Underwater mateable electro-optical connectors: the feedback from Antares

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Abstract

Underwater mateable electro-optical connectors operated by a submarine or a ROV are key components for present and future seabed detectors. After a test, Antares selected a type of connector from the Ocean Design (ODI) Company. The use of this device was not fully successful and it is considered today as the most critical part of the detector. Possible improvements in the use of this connector are suggested.

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1. Introduction

Antares is a cosmic neutrino detector located on the bottom of the Mediterranean Sea, under more than 2000m of water, off the French Provence coast. The detector is connected to the shore by a 40 km long telecommunication type cable ending by a Junction Box (JB). This device itself is connected to 12 detection strings. The JB has a total of 16 connection ports available. The link between the JB and each of the string anchors is made by a cable (2 electrical conductors + 4 single mode optical fibers) equipped at both ends by a pair of underwater mateable connector. The connection is performed by a Remote Operated Vehicle (ROV). This paper will summarize the experience gained in Antares with this key equipment.

2. The Antares interconnection system

The complete configuration of the link is illustrated schematically in fig.1. It includes the cable called jumper between the Junction Box (JB) and the first connector socket, another between the string anchor electronics container and the second connector socket and the interlink cable terminated at each end by a 'plug'. The sockets are located in a position convenient for the ROV and for the automatic release system of the string.

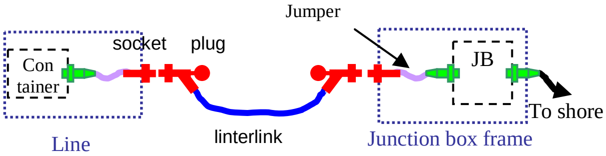

Fig.1

The 12 links needed in the detector have the following specifications:

- an operating depth of 2500m;
- a length between 120 and 350m;
- 2 power conductors for 500 VAC, 2.5A and 3mm^2 section each ;
- 2 single mode optical fibers for slow control and data transmission (8 x 1Gbit/s Ethernet DWDM, unidirectional);
- 2 redundant single mode optical fibers for clock distribution (bidirectional);
- optical losses less than 2dB on each channel;
- Each of the 16 outputs of the JB are electrically protected by an electro-magnetic breaker in the JB operated remotely from the shore station *via* three redundant control systems.

3. Connector selection

Two connectors were tested:

- the Hydrastar from Seacon Company,
- the MKII from ODI Company.

The tests include static pressure tests, connections under pressure, vibrations, temperature and thermal chocks. The Seacon connectors had oil leaks, so Antares chose the MKII from ODI Company.

4. Link connection

The interlink cable is initially stored on a drum equipped by an acoustic transponder-release. The connection procedure is the following:

- a surface boat launches the drum on the seabed, close to the site;
- thanks to the acoustic transponder, the ROV recovers the drum and place it in front of the JB;
- the ROV performs the connection on the JB side;
- the optical and electrical connection from the shore station are checked : the optics by a reflectometer and the electric test by reading the capacitive AC current measured inside the JB;
- In case of success, the ROV unrolls the drum up to the string anchor;
- The ROV performs the connection on the string side;

- The string is fully tested from the shore station.
- Thanks to the acoustic release of a deadweight, the empty drum reaches automatically the surface and is recovered

5. The ODI connector

The ODI connector is composed by a socket and a plug as shown in the fig.2. Both socket and plug are oil filled vessels in equipressure, closed by an aperture system called the “rollers”. During the first phase of the connection, the rollers rotate in such a way that both oil vessels communicate by a set of holes (one hole per fiber or contact). During the second phase, the fiber supports and the electrodes of the socket penetrate through these holes inside the plug and establish the optical or electrical contact. Then, a mechanical locking system keeps both parts in this position.

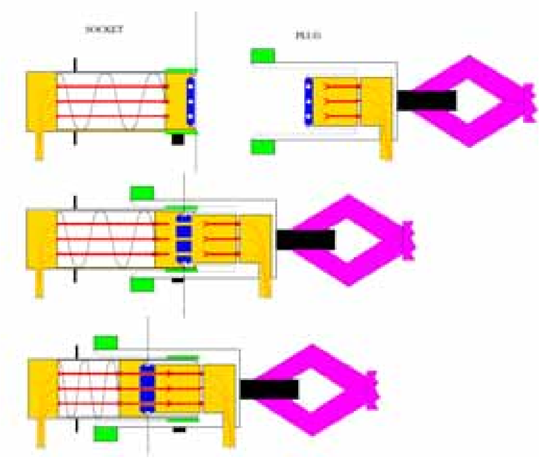

Fig.2

6. The Antares experience of connections

16 strings were connected by Antares, including prototypes. On the string anchor side, there was only one problem of connection while, on the JB side, 5 of the 16 connections made problems:

- In one case, both parts of the connector were mechanically damaged after some mate and de-mate operations. This was clearly observed via the video camera of the ROV. The link cable was recovered on the surface boat by the ROV and shipped to the manufacture which could not explain the damage observed.
- In two cases, the breaker of the JB trips at any attempt to put the socket under tension, meaning that the sockets are in short circuit. A possible explanation is that the oil was (at least partly) replaced by sea water.
- In a case the power was successfully connected but the attenuation of the fiber(s) was unacceptably large.
- In the last case, a mechanical part of the socket (a plastic ring used to center the plug with respect to the socket) was removed by the attempt of connection. In principle this socket could be repaired by the ROV but, until now, several attempts of repair failed.

7. Conclusion

Why are our connection problems only on the JB side?

- A possible explanation should be that, on this side, there is no mechanical guide helping the connection while, on the string anchor side, such a guide exists as part of the automatic disconnection system.
- Another explanation could be the difference in time spent in the water by the sockets before the connection: four to six years for the JB and only a few months for the string. Some absorption of water by plastic components could result in a mismatch of diameters, making the mating impossible. Or the deposit of sediments in the rear cavity of the JB socket (deposit which was observed when

the ROV cleaned this part with a water jet) could disturb the mechanism.

It is clear that these connectors are the most critical part of the Antares detector. The recommendations for a future detector are:

- for long term stay on the sea bed before connection, the socket must be protected against the sediments by a convenient protection cap, closing also the rear cavity, not by the basic cap used by Antares nor with the (expansive) connector-like protection proposed by ODI,
- modify the conception of the link and the JB in such a way that there is only one connector per link (i.e. mount the links and their drums on the JB or on the string anchors), which will reduce also the cost,
- train the pilots of the ROV to connections
- improve the reliability of the connector itself.