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Modular nodes: Design and development of a novel mechanism which enables the repair of individual underwater components in IMS hydrophone stations

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POSTER

P1.3-270

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ABSTRACT

The six hydroacoustic hydrophone stations within the CTBTO's International Monitoring System comprise a total of 11 triplets. These triplets have a 20-year design life with no scheduled underwater segment maintenance actions and are based on a linear non-modular design which offers the advantages of high reliability and efficient deployment in one continuous operation. However, a triplet employing modular components and Wet-Mate Connectors (WMC) has an advantage in that replacement of a failed component(s) in-situ becomes possible without disturbing the remaining functional system components, or requiring replacement of the entire triplet. For these reasons a modular design triplet that maintains the efficient deployment of a non-modular linear system has been investigated. A critical component that has been developed is a latch mechanism that secures the cable terminations to the node structure. This isolates the WMC plug and the cable from the deployment stress which they are otherwise unable to sustain. After deployment, the latch can be opened; should a repair then become necessary, detachment of the cable and termination can be undertaken by an ROV. The design principles, the status of fabrication and testing of the modular cable latch are presented, along with the envisaged development of a prototype.

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INTRODUCTION

- In all IMS hydrophone stations to remedy the failure of a node component or a near-node cable requires replacing the entire triplet. This is a complex, time consuming and costly operation.
- In most Ocean Observatories, modular technology that employs Wet-Mate Connectors (WMC) enables *in-situ* replacement of failed components underwater.
- However, WMC's are not made to resist the high mechanical loads during the linear deployment of the IMS hydrophone stations.
- To support WMC modularity during linear IMS station deployment, a Hybrid mechanism is developed which enables detaching seafloor cables from the node after deployment.
- This ePoster presents the first prototype of such a mechanism, referred to as "Latch", and discusses the status of its development, testing and further steps towards development of an operational model.

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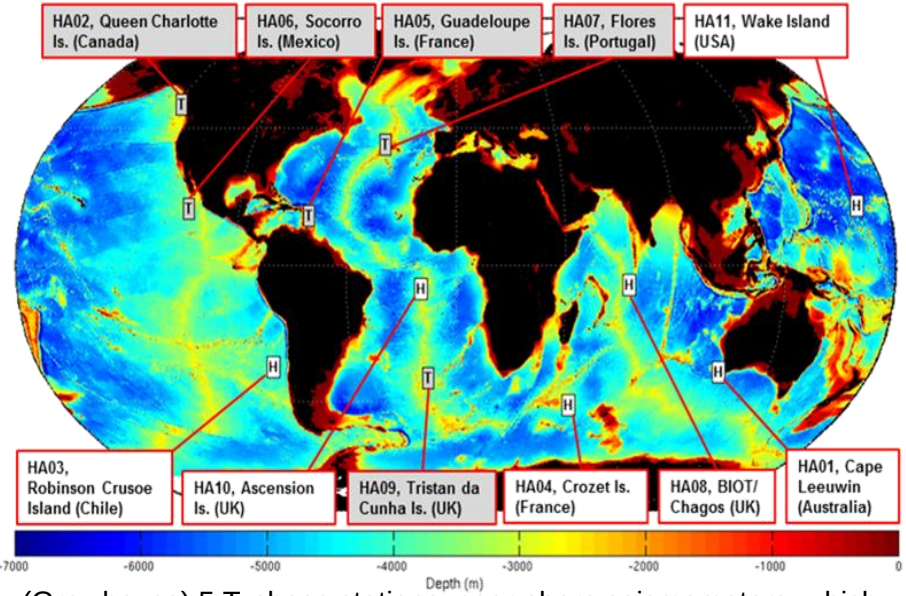
The IMS HA Network



- (Grey boxes) 5 T-phase stations: near-shore seismometers, which record waterborne hydroacoustic waves coupled upslope into the earth's crust.
- **(White boxes) 6 Hydrophone stations (11 triplets): moored hydrophones pick up hydroacoustic waves in the water column.**

Hydrophone Station		Water depth (m)	Hydrophone depth (m)
HA01	**W**	**1550**	**1100**
HA03	**N**	**1866**	**824**
	S	**2071**	**830**
HA04	**N**	**1310**	**541**
	S	**1309**	**535**
HA08	**N**	**2300**	**1250**
	S	**1800**	**1350**
HA10	**N**	**2000**	**850**
	S	**1700**	**850**
HA11	**N**	**1400**	**750**
	S	**1150**	**750**

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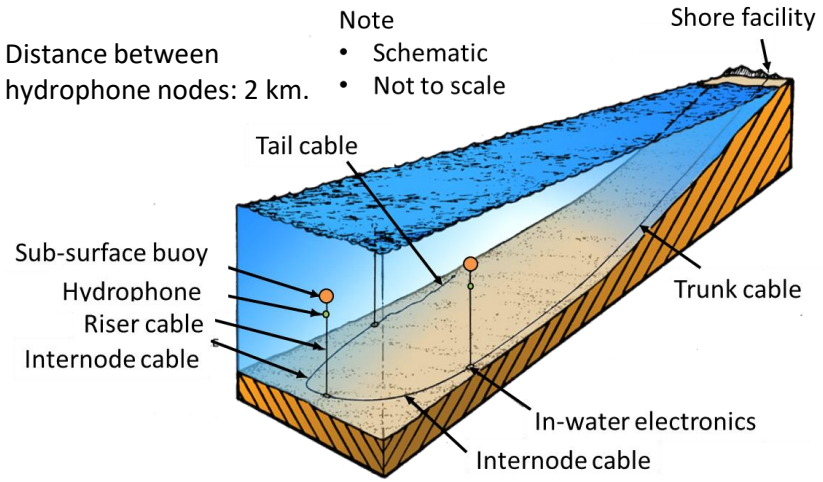
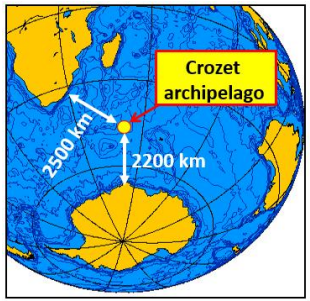
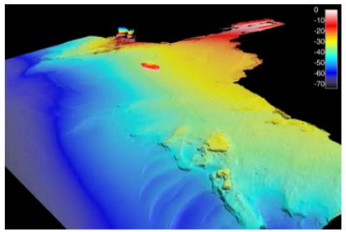
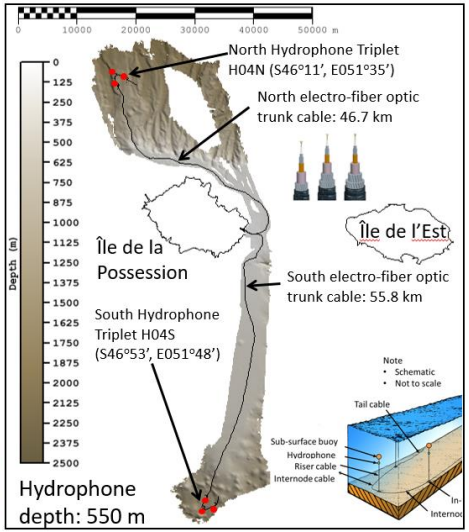
Schematic of a linear (non-modular) IMS HA Underwater System (UWS)



Example: IMS HA Hydrophone station HA04







- Present linear non-modular system is deployed from a ship in one contiguous operation, with the seafloor cables (trunk or internode cable) bearing the deployment stresses: ***reliable, efficient & proven***.
- However, ***sustainment*** to remedy failure of any triplet component, internode cable, or trunk cable out ~ 1.5 water depths from the most shoreward node requires removal and replacement of the entire triplet: ***costly & complex***.

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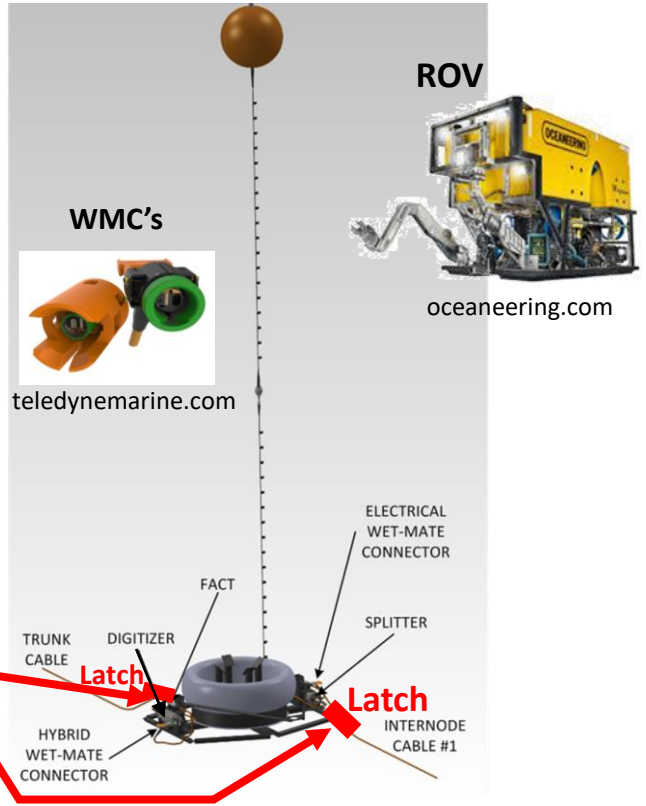
- **Hybrid Modular HA node,** all components attached on a common load-transfer frame:
  - Triplet is deployable in one continuous string, like the present HA triplets.
  - A modular version of the current linear triplet topology, as key components are connected by Wet-Mate Connector (WMC) to enable individual node and component-level reparability.
  - No Remotely Operated Vehicle (ROV) required for first installation. Proven linear deployment.
  - ROV required for repair.
  - Possibility to augment with additional scientific equipment (*e.g.* seismometers).
- **Latch** Mechanism is required to enable full modularity of the hybrid node whilst maintaining proven continuous linear triplet deployment:
  - Capable of fixing temporarily the seafloor (trunk and internode) cables and their terminations to the node base, protecting the **WMC's which connect the seafloor cables to the node** from the high deployment loads (several tonnes).
  - Capable of opening up after deployment, freeing the seafloor cables and their terminations from the node, so that they can be **disconnected at the WMC** by ROV.



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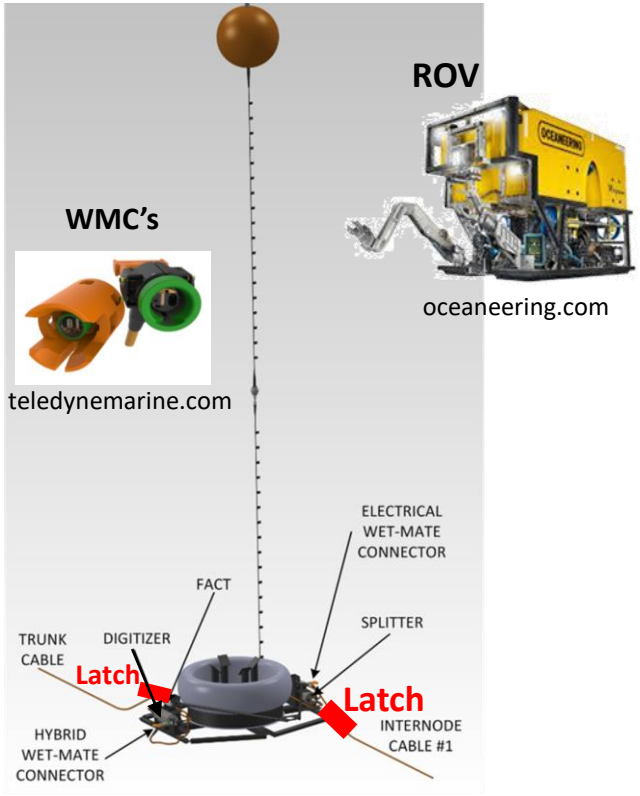
- **The Latch mechanism enables full modularity of the hybrid HA node after deployment by:**
  - *Node-level replacement*. Disconnecting intact seafloor (trunk/internode) cables from the node using an ROV, so that the failed node can be recovered (if required) and the intact seafloor cables can be reconnected by ROV to a replacement node which is lowered from the ship.
  - *Disconnection of failed seafloor (trunk or internode) cable* from the node using ROV, and reconnection by ROV of a repaired or new seafloor cable.
- Therefore, the Latch enables node-level modularity whilst maintaining the proven continuous linear triplet deployment.
- Component-level modularity (*e.g.* Digitizer replacement) is possible by dedicated WMC's connecting the component to the node.



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CONCLUSIONS

- Development of the first prototype mechanism (“Latch”) that protects WMC’s during linear deployments of IMS stations but also allows modularity during repairs.
- The Latch was designed, fabricated and opening/closing functionality tested underwater in a laboratory environment.
- Possible next steps include: (i) integration with a cable and WMC, (ii) extensive tension stress testing in the laboratory and (iii) ROV manipulation tests underwater.