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KM3NeT
INFRADEV-2

TOWARD FULL IMPLEMENTATION OF THE KM3NeT RESEARCH INFRASTRUCTURE

KM3NeT – INFRADEV 2 – HORIZON – 101079679

Report on the decommissioning and recycling procedures

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ABSTRACT

This report summarizes the results of the study for the definition of the KM3NeT decommissioning plan, for both the ARCA and ORCA detectors. The decommissioning, a complex, time consuming and costly procedure needs to be planned well in advance, taking into account all relevant National and International legislations and good practices to ensure the proper removal of deployed equipment ensuring that no damage is done on the sea environment. We present the current status of legislation requirements, schemes for equipment recovery and options for the recycling of recovered equipment.

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	Name	Partner and WP	Date
From	C. Markou	NCSR-D, CNRS, INFN / WP5	28/11/2025
Author(s)	C. Markou, N. Lumb, S. Biagi	NCSR-D, CNRS, INFN / WP5	28/11/2025
Reviewed by	V. Bertin	CPPM	8/12/2025
	S. Navas	UGR	8/12/2025
Approved by	KM3NeT IB		31/12/2025

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IV. APPLICATION AREA

This document is a formal deliverable of the Grant Agreement of the project, applicable to all members of the KM3NeT – INFRADEV2 project, beneficiaries and third parties, as well as its collaborating projects.

V. TERMINOLOGY

A&R	Abandonment and Recovery
ARCA	Astroparticle Research with Cosmics in the Abyss
BM	Base Module
CB	Calibration Base
CNRS	Centre National de la Recherche Scientifique
CSA	Coordination and Support Action
CTF	Cable Termination Frame
DOM	Digital Optical Module
DP	Dynamic Positioning
DU	Detection Unit
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMSO	European Multidisciplinary Seafloor and water column Observatory
IL	Interlink cable
IMO	International Maritime Organisation
INFN	Istituto Nazionale di Fisica Nucleare (IT)
IU	Instrumentation Unit
JB	Junction Box
LEO	Long-term Environmental Observatory
KM3NeT	Cubic Kilometer (km^3) Neutrino Telescope
MARPOL	International Convention for the Prevention of Pollution from Ships
MATTM	Ministry of Environment (IT)
MEOC	Main Electro-optical cable

MiBACT	Ministry of Cultural Heritage (IT)
MiSE	Ministry of Economic Development (IT)
ORCA	Oscillation Research with Cosmics in the Abyss
PMT	Photomultiplier Tube
RI	Research Infrastructure
ROV	Remotely Operated Vehicle
UKCS	United Kingdom Continental Shelf
UNCLOS	United Nations Convention on the Law of the Sea
UNMIG	National Office for Mining, Hydrocarbons and Geothermal Resources (IT)
VEOC	Vertical Electro-Optical Cable
WEEE	Waste Electrical and Electronic Equipment

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IX. PROJECT SUMMARY

The Kilometre Cube Neutrino Telescope (KM3NeT) is a large Research Infrastructure (RI) comprising a network of deep-sea neutrino telescopes in the Mediterranean Sea with user ports for Earth and sea science instrumentation. During the EU-funded Design Study (2006-2010) and Preparatory Phase (2008-2012), a cost-effective technology was developed, deep-sea sites were selected, and the Collaboration was formed in 2013. This proposal constitutes a second INFRADEV project dedicated to KM3NeT to implement an efficient framework for mass production of KM3NeT components, accelerate completion of its construction and provide a sustainable solution for the operation of the RI for ten or more years. Following the appearance of KM3NeT on the 2016 ESFRI Roadmap and in line with the recommendations of the Assessment Expert Group, this project addresses the Coordination and Support Actions (CSA) to prepare a legal entity for KM3NeT, accelerate its implementation, establish open access to the RI and its data and ensure its sustainability by implementing an environment-friendly operation mode and evaluating the Collaboration socio-economic impact.

X. EXECUTIVE SUMMARY

This report summarizes the results of the investigation on the decommissioning plan for KM3NeT and the possible associated recycling and deposition activities to be performed at the end of the infrastructure lifetime. The plan is meant to serve as a basis document, to be revised and updated closer in time to the decommission of KM3NeT to accommodate recent developments both in the legislation and the procedures and resources for the deposition of the recovered instrumentation.

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1 Introduction

The KM3NeT (Cubic Kilometre Neutrino Telescope) research infrastructure, a massive array of thousands of highly sensitive photo-sensors known as Digital Optical Modules (DOMs), deployed kilometers deep on the Mediterranean seabed, represents a monumental achievement in astroparticle physics and deep-sea technology. This colossal observatory, strategically situated at two sites, namely KM3NeT/ARCA (Astroparticle Research with Cosmics in the Abyss) off the coast of Italy and KM3NeT/ORCA (Oscillation Research with Cosmics in the Abyss) off the coast of France, was meticulously designed for an extensive operational lifetime. Its primary scientific mission is two-fold: to observe high-energy cosmic neutrinos, potentially pinpointing their astrophysical sources, and to precisely study neutrino mass hierarchy, addressing fundamental questions within the Standard Model of particle physics. The design of the detector infrastructure allows for more than 15 years of operation after the completion of the two detectors. Indeed, as has been the case in the past, experiments of the size, scope and complexity of KM3NeT tend to extend their useful data taking life far beyond their designed lifetime. In any case, however, upon the fulfillment of its scientific goals or reaching its predetermined design lifespan, the facility is eventually destined for its necessary and carefully planned decommissioning phase.

The decommissioning of a research infrastructure situated in the abyssal zone of the Mediterranean Sea presents unique and complex technical, logistical, and ecological challenges. Unlike terrestrial infrastructure, the retrieval of equipment from depths of 2500 to 3500 m mandates the use of highly specialized remotely operated vehicles (ROVs), precise navigational tools, and custom-engineered recovery mechanisms to ensure a controlled and contamination-free operation.

The KM3NeT operational sites are integral parts of a delicate and largely pristine deep-sea ecosystem. Therefore, the end-of-life process is governed by a paramount commitment to environmental stewardship. This commitment necessitates a proactive minimization of disturbance to the benthic (seabed) habitat and its associated biological communities, particularly during critical phases like the lifting and recovery of anchored structures.

This KM3NeT Decommissioning Plan is a foundational document that presents the comprehensive strategy for the safe, fiscally responsible, and environmentally compliant retirement of the entire KM3NeT observatory. The scope encompasses the complete retrieval or controlled disposition of all major and minor components, including the extensive network of Detection Units (DUs), the central Junction Boxes (JBs) that manage power and data, the inter-connecting seabed cable infrastructure, and the associated shore station facilities. The current report is meant to supplement the environmental impact studies, which were initially conducted prior to construction, to specifically model and mitigate the risks associated with reverse-deployment operations, such as severe ecosystem disturbance, pollution, and the potential release of minor material fragments.

2 The KM3NeT infrastructure

As already mentioned, KM3NeT comprises two major detectors, KM3NeT/ARCA and KM3NeT/ORCA. The two detectors share the same technology, but differ in size, deployment depth and distance from the shore. A brief general description of the detectors follows:

General description of the KM3NeT infrastructure

The KM3NeT infrastructure is deployed at two deep-sea sites in the Mediterranean: KM3NeT-ORCA (Oscillation Research with Cosmics in the Abyss), about 30 km from the French port of Toulon (coordinates: 42°48’21”N, 6°1’37”E); and KM3NeT-ARCA (Astroparticle Research with Cosmics in the Abyss), approximately 100 km from the coast of Sicily (coordinates: 36°16’4”N, 16°6’35”E). The two sites are operated by CNRS (Centre National de la Recherche Scientifique) and INFN (Istituto Nazionale di Fisica Nucleare) respectively.

The technology used at the two sites is very similar and is based on photomultiplier detection elements and their associated electronics, enclosed in pressure-resistant glass spheres (Digital Optical Module, or DOM) mounted on vertical lines (Detection Unit or DU). The two detectors are distinguished by the different vertical and horizontal spacings between the DOMs: roughly 9 m and 20 m respectively in the case of ORCA (for an overall DU height of about 200 m) and 36 m and 90 m for ARCA (overall DU height about 700 m). The different lattice spacings reflect the different scientific objectives of the detectors: The ARCA detector is designed for the detection of high-energy astrophysical neutrinos, covering an instrumented volume of about 1 cubic kilometer. It comprises two "building blocks" of more than 110 Detection Units each, totalling 225 operational strings in its full configuration, deployed at a depth of about 3500 meters. The ORCA detector is optimized for the study of the properties of neutrinos, specifically neutrino oscillations and mass ordering, through the detection of atmospheric neutrinos in the 1-100 GeV energy range. It consists of a single building block of 108 detection units instrumenting about 7 Megatonnes of seawater. Its location off Toulon, France, is at a depth of approximately 2500 meters.[1]

A schematic of the two detectors and their relative sizes is shown in Figure 1, and the diagrams of the sea floor network layout are presented in Figures 2 (ORCA detector) and 3 (ARCA detector).

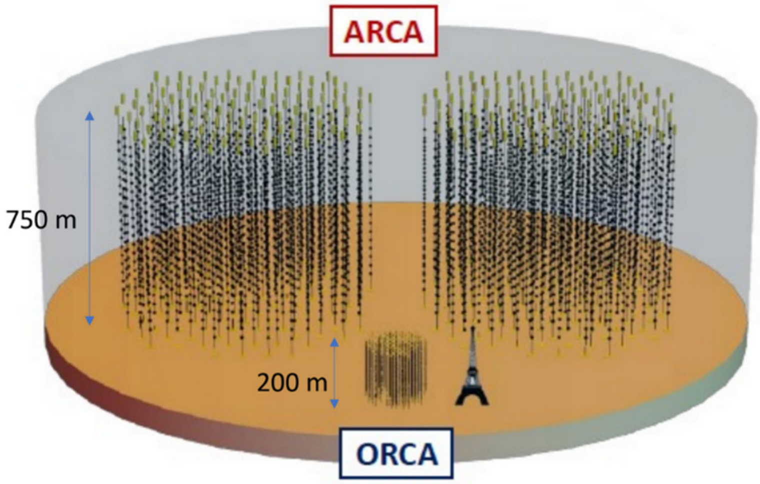

Figure 1: A schematic of the two KM3NeT detectors

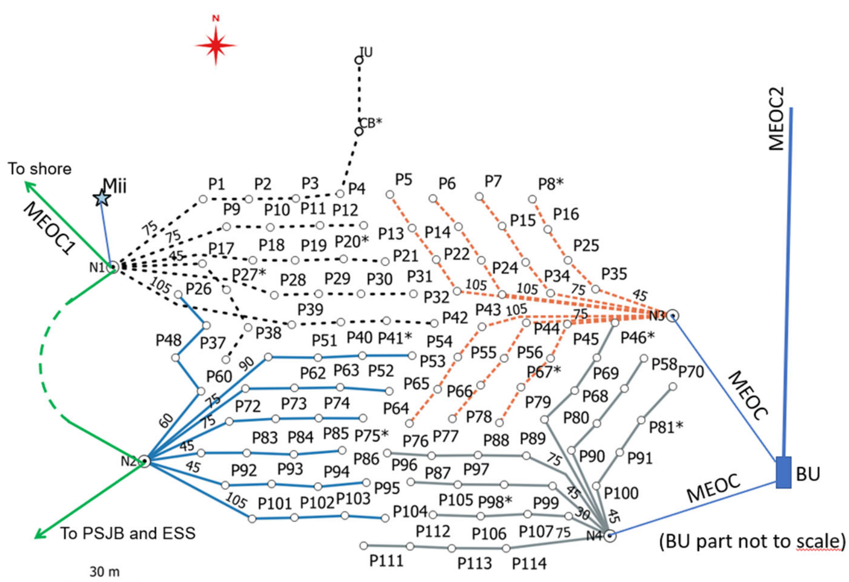

Figure 2: Schematic layout of the sea floor network for ORCA

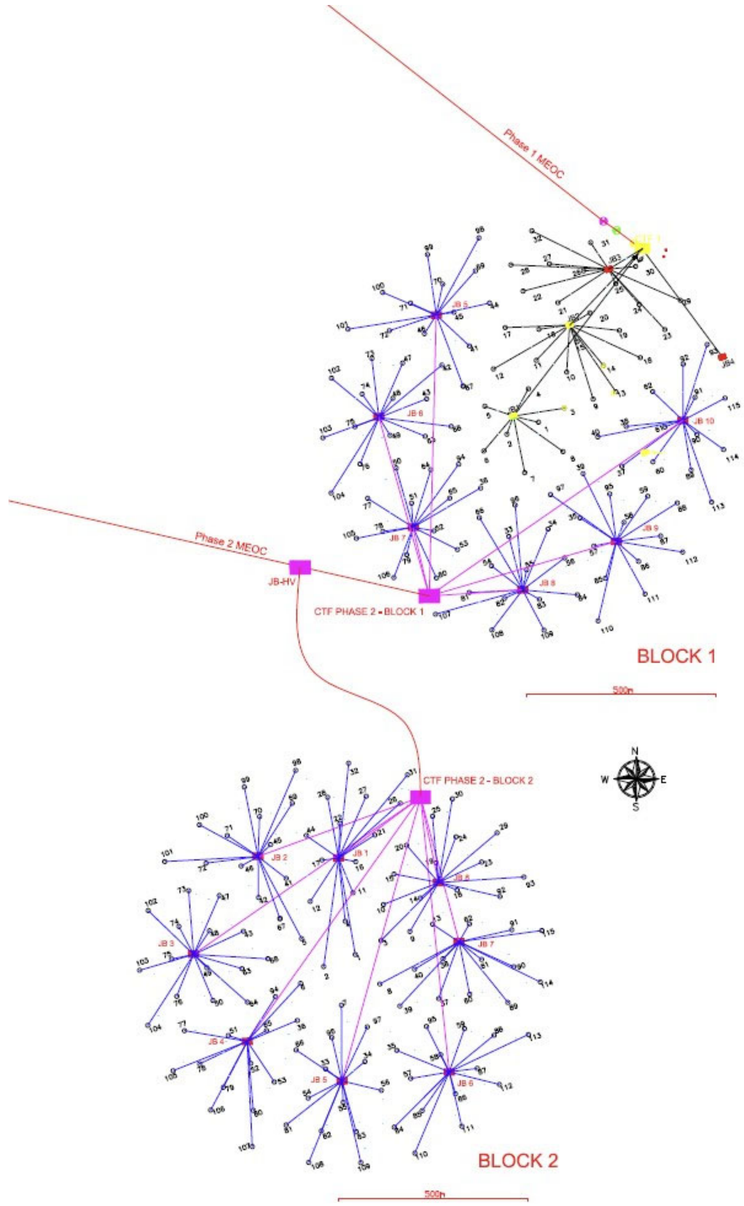

Figure 3: Schematic layout of the sea floor network for ARCA

3 Decommissioning Scope and Guiding Principles

The scope of decommissioning must encompass all fixed assets, including the DUs, the main electro-optical cables (MEOCs) linking the seafloor to shore, the Junction Boxes (JBs) that form the network hubs, and all anchoring systems. The primary objective is to develop a blueprint that achieves full compliance with international maritime law and regional environmental agreements while optimizing for cost-efficiency, technical feasibility, and maximized environmental stewardship.

3.1 Strategic Goals and Guiding Principles

The decommissioning strategy is guided by three non-negotiable principles:

1. **Mandatory Waste Electrical and Electronic Equipment (WEEE) Recovery:** Prioritize the full recovery of all potentially polluting or hazardous materials, specifically the massive inventory of complex electronics (Digital Optical Modules, PMTs, internal electronics, inter link cables and the Vertical Electro Optical Cables) classified under the WEEE designation.[2]
2. **Seabed Integrity:** Minimize physical disturbance of the seabed during recovery, particularly during cable extraction in shallower, environmentally sensitive zones and soft sediment areas.[3]
3. **Legacy Maximization:** Evaluate and propose the repurposing of high-value deep-sea assets as parts of Long-term Environmental Observatories (LEOs), capitalizing on the possible needs and long-term planning of such infrastructures at the time of decommissioning.

3.2 Key Findings and Strategic Recommendations

The operational complexities inherent in KM3NeT's deep-sea location dictate the strategic approach. The most substantial technical difficulty comes from the sea depth of the detectors, 3500 m depth of the ARCA site and 2500 m depth for ORCA necessitating highly specialized, vessels with high-specification Dynamic Positioning (DP) and deep-water A&R (Abandonment and Recovery) systems. It should be noted here that the deployment depth difference between the two detectors and their difference in relative size make the ARCA operations substantially more costly and time consuming, whereas the increased density of the deployment infrastructure in the ORCA case produce more technological challenges.

A review of international waste disposal legislation confirms that the sheer volume of DOMs and internal electronics (estimated at 6210 units containing over 500000 individual components based on the full KM3NeT 2.0 configuration) requires their 100% retrieval.[4] This WEEE mandate, driven by European regulations and the Barcelona Convention's protocols against dumping, supersedes any technical argument for the abandonment of the functional detection units in the deep sea.[2]

Strategic Recommendation: The recommended strategy is **Selective Full Recovery and Repurposing.** This involves the full recovery of all Detection Units (DUs) and associated WEEE (DOMs and electronics) as well as the anchor weights which should also be recovered and recycled appropriately. The plan advocates for the strategic repurposing of the robust Main Electro-Optical Cable and Junction Box infrastructure for ongoing oceanographic and environmental monitoring (LEO capability) if this will be desirable at a time closer to the infrastructure decommissioning. In the contrary case, these items should also be recovered.

3.3 Decommissioning activities

The strategy will be detailed across several defined work packages:

1. **Preparation and Regulatory Compliance:** Securing all necessary national and international permits, especially concerning marine laws and the disposal of electronic and composite materials. This phase also includes securing the necessary budget, which was factored into the original infrastructure business plan.
2. **Infrastructure Isolation and Safety:** A controlled shutdown of all power and data transmission systems before recovery operations begin.
3. **Controlled Recovery Operations:**
    - **Retrieval of Detection Units (DUs):** Utilizing specialized vessels and ROVs to disconnect and reel in the flexible vertical strings, ensuring the fragile Digital Optical Modules (DOMs) are handled to facilitate subsequent recycling.
    - **Recovery of Junction Boxes and Main Cables:** Removing the critical nodes and the main submarine electro-optical cables that link the detectors to the shore stations, managing the tension and integrity of the cables during retrieval.
4. **Disposal, Recycling, and Legacy:** The recovered material, consisting primarily of glass, plastics, specialized cables, titanium, iron and copper, will be sorted. The plan will strive for the **highest possible recycling rate**, treating material disposition not as waste but as a resource. Any non-recoverable material fragments will be thoroughly documented, and their precise locations will be lodged with international marine data centers for future reference and long-term monitoring.

The successful execution of this plan will serve as a responsible benchmark for the retirement of future large-scale, deep-sea scientific projects, guaranteeing that the significant scientific legacy of KM3NeT is not overshadowed by environmental cost. It ensures that, following decommissioning, the Mediterranean abyssal environment is returned to its pre-existing state with minimal residual impact.

4 Regulatory and Legal Framework Governing Deep-Sea Decommissioning in the Mediterranean

The decommissioning of KM3NeT must navigate a complex hierarchy of international conventions, regional agreements, and specific national legislation of Italy and France.

4.1 International Obligations: UNCLOS and IMO Guidelines

The global baseline for the removal of offshore infrastructure is established by the United Nations Convention on the Law of the Sea (UNCLOS, 1982) and the International Maritime Organisation's (IMO) Guidelines and Standards for the Removal of Offshore Installations and Structures on the Continental Shelf and in the Exclusive Economic Zone (EEZ) (1989).[5] These frameworks historically required the complete removal of structures on the continental shelf or in the EEZ at the end of their service life.[5]

However, there has been a significant change in customary international law regarding the abandonment of offshore facilities, particularly drawing from the precedent set in the North Sea oil and gas industry. This evolving approach permits partial removal, subject to crucial safeguards being maintained for navigation, the marine environment, and other legitimate users of the sea.[6] This critical provision allows the decommissioning plan to justify leaving heavy, non-toxic components, such as the DU anchors, *in situ*, provided that a thorough Environmental Impact Assessment (EIA) supports the notion that abandonment minimizes overall environmental damage compared to full extraction.[7]

4.2 The Barcelona Convention and Regional Protocols

The Mediterranean Sea is governed by the Convention for the Protection of the Mediterranean Sea against Pollution (Barcelona Convention) and its associated Protocols.[8] These regional instruments impose specific, highly restrictive rules regarding waste disposal and pollution prevention.

4.2.1 The Dumping Protocol and Hazardous Waste Classification

The Protocol for the Prevention of Pollution of the Mediterranean Sea by Dumping from Ships and Aircraft strictly regulates the deliberate disposal of waste.[8] Crucially, the presence of electronics, cables, glass, and plastic within the DUs elevates the materials recovered from KM3NeT into the category of complex Electronic Waste (WEEE).[9] International agreements explicitly prohibit sea disposal for radioactive waste and, by extension, complex electronic waste containing plastics, copper, and potentially trace heavy metals.[2] Therefore, the large quantity of Digital Optical Modules (DOMs) and electronics modules must be subject to **100% recovery**. This regulatory imperative overrides any potential technical feasibility argument for the deep-sea abandonment of the functional Detection Units, establishing the primary requirement for the entire decommissioning plan.

4.2.2 Offshore Protocol Relevance

The Barcelona Convention also includes the Offshore Protocol, which applies to activities concerning the exploration and/or exploitation of resources in the Protocol Area. Significantly, the defined "activities" include "Activities of scientific research concerning the resources of the seabed and its subsoil".[10] While KM3NeT's primary mission is astroparticle physics, its integrated function as an environmental observatory for geosciences and marine biology [11] could place its decommissioning under the administrative purview of this protocol. If this interpretation holds, the project must adhere to the rigorous removal and environmental criteria typically applied to hydrocarbon exploration installations, potentially mandating a higher standard of removal than might otherwise be required for pure scientific infrastructure.

4.3 National Jurisdictional Requirements and Divergences

The national regulatory contexts in Italy and France introduce distinct opportunities and constraints.

4.3.1 KM3NeT-It (ARCA) – Italy's Regulatory Landscape

Italy's framework, which governs the ARCA site, is strongly influenced by the 2019 Guidelines issued jointly by the Ministry of Economic Development (MiSE) and the Ministry of Environment (MATTM) for the decommissioning of offshore platforms. [12] These Guidelines establish a clear procedural roadmap, specifying deadlines and duties for each phase of the process, including asset removal.

A critical, differentiating feature of the Italian decree is the explicit legislative principle that mandates the consideration of the **possibility of re-using the offshore platforms and connected infrastructures**. This regulatory push actively encourages repurposing, providing a robust legal basis for the strategic proposal to retain the ARCA Junction Boxes and Main Electro-Optical Cable infrastructure for Long-term Environmental Observatory (LEO) functions.

The process requires comprehensive environmental documentation, imposing a rich requirement for assessment even for older assets that may predate modern *Autorizzazione Integrata Ambientale* regulations, thereby ensuring the highest standard of environmental management is applied. The regulatory procedure for removal involves multiple layers of governmental consultation: MiSE publishes an annual list of structures requiring removal, but this is only done after acquiring formal opinions from the relevant technical offices (UNMIG), the Ministry of Environment (MATTM), the Ministry of Cultural Heritage (MiBACT), and after consulting the affected Regions, demonstrating a highly centralized and consultative decision-making process. The detailed removal plan, prepared by the concession holder, is subject to a formal Environmental Assessment by the competent authority, and must include a comprehensive Major Hazard Report.

4.3.2 KM3NeT-Fr (ORCA) – French Regulatory Landscape

France's legislation, applicable to the ORCA site, reflects a strong national and European commitment to marine biodiversity protection. French national requirements align with European Union environmental directives and international obligations, such as the commitment to **assess the environmental impact of new activities** they are planning, even those beyond national jurisdiction.

Consequently, the decommissioning of the ORCA infrastructure must be supported by a comprehensive Environmental Impact Statement (EIS) and requires authorization from designated authorities, such as the Prefecture Maritime. This framework places a high administrative burden on the project to demonstrate that all removal operations adhere to the highest environmental safeguards.

A key concern stemming from French guidelines involves the strict necessity to minimize seabed disturbance, particularly in the shallow, sensitive coastal zone near Toulon. Unlike deep-sea cables, where abandonment is often considered environmentally preferable, the recovery of cables in shallow water is mandated for safety and compliance reasons but must be executed with minimal impact. French guidelines therefore strictly enforce prioritizing cable extraction methods that reduce the physical width and depth of the disturbance footprint and specifically avoid sensitive benthic communities, such as *Posidonia* meadows.

4.4 Regulatory Compliance Matrix

The following matrix summarizes the jurisdictional obligations informing the strategic planning phase:

Requirement/Protocol	Governing Body/Law	Status/Obligation	KM3NeT Relevance & Decommissioning Impact
Complete Removal / Partial Abandonment	UNCLOS / IMO Guidelines [5]	Legal baseline: partial abandonment (JBs, deep sea cables) requires justification based on environment/navigation safety and repurpose.	Influences strategic selection; provides basis for leaving non-toxic anchor weights.[6]
Prevention of Dumping (Hazardous Waste)	Barcelona Convention (Dumping Protocol) [2]	Strict prohibition on deep-sea disposal of WEEE and complex waste.	Mandates 100% recovery of all DOMs, JBs, interlink cables, VEOCs and associated electronics.[4]
Environmental Impact Assessment (EIA)	Italian/French National Law, Regional Protocols [13]	Mandatory comprehensive assessment of construction, operation, and removal activities.[14]	Required for both ARCA and ORCA; necessary precursor to obtaining final decommissioning permits.
Re-use of Platforms/Infrastructure	Italian MiSE/MATTM Guidelines [13]	Explicitly encourages the possibility of re-use for scientific/environmental purposes.	Strong strategic opportunity for repurposing JBs and MEOCs as LEOs.[15]

Table 1: Regulatory Compliance Matrix for KM3NeT Decommissioning

5 KM3NeT Infrastructure Configuration and Decommissioning Assets

A generic artists' view of the underwater KM3NeT infrastructure is shown in Figure 4 where the DU, and associated components are identified, while the components of a DU are shown in Figure 5.

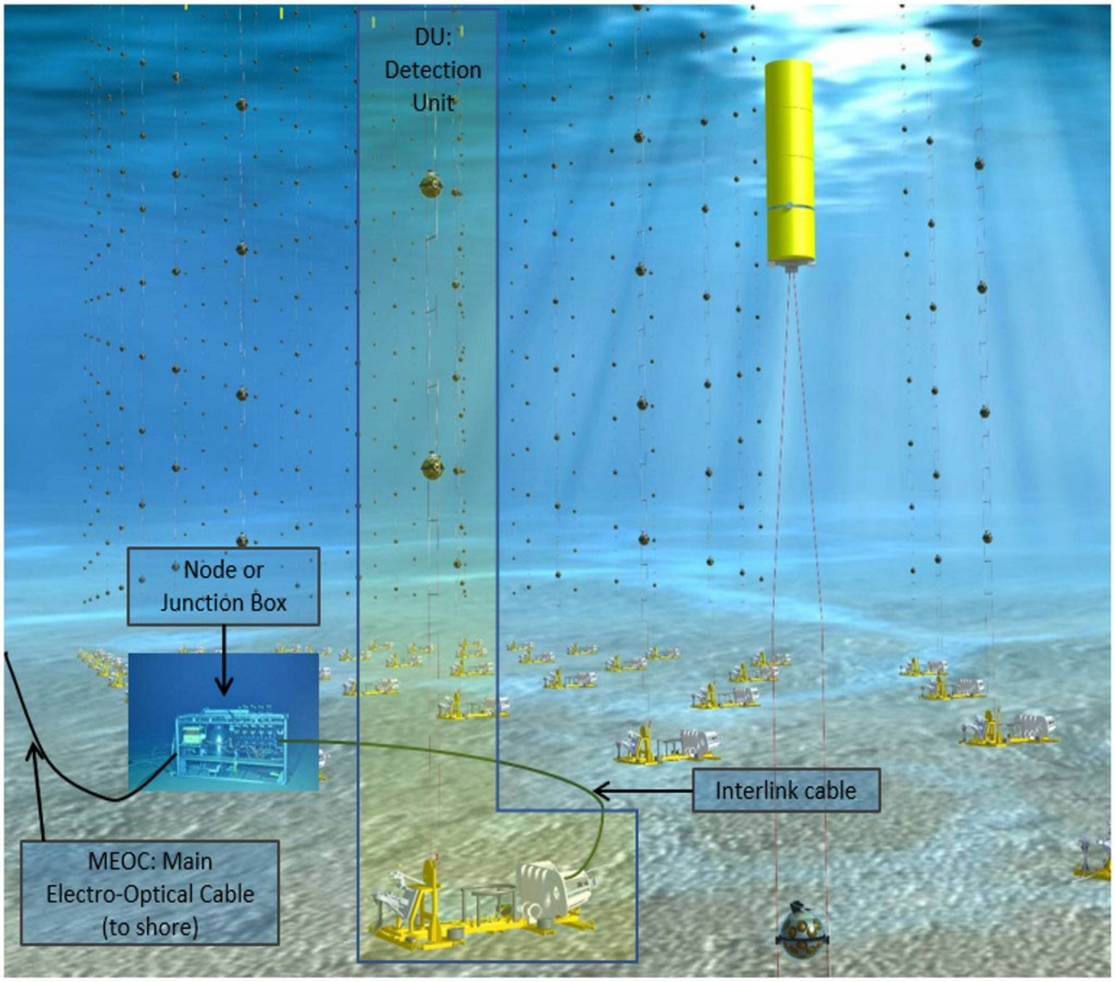

Figure 4: Artist's impression of the underwater infrastructure

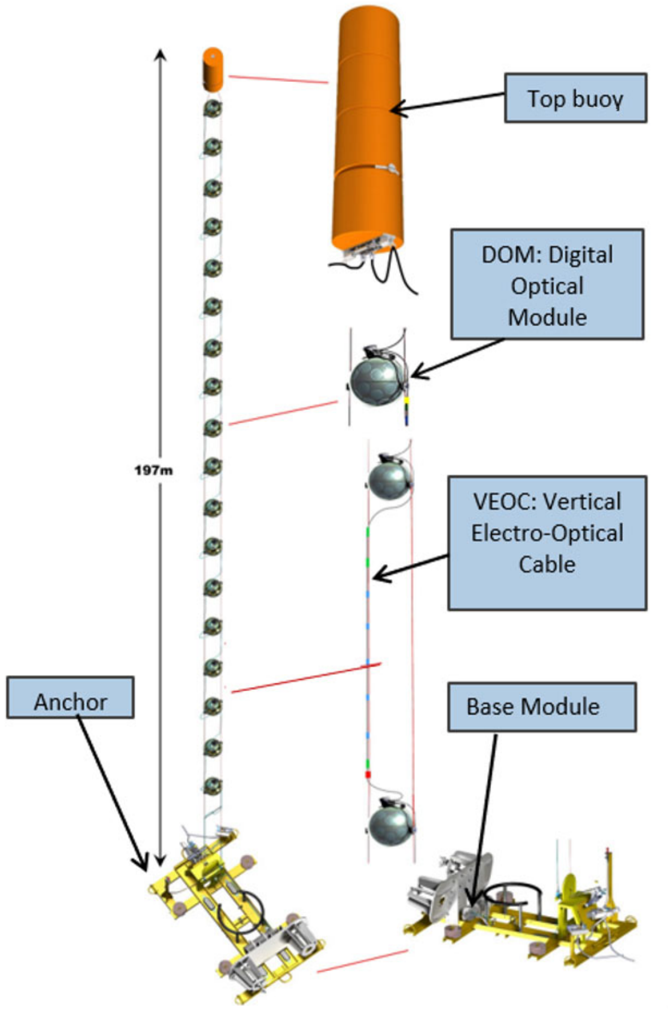

Figure 5: Elements of a DU

5.1 Component-Level Inventory

The main elements of the infrastructure to be recovered are listed below.

1. Digital Optical Module (DOM): borosilicate glass spheres housing 31 photomultipliers and their associated electronics. The spheres are 17 inches in diameter and have a wall thickness of 14 mm. The two detectors comprise 6210 DOMs.
2. Detection Unit (DU): a vertical array of 18 DOMs spaced along two parallel lengths of Dyneema rope. In the final configuration, there will be up to 108 DUs at the ORCA site and up to 225 at the ARCA site.

3. Anchor: placed on the seabed, the anchor serves to fix the position of the DU at its base via a connection to the Dyneema ropes. It consists of a steel structure with protective paint, equipped with sacrificial anodes. The anchor footprint is approximately 4.0m x 2.3 m, for a weight in air of around 1200 kg. There will be 345 anchors in total.
4. Base Module (BM): a cylindrical titanium pressure vessel located on the anchor containing electrical and optical components for inter-DU power and data distribution.
5. Vertical Electro-Optical Cable (VEOC): an oil-filled backbone cable connecting the BM to the 18 DOMs.
6. Top buoy: a syntactic foam buoy connected to the Dyneema ropes above the DOMs which provides additional tension in the ropes.
7. Calibration Base (CB) and Instrumentation Unit (IU): used to measure information needed for detector calibration (water salinity, sea current velocity, etc.) The IU uses an inductive line and has an overall height above the seabed of 248 m for ORCA and 650 m for ARCA.
8. Junction box (JB): a titanium pressure vessel containing electrical and optical components for distribution of power, data and slow control, serving multiple DUs (up to 28 in the case of ORCA, 14 in the case of ARCA). The pressure vessel is housed in a titanium frame with a footprint of approximately 4.0m x 2.0m for a weight in air of about 2000 kg (see Fig.2).
9. Cable Termination Frame (CTF): ARCA only; distributes power, data and slow control to several junction boxes. The CTF footprint is approximately 5m x 3.6m and its weight is 12400 kg in air.
10. Interlink cables (IL): electro-optical cables connecting DUs to nodes (ARCA and ORCA), and the DUs between themselves (ORCA only).
11. Main Electro-Optical Cable (MEOC): sub-sea telecommunications cable connecting the JB (or CTF in the ARCA case) to shore.
12. Autonomous acoustic beacons: a number of acoustic beacons are located at the sites. They are used to locate the anchors and DOMs (which contain acoustic receivers) in 3D space in real time for subsequent data analysis. Other beacons (RAMSES LBL beacons) are used to accurately position the detection lines during their deployment.
13. Non-KM3NeT equipment connected to the infrastructure. The main user of the infrastructure is KM3NeT but there is provision for other users. In the case of ORCA, several instruments linked to Earth and sea science have been deployed as part of a collaboration with EMSO (European Multidisciplinary Seafloor and water column

Observatory). Such third-party users will be responsible for the timely removal of their equipment prior to the full decommissioning of the sites.

All the above items are to be recovered with the possible exceptions of the anchors (item 3) the Junction Boxes (item 8) and the MEOCs (item 11), according to the conclusions of the Environmental Impact Assessment studies to be done in due time and the possibility of repurposing of the MEOC and JBs as part of a dedicated Long-term Ecological Observatory (LEO) mission.

Table 2 below summarizes the items to be recovered assuming a complete removal scheme.

	ORCA	ARCA
Detection Units (DU)	Up to 108	Up to 225
Calibration Base (CB)	1	2
Instrumentation Unit (IU)	1	2
Junction Box (JB)	4	17
Cable Termination Frame (CTF)	0	3
Interlink cables (IL)	Up to 108	Up to 256
MEOC	2	2
Long baseline beacons (LBL)	5	5
Acoustic beacons (AB)	Up to 4	Up to 6

Table 2: Summary of items to be recovered from the two KM3NeT sites.

5.2 Specialized Technical Risks of Deep-Sea Components

Implosion hazard

The DOMs utilize large spherical glass instrument housings designed to withstand pressures exceeding 350 bar. While statistically rare, the failure (implosion) of such a sphere during retrieval due to material flaws or pressure stress is a well-documented hazard.[16] An implosion event creates an extremely powerful, explosive shock wave. Studies show that this mechanical force, following the initial infall, is significant enough to shatter or damage ancillary mooring hardware and instruments located several meters away.[16]

Retrieval protocols must, therefore, be highly controlled. Acoustic and tension monitoring systems must be used throughout the ascent phase to detect anomalous stress or rapid movement.

Electrochemical Risk from Sea-Return Current Architecture

The KM3NeT power architecture, designed for efficiency, specified the use of a single copper power conductor, with the return current potentially being led through the seawater.[4] This design creates a chronic, localized electrolytic environment around the grounding point in the Junction Boxes. This electrochemical process poses a specific, long-term environmental liability that must be addressed during decommissioning planning.

A thorough chemical assessment must be conducted to determine if this prolonged electrolytic exposure has caused localized heavy metal leaching or accelerated corrosion products at the anchor or grounding interfaces. If significant contamination is detected, the anchors, otherwise classified as non-polluting ballast would be reclassified as hazardous material. The pre-decommissioning Environmental Impact Assessment (EIA) must specifically target this potential risk area through sediment sampling.

6 Decommissioning Strategy Selection and Justification

The selection of the final decommissioning strategy is a pivotal decision driven by regulatory compliance, environmental responsibility, and financial viability.

With the data currently available to us, there are two possible options as follows:

1. **Option 1: Full Recovery of All Assets:** This option satisfies the most stringent interpretation of UNCLOS and IMO guidelines.[5] However, it incurs the highest financial cost due to vessel time and complexity, and it carries the highest environmental risk. Full retrieval requires disturbing sediment along the entire length of all cables and removing all anchor weights, potentially damaging established benthic communities and creating widespread sediment plumes.[17]

2. **Option 2: Repurposing:** This involves the full recovery of all functional components (DUs/DOMs) but retains the robust seafloor network (JBs and MEOCs) for a dedicated Long-term Ecological Observatory (LEO) mission.[15] This option could prove to be environmentally superior because it eliminates the physical destruction associated with removing the Junction Boxes and the deep-sea cable segments. Crucially, the approach aligns directly with the Italian regulatory incentives that encourage the re-use of infrastructure.[13] By leveraging the existing high-value power and data

infrastructure [18], the project converts a significant financial liability (decommissioning cost) into a permanent, highly valuable scientific asset, extending the infrastructure's legacy.[19]

The final decision between options 1 and 2 above can only be taken at a point in time close to the decommissioning of the infrastructure when all the parameters affecting the decision will be known with greater accuracy, i.e. the possibility of establishment of a LEO, changes in the legislation at National and EU levels, results and conclusions of the necessary Environmental Impact Assessment studies.

7 Technical Execution Plan: Deep-Sea Recovery Operations

The decommissioning of the KM3NeT infrastructure will be a highly complex operation, which will invariably span many months of field operations. The location of the infrastructure (many tens of kms off shore) means that such operations will be highly dependent on time windows of favourable weather, and the simultaneous availability of vessels, ROVs and the relevant personnel. It is indeed highly possible that the complete recovery and decommissioning of the KM3NeT infrastructure may last for more than 1 year.

The execution phase requires meticulous planning, specialized equipment, and skilled personnel to manage the high depths and ambient pressures involved, in both sites.

It should be noted here, that the KM3NeT collaboration has already retrieved complete DUs after their deployment in cases where faults in the transmission of electrical power necessitated their complete removal from the seabed, and their subsequent repair in the KM3NeT integration facilities.

7.1 Vessel and Equipment Requirements

The operational capability of the vessel(s) used for the recovery of equipment from the sea floor is the core determinant of the execution plan's viability and cost. For both ARCA and ORCA detectors, the great deployment depths require the use of dedicated, high-specification offshore operations vessels, in complete analogy to the ones used for the initial detector deployments. The complexity of the operations requires accurate Dynamic positioning capabilities (Dynamic Positioning Class 3) to accurately maintain position, essential for working over fixed seafloor assets without anchoring.

The vessel must be equipped with specialized deep water lowering and A&R systems capable of operating reliably at 3500 meters and able to lift the heaviest components of the infrastructure, i.e., the DU anchors safely from the seabed. Furthermore, the deployment of high-specification work-class ROVs is essential. ROVs provide the necessary precision for visual confirmation, delicate release operations, manual intervention, and retrieval of delicate objects. As in the case of deployment, an ROV must be rated, at least, to 3500m for ARCA operations and somewhat shallower depths for ORCA, and capable of carrying significant net loads, a capability which may be used if necessary.

7.2 Recovery Methodology

7.2.1 Detection Units (DUs)

The deployed DUs are extended objects, which must be recovered intact from the sea bottom. The recovery method relies on the ability of the surface vessel to lift the entire DU structure, including the anchor, the DOMs and the buoy.

For both ARCA and ORCA, the details of the DU recovery have been worked out in the context of dedicated DU recovery for repair and recommissioning purposes. The specific procedures for such recoveries can be found in relevant documents which are attached to the current decommissioning plan as Appendices A (for ORCA) and B (for ARCA). It should be noted that these documents deal with the DU recovery operations irrespective of the subsequent fate of the recovered DUs.

For completeness, a very rudimentary breakdown of the main operations is presented below. The recovery sequence is as follows:

1. The DP vessel positions precisely over the DU location.
2. The ROV is lowered to the sea bottom and precisely positioned.
3. The ROV disconnects the interlink cables between the DU Base module and the JB;
4. The ROV hooks up the lift line from the surface vessel to the anchor and the whole structure is lifted to the sea surface. Continuous monitoring of the process will be needed especially at the first stage of recovery when there exist an increased chance of mechanical interference with the DUs still in the sea.
5. Due to the self-buoyancy of the DU, the structure will surface before the anchor, which necessitates the careful manipulation of the DU on the sea surface, before the recovery on the vessel.
6. The final part of the operation involves the hoisting of the complete DU plus anchor on the vessel for transportation to shore.

7.2.2 Seafloor Component Retrieval (Junction Boxes, Anchors and Acoustic Beacons)

The Junction Boxes (JBs) are substantial, high-value components containing complex electronics and high-voltage connections. If the LEO repurposing strategy is abandoned, JBs must be retrieved.

Retrieval of the JB necessitates the precise intervention of the ROV in order to raise the JB while connected with the MEOC during the cable recovery phase of the decommissioning activities. In the ARCA configuration, each JB is connected to the CTF through two electro-optical interlink cables. These cables are connected to the JB on one side and to the CTF on the other, where Medium Voltage Converters (MVCs) are housed. As a consequence, the JB–CTF connections are based on medium-voltage wet-mateable electro-optical connectors.

For all equipment that needs to be lifted from the sea floor (anchors, Junction Boxes, acoustic Beacons, etc) a heavy-lift system on the DP vessel is required for the controlled ascent. Careful handling is necessary to maintain the integrity of the pressure housing and prevent internal fluid leakage during recovery where this is relevant.

7.2.3 Cable Retrieval Strategy (MEOCs to Shore)

The disposal method for the approximately 100 km of Main Electro-Optical Cable per site varies critically based on depth and proximity to sensitive coastal environments. This operation requires the use of a specialized cable ship.

1. **Shallow Water and Continental Shelf:** All MEOC sections traversing the continental shelf and coastal areas must be fully recovered. This is necessary to minimize navigational hazards and comply with stricter national regulations in the coastal zone. However, this operation presents the highest environmental risk. Cable recovery involves disturbing significant volumes of sediment, potentially leading to increased nutrient releases into the water column and localized eutrophication effects. Mitigation measures, such as the use of specialized mass flow excavation systems [20] or specific burial techniques, must be employed to reduce the physical width of disturbance and avoid sensitive habitats identified during the route selection process.[7]
2. **Deep Water (Abyssal Plain):** For MEOC segments lying below 500 meters on the abyssal plain, the need of recovery is less critical than for the shallower waters. If the cable is not retained for LEO use, then careful assessment of the disturbance of the ocean floor upon cable recovery and the impact of such an option should be performed, in view of the latest scientific data and procedures at the time. If abandoned, the cables must be cleanly cut at the transition point (shelf edge/abyssal zone) and the cut ends secured or safely buried to prevent future snagging by trawlers or research gear. However, it should be emphasized, that the current viewpoint favours the complete recovery of the cable(s) from all depths.

7.3 Environmental Impact Assessment (EIA) and Mitigation

A comprehensive Environmental Impact Assessment (EIA) is mandatory under both Italian and French national laws and regional protocols.[13] This assessment must precede and justify all proposed decommissioning actions.

7.3.1 Pre-Decommissioning Site Characterization

The EIA process must begin with rigorous site characterization surveys for both ARCA and ORCA.[21] The primary focus is the identification and mapping of existing benthic communities, particularly Vulnerable Marine Ecosystems (VMEs). For both the KM3NeT-It and KM3NeT-Fr sites, there is proximity to rich biodiversity areas, including possibly endangered ecosystems. The EIA must specifically evaluate the potential impact on these VMEs and establish a baseline survey of an undisturbed comparison area,[21] while assessing, among others, the recovery impact on the following issues.

7.3.1.1 Sediment Plume and Turbidity

The physical recovery of DUs, anchors, and especially cables, involves the direct manipulation of the seabed. This operation risks mobilizing substantial volumes of sediment which, when lifted or dragged, creates extensive sediment plumes that temporarily increase turbidity in the water column.

While the KM3NeT operational volume is geographically smaller than large industrial projects, the scale of disturbance is significant. Historical data from cable installation activities suggests that the cumulative wet volume of disturbed sediment may range from 0.15 to 1.22 km^3 in water depths up to 2000 meters.[17] The recovery process effectively reverses this action, leading to the resuspension of settled material.

The increased turbidity poses several specific risks:

Biological Impact: The plumes can directly affect marine life, particularly benthic organisms and species in the coastal zone, by smothering habitat or interfering with filter feeders.

Chemical Release and Eutrophication: In coastal and shallow areas, disturbing older, established sediments carries the risk of increased **nutrient releases** into the water column. This increase in nutrient load can contribute to localized **eutrophication effects**, particularly if the seabed is contaminated, although contamination is primarily a risk in heavily impacted industrial locations.

Mitigation Measures: To minimize the impact, the plan emphasizes precision operations, which include: utilizing specialized cutting and lifting techniques to reduce drag on the seabed; imposing strict operating limitations during periods of high current where plume dispersal is maximized. The mandatory EIA must assess these potential changes to water quality and marine ecosystems.

7.3.1.2 Protecting the Posidonia Meadows and Coastal Benthic Communities

The coastal approach zone for both the ARCA (Italy) and ORCA (France) Main Electro-Optical Cables (MEOCs) falls within the zone where sensitive benthic habitats, such as the protected Mediterranean seagrass (*Posidonia oceanica*) meadows, are prevalent. While deep-sea cable abandonment is generally environmentally favorable, recovery of cables in shallow water is mandated for compliance and safety. This operation carries the highest risk of environmental damage due to physical disturbance. The decommissioning plan must implement strict mitigation measures:

1. **Route Assessment:** The final removal plan must utilize the original baseline surveys to confirm the exact location of the MEOC segments relative to *Posidonia* beds. Planning for the final cable recovery must avoid or minimize impact on sensitive habitats.
2. **Minimizing Disturbance:** Recovery operations in these sensitive coastal areas must prioritize techniques that minimize sediment disturbance. This includes utilizing specialized technologies, such as mass flow excavation systems, to loosen and recover the cable with minimal disruption to the surrounding sediment matrix.
3. **Eutrophication Risk:** Special attention is required in these coastal areas, as seabed disturbance can lead to increased nutrient releases into the water column, potentially contributing to localized eutrophication effects. Compliance with regulatory guidance in both nations requires that cable extraction methods are chosen specifically to reduce the physical width and depth of the disturbance footprint.

7.3.1.3 Risk of Contamination Release

In light of the potential use of a sea-return current in the power architecture [6], the EIA must include stringent post-sampling analysis of sediment and benthic fauna around the MEOC termination points and anchor locations. This is required to monitor the level of any residual contaminants, such as heavy metals or accelerated corrosion products.[22]

The final submission to the competent authorities (e.g., MiSE/MATTM in Italy) must include a detailed Environmental Assessment of the removal project and a Major Hazard Report, confirming that potential risks from serious accidents, waste generation, and resource disturbance have been minimized.[14]

7.3.1.4 Physical Damage and Benthic Disturbance

The use of ROVs and heavy-lift systems of the surface vessels carry a small but nonetheless existent amount of risk for physical damage of surrounding seabed environment. In particular, operations involving dredging or grappling can result in disturbances of the soft sediments around the recovered equipment, with the cables being the most important items. Such issues should be carefully considered and the associated risk properly mitigated.

7.4 Decommissioning planning and time schedule

Although it is quite premature to define a definite time plan for the KM3NeT decommissioning at this stage, we strongly advocate that the KM3NeT collaboration plans for a timely implementation of all relevant steps of the decommissioning stage well in advance in time. As the required permits and the associated AIAs may need substantial time to be completed, the process should be initiated as early as possible. A thorough investigation on the European and National legislation should be conducted well in advance to accommodate possible changes to the existing legislature.

8 Waste Management, Logistics, and Disposal

KM3NeT can benefit from the experience and know-how gained from the corresponding decommissioning of the ANTARES infrastructure which took place between 2022 and 2023. In the ANTARES case, the recovery of the detector has produced a large set of material, which was treated first under the direction of cyclic re-use and then in the context of recycling and waste disposal.

In the case of ANTARES, the electro-optical cables were recycled by an industrial partner, while the titanium present in the mechanical structure was sold. Equipment which was functioning (acoustic releases, hydrophones) were distributed to ANTARES participating institutions to be used again, while dead weights, and buoys were donated to private companies and/or participating institutes. Some of the optical modules of ANTARES were used in new projects, although a large number of them is simply stored in a warehouse.

In the case of KM3NeT, the decommissioning process will generate a complex waste stream dominated by high-value, high-regulation electronic waste, requiring a specialized, cross-European logistics chain.

8.1.1 Classification and Segregation of Recovered Materials

All materials recovered onshore must be immediately segregated into distinct streams to maximize resource recycling and ensure compliance with the WEEE Directive (which references MARPOL for transport).[23]

A major issue will be the identification of possible re-use cases of recovered material, either in new projects or as part of ongoing activities in the scientific partners of KM3NeT. Cyclic uses of recovered material is to be preferred over recycling and disposal as waste. All functioning equipment are to be considered as candidates for re-use. These include acoustic beacons, acoustic releases, ferrous dead weights, buoys, etc.

The main part of the recovered material will consist of the DOMs which present the most challenging part of the disposal activity. Indeed, the sheer volume of the recovered DOMs make their disposal a difficult task. Every effort should be made to ensure that as many DOMs as possible are re-used in scientific projects or alternatively in outreach or related activities.

8.1.2 Management of Hazardous and Specialized Waste Streams

8.1.2.1 WEEE (Electronics and PMTs)

The DOMs and the internal electronics of the Junction Boxes constitute the largest volume of high-risk waste. The scale is massive, involving thousands of modules.[4] These materials require specialized handling and recycling in compliance with the European WEEE Directive.[23] The logistics plan must organize safe and compliant shipment from the primary recovery ports (Toulon and a port near Portopalo di Capo Passero) to licensed WEEE processing facilities in Europe, potentially utilizing the logistics centre already established in Caserta.[12]

8.1.2.2 Glass Spheres

The primary component of the DOM structure is high-pressure, high-quality glass.[4] While glass is generally recyclable, glass spheres must be managed carefully. Undamaged or cleaned glass should be processed for recycling, but any contaminated or structurally compromised glass resulting from implosion or retrieval damage must be segregated and disposed of under industrial waste protocols, ensuring no contamination of the clean recycling stream.

8.1.2.3 Cables and Metals

The copper conductors and fiber optics within the MEOCs and interlink cables [24] represent high-value commodity streams suitable for recycling.[25] The retrieval phase must ensure that the recovered cable segments are properly de-jacketed and separated to maximize the yield of copper and fiber materials. The titanium present in both the DOMs and the base modules and Junction Boxes should be removed and sold separately as it is a high-value component under constant demand from industry.

8.1.3 Shore-Based Logistics and Transportation

Establishing robust shore-based infrastructure is essential. Secure, temporary storage, and processing areas must be designated at both French and Italian port facilities near the operational sites. These facilities must be capable of handling large, continuous cargo transfers and adhering to environmental safety standards during the breakdown and initial classification of recovered deep-sea components.

To manage the significant volume of WEEE recovered, a dependable logistics system is required for transportation across Europe. The established KM3NeT logistics framework, should be adapted for the reverse transportation of classified electronic waste to centralized recycling hubs.[4]

8.2 Cost Estimation and Financial Planning

The decommissioning cost is a major financial responsibility that must be rigorously managed to maintain fiscal integrity. The expense of retiring deep-sea scientific infrastructure is benchmarked against analogous operations, particularly the decommissioning of offshore oil and gas facilities, while accounting for the unique challenges of WEEE recovery.

8.2.1 A. Cost Drivers and Benchmarking

The primary cost drivers for KM3NeT decommissioning are highly dependent on the location:

1. **Vessel Charter Rates:** This is the dominant cost factor. The requirement for a DP-3 rated vessels with 3500m A&R capability translates directly into high premium day rates. These costs are subject to inflation and competition from the broader offshore market.
2. **Contingency Operations:** High contingency reserves are mandatory to cover risks such as prolonged weather downtime and subsequent lengthy ROV intervention operations.[4]

3. **Waste Management Complexity:** Specialized WEEE processing and compliance with international transport regulations for hazardous electronic waste substantially inflate the disposal cost compared to general industrial waste.
4. **Site Differences:** The higher depth and increased DU count at ARCA mean that the Italian operation will inherently carry a greater unit cost and require a significantly larger overall budget and longer timeframe than the ORCA operation.

Industry benchmarks, such as those from the UK Continental Shelf (UKCS), show that decommissioning costs are often subject to upward revisions due to inflation and activities exceeding initial estimates.

8.2.2 Financial Provisioning and Liability

The cost of decommissioning was intended to be included in the infrastructure's original business plan.[19] However, updated cost projections must be implemented immediately to account for modern inflation and high offshore service pricing.

A critical element of financial planning is establishing sufficient long-term financial provisioning for environmental liabilities. Liability can be incurred during both the exploration (scientific research) and eventual abandonment phases. International discussions on deep-sea liability emphasize that sponsoring states remain accountable for environmental damages.[26] A substantial financial buffer must be reserved to cover post-decommissioning monitoring activities and potential long-term environmental remediation, particularly regarding any materials approved for *in situ* abandonment.[27]

8.3 IX. Post-Decommissioning Obligations and Site Closure

Upon completion of the physical removal or repurposing phase, a final set of obligations ensures that the site is secured and its legacy documented. This phase transitions the project from a research operation to environmental stewardship.

8.3.1 A. Seabed Verification and Restoration

The physical decommissioning phase concludes with a final verification survey of the seabed.[20] This geophysical survey confirms that the defined scope of recovery has been achieved, that all removed assets are accounted for, and that any remaining materials (e.g., DU anchors, cut cable ends) are stable, non-hazardous, and secured against movement or snagging.[20] Where soft sediments were disturbed, the restoration phase relies primarily on natural restoration processes, guided by the baseline surveys conducted during the EIA.

8.3.2 Long-Term Monitoring and Scientific Legacy

8.3.2.1 Post-Decommissioning Monitoring

To ensure compliance and mitigate long-term environmental risk, a defined period of post-decommissioning environmental monitoring is mandatory.[20] This involves periodic environmental seabed sampling to monitor the level of any residual contaminants (heavy metals, etc.) in the sediment, flora, and fauna in the vicinity of the former installation.[22] This is particularly critical if the anchor abandonment strategy was pursued, verifying that these remaining structures are not contributing to pollution.

8.3.2.2 B.2 Archiving and Scientific Legacy

A key commitment outlined in the infrastructure planning is the maximization of legacy post-decommissioning.[19] Following the completion of decommissioning, the precise geo-referenced locations of any remaining material on the seafloor (e.g., DU anchors abandoned *in situ*, or secured, cut cable ends) must be meticulously logged and lodged with international marine data centers.[19]

This final act of detailed documentation serves a vital scientific purpose: it transforms the abandoned remnants from mere waste into **long-term material degradation experiments**. The known composition of the materials and their precise deployment time in the deep sea create a unique historical dataset for future investigations of marine processes on materials deployed at a known time, thereby ensuring the infrastructure maintains a scientific legacy even after its primary mission is complete.[19]

9 Conclusions and Strategic Recommendations

The decommissioning of KM3NeT is primarily governed by the mandatory requirement to recover the extensive volume of deep-sea electronic waste (DOMs/WEEE) under European and Mediterranean environmental protocols. This dictates a strategy of full recovery for all Detection Units across both sites.

The recommended strategy of **Selective Full Recovery and Repurposing** minimizes financial outlay and environmental damage while maximizing scientific legacy. This approach leverages the Italian regulatory environment favourable to reuse and converts the MEOCs and Junction Boxes into functioning Long-term Ecological Observatories (LEOs).[13]

The most critical differentiators affecting project complexity and cost are summarized below, highlighting the substantially greater logistical and financial challenge posed by the ARCA site.

Parameter	KM3NeT-It (ARCA)	KM3NeT-Fr (ORCA)	Implication for Decommissioning
Water Depth (Approx.)	3500 m [1]	2500 m [1]	ARCA requires specialized, high-capacity DP-3 A&R systems. This necessitates higher vessel day rates and introduces greater operational risk due to extreme depth.
Detector Size (Units)	225 operational strings	108 operational strings	ARCA's greater scope doubles the volume of WEEE to be recovered and the total duration of deep-sea operations.
National Regulator	Italy (MiSE, MATTM) [13]	France (Prefecture Maritime) [28]	Italian regulation explicitly supports re-use, strongly facilitating the LEO repurposing strategy.[13]
Benthic Environment	High potential for VMEs (e.g., deep corals near Sicily).[29]	Standard abyssal environment.	ARCA EIA must place heightened emphasis on VME protection and minimize physical disturbance in potentially VME-rich areas.
Recovery Difficulty	High (Extreme depth, high-stress recovery)	Moderate (Standard deep-water recovery)	Cost projections must assign a higher contingency budget for ARCA operations due to pressure-related equipment failure and required ROV complexity.

Table 3: KM3NeT ARCA and ORCA Site and Decommissioning Profile: Critical Differentiators

The technical success of the entire decommissioning plan hinges on the ready availability of deep-water ROV and DP vessel capacity and the efficient use of said ROVs. The final approval for leaving non-toxic cables and JBs *in situ* as part of a LEO in Italy requires rigorous pre-decommissioning EIA results, specifically validating the integrity of the infrastructure to be left in place and the viability of the long term environmental observatory. If successful, the repurposing strategy provides a scientific and financially sound pathway to site closure, leaving behind a valuable long-term environmental monitoring asset.

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XIII. APPENDIX A

PROCEDURE DE RECUPERATION : Ligne ORCA- DU déroulée et autres structures (RAB, tripodes, BJS…)

Référence : ATRIUM-1072229

PROCEDURE DE RECUPERATION : Ligne ORCA- DU déroulée et autres structures (RAB, tripodes, BJS…)

Référence : ATRIUM-1072229

Auteurs : Laurence Caillat, Marie-Ange Cordier, Christophe Lerouvillois, Aurélien Marini, Nick Lumb

Institut: CPPM

Résumé/Abstract

This document defines the procedure to follow when recovering ORCA-DU lines, but also other structures (RAB, Tripods, bjs etc.).
Ce document définit la procédure à suivre lors d'une récupération de lignes ORCA-DU déroulée, et servira de base pour la récupération d'autres structures (RAB, Tripodes, BJS, Bathybot, etc...)

Destinataires / Recipients

Internal CPPM/ Interne au CPPM

Document Status

Revision	Date	Description
V10	**07/04/2025**	**Refonte totale**

Revision History

Revision	Date	Comment	Reviewed by	Approved by
		Il existe d'autres versions de l'annexe A8 mais sur des sujets différents. Ne sont tracées ici que les dernières versions concernant la procédure de récupération		
V8	09/09/2022		M-A Cordier	
V9	05/23	Annexe 8 : procédure de récupération et outillage scindée en 2	M-A Cordier	
V10	07/04/25	Refonte totale. Cette annexe n'est plus une pièce jointe à la procédure générale KM3NeT_ISFR_2017_020 /ATRIUM-277459. Elle est référencée comme document annexe sous ATRIUM-1072229	L. Caillat, M-A Cordier, C. Lerouvillois, A. Marini	N. Lumb

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I. SITUATION AU FOND ET DISPOSITIONS PRELIMINAIRES

a. SITUATIONS AU FOND

ORCA-DU(x) ou la structure (BJS, RAB etc..) a été installée au fond. La ligne (ou structure) a été déconnectée du câble GF du Castor. La ligne (ou structure) est équipée d'un anneau de levage adapté à l'outillage de récupération (d'une ouverture de 100mm minimum). La ligne (ou structure) doit respecter la CMU (Charge Maximale d'Utilisation) de l'outillage de récupération.

S'il s'agit d'une ligne ORCA-DU(x), plusieurs cas de figure peuvent se présenter :

- Elle peut être connectée par son interlink au nœud ou à une ligne amont.
- Une ligne aval peut être connectée également sur ORCA-DU(x).
- Le largage du LOM et le déroulement de la ligne ont pu être effectués
- Le largage du LOM n'a pas encore été effectué (ligne encore enroulée)

⚠ Toute remontée avec le LOM accroché en bout de ligne est déconseillée (dans ce cas, envisager de couper la ligne au plus proche du LOM afin de préserver les modules optiques).

b. CONTEXTE ET DISPOSITIONS NÉCESSAIRES

- La récupération est possible de jour comme de nuit.
- Les caractéristiques principales de la ligne ORCA-DU sont précisées en annexe A1.
- Le système de positionnement est en fonctionnement
- Les forces et direction du courant sont connues
- Le courant de surface est observé, et s'il est significatif (plus de 0,5 nœud) la dérive de l'outillage de récupération pendant la phase de descente sera anticipée, son déploiement pouvant être mené « en dérive » au meilleur cap (autocap). (Sur décision du capitaine du Castor).
- La ligne à remonter doit être en bordure du détecteur pour ne pas risquer d'accrocher une autre ligne
- Météo très calme avec houle < 0.5 m
- Le ROV est disponible pour débrancher la ligne (éventuellement ramener le connecteur sur la DU et inspecter le chemin du câble pour s'assurer qu'il est libre), et placer le crochet de récupération
- Les moyens de communication à bord et entre les navires fonctionnent
- Les positions des bateaux et la trajectoire d'échappement du CO_2 sont vérifiées par le chef de mission et validées par les capitaines des 2 bateaux.

- La plage arrière du Castor est libre
- 8 personnes KM3NeT sont disponibles pour la récupération des Modules Optiques et leurs rôles sont définis lors d'une réunion briefing faite en avance.
- L'équipage du Castor est disponible (en particulier 4 personnes sur la plage arrière).

II. MATERIEL A UTILISER

Le matériel à utiliser est défini dans la checklist Mobilization Castor for ORCA DU sea operation KM3NeT_ISFR_2018_019 (ATRIUM-352235).

Note : Ce matériel devrait être présent à bord

Note : La préparation de l'outillage de récupération est détaillée dans la procédure ATRIUM-1071725.

III. PROCEDURE

Note : Pour une récupération d'une ligne ORCA-DU, remplir la « checklist ORCA-DU Recovery » (KM3NeT_ISFR_2022_001 / ATRIUM-654004)

- On vise une distance de pose de l'outillage de récupération inférieure à 10/15m de la ligne à récupérer.
- Faire attention que le ventre du câble grand fond ne heurte pas la ligne (ou une autre…)
- Contrôler le courant au fond.
- Le lest de l'outillage de récupération sera posé sur le fond.

a. TRAVAIL DU ROV

Avant ou durant la descente de l'outillage de récupération, le ROV peut commencer son travail. Il doit descendre avec un connecteur-bouchon ODI.

- Dans le cas où un interlink est connecté en aval de la ligne ORCA-DU(x) (coté outillage de connexion), le ROV doit déconnecter cet interlink et l'éloigner de la ligne à récupérer. Le connecteur de l'interlink doit être posé sur le support d'inspection de la ligne restant à l'eau.
- Le ROV doit déconnecter l'interlink de la ligne ORCA-DU(x) (sur le noeud ou sur la ligne en amont).
- L'interlink est rapproché de la ligne à récupérer. On vérifie qu'il pourra glisser sans risque sur le fond. Dans la mesure du possible, le ROV placera le connecteur en sécurité sur la DU (dans la structure d'enroulement de l'interlink), afin d'éviter la possibilité qu'il traine au fond.
- Le ROV place le connecteur-bouchon ODI sur le connecteur libéré (pour le nœud amont : bloc 4C ou 5C, pour la ligne amont : bloc 1C de la ligne).

Le ROV doit surveiller l'arrivée de l'outillage de récupération (visuel, communications entre Janus et passerelle Castor ; navigation).
Le lest est posé au fond par le Castor. On donne du mou sur le câble grand fond (pas trop pour ne pas que le ventre du câble touche les DU déployées à coté – 5 à 10m). Le Castor doit rester en position.
Le ROV contrôle le bon positionnement et l'intégrité de l'outillage de récupération (accessibilité du verrouillage du dyneema).

- Après vérifications de distance, et d'accessibilité, et accord du chef de mission : le ROV doit retirer la goupille de maintien du dyneema de l'outillage de récupération. Il prend le crochet et se dirige vers l'anneau de levage de la ligne ORCA-DU(x) à récupérer. ~~s'éloigne en sortant et déroulant le dyneema.~~

➢ Choix du coté de relevage :

Bien qu'il soit techniquement possible de récupérer la ligne ORCA-DU(x) d'un côté ou de l'autre, le côté recommandé est celui où se trouve l'outillage de connexion.

➢ Récupération coté outillage de connexion : (coté préférentiel)

- Pas de risque d'abîmer l'outillage de connexion (bloc 1C) en frottant contre le fond
- Diminution de risque d'écrasement de l'interlink sur le fond
- Diminution de risque d'abîmer l'interlink lors de la sortie de l'ancre sur le bateau.
- Risque d'abîmer l'outillage de connexion en tout début de relevage par le câble GF.

➢ Récupération coté support interlink :

- Inversion des avantages et risques cités précédemment.

⚠ Ce choix n'est à faire qu'en cas de force majeure.

Le ROV fixe le crochet de l'outillage de récupération dans l'anneau de levage. Le linguet maintient le crochet sur l'anneau de levage ~~mais si besoin, il peut être arraché~~.
Le ROV recule en position de sécurité tout en gardant le visuel.

➢ Relevage :

~~Une fois le câble accroché et le ROV en sécurité, mais en visuel, on commence le relevage :~~
Le Castor fait route en avance lente sur un cap qui permette de tirer l'ancre en évitant le matériel au fond. Ce cap est défini par avance.
En DP, le Castor met le câble en tension sous contrôle du ROV. Il met l'ancre à la verticale, puis commence à avancer tout en remontant le câble. L'ancre va frotter sur le fond avant d'être complètement soulevée.

- Durant toute la remontée, le Castor maintient son avance lente pour assurer que les modules optiques ne heurtent pas le câble grand fond (en drapeau)
- Le travail du ROV s'achève quand l'interlink sort de son champ de vision.

- Le câble est remonté à vitesse normale, et le Castor reste en avance lente. Quand la ligne est au-dessus du sommet du détecteur, il peut évoluer sur des virages de grandes courbures.
- Une fois les premiers modules optiques en surface, le bosco communique avec le capitaine du Castor qui maintient une avance lente permettant de garder la ligne en tension.
- ~~Mise à l'eau éventuelle de l'annexe pour surveillance de la ligne (tout particulièrement le dernier DOM et la bouée) avec l'équipement pour éventuellement écarter la bouée du DOM ou mettre la ligne sous tension si besoin. Communication avec chef du pont qui communique avec Zodiac vis-à-vis tension sur la ligne.~~

b. RECUPERATION DE L'ANCRE

Il sera demandé au Bosco quelle configuration il souhaite pour la récupération des modules optiques : stockage de l'ancre à Bâbord ou à Tribord.
Le stockage de l'ancre à bâbord gêne les mouvements de pont pour l'équipage (risque de blessures par coups du bélier du dyneema).

Le stockage de l'ancre sur tribord nécessite de laisser une zone de passage à tribord de l'ancre le temps de retirer le base module.

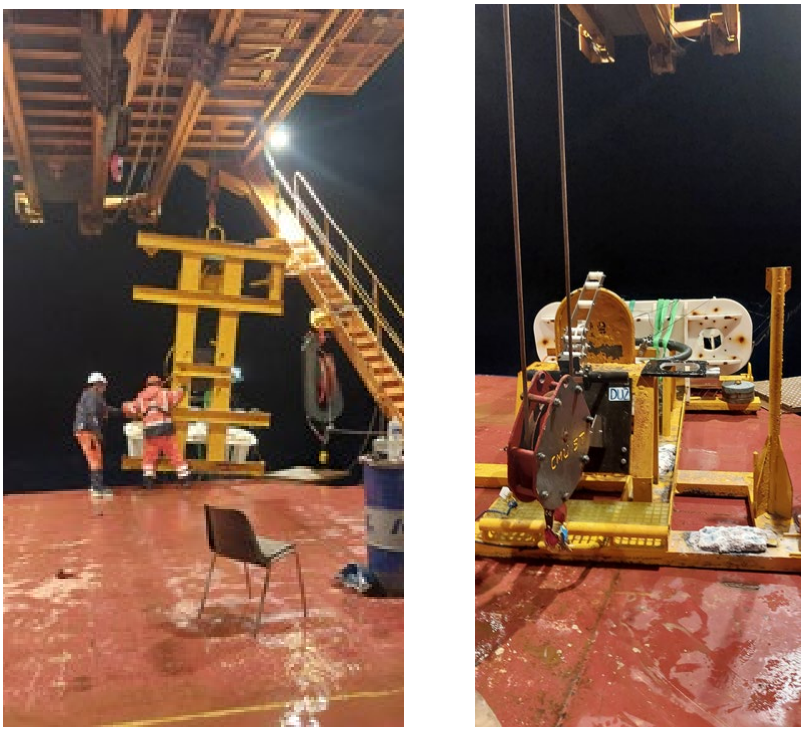


Photo 1 : Manœuvres lors de la récupération de l'ancre

Attention Sécurité :

- **Durant les phases de déplacement de fortes charges (comme pour l'ancre), il est interdit au personnel KM3NeT de s'approcher du matériel.**
- **Le travail sur l'arrière du pont impose le port d'un gilet de sécurité, d'un casque, de chaussures de sécurité et de gants.**

A l'arrivée en surface, en fin d'aussière, on doit retirer :

- la balise de positionnement (assurer la balise avec un faux bras durant son démontage)
- le magasin vide du crochet
- retrait du lest de descente, avec le palan bâbord

- Il faut surveiller l'orientation de l'ancre. La traînée des modules optiques a dû orienter la face supérieure de l'ancre vers l'arrière.
- On remonte l'ancre le long du tableau arrière le plus haut possible près de la poulie. On reprend la charge avec le palan bâbord, et on donne du mou sur l'aussière pour ne pas gêner
- On monte l'ancre avec le palan bâbord, en conservant le bas de l'ancre contre le tableau arrière.
- Quand le lest est suffisamment haut, on recule le palan bâbord pour basculer l'ancre et on la pose sur le pont.

Durant cette opération :

- **Surveiller les dyneema, le VEOC + Dyneema et l'Interlink pour ne pas les blesser.**
- **Le personnel du CPPM ne doit pas intervenir directement (charges en mouvement).**

- L'ancre est déposée sur le pont. Si besoin, on la replace correctement (Élingue 4 brins).
- Le Castor est libre de manœuvrer. Il doit assurer le bon positionnement en surface de la ligne (courant, bateau éventuels)

c. PREPARATION DE LA PLAGE DE TRAVAIL SUR LE CASTOR

Photo 2 : Caisses MO numérotées pour la récupération

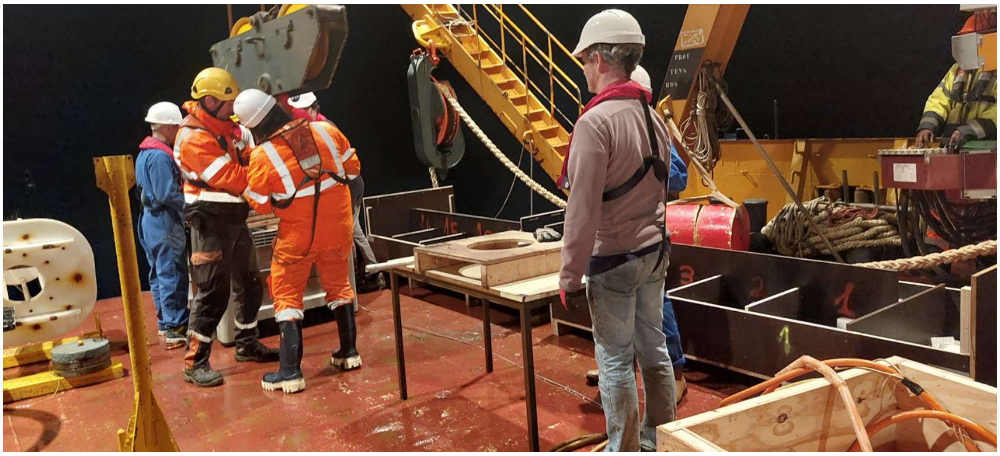


Photo 3 : Mise en place sur le pont

- Une fois que les marins ont donné l'autorisation d'approcher, on commence à installer le pont.
- Mise en place d'un tapis protection en caoutchouc sur le tableau arrière au cas où les MO heurtent le bateau.
- Mise en place et ouverture de la caisse de MO. Le côté dépendra du choix initialement fait lors de la remontée de l'ancre (cf § b).
- Mise en place des caisses Interlink et base module. Le côté dépendra du choix initialement fait lors de la remontée de l'ancre (cf § b).
- Au centre, à l'arrière, on place la caisse plastique et son support de MO.
- Derrière (vers l'avant) on installe le deuxième support de MO pour rinçage et inspection.
- Sur un treuil de pont, on installe un bout (20 m diamètre 10).

REMARQUE : le volume de dyneema à mettre sur le treuil n'est pas important : On laisse le câble en place

- On place la grande poulie ouvrante du CPPM sur le palan 25T au-dessus de la caisse grise à 2m en hauteur.

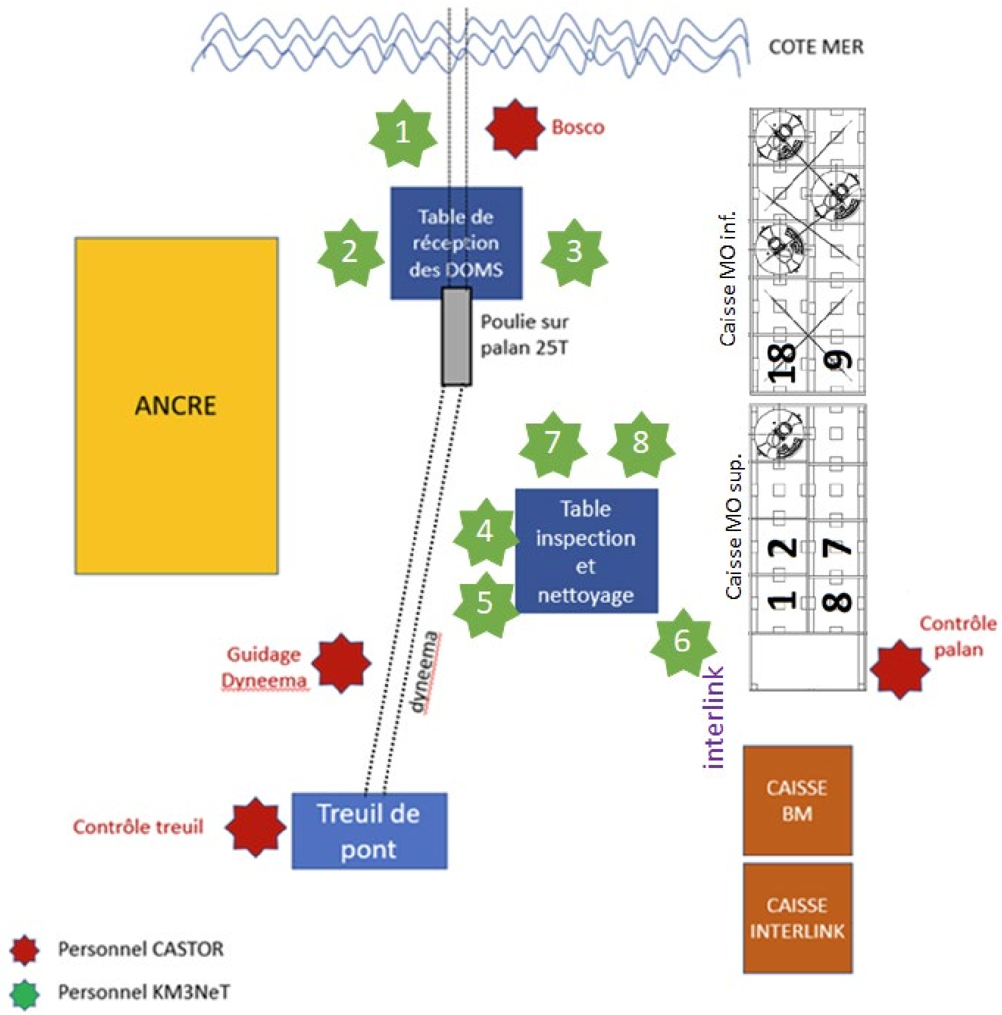
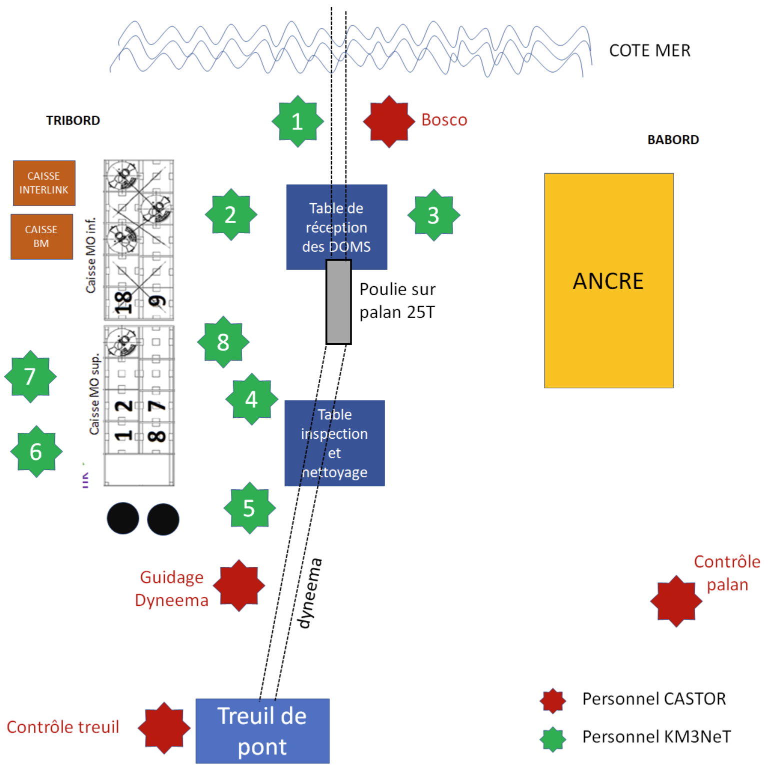


Figure 1 : plage de travail sur le pont du Castor



d. DEMONTAGE DU MATERIEL DE L'ANCRE

- **Interlink :**
  - Récupérer l'Interlink en le sortant du support d'Interlink.
  - Le rincer et le lover dans sa caisse (Au moins 2 personnes). Prévoir l'accès au connecteur qui se trouverait normalement au fond de la caisse. Poser un bouchon en silicone sur le connecteur.

- **Base Conteneur** :
  On défait les fixations du base conteneur et on le prépare (déconnexion câble hydrophone, rinçage, … A COMPLETER) pour le mettre dans sa caisse.

⚠ **Note/Sécurité : Quand on récupère un conteneur soupçonné d'avoir pris l'eau, on doit faire attention, il peut y avoir 250 bars piégés à l'intérieur. L'histoire raconte de nombreux accidents : le scellement d'un connecteur qui s'arrache, et se transforme en balle de fusil, un joint qui sort de son logement et projette des débris, voir même la tape en cours de démontage qui est propulsée à plusieurs mètres !**

L'ancre sera posée sur le pont dans le sens axial. Aucune personne ne se devra se trouver dans l'axe du base module. Une des flanges sera légèrement desserrée pour s'assurer d'évacuer toute surpression éventuelle. Ensuite la protection du cylindre pourra être retirée et le base module manipulé.

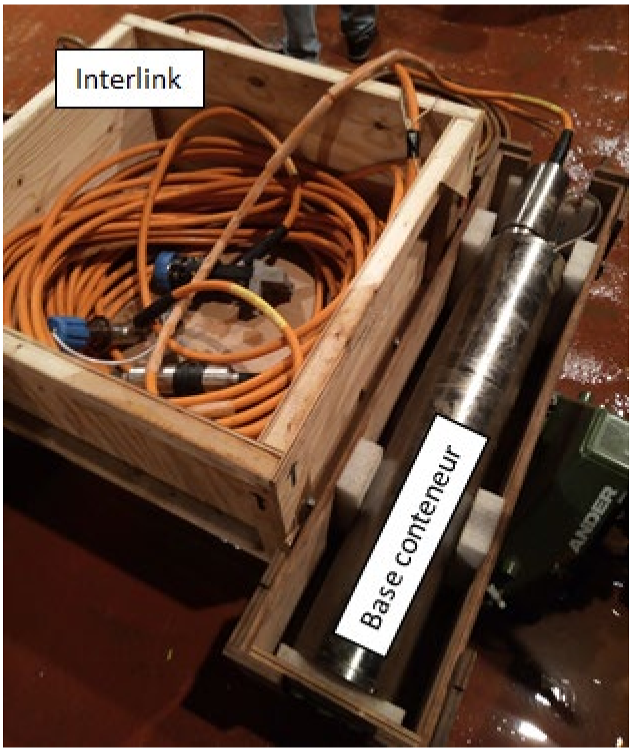


Photo 4 : Interlink & base conteneur rangés

- Hydrophone :
  On démonte l'hydrophone et on le prépare (pose d'un bouchon, rinçage… A COMPLETER) pour le mettre dans la caisse Interlink ou avec le base conteneur selon la longueur de câble.

- VEOC/Dyneema :

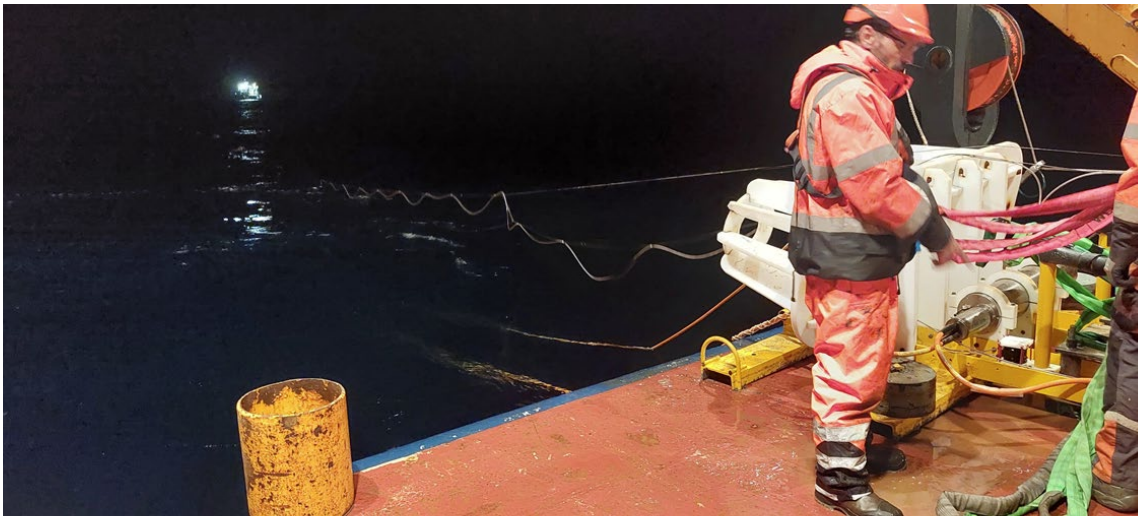


Photo 5 : VEOC attaché à l'ancre

- Le VEOC est détaché de l'ancre.
- Le bout du treuil de pont est partiellement déroulé. Il est passé dans la poulie ouvrante et rapproché des manilles des dyneema de la ligne.
- Remontée et enroulement des câbles dyneema jusqu'au premier DOM en décrochant le VEOC des dyneema ainsi que les 2 spacers entre l'ancre et le DOM1
- On maintient les dyneema par les poignées coinceurs disponibles dans l'atelier. On défait les attaches des dyneema, on les attache entre eux et on les fixe sur le bout.
- On coupe les attaches entre dyneema et VEOC.

Attention à ne pas blesser le VEOC :

Pour cela on utilisera des ciseaux très fins que l'on glissera entre le VEOC et le dyneema pour couper le scotch.

- Avec le treuil de pont on reprend le mou. Les Dyneema passent dans la poulie, et s'enroulent sur le treuil. Le VEOC est séparé du dyneema et ne passe jamais dans la poulie.
- L'ancre est ainsi complètement séparée du matériel de détection.

e. RECUPERATION DES MODULES OPTIQUES

On doit maintenant récupérer les Modules Optiques (MO).

- Il est conseillé de laisser le responsable navigation se reposer lors de la récupération des modules optiques.
- La barre de levage doit être mesurée **Longueur caisse grise + 80 cm**
- Raccourcir la hauteur de l'outillage de levage au maximum et sécuriser e nœud avec un colson

8 personnes KM3NeT travaillent ensemble :

- **1 personne récupère le MO (position 1 en duo avec le bosco)** :

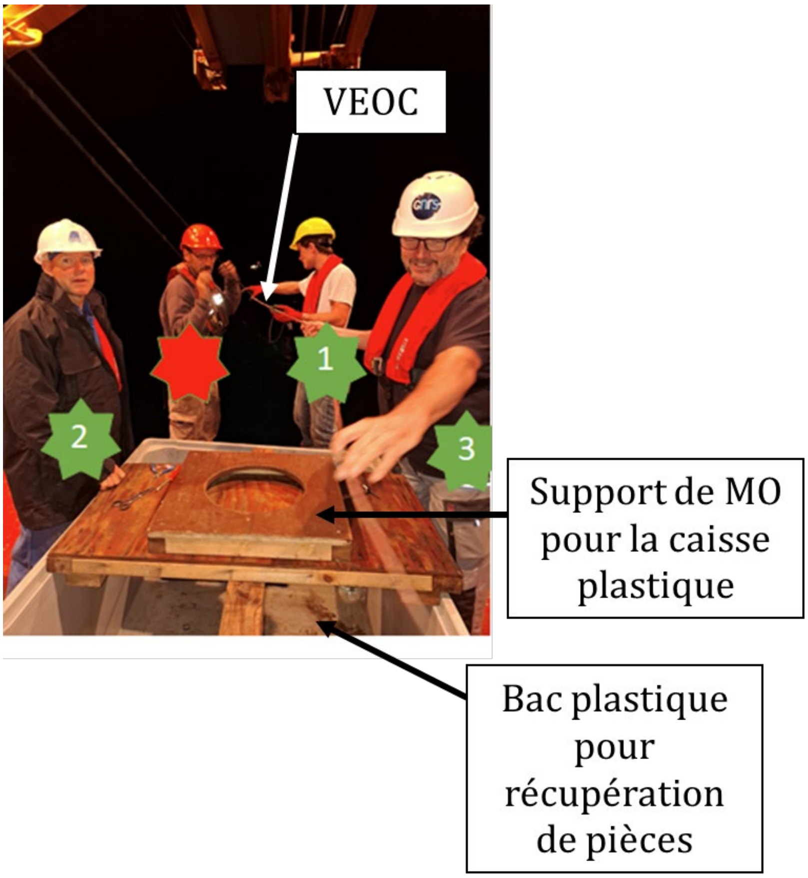
  - Elle **garde le dyneema en main en permanence**
  - Elle retire ou fait glisser les clips vers le bas (au plus proche du MO), **sans endommager le VEOC**
  - Elle explique cette technique au bosco qui doit faire de même lorsque le dyneema est de son côté
  - Elle dirige le treuil de pont : elle stoppe si le VEOC risque d'être avalée par la poulie afin de ne pas l'endommager
  - Elle surveille le retrait des clips
  - Elle surveille l'approche du MO en surface et en l'air

    ATTENTION :

  - Si la ligne **<u>n'est pas assez tendue</u>**, les MO risquent de se heurter sur l'arrière du CASTOR **: ALERTER** le bosco qui demande au capitaine **d'accélérer** le CASTOR
  - Si la ligne **<u>est trop tendue</u>** : il devient impossible de garder le dyneema en main : **: ALERTER** le bosco qui demande au capitaine de **ralentir** le CASTOR
- Elle pivote le MO avec le bosco pour le poser sur le support de caisse BOB en haut (obligatoire pour ne pas endommager le mastic de l'équateur)

❖ **2 personnes (positions 2 et 3) sont en charge de :**

- Retirer les clips restants et les jeter dans le bas en plastique
- Couper minutieusement le ruban auto-amalgamant qui lie le Dynema au VEOC à l'aide des ciseaux chirurgicaux
- Démonter à l'aide de clés à pipe, les fixations (« oreilles ») des Dyneema sur les MO et les jeter dans le bas en plastique
- S'assurer que le VEOC n'est pas emmêlé avec le Dyneema
- Transporter le MO du bac plastique vers le poste de nettoyage
- Prévenir les personnes en position 7 & 8 que le MO est prêt à être déplacé

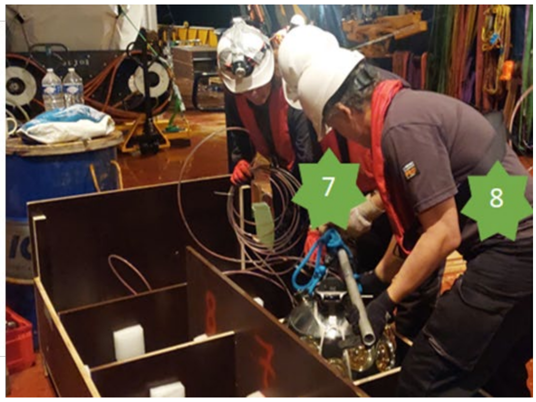


❖ **1 personne (position 4) est chargée de :**

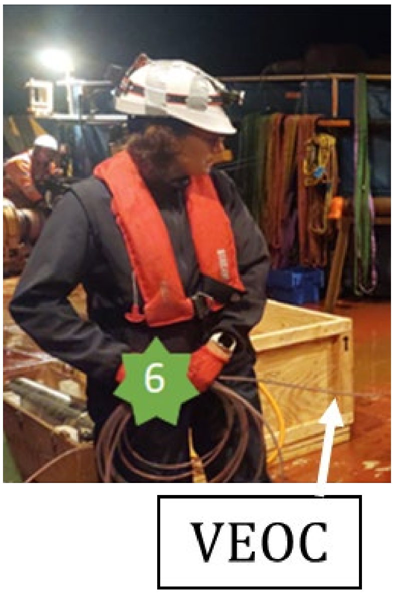
- Rincer le MO
- Réaliser une inspection rapide, guider les personnes 7 & 8 vers le bon emplacement du DOM dans sa caisse

- **1 personne (position 5)** est chargée de remplir la checklist et de prendre des photos (elle peut aussi aider la personne en position 4 pour le rinçage). Elle surveille le VEOC pendant chaque transfert de module optique (de la position de démontage à la position de rinçage, puis de la position de rinçage à la position de rangement dans la caisse de modules optiques.

- **2 personnes (positions 7 et 8) de même taille sont en charge de :**
  - Transporter le MO du bac plastique vers le poste de nettoyage grâce à l'outillage de levage dans la caisse de transport
  - S'assurer au préalable d'avoir assez de mou de VEOC demandez au poste 1 et au bosco
  - Ouvrir le robinet de rinçage



- **1 personne (position 6)** est chargé de surveiller le VEOC, de le ranger et de le fixer dans la caisse de MO, aider des personnes en position 7 & 8



En complément, 4 personnes du CASTOR sont en charge de :

- Bosco : Aider à la récupération des DOMs et coordonner l'équipage CASTOR
- Contrôler le palan
- Contrôler le treuil
- Guider les Dynema

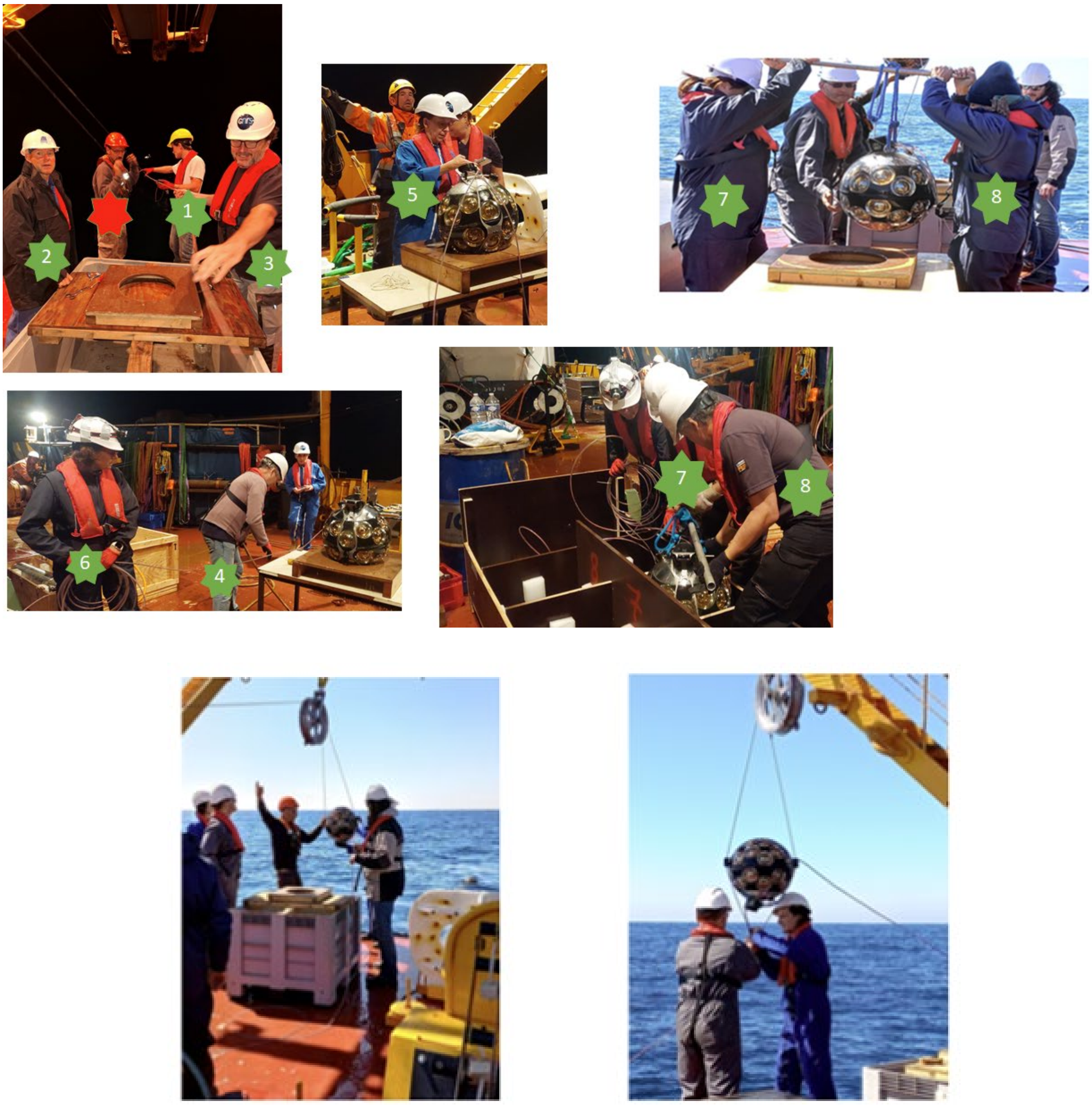


Photo 6 : Postes de travail lors de la récupération

f. PREPARATION AU TRANSPORT

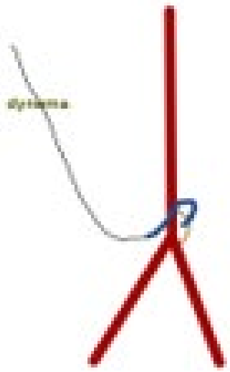
- Après récupération de tous les MO, on récupère la bouée
- La bouée est séparée des dyneema.
- Mettre barres de DOMs en place (on doit s'assurer que les MO soient bien calés) et fermer la caisse M.O. en prenant soin de protéger le VEOC extérieur.
  Note : Se référer à la procédure « DU transport crate opening and closing » (KM3NeT_MECH_2019_003/ATRIUM-376464)
- La caisse du base conteneur est posée sur la caisse des MO

- La caisse Interlink est fermée et posée sur la caisse des MO
- Les deux caisses sont sanglées sur la caisse des MO. Elles ne seront pas séparées avant arrivée au CPPM.
- Les dyneema sont retirés du treuil de pont, et mis en caisse.
- Les pièces de fixation des dyneema de la caisse plastique sont récupérées.
- Rangement de l'outillage et du matériel.

IV. CAS DE LA RECUPERATION DE TRIPODES

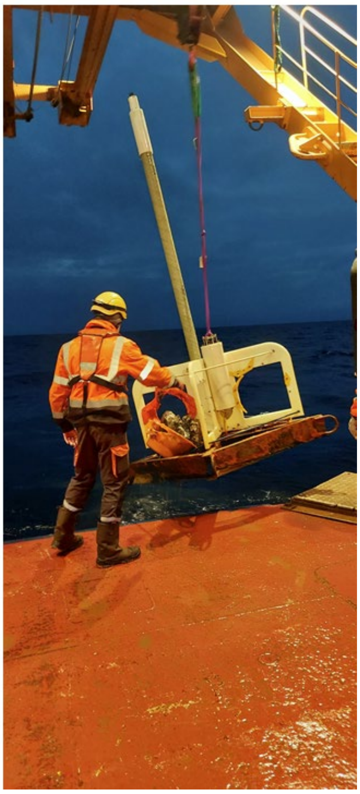
Le ROV vient positionner le crochet avec linguet dans un des anneaux de levage soudés.

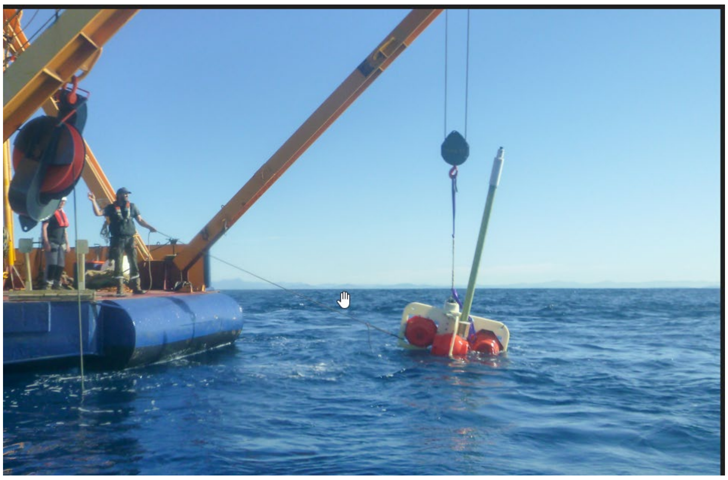
⚠ Attention si les anneaux sont trop petits, le ROV a du mal à l'accrocher.



V. CAS DE LA RECUPERATION D'UN RAB

Le ROV vient positionner le crochet avec le linguet dans l'élingue violette fixée sur la balise





XIV. APPENDIX B

IDMAR Project document No: KM-PM-19-II

IDMAR Project document No: *KM-PM-19-II*	Created 28.06.2022	
	Modified 08.08.2022	Rev No 02

SUBJECT:

OPERATION
Deployment JB1
Deployment 2 DU (32 and 05)
Recover T2003 and ARCA.0018

Prepared by:
K. Leismüller

	N. Randazzo	MTS
	S. Biagi	FUGRO
	S. Viola	G. Cuttone
	A. D'Amico	G. Riccobene

HISTORY OF CHANGES			
Rev No	*Date*	*Pages*	*Description of changes*
01	11.07	8,12	TAB deployment
		10,11	DU User Ports
02	08.08.22	Entire Doc	NO CB to deploy and test DU1018
		Entire Doc	No DU 31 available
		Entire Doc	DU 05 will be deployed instead
		20	SOE

Frequently Used Technical Abbreviations	
DU	Detector Unit
CB	Calibration Base
TJB	Temporary Junction Box
LOM	Launcher Optical Modules
VEOC	Vertical Electrical Optical Cable
ITF	Interlink Test Frame
SHB	Subsea Hybrid Bridge
CT	Cable Tray
CTF	Cable Termination Frame
JB	Junction Box
IL	Inter Link
HLL	Heavy Lift Line
TAB	Tripod Acoustic Beacon for Long Base Line
ROV	Remote Operated Vehicle
FAD	Fishing Aggregation Device
MEOC	Main Electrical Optical Cable
RP	Reference Point
DOM	Digital Optical Module

1. Document Purpose

Outline the requirements for managing and controlling the deployment, reconnection, and recovery activities.

1.1 Application

All work involving preparation and execution of the operations.

1.2 Performance

- Review
- Define necessary means and activity step by step
- Identify risk
- Evaluate risk

1.3 Responsibility **ROV Supervisor/Survey Supervisor/Back Deck Supervisor**

Ensure that all operations are adequately planned and executed, and that all equipment used on site is according to procedure.

Liaise with all members of the Site Management Team, Supervisors and Subcontractors regarding the planning of the activity.

To ensure that all persons involved in the operation are competent and suitably trained in matters for the operations to be performed.

To ensure that adequate inspection and maintenance of the equipment has been carried out.

2. Risk Management Method

- Overall risk assessment of defined operations
- Specific risk identification
- Reduction of risk to an acceptable level

Operations risk will be assessed against criteria for; Personnel safety, Environment, Assets and Reputation

3. Lifting and Lashing

Lifting to vessel in Malta	**Lifting off vessel in Malta**
INFN Activities	
JB 1 x	Old JB1.1 1 x
String Detection Unit (DU) 2 x	Pallets with LOM 2 x
Cable Tray (CT) 1 x	Cable Tray 1 x
TAB 1 x	Anchor ARCA.0018
Pallets for LOM 2 x	Boxes ARCA.0018 filled
Boxes for ARCA.0018 DOMS	Tower T2003
Pallets extra 2 x	Pallets extra 2 x
Additional activity FOCUS	**Info will be provided through FOCUS**

All equipment is designed to be handled by its main lifting point.

The weight in air of the units is provided in the document *IDMAR Project Document No:KM-PM-19-I*

The equipment shall be boarded and laid on the deck in a position suitable for offshore handling by lifting it through the central lifting point. Soft slings with a capacity of not less than double the weight in air shall be used for lifting. The operator will provide a deck plan prior to lifting and operations.

Once placed on the deck, the equipment shall be secured for sailing by lashing it at the dedicated lashing points at the 4 corners of the structure. The sea fastening shall be done by means of either chains or cargo straps. For each direction (frontward, backward, sideward), the travel fastening slings shall have an SWL of at least two times the mass of the package.

4. Rigging and Deployment

Lifting Point

The main deployment cable HLL shall be linked to the lifting point with a ROV friendly hook. The equipment can be lifted and put overboard by using suitable deck lifting devices. All the items used for the deployment rigging shall have a SWL at least equal to two times the mass of the package in air. During the lifting and the handling offshore, the package must be secured against hitting any part of the ship according to standard good practice.

Heave

The maximum acceptable heave on the hanging point of the sheave used to lift and deploy the pack shall be 1,5 m. The value shall be checked before the beginning of the deployment, to decide if to proceed or not with the operation.

Weather and sea state

The short-term local weather forecast must guarantee at fixed number of hours of stable condition without significant increase in wind force or sea state. The sea state for deployment operations shall not exceed Sea State 2. The weather forecast must be discussed with the INFN Rep prior to operations.

Deployment speed

When below the splash zone the deployment will proceed at a maximum speed not exceeding the value in the table below. During the deployment the tension on the HLL shall be continuously monitored.

Equipment	Lifting Point	Deployment Speed m/s*	Heave+ Waves Meters	Weather window hours	Daylight Operation
DU	Central lifting point on top	(0.3) 0.5	1	12	Yes**
JB	Central lifting point on top	(0.3) 0.5	1	12	No
Tower DU recovery	Central lifting point on top of the anchor. Top buoy and floors are slinged	(0.1) 0.3	1	24	Partly
CT	Central lifting point on top	1	1.5	6	No
CB	Central lifting point on top	(0.3) 0.5	1	12	No
Tripod TAB and RP	Lifting Ring on the side of the structure	1	1.5	6	No

***1 Meter per second is equivalent to 60 meter per minute.**
****The DU can be deployed at night, but the recovery of the LOM is a day light operation. Typically, there are 6 hours between splash DU and recovery LOM**

5. Operations Subsea

5.1 Main Operations

5.1.1 Activities

NB! Removal of FAD in case Fishing Aggregation Devices are found. ROV shall bring adequate tools to cut fishing lines

5.1.2 Main Activities

- **Recover old JB1.1 and deploy new JB1**
- **Deploy Cable Tray (CT) with cables for DU1032 and DU1005 and lay cables**
- **Deploy DU1032 and connect**
- **Deploy DU1005 and connect**

- **Test DU1018 using DU1005 and protect IL1018 with ITF**

- **Recover DU1018**
- **Recover Tower T2003**

5.1.3 Additional Activities

- **Deploy TAB#2**

5.2 General Information

The operations are organized in one trip and in operational blocks. The below sequence is the preferred sequence. However, should there be operational needs, constraints or weather changes, the blocks or parts of blocks can be executed separately and in different order. In coordination with the INFN Rep.

All connector mating and de-mating activities must be performed by experienced ROV operators and the ODI mating instructions must be followed precisely. Also, the ODI Teledyne recommended manipulator shall be used for mating. Prior to every mating activity, both the bulkhead connector and the connector of the flying lead must be inspected and a still picture of the status must be taken. The position of the rolling seals and the flap mating mechanism must be documented and confirmed with the INFN Rep prior to continuing the operation. A low-pressure water jetting device shall be mounted on the ROV to allow water jetting subsea. Every connector shall be cleaned prior to connection.

During the operation it will be necessary to power on and - off structures and sometimes the entire system. This will be clearly communicated by the INFN Rep. However, the ROV operator shall double check prior to touching or connecting a structure what the power status of the structure is to avoid any damage on the ROV or the equipment.

5.3 Sequence of Events

Area around JB1

Recover old JB1.1 and deploy JB1 - N36°17’34,08’’ E015°58’28,43’’

1. **Disconnect the IN Inter Link cable from old JB1 and wet-stow in safe position.** The IL cable shall be removed and stowed in a position at last 15 meters away from the centre of the JB. The cable shall be flown back along the CTF cable line to simplify identification afterwards. Carefull storage is important to avoid mud contaminatiin of the connectors.

2. **Recovery old JB.** The vessel shall position itself to lower the HLL equipped with a ROV friendly hook. The HLL target point is 50m NortWest of the JB1 position. The ROV shall await the HLL to walk the HLL to the position of the JB1 and connect the HLL to recovery sling mounted on top of the unit. The structure is classified REUSE. The JB shall be recovered. Note there are unfurled assets in ther vicinity of the structure. DU1012, 1011, 1010 and Tower T2003

3. **Deployment new JB1** All the tools used for the deployment rigging shall have a SWL at least equal to two times the mass of the JB. The main deployment cable will be linked to the lifting ring using a ROV friendly hook and released by the ROV subsea. When below the splash zone the deployment will proceed at a maximum speed of 0.3 m/s for the first 200 m, after 200m water depth the deployment can be increased to 0.5 m/s. During the deployment the tension on the deployment cable shall be continuously monitored. If slack occurs, the deployment shall be immediately aborted, and the package shall be recovered. The deployment cable shall be paid out at constant speed until the unit will be at 50 m from the seabed. Here the ROV shall take over the package and determine the HLL speed.

4. **Landing:** The ROV shall orientate the JB in a way that the connector panels are orientated logical towards the position of the DU to be connected. The INFN Rep will guide the landing. After touchdown subsea a visual inspection of the unit shall be performed. The HLL shall be recovered.

5. **Connection and Testing.** The CTF IN interlink will now be reconnected to the new JB. The INFN Rep will ensure that the entire system is OFF. No activity shall take place prior to this confirmation. The unit can only be tested after connecting the IL CTF to the CTF.

Deploy CT1

Connection plan JB1

UPI	Position	Type	JB#.UP#	Ch.	Freq.	IL length	ODI PN-SN	Comments
3/DU-A-BEACON:IT/1.64	ARCA.0005	A	JB1.05			150m		Deploy in Sept 2022

1. **Deploy Cable Tray CT1 with cable for 1032 and 1005 at position DU1005** facing JB. ROV to unspool cable IL1005 and position connector on JB1 later connect to connector #UP05 at JB1). ROV to return to CT1 and unspool remaining cable using monkey fist/yale grip to spool remaining cable. Connector to be parked in safe position on seafloor at 10 m distance away from CT1.

   Depending on weather, move HLL to safe position during unspooling or leave connected to CT.

The connector and the coils of the cable are fastened on the cable tray by means of cable ties (capacity 18 lbs). The cable ties shall be broken by the ROV pulling the cable. The ROV shall grab the connector using the monkey fists on the connector end or by its handle and shall begin to move backward by maintaining the Cable Tray in front of it. The correct ROV route must be checked and monitored.

2. **Recover CT1**: After connecting the HLL and a visual conformation that the base has been lifted CT1 shall be lifted at 1 m/s. In case necessary (current) the ship can start moving away from the field in Northwest direction.

NB ! The next step will happen only AFTER connecting the JB1 to the CTF !

Deploy DU 1005 and connect - N36°17'34,96'' E015°58'25,40''

1. **Survey:** The ROV shall dive to the position of the DU1005. Once at nominal position, an area having a radius of 20 meter around shall be surveyed, to verify that no obstacle that could damage the equipment is on the seabed. At the target point for String DU1005 the ROV SV shall decide on a deployment point with the INFN Rep.

2. **Deployment:** All the tools used for the deployment rigging shall have a SWL at least equal to two times the mass of the String DU. The main deployment cable will be linked to the lifting slings through an ROV friendly hook and released by the ROV. When below the splash zone the deployment will proceed at a maximum speed of 0.3 m/s for the first 200 m, after 200m water depth the deployment can be increased to 0.5 m/s. During the deployment the tension on the deployment cable shall be continuously monitored. If slack occurs, the deployment shall be immediately aborted, and the package shall be recovered. The deployment cable shall be paid out at constant speed until the unit will be at 50 m from the seabed. Here the ROV shall take over the package and determine the HLL speed.

3. **Landing:** The ROV shall orientate the DU in a way that the side with the connector panel shall be on a direct line to the JB1. After touching down a visual inspection of the unit shall be performed. Check for all possible items that can jeopardize the unfurling (e.g., a rope disconnected from the anchor, or something odd in the ways the ropes are wrapped on the LOM). Anything extraordinary shall be reported and documented.

4. **Connection and Testing:** The ROV shall pick up the connector IL cable from the wet stow position.

   Prior to this operation INFN Rep will ensure that the entire system is OFF. No activity shall take place prior to this confirmation. The ROV shall pick up the DU end of the IL cable and move to DU position

   In front of the String, the ROV shall perform the following tasks:

   - visually inspect the status of the bulkhead and IL connector
   - flush the bulkhead and IL connector by means of a low-pressure water jetting.
   - plug the connector of the interlink cable on it, until the yellow latching plate on both sides disappears. Maximum mating speed is 2 inch/s. During the plugging operation, the ROV pilot can use the base anchor on the bottom of the connection panel to grab it with the manipulator free from the connector. During the connection attempt the ROV pilot must be very careful, avoid putting the manipulator in contact with the back of the connector housing, otherwise the connector's self-latching mechanism will not work properly.

The same procedure will be performed at the JB side of the Inter Link cable.

INFN will now run a test sequence on the DU to determine the functionality of the structure. The ROV shall fly to a safe distance during POWER on and remain there with a good visual of the structure (5-10m distance)

5. **Unfurling:** After receiving positive feedback from the onshore station at Capo Passero and once the main lifting line has been released from the package and the HLL is at mid-water, the ROV shall activate the release mechanism to unfurl the String DU. The unfurl rope is WHITE. The ROV shall fly to the connector panel at the front of the structure. A ROV friendly white marked sling, approximately 5 meters long is installed on the left side of the structure's connector panel. The ROV shall grab this sling and move into a position facing the left side of the package and pull the release sling in a straight line to activate the release mechanism. As soon as the mechanism is activated the LOM (buoyant) will start to move up unfurling the spooled detector unit. Maintaining a good visual of this is important. Ideally the ROV camera should follow the LOM if possible, to take footage of the unfurling.

6. **Inspection:** Once the String DU is unfurled and the ropes are under tension, the ROV shall perform a visual inspection of the unit. During the travel upwards, the ROV shall fly alongside the String DU recording footage of the Detector Modules in working position.

   To have a visual check of the relative positioning of the vehicle respect to the String DU, the pilots shall take the white Dyneema ropes as reference, which should be well visible. On the overlay both the depth (in meter) and the compass shall be indicated.

   At level of each Module the ROV shall be aligned to the DOM to provide the opportunity to take the heading as reference for each module heading.

7. **Recovery of LOM surface:** Once the line is released, the LOM will float up to the surface and must be recovered onboard. The preferred solution would be by launching a small boat to rig the components and pull them onboard from the crane of the ship. An alternative solution for recovery would be a slow approach with the vessel and to then latch into the LOM with the crane or davit.
   Unfurling must be performed during daylight for a safe recovery of the LOM.

   The LOM is reported to ascent (once unfurling is completed) at a speed of 1 m/s and surfaces roughly one hour after release.

Area around CTF and JB3

The vessel shall take position in the field on top of the CTF. The ROV shall dive to the CTF and take a fix of the structure. This fix will be used as reference for the entire operation and shall be performed every time returning to the field.

Connect JB1 to CTF

The inter link cable of JB1 is currently connected to an ITF right next to the CTF. The ROV shall disconnect the jumper from the ITF and connect it to the CTF at User Port #1. Prior to this operation INFN Rep will ensure that the entire system is OFF. No activity shall take place prior to this confirmation.

In front of the CTF, the ROV shall perform the following tasks:

- visually inspect the status of the bulkhead and IL connector
- flush the bulkhead and IL connector by means of a low-pressure water jetting.
- plug the connector of the interlink cable on it, until the yellow latching plate on both sides disappears. Maximum mating speed is 2 inch/s. During the plugging operation, the ROV pilot can use the base anchor on the bottom of the connection panel to grab it with the manipulator free from the connector. During the connection attempt the ROV pilot must be very careful, avoid putting the manipulator in contact with the back of the connector housing, otherwise the connector's self-latching mechanism will not work properly.

INFN will now run a test sequence on the JB to determine the functionality of the structure. The ROV shall fly to a safe distance during POWER on and remain there with a good visual of the structure (5-10m distance)

Re-Deploy CT1

Connection plan JB3

ARCA.0032	B	JB3.10	310m	Deploy in Sept 2022, LOM refurbished, SFP changed

1. **Deploy Cable Tray CT1 with cable for 1032 at position DU1032** facing JB. ROV to unspool cable IL1032 and connect to connector #UP10 at JB3. ROV to return to CT1 and unspool remaining cable using monkey fist/yale grip to spool remaining cable. Connector to be parked in safe position on seafloor at 10 m distance away from CT1.

   Depending on weather, move HLL to safe position during unspooling or leave it connected to CT.

   The connector and the coils of the cable are fastened on the cable tray by means of cable ties (capacity 18 lbs). The cable ties shall be broken by the ROV pulling the cable. The ROV shall grab the connector using the monkey fists on the connector end or by its handle and shall begin to move backward by maintaining the Cable Tray in front of it. The correct ROV route must be checked and monitored.

2. **Recover CT1**: After connecting the HLL and a visual conformation that the base has been lifted CT1 shall be lifted at 1 m/s. In case necessary (current) the ship can start moving away from the field in Northeast direction.

Deploy DU 1032 and connect - N36°17’49,98’’ E015°58’30,58’’

3. **Survey:** The ROV shall dive to the position of the DU1032. Once at nominal position, an area having a radius of 20 meter around it shall be surveyed, to verify that no obstacle that could damage the equipment is on the seabed. At the target point for String 1032 the ROV SV shall decide on a deployment point with the INFN Rep.

4. **Deployment:** All the tools used for the deployment rigging shall have a SWL at least equal to two times the mass of the String DU. The main deployment cable will be linked to the lifting slings through an ROV friendly hook and released by the ROV. When below the splash zone the deployment will proceed at a maximum speed of 0.3 m/s for the first 200 m, after 200m water depth the deployment can be increased to 0.5 m/s. During the deployment the tension on the deployment cable shall be continuously monitored. If slack occurs, the deployment shall be immediately aborted, and the package shall be recovered. The deployment cable shall be paid out at constant speed until the unit will be at 50 m from the seabed. Here the ROV shall take over the package and determine the HLL speed.

5. **Landing:** The ROV shall orientate the DU in a way that the side with the connector panel shall be on a direct line to the JB3. After touching down a visual inspection of the unit shall be performed. Check for all possible items that can jeopardize the unfurling (e.g., a rope disconnected from the anchor, or something odd in the ways the ropes are wrapped on the LOM). Anything extraordinary shall be reported and documented.

6. **Connection and Testing:** The ROV shall pick up the connector IL cable from the wet stow position.

   Prior to this operation INFN Rep will ensure that the entire system is OFF. No activity shall take place prior to this confirmation. The ROV shall pick up the DU end of the IL cable and move to DU position

   In front of the String, the ROV shall perform the following tasks:

   - visually inspect the status of the bulkhead and IL connector
   - flush the bulkhead and IL connector by means of a low-pressure water jetting.
   - plug the connector of the interlink cable on it, until the yellow latching plate on both sides disappears. Maximum mating speed is 2 inch/s. During the plugging operation, the ROV pilot can use the base anchor on the bottom of the connection panel to grab it with the manipulator free from the connector. During the connection attempt the ROV pilot must be very careful, avoid putting the manipulator in contact with the back of the connector housing, otherwise the connector's self-latching mechanism will not work properly.

   The same procedure will be performed at the JB side of the Inter Link cable.

   INFN will now run a test sequence on the DU to determine the functionality of the structure. The ROV shall fly to a safe distance during POWER on and remain there with a good visual of the structure (5-10m distance)

7. **Unfurling:** After receiving positive feedback from the onshore station at Capo Passero and once the main lifting line has been released from the package and the HLL is at mid-water, the ROV shall activate the release mechanism to unfurl the String DU. The unfurl rope is WHITE. The ROV shall fly to the connector panel at the front of the structure. A ROV friendly white marked sling, approximately 5 meters long is installed on the left side of the structure’s connector panel. The ROV shall grab this

sling and move into a position facing the left side of the package and pull the release sling in a straight line to activate the release mechanism. As soon as the mechanism is activated the LOM (buoyant) will start to move up unfurling the spooled detector unit. Maintaining a good visual of this is important. Ideally the ROV camera should follow the LOM if possible, to take footage of the unfurling.

8. **Inspection:** Once the String DU is unfurled and the ropes are under tension, the ROV shall perform a visual inspection of the unit. During the travel upwards, the ROV shall fly alongside the String DU recording footage of the Detector Modules in working position.

   To have a visual check of the relative positioning of the vehicle respect to the String DU, the pilots shall take the white Dyneema ropes as reference, which should be well visible. On the overlay both the depth (in meter) and the compass shall be indicated.

   At level of each Module the ROV shall be aligned to the DOM to provide the opportunity to take the heading as reference for each Modules heading.

9. **Recovery of LOM surface:** Once the line is released, the LOM will float up to the surface and must be recovered onboard. The preferred solution would be by launching a small boat to rig the components and pull them onboard from the crane of the ship. An alternative solution for recovery would be a slow approach with the vessel and to then latch into the LOM with the crane or davit.
   Unfurling must be performed during daylight for a safe recovery of the LOM.

   The LOM is reported to ascent (once unfurling is completed) at a speed of 1 m/s and surfaces roughly one hour after release.

ITF recovery

After releasing DU1032 and prior to unfurling, the ROV shall fly the HLL over to the ITF at CTF position and hook the ITF to the HLL and recover it. The ITF will be required later during this sea campaign.

Deploy TAB – N36°17’54.636’’ E15°58’32.272’’

Area Southeast of the field DU1018 and T2003

Check DU1018 - N36°17’38,99’’ E015°58’41,92’’

The project is facing communication problems with DU1018. To better assess the challenges the following actions shall be performed.

ROV to fly to DU1018 and perform a survey to assess a possible landing position for DU1005. DU1005 will be used to test the IL1018 In the meantime, the DU shall be rigged and lowered to this position. After landing the DU the ROV shall perform the following tasks:

- unplug the connector from the connector panel at DU0018
- visually inspect the status of the bulkhead and the connector
- plug the connector to the DU1005

A series of tests will be performed on IL1018 and the DU onshore

ROV shall then unplug the connector, wet stow the connector on top of DU1018 and guide the HLL with DU1005 to the position 1005 - **N36°17’34,96’’ E015°58’25,40’’.** The interlink cable has been deployed previously during this sea campaign.

The FUGRO SV and the INFN Rep will decide how to cover the transit and either recover or move the DU subsea.

Deploy ITF

The vessel and ROV shall move back to the position of DU1018, the previously recovered ITF shall be lowered to the position, landed and the inter link cable IL0018 wet stowed on the DU shall be connected to the ITF for protection.

Recover DU1018 - N36°17’38,99’’ E015°58’41,92’’

If all tests with DU1018 show that the DU is faulty. The DU shall be recovered.

1. **Recover DU1018**

   The string base and every part of the structure including the optical modules (DOM) are classified REUSE.

   The dead weight of the HLL line shall be landed in front of the DU bail at the opposite side of the connector panel. The ROV shall then grab the ROV friendly hook and hook the DU anchor to the HLL using the large bail The vessel shall now move to the East and constantly pay out HLL to avoid the HLL headache ball to lift of. When the maximum distance is reached (defined by the ROV umbilical) the HLL shall start to slowly pay in 0.1 m/s, with the vessel maintaining constant speed at 0.2 knot and heading East. The ROV shall provide visual conformation that the base has been lifted. The ROV shall move then into the TMS for safety reason. After the HLL has reached 2500m water depth the ship can adjust the direction to surface current and wind.

   Reaching 1000m to surface with the HLL the ship shall start to adjust the course and steer directly into the wind or surface current at 0.2 knots. The speed of the HLL must be adjusted to this maneuver to reach a point with the ship where the base anchor reaches the water surface, and the entire structure is floating down wind or down current behind the vessel. The vessel shall maintain minimum cruising speed to ensure the structure is lined up behind the ship. In case necessary a RIB can, be lowered to the sea to support the operation.

The actual speed and directions required can only be determined when at site, considering ambient conditions – wind, waves, subsea and surface currents.

The anchor will be recovered onboard and parked on a designated place on the deck first. A safety measure to avoid pressure traps is to stop of 5 minutes at 50 meters water depth before recovering the unit.

The base unit must be washed down with freshwater and no connectors or communication lines shall be disconnected or cut.

Then the recovery of the DOMs, which will be floating on the sea surface, will start. The DOMs will be pulled on board. The ship crew will take care of first handling onboard (which requires a separation of the DOMs and the VEOC from the ropes) before they are passed to a KM3NeT team, who will take care of first inspection, cleaning with fresh water and proper arrangement on a transportation crate.

Such crate will be also used for unloading the DU from the ship as well as for transportation from Malta. The crate is built by putting two sub-crates on top of each other, with the bottom one hosting 10 DOMs and the top one hosting 8 DOMs and the base module. Also the remaining elements of the DU especially the base module shall be separated from the amchor, stored and secured on a pallet attached to the transportation crate.

The last part to be recovered is the top buoy. The buoy will be disconnected from the ropes on the ship and installed on a pallet. At the end of all such activities, therefore the following components will be on the deck and will have to be transported to Malta: an anchor, a box containing ropes and various mechanical components (bars, clips, fixing points of the DOMs to the ropes, etc.), a pallet with the top buoy, a box containing the jumper and a hydrophone, and a crate containing the full DU (i.e., base plus the 18 DOMs, all connected by the VEOC).

Dyneema Spec: Diameter is 5 mm, MBF is 11.8 kN for the rope (tested at 850 kg, safe would be 70% of that)

2. Back deck organization and activities

The ship crew will take the lead during the recovery operation. The back deck crew has a designated crew leader that will give all commands back deck.

All elements of the string except the base anchor are floating.

The structure is made of an anchor, 18 DOMs on top of it and 1 top buoy above the DOMs.
All DOMs are 17" spheres.

Weight of the elements.
- Anchor ~900 kg in air, ~700 kg in water
- DOMs 31 kg in air, 11 kg buoyancy in water
- Top buoy 180 kg and 140 kg buoyancy in water

The distances between components are

- Base anchor first DOM 40 meters
- DOM to DOM 40 meters
- Last DOM to top buoy 10 meters

Together (40+17x40+10) = 730 meters high

INFN will send a team back deck that can support the second stage of the recovery operation; securing and analyzing the recovered unit.

Recover Tower T2003

1. **Survey T2003 – N36°17'34,74'' E015°58'33,85''**

   The ROV shall perform a full survey of T2003. This combined with the weather forecast will determine the final recovery strategy (direction and speed). Right now, the preferred direction out of the field is East. Also, possible FADs must be identified and cut.

   Starting from the base/anchor of the structure and along the Vertical Electrical and Optical Cable (VEOC). At the end of the structure is a top buoy which keeps the structure in place. This buoy must be inspected, and an acoustic beacon shall be attached to the top buoy if possible. Of special interest are any damaged PMT (reduced buoyancy), possible rust and degradation. The anchor structure must be inspected fully and from all angles to understand the state of degradation and possible danger to disintegrate during the recovery attempt.

2. **Recover T2003**

   The Tower base and every part of the structure including the optical modules (DOM) are classified SCRAP.

   The vessel shall position itself to lower the HLL with the recovery backbone. The HLL target point is 50m East of the Tower position. ROV shall grab the HLL and position it next to the tower structure. The tower floors are buoyant. The ROV shall now use the hooks attached to recovery backbone and connect one story after another to the backbone, finishing with the top buoy.

   The ROV shall now cut the Dyneema lines between the 1st floor and the base anchor. Also, the VEOC shall be cut using a hydraulic cutter. The HLL shall now be recovered with the vessel heading to the East with a speed of 0.2 knots. Max recovery speed is 0.3 meter per second.

   The tower base (anchor) must be inspected thoroughly again to assess if it is possible to recover the structure without the danger of elements breaking loose and damaging deployed assets during the recovery. Should the responsible conclude there is a danger during recovery to assets or the vessel, the tower base will remain subsea. A proper risk assessment must be performed and communicated. There is a central lifting point with a lifting ring in the middle of the structure the ROV shall connect the HLL to this lifting ring. In the past it has proven that a sling around the base frame was the preferred way to recover.

Then the HLL shall lift the structure 5 meters to test the integrity of the anchor. In case the lifting test is successful the tower base shall be moved 100m to the East of the field at the same height and under the supervision of the ROV and only then lifted to the surface. This shall ensure a safe distance to the field. The tower base shall be recovered with a max speed of 0.3m per second. The ROV shall move into the TMS for safety reason. After the HLL has reached 2500m water depth the ship can adjust the direction to surface current and wind to minimize stress during recovery, but always away from the field.

The actual speed and directions required can only be determined when at site, considering ambient conditions – wind, waves, subsea and surface currents.

3. Back deck organization and activities

The structure is made of an anchor, 14 storeys and one top buoy. Top buoy and floors are floating in water.

- The base anchor weight in air 3060 kg
- 14 storeys - weight in air 140 kg each, buoyant in water (buoyancy unknown)
- A Top buoy 820 kg, buoyant in water (buoyancy unknown)

The distances between components.

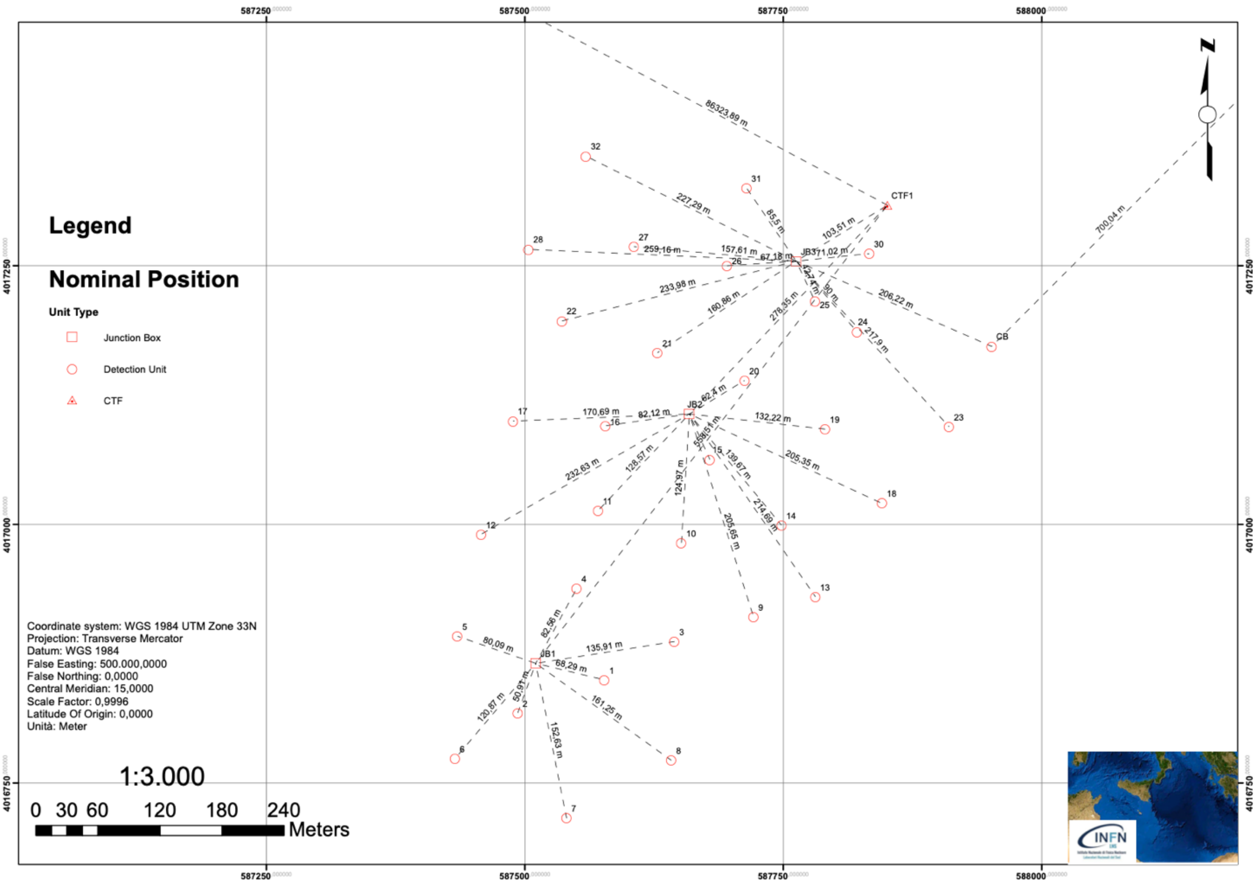
- Base anchor first storey 40 meters
- Storey to storey 20 meters
- Last storey to top buoy 100 meters

Together (40+13x20+100) = 400 meters high

The first part to be recovered is the top buoy.

The ship crew will take the lead during the recovery operation. The back deck crew has a designated crew leader that will give all commands back deck.

6. Annex – INFN detector map



	UTM		WGS84(DMS)		
Unit	Easting	Northing	Longitude	Latitude	Distance from JB(m)
CTF1	587850,810	4017308,510	15° 58' 42,249" E	36° 17' 48,341" N	
JB01	587510,510	4016865,650	15° 58' 28,428" E	36° 17' 34,082" N	
JB02	587659,130	4017106,670	15° 58' 34,483" E	36° 17' 41,854" N	
JB03	587762,550	4017254,440	15° 58' 38,689" E	36° 17' 46,616" N	
DU001	587576,911	4016849,678	15° 58' 31,083" E	36° 17' 33,542" N	68,29
DU002	587493,167	4016817,785	15° 58' 27,713" E	36° 17' 32,534" N	50,91
DU003	587644,779	4016886,729	15° 58' 33,819" E	36° 17' 34,722" N	135,91
DU004	587550,148	4016938,069	15° 58' 30,046" E	36° 17' 36,419" N	82,56
DU005	587434,825	4016891,838	15° 58' 25,404" E	36° 17' 34,956" N	80,09
DU006	587432,387	4016773,421	15° 58' 25,259" E	36° 17' 31,114" N	120,87
DU007	587540,340	4016715,962	15° 58' 29,563" E	36° 17' 29,214" N	152,63
DU008	587641,695	4016771,884	15° 58' 33,649" E	36° 17' 30,996" N	161,25
DU009	587721,118	4016910,588	15° 58' 36,889" E	36° 17' 35,471" N	205,65
DU010	587651,392	4016981,939	15° 58' 34,122" E	36° 17' 37,809" N	124,97
DU011	587570,812	4017013,238	15° 58' 30,905" E	36° 17' 38,851" N	128,57
DU012	587457,660	4016990,365	15° 58' 26,360" E	36° 17' 38,146" N	232,63
DU013	587781,131	4016930,018	15° 58' 39,302" E	36° 17' 36,082" N	214,69
DU014	587748,307	4016999,178	15° 58' 38,014" E	36° 17' 38,337" N	139,67
DU015	587678,916	4017062,728	15° 58' 35,258" E	36° 17' 40,422" N	48,19
DU016	587577,803	4017095,303	15° 58' 31,218" E	36° 17' 41,512" N	82,12
DU017	587488,578	4017099,875	15° 58' 27,643" E	36° 17' 41,690" N	170,69
DU018	587845,434	4017020,301	15° 58' 41,916" E	36° 17' 38,990" N	205,35
DU019	587790,541	4017092,041	15° 58' 39,745" E	36° 17' 41,337" N	132,22
DU020	587712,461	4017139,074	15° 58' 36,634" E	36° 17' 42,888" N	62,40
DU021	587628,281	4017165,855	15° 58' 33,270" E	36° 17' 43,785" N	160,86
DU022	587535,830	4017196,589	15° 58' 29,576" E	36° 17' 44,813" N	233,98
DU023	587910,449	4017094,426	15° 58' 44,553" E	36° 17' 41,375" N	217,90
DU024	587821,282	4017186,244	15° 58' 41,031" E	36° 17' 44,379" N	90,00
DU025	587780,736	4017215,762	15° 58' 39,402" E	36° 17' 45,355" N	42,74
DU026	587695,521	4017249,964	15° 58' 36,000" E	36° 17' 46,492" N	67,18
DU027	587605,570	4017268,566	15° 58' 32,401" E	36° 17' 47,126" N	157,61
DU028	587503,639	4017265,787	15° 58' 28,314" E	36° 17' 47,069" N	259,16
CB	587951,573	4017171,993	15° 58' 46,233" E	36° 17' 43,878" N	206,22
DU030	587833,196	4017261,715	15° 58' 41,524" E	36° 17' 46,829" N	71,02
DU031	587714,409	4017325,099	15° 58' 36,787" E	36° 17' 48,924" N	85,50
DU032	587559,150	4017355,886	15° 58' 30,576" E	36° 17' 49,974" N	227,29
IU	588446,573	4017666,993	15° 59' 6,278" E	36° 17' 59,778" N	700,04

7. Annex Timing: Sequence Of Events M01-2022

Activity	Duration hours	Weather Best = 1 – 2 – 3	Comments
Day 1 – (7th of September)			
Transit to Site	12	3	
Recover JB1	6	3	800A
Deploy new JB#1 and connect	6	2	
Day 2 –			
Connect JB1 to CTF	3	3	Test
Deploy CT1	3	3	
Lay 1st cable CT 1 (05)	6	3	150 m
Recover CT 1	3	3	
Deploy CT 1	3	3	
Lay 2nd cable (32)	3	3	310 m
Day 3 –			
Deploy 1032 recover ITF	6	2	Test 1
Deploy TAB#2	6	3	
Deploy 1005	6	2	At 1018 position
Test IL 1018	3	3	Test IL
Move 1005 to position at JB1	3	3	
Day 4 –			
Connect 1005	3	3	Test 2
Deploy ITF to IL1018	3	3	
Recover 1018	12	2	
Prepare T2003 for recovery	9	3	
Day 5 –			
Recover T2003	24	2	
Day 6 -			
Transit to CT	6	3	
FOCUS	18	2	Recover tripods and OBS
Day 7 –			
FOCUS	18	3	Cont. recover, Inspect MEOC
Transit to Malta	12	3	
Day 8 offload			
EOM			