UXO RISK IS NOT A SURVEY DELIVERABLE: MANAGING IT ACROSS THE OFFSHORE PROJECT LIFE CYCLE

By Andrzej Gorski, a UXO/EOD and infrastructure risk specialist

SURVEY IS A STAGE OF THE PROJECT, NOT THE END OF RISK

On 10 June 2023, during a major dredging project in a Baltic seaport, a trailing suction hopper dredger recovered an aerial bomb from the seabed, identified by EOD personnel as a 1,000-pound S.A.P. Bomb AN-M59. The object was found in the dredger suction head, after which the vessel remained outside the port until the Polish Navy carried out the necessary action.[1]



Figure 1. 1,000-pound S.A.P. Bomb AN-M59 recovered from the suction head of the dredger *Pedro Álvares Cabral* in the Port of Gdynia, June 2023. Photo credit: 8 Flotylla Obrony Wybrzeza (8FOW).

Finding UXO in a port with an intense wartime history is not, in itself, particularly surprising. The significance of this case lies elsewhere.

Before the incident, a separate package of work had been completed, including a ferromagnetic survey, data interpretation, physical investigation of selected anomalies and a final UXO risk assessment. ALARP certificates for the individual areas were issued in October and November 2022, and the project documentation records that the works relating to clearance of the basin from ferromagnetic objects were completed and accepted by the Client on 14 December 2022.[2]

The subsequent discovery of the bomb does not automatically prove that the entire survey or all EOD work was carried out incorrectly. It demonstrates something more important: **A survey is not the final safety deliverable. It is one element of a decision-making process that must remain current throughout the project life cycle.**

Survey data are valuable only when their coverage and limitations are known, together with which anomalies were physically investigated, how the remainder were closed out, and for which technology, depth and type of work the final assessment remained valid.

FROM 8,214 ANOMALIES TO 774 PHYSICAL INVESTIGATIONS

The final certificates recorded a total of **8,214 automatically generated anomalies.** A combined review of the data in both certificates shows that, after "further manual interpretation and analysis", 774 points were selected for physical investigation. Each was checked together with an area extending 3 m around it. This represents physical investigation of approximately **9.42% of all generated anomalies.**[3]

This does not mean that only 9.42% of the seabed area was checked; these are different measures. The figure does, however, show the importance of interpretation: most anomalies were closed out without individual field identification.

The remaining **7,440 anomalies** were excluded under several criteria. Of these, 4,412 were located in areas from which more than 3 m of material had been

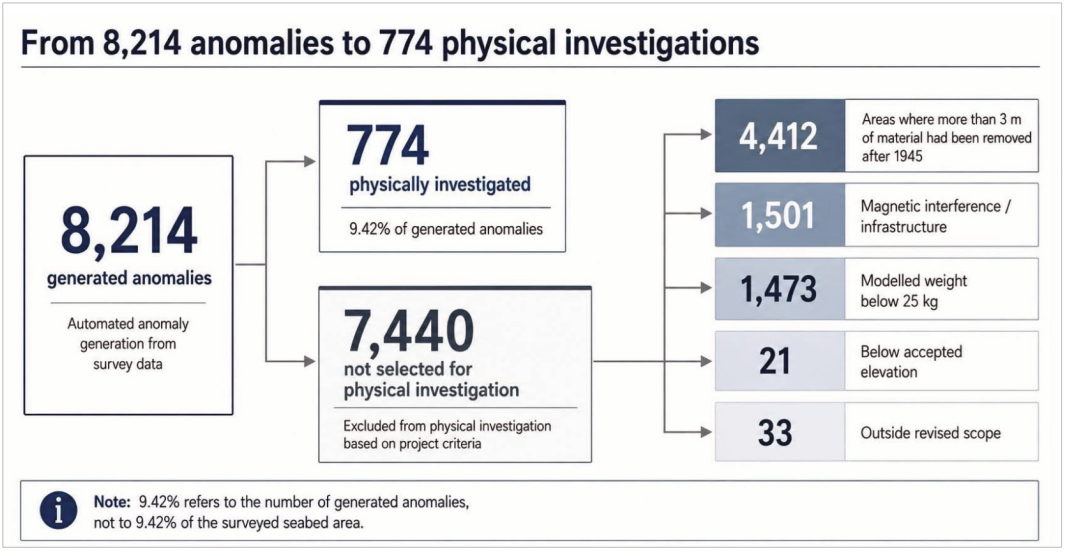


Figure 2. From 8,214 generated anomalies to 774 physical investigations.
The diagram summarises the anomaly-selection process recorded in the project certification documentation. The figure of 9.42% refers to the number of generated anomalies selected for physical investigation and not to 9.42% of the surveyed seabed area. *Source: Author, based on project certification documentation.*

removed after 1945. A further 1,501 were assigned to areas adjacent to quay walls, cables, pipelines and other infrastructure causing strong magnetic interference. Another 1,473 had a modelled weight below 25 kg. A further 21 were below the accepted elevation, while 33 fell outside the revised scope of works. [4]

Selection is not inherently wrong. Classification and prioritisation are necessary in a large geophysical campaign.

The key question is different: **At what point does limited information become sufficient evidence to decide that further physical investigation is unnecessary?**

This is where a survey becomes a risk-management issue, not merely a measurement issue.

HISTORICAL DREDGING DOES NOT IDENTIFY A CURRENT ANOMALY

The largest category comprised 4,412 anomalies, more than half of the entire dataset.

They were located in areas from which more than 3 m of material had been removed after 1945. It was assumed that dangerous objects should have been encountered and removed during earlier dredging or port-expansion works.[5]

That assumption requires caution.

Historical dredging means that material was removed. It is not automatically equivalent to documented, systematic UXO clearance carried out to modern standards.

Moreover, the 2022 survey provided new evidence: thousands of ferromagnetic anomalies were still present in those areas.

This does not mean there were thousands of UXO items. The anomalies could have represented scrap, infrastructure, anchors, metallic waste or other sources. It does mean that historical activity did not identify objects detected decades later.

The contractor's subsequent explanation adds another element. After the bomb was found, it was stated that, in an active port, ferromagnetic objects may move during vessel traffic, particularly those lying on the seabed, and that new ferromagnetic objects may also appear. [6]

This is a reasonable residual-risk argument.

At the same time, it leads to an important question: **If migration and the later appearance of objects are sufficiently real phenomena to explain the presence of UXO after a campaign has been completed, why should historical dredging, by itself, be considered sufficient grounds for closing out a currently detected anomaly?**

Historical dredging may explain why the hazard was expected to have been removed previously. It does not identify an anomaly present in the current dataset.

LACK OF RELIABLE DATA IS NOT EVIDENCE THAT NO HAZARD EXISTS

The second important issue concerns 1,501 anomalies located in areas where, according to the certificates, reliable magnetic data could not be acquired.[7]

An exact number of anomalies is not, in itself, contradictory. An algorithm can generate defined points even where the magnetic background does not allow their sources to be characterised reliably.

The problem lies elsewhere.

If the data cannot reliably distinguish a structural signal from a separate ferromagnetic object, the correct conclusion is lower confidence, not greater confidence that no hazard exists.

Following the incident, the contractor used an analysis of the dredger track, the available magnetic data and MBES data to identify the area from which, according to that analysis, the UXO had originated.

The documentation states that this same area was subject to strong magnetic signal interference caused by a cable. At the same time, numerous ferromagnetic objects had been removed from the area during the earlier campaign, some of which had also produced weak and disturbed readings.

An analysis of the dredger logs identified an unusual spike in measured suction-head pressure in the same area, which the contractor considered likely to have resulted from encountering the UXO.[8]

This does not prove that the bomb was one of the 1,501 anomalies previously excluded. The available documentation does not allow it to be linked to a specific target number.

It does, however, show something equally important:

The area identified by the contractor after the incident as the source of the UXO was also affected by strong magnetic interference. The data-quality limitation therefore ceases, in this case, to be merely an abstract methodological issue.

This is where risk management should go beyond simply removing the object.

The question should not be limited to:

"Is there another bomb nearby?"

It should also ask:

"In how many other parts of the project did we apply the same assumptions, and after this event can we still assign them the same level of confidence?"

MODELLED WEIGHT IS NOT EOD IDENTIFICATION

A further 1,473 anomalies were excluded because their modelled weight was below 25 kg. The certificates describe this category as "ferromagnetic objects with modelled weight of less than 25 kg". This threshold was linked to the assumption that conventional Second World War ammunition and UXO with a gross weight below 25 kg contain less than 10 kg of explosives and that, under the stated conditions and mitigation measures, the associated risk during dredging could be reduced to ALARP. [9]

The certificates do not, however, explain how modelled weight derived from magnetic data was related to the object's actual gross weight, how the model was validated or what uncertainty applied.

Modelling is a normal selection tool. It is not, however, physical identification of ordnance. A magnetometer does not directly measure either the gross weight of an object or the amount of explosive it contains. The result depends, among other factors, on the object's ferromagnetic characteristics, geometry, orientation, depth, sensor distance and local magnetic background.

Modelled weight can support a decision, but it should be linked to clearly defined model uncertainty and to the ability to reconstruct the basis of that decision later.

The available certificates identify EOD managers and those responsible for the final ALARP assessment, but they do not allow the full decision chain behind the selection of the 8,214 anomalies to be reconstructed. They do not show who carried out the "further manual interpretation and analysis", how the modelling was validated, who approved the individual exclusion criteria, or whether the decisions relating to the 7,440 anomalies that were not physically investigated were subject to independent quality control.[10]

A certificate shows the outcome of a decision. Managing risk throughout the project life cycle also requires a process that can be reconstructed to show how that decision was reached.

RESIDUAL RISK DOES NOT INVALIDATE QUESTIONS ABOUT THE EARLIER DECISION

Following the incident, the contractor stated that no UXO campaign can guarantee the detection of 100% of all potentially hazardous objects.

Additional safety barriers during dredging were also identified: a protective grid at the suction head, EOD personnel and a UXO container on board, additional physical protective measures on board, and an existing agreement with the Polish Navy concerning the safe removal of objects considered more hazardous.[11]

Such measures are an important part of residual-risk management.

They do not, however, answer the same question as the earlier survey.

The survey and target-selection process address the question: **What hazards can we detect and remove before the works begin?**

The measures applied on the dredger address a different question: **How do we limit the consequences if, despite the earlier measures, UXO is encountered?**

These are two distinct layers of protection.

The effectiveness of the second cannot be treated as evidence that the first was correct.

S/S STUTTGART: A FEW METRES CAN CHANGE THE ALARP OUTCOME

The S/S Stuttgart wreck case illustrates a second aspect of life-cycle risk management: an ALARP

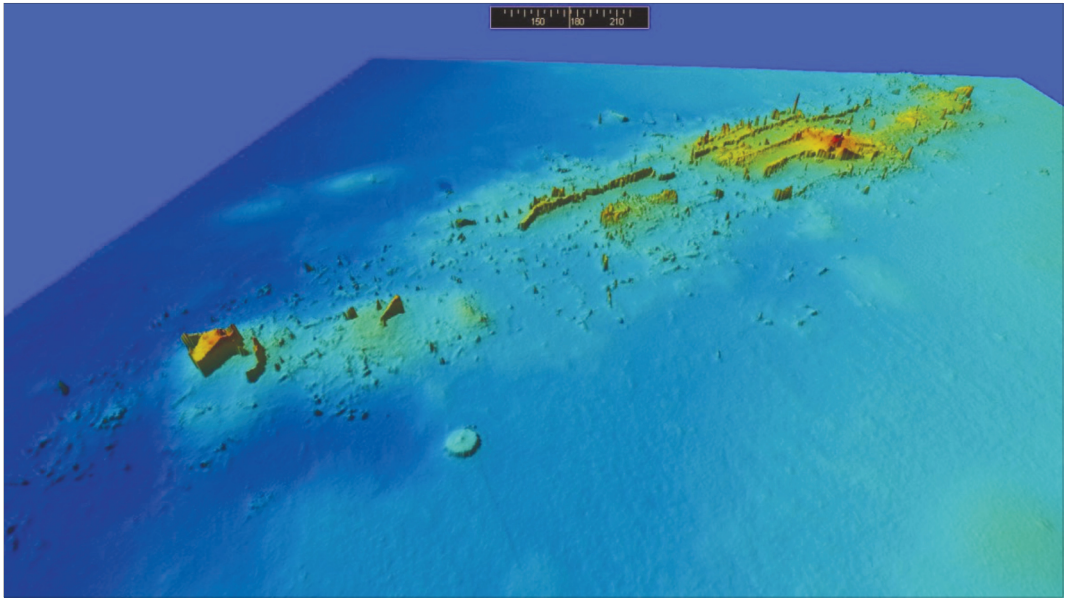


Figure 3: Multibeam/bathymetric representation of the wreck site of S/S Stuttgart in the Gulf of Gdansk.

Source: mat. prasowe Urzedu Morskiego w Gdyni.

assessment is tied to a specific activity, not simply to site geography.

Separate assessments were carried out for twelve planned investigation boreholes using bathymetric, sonar and magnetometer data. Each location was assessed against specific coordinates, a 10 m radius buffer zone and the planned intrusive activity.

Four boreholes required relocation: two by at least 5m and two by at least 7m.

This may appear a small difference. In practice, it clearly illustrates what ALARP is not.

If five metres can change the outcome, the document does not mean that "the whole area is safe". It means that, for a specific activity at a specific location, using defined data and assumptions, the risk was demonstrated to have been reduced to ALARP.[12]

An assessment prepared for a borehole cannot automatically be transferred to dredging, anchoring, cable trenching, foundation installation or intervention on the wreck itself.

Changing the activity changes exposure to the hazard.

The Hazard Neutralisation Plan for the wreck itself recognises that undetected UXO may remain even after identified objects have been neutralised, and provides for long-term monitoring, the possibility of adapting methods and a stop-work procedure if a greater hazard than previously assumed is identified.[13]

This is the logic of the project life cycle: an assessment remains valid only for as long as its assumptions remain valid.

WHEN A DOCUMENT CLAIMS MORE THAN THE METHOD CAN SUPPORT

The third case, from an inland-water project, provides a useful comparison.

After work over a 4,800 m≤ water area, a "Certificate of Seabed Cleanliness" was issued. The documentation states that the inventory was conducted in a single day –16 September 2024 – using a sector-based method, with visibility of approximately 0.5m, while also declaring that the seabed had been checked to 2 m below its level.[14]

No ferromagnetic scanning was carried out. In its response of 15 May 2026, the Municipality stated that the work consisted of an underwater seabed search rather than ferromagnetic survey work, and that confirmation that the required depth had been achieved was based on ongoing supervision of the activities and the experience of the team.[15]

This does not mean that the divers' work had no value. Among the objects located during the work were an object of military origin resembling a grenade, an object of military origin resembling a firearm, and other objects lying on the seabed.[16]

The issue is the boundary between **what the method can actually confirm and what the subsequent document claims.**

The same principle applies in marine projects: a final document should not carry a broader meaning than the evidence supporting it.

RISK MUST TRAVEL THROUGH THE ENTIRE PROJECT LIFE CYCLE

These three cases illustrate the same problem at different stages of a project: the result of a survey or assessment may close a defined scope of work, but it does not close the physical UXO risk.

First, a hazard model is developed. A survey follows. The data are interpreted, targets are classified, some are physically investigated, and a risk decision is then made.

But the project does not end there. Detailed design, technology selection, dredging, drilling, anchoring, infrastructure installation, operation, maintenance and later seabed interventions follow.

At each stage, information may emerge that was unavailable when the earlier risk decision was made.

That is why **UXO risk management must retain the ability to reopen an earlier decision.**

A new cable route, a greater dredging depth, a different technology, a change of location, new survey data or the physical discovery of UXO are not merely operational events. They are feedback to the earlier risk model.

This logic is reflected both in CIRIA guidance on UXO risk management in the marine environment and in IMAS. CIRIA C754 addresses UXO risk management across successive stages of the marine

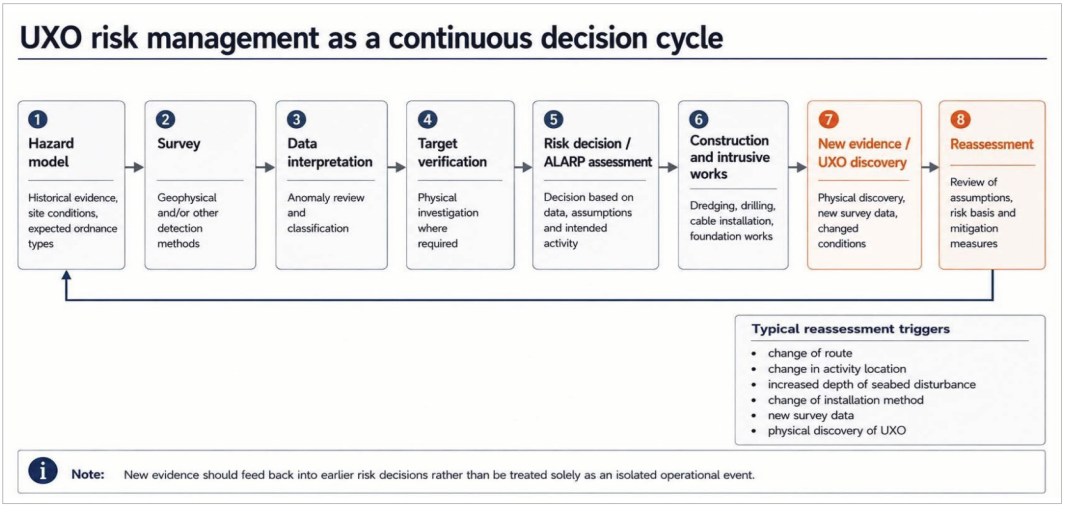


Figure 4. UXO risk management as a continuous decision cycle.
The diagram illustrates how new survey data, changed project conditions or the physical discovery of UXO should feed back into earlier assumptions and risk decisions rather than be treated solely as isolated operational events.
Source: Author.

project life cycle,[17] while IMAS treats risk management as a continuous and cyclical process that should be updated as new evidence emerges or conditions change.[18]

Documentation handed over with the report should therefore include not only maps and the final conclusion, but also detection limitations, unverified anomalies, low-confidence areas, assessment depth, assumptions, residual risk and the activities for which the assessment was prepared.

Most importantly, the link between **new evidence and the earlier decision must be preserved.**

If UXO is found after a survey, the appropriate response does not end with its safe removal.

It is also necessary to ask:

- **Which earlier assumption failed to describe reality sufficiently well?**
- **Was the same assumption applied elsewhere?**
- **Does the scope of the earlier assessment still correspond to the planned activity?**
- **Does the new information require a change to the risk model, methods, safety measures or the scope of further verification?**

This distinguishes management of a single incident from management of UXO risk throughout the project life cycle.

A document can close a stage. The hazard remains subject to reality.

A survey can be completed.

A report can be accepted.

A certificate can be signed.

A contractual stage can be closed.

But a physical hazard does not recognise a project schedule or the date on a document.

UXO risk is therefore not a deliverable handed over with a report. It is an element of the project that must remain actively managed for as long as current or future activities may come into contact with the hazard.

And when reality provides new evidence, a sound risk-management system should be ready not only to remove the object, but also to **reopen the earlier decision on the level of risk and the measures used to reduce it.** ■

REFERENCES

1. Operational notification to the Polish Navy, 10 June 2023; Contractor Monthly Report No. 12, June 2023. The notification records the dredger Pedro ¡lvares Cabral, Port of Gdynia, c. 02:00, and EOD identification of the object as a "1,000-pound S.A.P. Bomb AN-M59"; the monthly report records the subsequent Polish Navy intervention and removal of the UXO.
2. UXO ALARP Certificates Nos. 2022/10/001 (21 October 2022) and 2022/11/002 (10 November 2022); handover record Ref. 0081.T.JDN7707.ZMP.AST, 14 December 2022; Contractor Monthly Report No. 12, June 2023. Works relating to clearance of the basin from ferromagnetic objects were completed and accepted by the Client on 14 December 2022.
3. UXO ALARP Certificates Nos. 2022/10/001, pp. 4-6, and 2022/11/002, pp. 3-6. The certificates record 8,214 generated anomalies, of which 7,440 were not selected for physical investigation and 774 were physically investigated. The 9.42% figure is the author's calculation and refers to generated anomalies, not seabed area.
4. UXO ALARP Certificates Nos. 2022/10/001 and 2022/11/002. The 7,440 anomalies not selected for physical investigation comprised 4,412 in areas where more than 3 m of material had been removed after 1945; 1,501 affected by magnetic interference; 1,473 with modelled weight below 25 kg; 21 below the accepted elevation; and 33 outside the revised dredging scope.
5. UXO ALARP Certificates Nos. 2022/10/001 and 2022/11/002, p. 4. Both applied an exclusion criterion to areas where more than 3 m of material had been removed after 1945, on the assumption that previous dredging or port-expansion works should have encountered and removed dangerous items.
6. Ref. 0196.L.JDN7707.ZMPG.AST, 21 June 2023, p. 1. In an active port, ferromagnetic objects may move during vessel traffic, particularly those lying on the seabed, and new ferromagnetic objects may appear.
7. UXO ALARP Certificates Nos. 2022/10/001 and 2022/11/002, pp. 4-5. The certificates describe areas where "no reliable magnetic data could be acquired", including locations adjacent to quay walls, pipelines, underwater cables and other man-made objects.
8. Ref. 0196.L.JDN7707.ZMPG.AST, 21 June 2023, pp. 2-5. The post-incident analysis combined the dredger track, available magnetic data and MBES data and identified an area considered by the contractor to be the UXO source. The area was affected by strong magnetic interference

from a cable; dredger logs also showed an unusual suction-head pressure spike considered likely to have resulted from encountering the UXO.

9. UXO ALARP Certificates Nos. 2022/10/001 and 2022/11/002. "Ferromagnetic objects with modelled weight of less than 25 kg" were an exclusion category. The threshold was linked to the assumption that conventional Second World War ammunition and UXO below 25 kg gross weight contained less than 10 kg of explosives and that the associated dredging risk could be reduced to ALARP subject to stated conditions and mitigation measures.
10. UXO ALARP Certificates Nos. 2022/10/001 and 2022/11/002. The certificates identify EOD management roles and responsibilities for the final ALARP assessment, but do not state who performed the "further manual interpretation and analysis", how modelled weight was validated, the approval chain for the exclusion criteria, or whether the decisions relating to the 7,440 anomalies were subject to independent QA/QC.
11. Ref. 0196.L.JDN7707.ZMPG.AST, 21 June 2023, pp. 1-2. The contractor stated that a UXO campaign cannot guarantee 100% detection and removal and described mitigation measures including a protective grid at the suction head, EOD personnel and a UXO container on board, physical protective measures and an existing agreement with the Polish Navy.
12. UXO ALARP Certificate - Planned Boreholes (MBES/SSS/MAG), Annex 1, 24 September 2025, sheets V_5EK, V_8EK, V_10EK and V_11EK. Twelve planned boreholes were assessed individually within a 10 m buffer; four required relocation by at least 5-7 m.
13. S/S Stuttgart Hazard Neutralisation Plan, Part I, Sections 1.5.1-1.5.5, pp. 20-22. The plan recognises that undetected UXO may remain and provides for long-term monitoring, adaptation of methods and stop-work procedures where new information indicates a greater hazard.
14. Certificate of Seabed Cleanliness, 18 September 2024. The certificate records a sector-based underwater inventory of 4,800 m≤ carried out on 16 September 2024, with visibility of approximately 0.5 m, and states that the seabed was inventoried to 2.0 m below its level.
15. Town and Municipality of Sztum, Ref. IM.IX.7013.1.29.2026, 15 May 2026. The authority stated that the work was an underwater seabed search rather than a ferromagnetic survey, that no ferromagnetic scan was performed, and that confirmation of the required depth was based on ongoing supervision and team experience.
16. Certificate of Seabed Cleanliness, 18 September 2024, p. 3. The certificate records objects of military origin resembling a grenade and a firearm, together with other seabed objects.
17. Cooper, N. and Cooke, S., Assessment and Management of Unexploded Ordnance (UXO) Risk in the Marine Environment, CIRIA C754, 2016.
18. UNMAS, IMAS 07.11 Land Release, Ed. 2, 16 January 2026; IMAS 07.14 Risk Management in Mine Action, Ed. 1, 4 February 2019.

ABOUT THE AUTHOR



Andrzej Gorski is a UXO/EOD and infrastructure risk specialist with extensive operational, instructional and supervisory experience in explosive ordnance disposal and underwater operations. His professional background includes international service in UNPROFOR, UNDOF and KFOR missions, as well as several years of experience as an EOD instructor.

During his career, he has been involved in UXO/EOD operations covering more than 10,000 hectares of land, including former military training areas, road and transport infrastructure projects, urbanised areas and other sites affected by explosive remnants of war. His experience also extends to port, waterway and maritime environments, including work connected with the Swinoujscie-Szczecin waterway in Poland.

His professional experience covers EOD operations, technical supervision, documentation review, risk assessment and the practical application of UXO clearance methodologies in complex infrastructure environments. His current focus is on UXO risk management across offshore, nearshore, port and onshore projects, particularly QA/QC, compliance, ALARP assessments, survey and clearance methodology, and the relationship between technical evidence and project-level risk decisions. He also has experience in integrated management systems and auditing against ISO 9001, ISO 14001 and ISO 45001.