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Synthesis of Junction Box Quality Assurance for KM3NeT-ARCA Neutrino Detector

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Abstract: The KM3NeT-ARCA neutrino detector is the largest underwater neutrino telescope operating in the Mediterranean Sea at a depth of 3500m, 100 km from the coast of Portopalo di Capo Passero. It is composed of strings anchored in the deep sea and kept vertical using a buoy.

Each string hosts 18 Digital Optical Modules (DOMs), containing 31 optical sensors. The entire telescope, once completed, will be composed of 230 identical strings named Detection Units (DUs) that will send data to shore in real time.

A Junction Box (JB) and an electro-optical cable permit the connection to the shore and the powering of the entire system. Each JB connects to the shore, handling up to12 strings. Therefore, it turns out to be a crucial element that requires precise Quality Assurance rules.

During the phases of the JB project's lifecycle, such as design, manufacturing, assembly, integration, and operation, a strict Management Procedure has been applied.

This article will focus on the Quality Assurance process that has allowed the JB to be a robust and reliable element of the entire KM3NeT-ARCA background network.

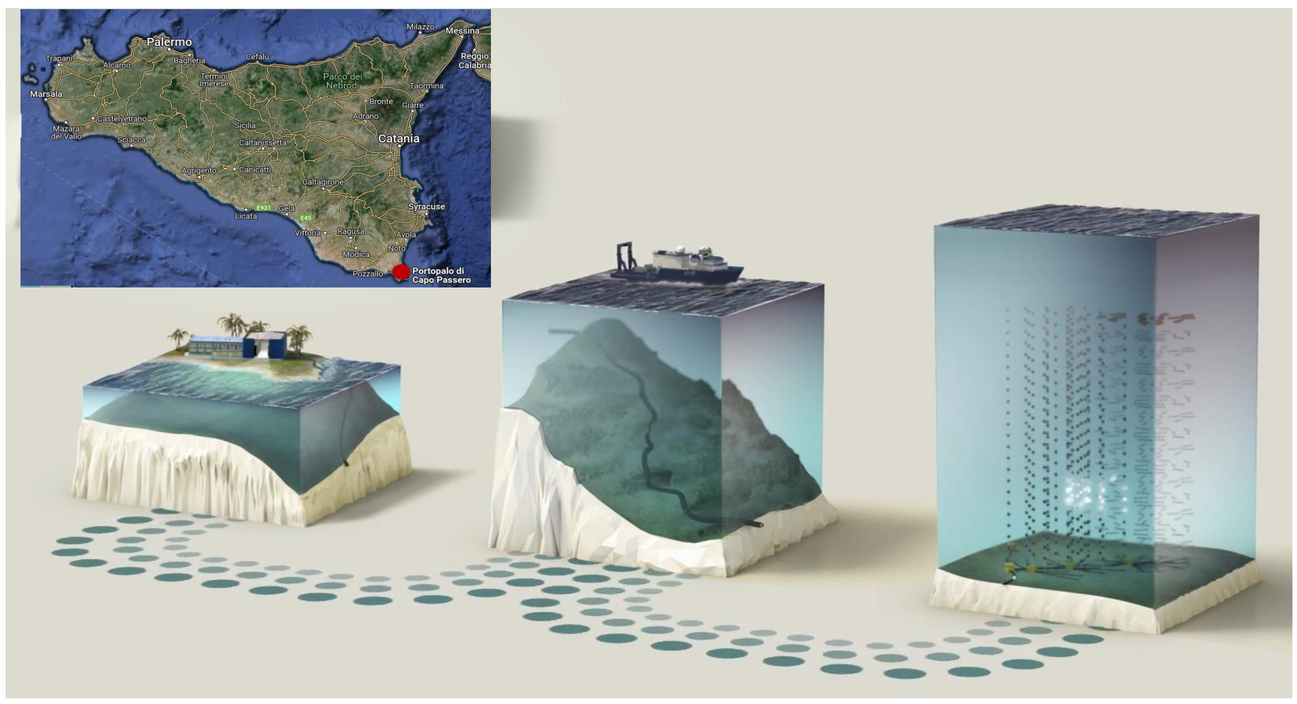


Figure 1: Artistic view of the background network and the KM3NeT underwater neutrino telescope off the coast of Portopalo di Capo Passero in Sicily.

1. KM3NeT

KM3NeT is the biggest array of optical sensors cabled in the deep sea. It is located at 3500 m depth in the Mediterranean Sea and at 100km far by the cost of Portopalo di Capo Passero in Sicily [1]. Two electro-optical (e.o.) cables named MEOC (Main Electrical Optical cable) branch out from the Harbor for 100 km on the bottom of the sea and connect the shore station at the Detection Units (DU) (Fig. 1).
The two e.o. cables end with two primary node named CTF1 (Cable Terminal Frame I) (for phase I) and CTF2 (Cable Terminal Frame II) (for phase II) respectively (the latter will not be the subject of this poster).
The CTF1 host one MVC (Medium Voltage Converter) and five Teledyne ODI Nautilus Rolling Seal bulkhead NRH connectors [2] (Fig. 2). The MVC is provided by ASN [3] and converts the 10 kV to an instrument-friendly 375 V for a 10 kW power. The power converter is housed in a pressure vessel, filled with Fluorinert to facilitate cooling and to reduce voltage clearances [4]. The five bulkhead NRH connectors have a wet mateable flying counterpart that can be connected using a Remote Operable Vehicle (ROV). Moreover, for each of the 5 connectors there are 4 optical fibers for a total of 20 optical fiber on the MEOC traveling towards the shore station and 2 electrical conductors [5-6]. Successively, through 5 interlink cables the CTF1 is connected at 5 Junction Box (JB) which can accommodate up to 12 Detection Units (DUs) (Fig.2) [5].

2. JB Quality Assurance

JB is made up of one titanium vessel high pressure resistant that hosts the active sub-systems, including control and power electronics, and the optical circuits (Fig. 3). 12 Teledyne ODI Nautilus Rolling Seal bulkhead NRH connectors ensure the connection with the DUs through interlink cables. The entire system is built to ensure reliable operation for a period of 20 years. For these reason, High-quality materials are selected, and all the connectors and components meet stringent standards for high reliability [6].
A Documentation Management Procedure has been implemented to defines the rules for managing the JB project documentation: identification,creation,validation,storage,distribution and modification of documents. In particular, the ISO 9000:2015 was established as International Standard for Quality management systems of the fundamentals and vocabulary. And the standard ECSS-M-S-40 was implemented to ensure timely and effective creation, collection, review, delivery, storage and archiving of project information [7]. The redundancy of the different crucial elements of optics and electronics was the most important points to build a robust and reliable system.
Particularly, studies of Failure Rate and Reliability have been required. Different reports have been collected to provide the preliminary reliability figures of the system. The reliability analysis has been performed through the following elements: Reliability Block Diagram definition, Evaluation of failure rate of each block of the Reliability Block Diagram, Failure rate (FIT) and Probability of success.

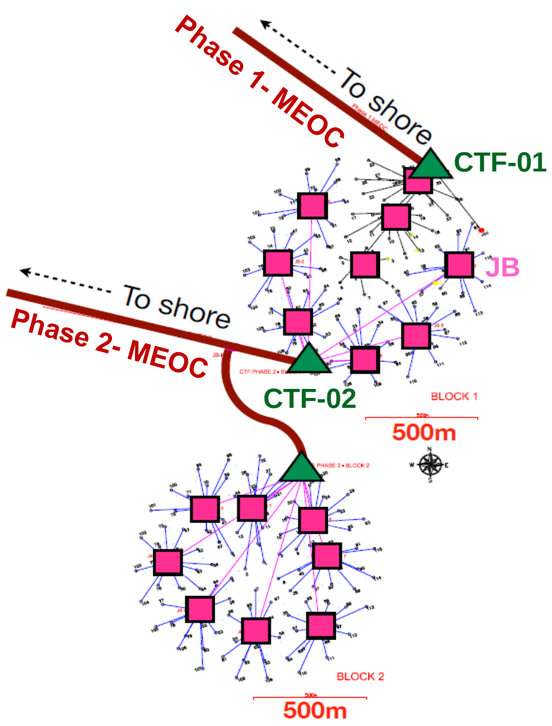
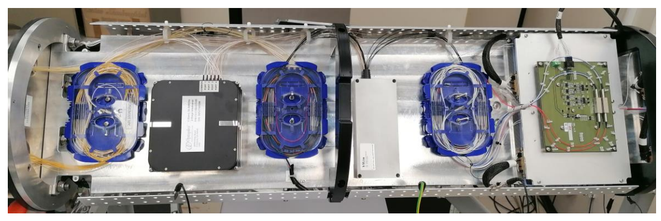


Figure 2: The shore station at Portopalo di Capo Passero (top left). Cable Terminal Frame I (CTF) (down left). Layout of the KM3NeT-ARCA *b*ackground network: the red lines *indicate the two e.o. cable; the green triangular the two CTF and the pink boxes the JBs; the dots the Detection Units; the blue and pink lines are the interlink cables (right) [5].*

3 Conclusions

Thanks to the Quality Assurance and Quality Control process adopted, the system is very reliable for the operating lifetime.



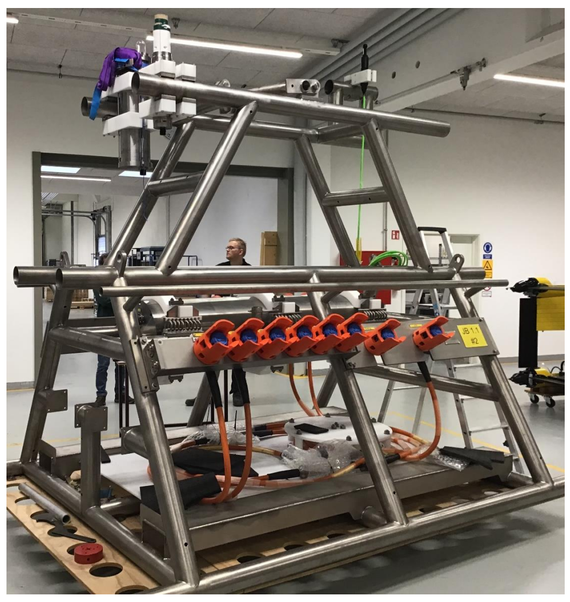


Figure 3: Pictures of the external and internal part of the Junction box (optical part and electronic part).

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