The sustainment of the IMS Hydrophone Hydroacoustic Network of the CTBT

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POSTER

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ABSTRACT

Hydroacoustics is the only verification technology of the International Monitoring System (IMS) of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) to be fully certified. Five T-phase stations and six hydrophone-based hydroacoustic stations monitor the world oceans 24/7 for signs of nuclear explosions. Hydrophone stations comprise triplets of underwater microphones, called hydrophones, suspended hundreds of meters below the sea surface and cabled to shore with electro-optical cables, providing near real-time hydroacoustic data to the International Data Centre in Vienna, Austria. Installing the six hydrophone-based hydroacoustic stations in some of the most remote places on the planet constituted a major engineering accomplishment – sustaining or repairing them turns out to be equally, if not more, challenging.

Failure causes include natural phenomena, such as underwater landslides which damage underwater segments of cables, degradation of cable protective material in the near-shore areas, and obsolescence or malfunctioning of shore equipment. This poster summarizes the on-going sustainment projects of the IMS hydrophone hydroacoustic network though re-establishment solutions of damaged sections, risk mitigation studies and external aggression protective measures, innovative modular solutions for easy of repair of underwater components and enhanced resilience together with protective measures for onshore electronics.

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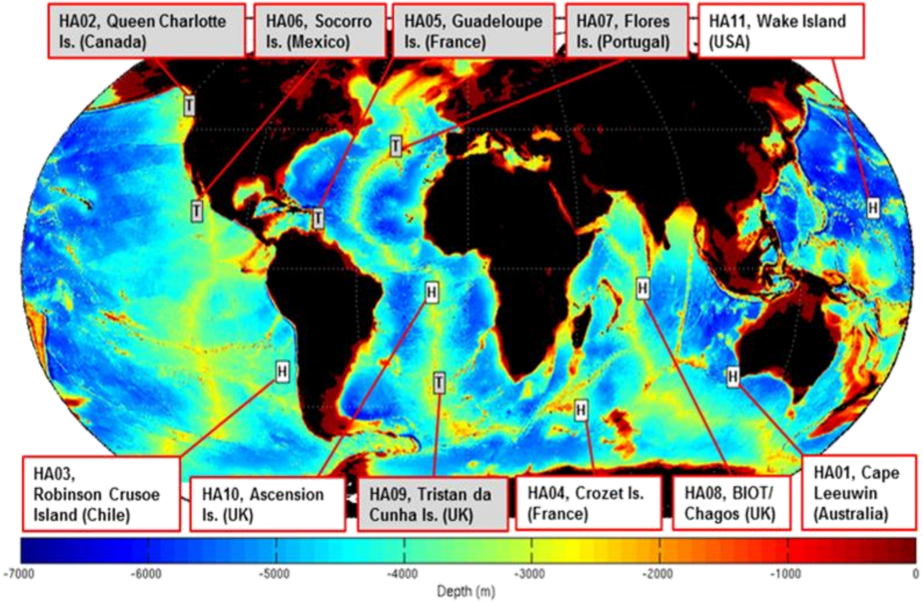
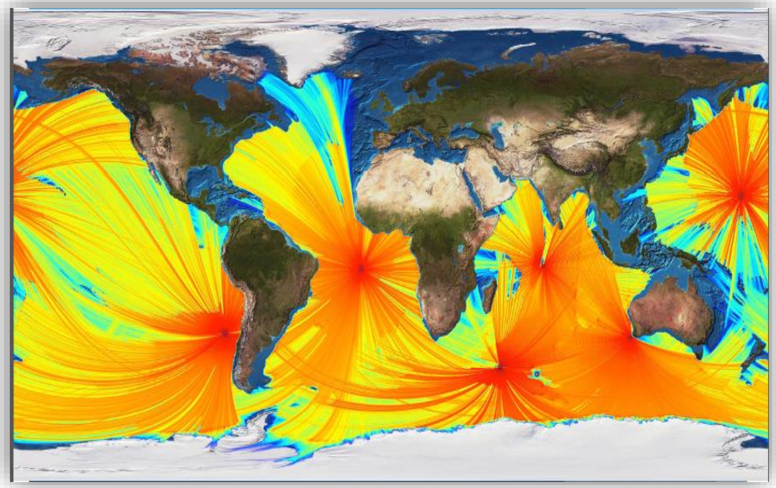
CTBTO PREPARATORY COMMISSION

INTRODUCTION



- (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: moored hydrophones pick up hydroacoustic waves in the water column.

The IMS Hydroacoustic Network



Acoustic coverage provided by the IMS HA hydrophone stations

(K.D. Heaney, R.L. Campbell (OASIS Inc., USA), presented at International Hydroacoustics Workshop, CTBTO, (June 2015).)

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METHODS

Key Drivers: - condition of equipment
- technological obsolescence/advancements

Methodology:

Three distinct components of a Hydroacoustic Hydrophone station – treated differently

Component	Methodology	Notes
Under-water cable and triplet	- run-to-failure (failure meaning when the station becomes incapable of providing useful data) - Hybrid modular design	Current experience and SoH factors indicates that its lifetime most likely will exceed 20 years Cost of replacement expensive, so wish to maximize use of current assets
Near-shore cable and cable landing	- Inspections on a 3-5 year cycle – more frequent as necessary - Repair as required	Cable in the near-shore is the most subject to rough conditions. Inspect, repair/replace extends the life of the full UWS
Central Recording Facility	- Frequent inspections by SO and repairs undertaken - Technological refresh of computer hardware and software	Regular inspections, repairs and technological upgrades extends its life

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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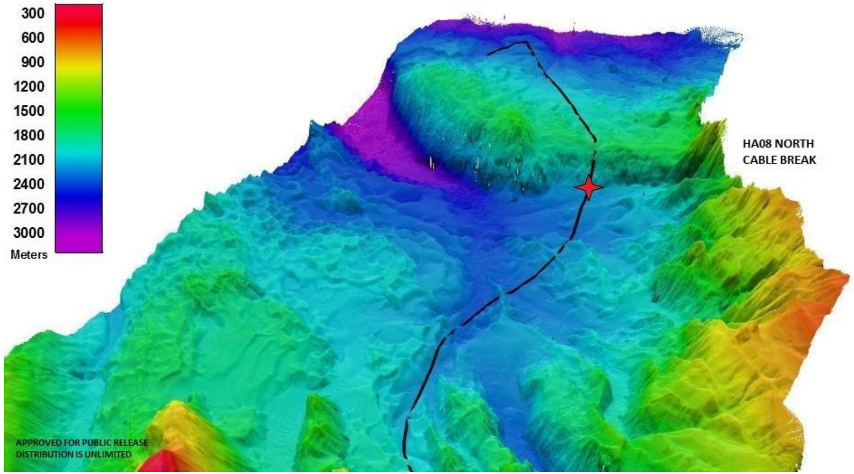
Hydroacoustic Station HA08, Diego Garcia, BIOT/Chagos Archipelago, UK (operated by the USA)



Detail of the undersea topography in the area of the H08N cable break (marked by a red star). The black line shows the route of the hydroacoustic station fibre-optic trunk cable. The colour-scale represents the water depth. Undersea terrain model from US Naval Oceanographic Office.

The Hydroacoustic Station, HA08 at Diego Garcia was **installed in the year 2000** and worked flawlessly until March 2014 when the H08N segment stopped operating due to a cable fault localized at about 190 km from Diego Garcia shore.

The IMS/ED hydroacoustics team has conducted a thorough investigation into a viable solution for the damaged north segment of HA08, in conjunction with the independent experts.

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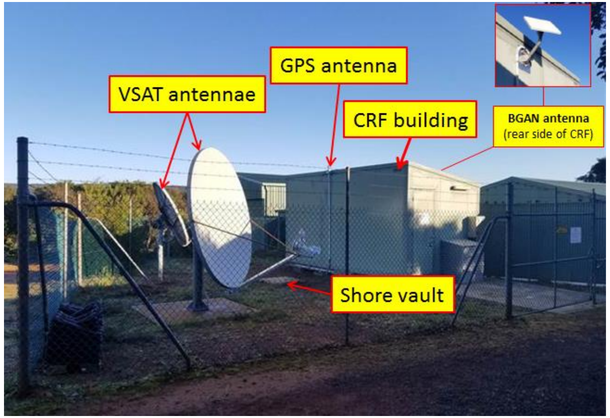
Hydroacoustic Station HA01, Cape Leeuwin, Australia [see also ePoster P4.4-323]

The nearshore cable inspections conducted in 2018 and 2019 identified failing cast iron split pipe protection in the very nearshore. This section of split pipe being subject to highly energetic surf action, dynamic sand movements and accelerated corrosion.

IMS/ED has identified two options for cable sustainment:
a) Replace the failing nearshore cable with the application of new split pipe protection.
b) Replace the failing nearshore cable using a Horizontal Directional Drilling approach

Nearshore split pipe cable protection inspection



As more frequent and strong lightning strikes were observed in the vicinity of the HA01 CRF, the CRF will be upgraded with a lightning protection system in-line with the CTBTO best practices. The figure above shows the HA01 CRF.

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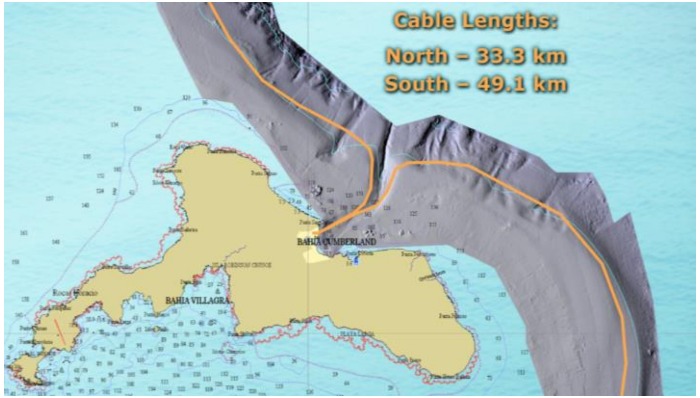
Hydroacoustic Station HA03, Robinson Crusoe Island, Juan Fernandez Archipelago, Chile



The seas in the Bay are highly energetic and particularly in the surf zone the split pipe protection is exposed to high dynamic loads. Consequently, these shallower sections of spilt pipe, up to a depth of ~30m, should be routinely inspected for damage by divers and remedial actions undertaken as required.

The nearshore cable at HA03 is exposed to anchor damage risk from fishing, cruise ships, and cargo ships operating in and around Cumberland Bay. A navigational marker buoy equipped with a flashing light is deployed to mark the cable route to mitigate the risk of ships accidentally damaging the cable. The buoy and its moorings should be maintained on a regular basis.

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Modular design – Next generation sustainable hydroacoustic stations [see also ePoster P1.3-270]

METHODS

- Modular Design Studies conducted jointly with Independent Experts (IE) to enhance IMS HA Station Sustainability:
  - Maintain the current linear, all-connected, sequential and robust deployment method

  while
  - Enabling replacement of failed IMS HA Node Components without replacing the entire Underwater System Triplet.
- Proposed solution: Hybrid-Modular design of a Node component, called the Modular Latch, that incorporates underwater wet-mate connectors able to be plugged/un-plugged directly underwater using a Remotely Operated Vehicle (ROV)

ROV's are equipped with suitable robotic arms, which can enact an underwater repair by disconnecting failed components and replacing them with new ones.

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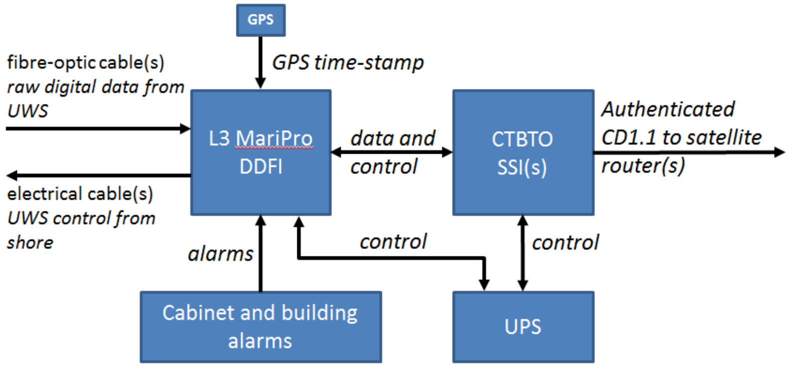
Enhanced resilience of the cabled HA station CRF electronics [see also ePoster P4.3-267]

METHODS



A schematic of the data-flow in the CRF of a cabled HA station.

Presently, this system remains vulnerable to data loss in the case of SSI malfunction, issues with the CRF network, satellite link or GPS Week Number RollOver (WNRO).

On-going upgrade of CRF electronics:

- upgraded DDFI to continuously save in a local buffer all UWS data and DDFI diagnostic information

- enhance the capability of the DDFI's and HA SSI's, in order to allow remote access to this local buffer

- upgrade SSI/processing to temporary mediate (patch) unforeseen GPS rollover issues and in the medium term upgrade DDFIs' software (and GPS receivers where needed) to become resilient to future WNRO's.

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RESULTS

- Surveys, inspections, enhancements and repairs to the hydroacoustic network are being undertaken/scheduled with the intent to maximize station availability – major projects related to HA01, HA03, HA04 and HA08 are in the pipeline for the upcoming strategic planning cycle
- A novel modular design solution to facilitate individual underwater component replacement is under evaluation and testing
- Improved HA station CRF electronics are of paramount importance to safeguard data availability, thus supported by ongoing enhanced capability actions

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CONCLUSIONS

- The IMS hydroacoustic network is unique in a global scale in terms of
  - Operational readiness level
  - Spatial and temporal coverage of the Oceans
  - Data sharing
- The safeguarding of its operability and the protect this extraordinary investment requires
  - Maintaining the periodic sustainment schedule to avoid failures, especially in the nearshore underwear segment
  - Stay abreast of new technologies and concepts to facilitate resilience and curb maintenance costs
  - Preserving a wide range of technical skills to protect this multi-faceted network and preserve high data availability.