insert) in recent years has become a key topic for many government organizations, (international) maritime authorities, substructure and turbine suppliers, and wind farm developer and service providers. When many ordinary people think of dangerous sea-based explosives, their primary association is often pictures of 'floating' sphere-shape contact mines with characteristic radial steel pins and a steel chain for seabed linkage. "The placement of these and other early sea-mine types typically started in WWI, and the first ammunition drops usually originate from that same period. The highest threat going forward remains the larger munition types. Beyond the obvious greater potential damages these could cause, they are also the type which is most volatile and at a point (80 – 100 years later) that they are being breached through corrosion and degradation. Beyond the obvious explosive threat of previously fired or dumped munitions and dumped chemical weapons, there is a major environmental risk from the chemicals they now release into the marine food chain" says Gilissen, adding some historical context. He continues that leakage of shells containing munition chemical constituents (MC) through corrosion or mechanical impact is for instance known to cause serious adverse toxic effects and risk for human and marine life. One visual manifestation is 'biologically dead' seabed patches at and around some such dump sites. Gilissen further notes significant knowledge gaps on many possible impacts including the potential danger of sub-lethal and/or metabolic effects and others on aquatic organisms, and MC persistence. Another not well understood phenomenon is bioaccumulation, whereby organisms absorb a substance at a faster rate than 'losing' it through catabolism and excretion.



Historical image of German-made WWII influence mine

Main categories

Gilissen: "UXO experts generally consider three main categories of sea-dumped munitions. The first is munition dumpsites, which typically occur in large concentrations with dump site individual locations mostly known, and which are chemical and/or conventional in composition. The second loose munition category from fired or placed munitions usually has low concentrations, the exact whereabouts can be difficult to predict, and munitions finds are either exposed or buried beneath the seabed. Finally, munition in wrecks mainly concerns merchant and warships sunk in WWI, WWII and subsequent localised conflicts, and with locations mostly known." When Fugro surveys the seabed for a proposed offshore wind farm or other marine requirement, it deploys dedicated surveying vessels equipped with various towed and other detecting tools accommodating sensors and sonars. When a possible UXO target location has been detected in such 'specific areas of interest', a remotely operated vehicle (ROV) is deployed for further investigation and uncovering. This identification process is the most expensive part of UXO risk mitigation for clients as it involves visualisation and identification, for which trained UXO experts are available onboard. However, quite often a suspicious target is buried up to 6 – 8 metres or more in the seabed, representing a complicating factor for target identification.

"Our current highest activity is in North Sea and Baltic Sea wind farm locations, for which we can conduct a starting historical and desktop study with historical WWI and II data and records from Allied, German and other military forces' archives. These individual forces kept surprisingly detailed records on, for instance, where munitions were dropped, deployed or dumped, and the types and sizes used. It was of course in their own interest to keep accurate records to safeguard their own submarine and surface ship movements", he added.

UXO definitions, terminology and jargon

The United Nations defines unexploded ordnance or UXO as explosive munitions which have not yet exploded. UXO may already have been fired, dropped, or launched but has failed to detonate as intended.

The US Department of Defense (DOD) in 2018 defined UXO as: 'Explosive ordnance that has been primed, fused, armed, or otherwise prepared for action, and which has been fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard to operations, installations, personnel, or material and remains unexploded either by malfunction or design or for any other cause.'

AXO – Abandoned Explosive Ordnance is defined as: 'Not having been used during an armed conflict or was left behind or dumped by a party to an armed conflict. Furthermore, is no longer under control of a party that left it behind or dumped it, and AXO may or may not have been primed, fused, armed or otherwise prepared for use.'

ERW – Explosive Remnants of War is a UXO and AXO umbrella category.

MEC – Munitions and Explosives of Concern.

Perhaps unsurprisingly, several of the largest dump site concentrations coincide with geographic locations where major past military conflicts were fought (Europe – North Sea and Baltic Sea; South East Asia). A second major dumpsite category is found along the US east coast. Their main ports supplied vast quantities of military goods to Allied forces during WWII. Large quantities of leftover weaponry and explosives were disposed on land and/or dumped in nearby seas and oceans after WWII and many other past conflicts. It is documented that vessels returning to the US (for example) after the end of WWII, and that were still loaded with military cargo, dumped their cargo in the ocean to resume merchant shipping of commercial goods.

Reference: IMAS 04.10 – Glossary of mine action terms, definitions and abbreviations

False positives

The visual identification process often results in many false positive identifications, with a low percentage proving to be UXO. Many turn out to be ferrous material such as old anchors, lost-at-sea metallic debris, steel wire rope, fishing gear, et cetera. However, as general debris uncovered during the UXO risk mitigation is equally of a concern to the construction of wind farms, the UXO identification serves a dual purpose of allowing these non-UXO targets to be identified and removed before a wind farm installation. Gilissen stresses that this sounds like a straightforward process, but the reality is far more complex. Most efficient is when the process is under the guidance and control of a contractor who can carry out the full spectrum of UXO risk mitigation services. This ranges from the identification of potential risk through to the ultimate issuance of a clearance report and/or certificate.

A second complicating factor is that original bomb-drop or mine-laying locations noted in historical records can deviate substantially from the current locations. These differences can be explained by at least two main reasons. The first is the inadvertent relocation of UXO through fishery activities. UXO can be dragged during trawl fishing activities, or by fishing nets pulling over the seabed surface, hooking UXO and then bringing the explosives up

onboard fishing vessels. These finds are not always recorded and reported to responsible clearing authorities, but simply thrown back into the sea. The second reason for location deviation is dynamic seabed movement since the time of placement, which can result in substantial migration of the UXO. In answer to these combined challenges, Fugro dedicates much effort in using combined modelling of seabed changes post deployment, along with historical records and understanding of sediment type and how they would have moved and acted on the UXO.

Target detection

Gilissen: "Fugro has many geotechnical, geophysics and geoconsulting resources to draw on. This includes specialised tools to aid in all processes from desktop study through survey (target detection) and through the identification and if needed – and locally allowed – clearance services. We are also heavily investing in advanced, improved and higher resolution remote sensing technologies and developing machine-learning to continuously optimize and reduce cost of false positives leading to lengthy and expensive UXO visual identification processes." He explains that a future challenge will be the detection and location of post-WWII UXO that are increasingly non-ferrous, such as for instance carbon and plastics-composite-based explosives. Examples of this can be found in regions associated with the former Yugoslavia and the Adriatic Sea, and similar modern warfare remnant munitions exist following the Middle East's more recent conflicts.

Acoustic methods have proven effective in finding non- or low-ferrous UXO, through their capability to detect sub-seabed material density contrasts. This methodology is also easier to use in challenging environments such as undulating seabeds where large areas need to be covered. Increasingly the move of the industry is to use a combination of acoustic and magnetometry methods to further define and refine the target list before visual identification. The ultimate aims are to reduce the 'false positive' count and streamline the ensuing visual identification processes.

Image of a recently found German Influence mine

Where UXO is identified, contractors must carefully weigh the risk of leaving the explosive(s) undisturbed versus clearance. In practice, such decisions depend on multiple factors such as UXO type, depth relative to the seabed linked to future seabed usage, and position in relation to the coastline.


Fugro Geowing being launched for a ferrous UXO detection project

Fugro's Atlantis Dweller, a dedicated UXO identification vessel
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ALARP

Gilissen: "Following confirmation of an object as UXO, we at Fugro deploy a standard ALARP [as low as reasonably practicable] risk-assessment procedure. This methodology establishes a balance between level of risk and acceptable additional expenditure which will no longer reduce the risk further." He adds that the Netherlands currently has several certified UXO contractors and, in his view, together with Belgium, Denmark, France, and Germany, boasts the most advanced controls and legislation guiding how UXO risk-mitigation processes are to be undertaken. Many nations and states only allow their military or a government-mandated organization to clear (remove and/or detonate) UXO and, in this case, typically the contractor (such as Fugro) hands over the removal of the confirmed UXO to the authorized authority. In the UK for example and several other regions of the world, contractors can by contrast clear confirmed UXO themselves with no state or other authority intervention. Besides the building of many wind farms inside and outside European waters, there are new realities emerging directly linked to climate change. In the Netherlands, for instance, increasing volumes of sand and sediment will be required for strengthening and increasing dykes and reinforcing the coastline as sea levels rise. And there are fresh plans and discussions about building a new Schiphol international airport in the North Sea as a potential longer-term option. UXO risk mitigation is going to form a key component in both site clearance and the harvesting of material to build up land for the terminal. "Here the Dutch Department of Public Works [Rijkswaterstaat] has become a main driver of UXO contractors to identify processes and improve efficiencies to clear areas of UXO. These and other increasing demands for sand to be withdrawn from the marine environment mean that there will be little room left in future for attempting to work around known and potential UXO dump sites", he concludes.

By Eize de Vries

Fugro

Fugro is a Dutch multinational publicly listed company head-quartered in Leidschendam (The Netherlands), and a world-leading Geo-data specialist, collecting and analysing comprehensive information about the Earth and the structures built upon it. Fugro is a solutions provider predominantly in the energy and infrastructure industries, both offshore and onshore. It offers an integrated approach that incorporates acquisition and analysis of Geo-data and related advice. Fugro employs approximately 10,000 people in 65 countries.