2025 February Deployment and Emergency Recovery of unit_1024 1024-20250224

Summary

The Ecosystem Science Division (ESD) at the Southwest Fisheries Science Center (SWFSC) deployed glider “unit_1024” on February 24, 2025 approximately 22 km west of Mission Bay in San Diego, CA (32º45.47’ N, 117º29.27’ W) (Figure 1). This glider was deployed in conjunction with Teledyne Webb Research from the vessel R/V *Benthic Cat*. The main objective of this deployment was to test two new sensors: a photosynthetically active radiation (PAR) sensor (Biospherical Instruments) and a passive acoustic monitor (“Wispr”, Embedded Ocean Systems). The glider was programmed to fly approximately 70 km north between 9-Mile Bank and Del Mar Steeples toward Oceanside Harbor. However, 36 hours after deployment (9:54 p.m. PST February 26, 6:54 a.m. UTC February 27), approximately 25 km due west of Point La Jolla, the glider aborted its mission for a leak in the aft section. Because the voltage across the leakdetect sensor remained low and continued to decline after the initial abort, we determined that the leak was real and let the glider drift at the surface overnight. Although the leakdetect value returned to normal (~2.5 V) after approximately 5 hours, we decided to move forward with an emergency recovery.

Prior to the leak, the glider traveled a total of 29.74 km while performing 29 dives to a maximum depth of 600 m.

This glider was ballasted, sealed, and tested by the Teledyne Glider Training class between February 17 and 21, 2025.

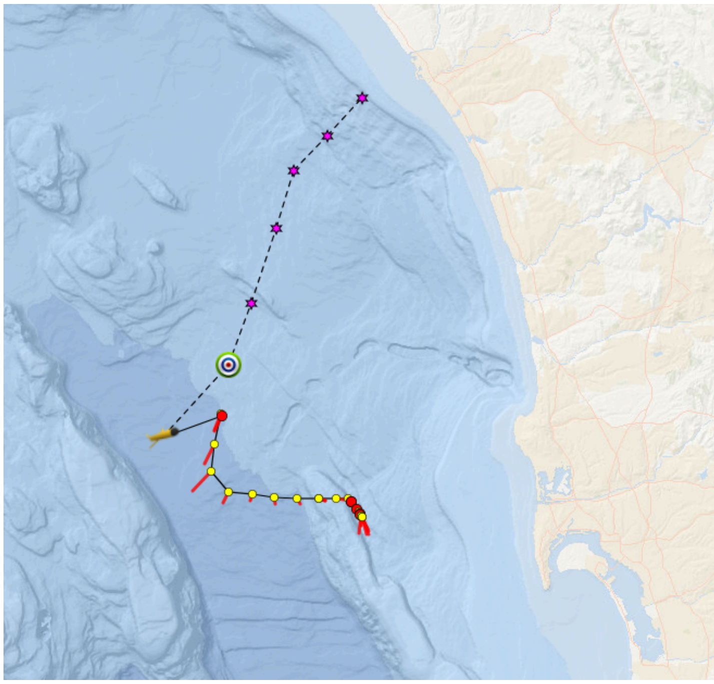

Figure 1. Path of “unit_1024.” unit_1024 was deployed 22 km west of Mission Bay, San Diego, CA on February 24, 2025. The glider flew a path west from the initial deployment location and was headed north toward Oceanside, CA, when it aborted its mission for a leak in the aft section. The glider drifted southwest overnight and was recovered on February 26, 2025 by the F/V *Outer Limits*. Yellow dots indicate where the glider surfaced throughout its deployment, red dots indicate points where the glider aborted its mission, and the bullseye represents the glider’s next waypoint.

Introduction

The Ecosystem Science Division at NOAA Fisheries’ Southwest Fisheries Science Center monitors the living marine resources within the Southern Ocean and the California Current in order to satisfy the requirements of several legislative mandates to provide management advice. To achieve this goal, we use autonomous underwater buoyancy-driven gliders with integrated sensors for measuring ocean conditions, plankton densities, and marine mammal distributions.

Depending on the specific deployment objective, gliders are equipped with a suite of sensors. We obtain acoustic estimates of zooplankton density (primarily Antarctic krill in the Southern Ocean) using one of two different echosounders: an Acoustic Zooplankton Fish Profiler with discrete frequencies at 67.5 and 125 kHz (AZFP, ASL, Inc) and a mini-Signature 100 wideband echosounder with continuous frequencies between 70 and 120 kHz (Nortek). We also collect ancillary oceanographic data (temperature, salinity, dissolved oxygen, chlorophyll, colored dissolved organic matter, backscatter, and photosynthetically active radiation) to characterize the marine environment. Additional sensors may include passive acoustic monitors for marine mammal detection (“Wispr”, Embedded Ocean Systems; digital acoustic monitoring “DMON”, Woods Hole Oceanographic Institution), “glidercams” for verifying acoustic targets (Williamson and Associates, Inc.) and shadowgraph cameras for obtaining imagery of the plankton community (Williamson and Associates, Inc.). Imagery is used to train artificial intelligence (AI) models to automate plankton identification.

Pre-deployment preparation and testing

Prior to deployment, the ESD has a standard protocol for preparing and testing gliders to minimize or eliminate issues that may occur due to human error during deployment. (NOTE: This glider was prepared and tested by the Teledyne Webb Glider Training class held at the Southwest Fisheries Science Center from February 17 - 21, 2025.)

1. Gliders are properly ballasted (i.e., weighted) so that the density of the glider matches the density of the water in which it will be deployed. Weight and flotation configurations are documented
2. The junctions between glider sections are thoroughly cleaned, old o-rings are discarded, new o-rings are inspected for damage that may compromise their ability to form a water-tight seal, new o-rings are properly lubricated, and the glider is sealed together. All cable connections are photographed to document the “final seal” and ensure the glider was reassembled properly
3. A “Functional Checkout” is performed to ensure and document that all glider systems and science sensors are functioning properly. During the Functional Checkout, we verify the battery type installed in the glider (lithium primary or lithium rechargeable) and that the appropriate battery duration (total coulomb amp hours) is active in the glider’s autoexec.mi file
4. Two test missions are performed in the SWFSC test tank (20 m x 10 m x 10 m) to ensure the glider is performing as expected
5. Once per year, glider compasses are calibrated (as this was this glider’s first deployment, we did not calibrate the compass prior to this deployment)
6. Biofouling prevention measures are applied as necessary
7. Glider flight and science sampling files are prepared according to mission objectives. These objectives are identified by the Principal Investigators for each deployment. Files are uploaded to the Teledyne Webb Research Slocum Fleet Mission Control (SFMC) web interface and sent to the glider just prior to deployment over the Iridium connection
8. When gliders are shipped to their deployment location, ESD glider technicians perform a second Functional Checkout to ensure the gliders function properly after transit

All glider flight and science sampling files, as well as metadata specific to each deployment, are maintained on the Google Cloud Platform as part of ESD’s effort to house and organize large datasets. A summary of science sampling strategies for this deployment can be found in Table 1.

File name	Sensor	Serial no.	State to sample	Depth to sample
sample01.ma	Sea-Bird Conductivity Temperature Depth (CTD) (SBE-41)	9807	Diving, hovering, climbing	1000 m
sample48.ma	Sea-Bird ECO Puck (backscattering and fluorescence measurements) (FLBBCD-SLC, CDOM)	8411	Diving, hovering, climbing	1000 m
sample56.ma	Photosynthetically active radiation (PAR) sensor (Biospherical Instruments)	50430	Diving, hovering, climbing	1000 m
sample93.ma	"Wispr" passive acoustic monitor with hydrophone (Embedded Ocean Systems)	Wispr: WR2; hydrophone: 856196	Diving, hovering, climbing	1000 m

Table 1. Science sampling strategies for the February 24, 2025 glider deployment. Additional settings for the Wispr passive acoustic monitor are defined in configuration and initialization files on the glider's science computer, and are also housed on the Google Cloud Platform. All deployment files are available on request.

Deployment-specific testing

Because this glider was prepared by Teledyne staff and this was its first deployment, no deployment-specific testing was done beyond our standard pre-deployment preparations and tests. Configuration and initialization files for the Wispr were obtained from Selene Fregosi of NOAA Fisheries' Pacific Islands Fisheries Science Center. We were unable to simulate missions with these files prior to deployment because of tight scheduling between glider training and boat availability.

This glider also had a small oil leak from the 1000 m oil pump prior to deployment (see notes below). Teledyne was aware of the leak and advised that we could still deploy the glider, but that the forward section should be returned for service post-deployment.

Deployment

The glider “unit_1024” was deployed on February 24, 2025, approximately 22 km west of Mission Bay in San Diego, CA (32º45.47’ N, 117º29.27’ W). This glider was deployed with the sensor configuration above, and with lithium rechargeable batteries (coulomb amp hour total = 215). This glider did not have an extended energy bay; therefore, it had one aft battery and one pitch battery. This glider was not equipped with a wet bay nose section. We began this deployment using the autoballast feature to maximize oil pump efficiency.

Initial deployment activities from the R/V *Benthic Cat* were completed normally. Deployment files were transferred to the glider via Iridium using the Slocum Fleet Mission Control (SFMC) web application. The Iridium connection dropped once during the file transfer and was completed once the Iridium connection was re-established. The system-check mission “status.mi” completed successfully on the boat and in the water. The mission “od5.mi” resulted in an overdepth abort, which is the desired outcome of this mission designed to test the glider’s pressure sensor by setting the overdepth depth to 5 m and commanding the glider to dive to 10 m. Following the overdepth abort, the glider’s digifin issued an error after the maximum numbers of oddities and warnings accrued and was taken out of service. We then put the digifin back into service.

Once all pre-deployment checks were completed, ESD’s standard mission “1k_n.mi” was sequenced and the glider was commanded to perform one 20 m dive. The glider did not end its Iridium connection and dive as expected; instead, it remained connected to the SFMC and repeatedly reported out-of-deadband digifin oddities. The glider eventually ended its Iridium connection, but reconnected a few minutes later after a period of time too short to have completed a 20 m dive. We attempted to retrieve data files but the glider would not accept commands. Because we were unsure whether the glider dove (the boat had moved away to deploy another glider), we ended the mission and attempted to retrieve data files. One tcd file was retrieved, but we could not visualize science data on the SFMC, although no cache files were missing. The glider appeared to get “stuck” sending a large (43 kb) scd file and required the “zcancel” command to regain control. We tried retrieving the file again and the glider dropped its Iridium connection. Once the glider re-established the connection, we performed an exit reset.

Once the glider re-established its Iridium connection following the exit reset, we issued the commands “put u_digifin_hide_oddities_at_surface 1” and “put u_digifin_mask_movement_warning_at_surface 1” to hide digifin oddities from the surface display. We tried two more times to sequence “1k_n.mi,” but the glider did not dive and remained connected to the SFMC both times.

Pilots on the boat were able to complete the missions “od5.mi” and “ini0.mi” successfully. Pilots in the lab took over with a modified version of the Teledyne mission “astock.mi” that called our individual sample files for science sensors and our yo file to specify flight parameters. We ran this mission twice with two aborts for “DE_PUMP_IS_IDLE.” Lab pilots had commented surfac23.ma out of the mission, which was critical for the success of the mission. Once surfac23.ma was commented back into the mission, the glider ran “astock.mi” successfully and dove. We re-transferred all .mi and .ma files for our standard mission “1k_n.mi” and sequenced the mission with no further issues except for a driver oddity for a bad line from science. We were advised that this was likely due to characters getting stuck in the buffer during the file transfer and that this would not affect the mission. Teledyne suspects that during the first file transfer at the beginning of the deployment, some characters were dropped, preventing the mission from running successfully, although pilots checked the file sizes on the glider after the file transfer. After files were re-transferred, we were able to visualize all data on the SFMC.

Emergency Recovery

At 9:54 p.m. PST on February 26 (5:54 a.m. UTC on February 27), unit_1024 aborted its mission for a leak in the aft section. The abort occurred at 155.78 m, as the glider was climbing after a 600 m dive. Prior to the abort, the glider had performed four dives to 600 m. At the time of the abort, the aft leakdetect sensor returned a value of 1.81 V, well below the steady value of 2.485 V the sensor had maintained prior to the leak (Figure 2). Pilots retrieved a log file, but the cause of the leak remained unclear. Pilots repeatedly checked the leakdetect voltage to determine whether the abort was caused by an errant reading, but because the voltage continued to drop to a low value of 1.5 V, we concluded that the leak was real. We allowed the glider to drift at the surface overnight, although the leakdetect voltage returned to 2.487 V approximately 5 hours later. The glider was recovered on the afternoon of February 26 from the F/V *Outer Limits.* Prior to the leak, the glider traveled a total of 29.74 km while performing 29 dives to a maximum depth of 600 m.

Post-Deployment Inspection

On February 27, ESD and Teledyne staff carefully opened and inspected unit_1024 to determine the source of the leak. The glider was opened methodically and slowly to allow for water between glider sections and on top of o-rings to be carefully removed. There was no evidence of water inside the glider at the junction between the aft section and the science bay, suggesting the leak occurred near the tail. There was evidence of dried salt, but no water, behind the aft battery in the hull (Figure 3), on the back edge of the battery itself (Figure 4), and on a metal plate behind the main board (Figure 5). There was also a trail of dried salt from one of the through-holes for an MCBH connector in the aft cap down to the bottom of the aft cap (Figure 6), suggesting that the MCBH connector may have been the source of the leak. The internal desiccant pack, when weighed, was 6 g heavier than it was prior to deployment, indicating that the desiccant pack had absorbed the water in the glider. The tail will be shipped back to Teledyne for further diagnostics.

Below is the summary of events compiled by Cordie Goodrich, Slocum Glider Technical Support and Field Operations Manager for Teledyne Webb Research:

Unit_1024 has a small amount of oil seeping from the oil reservoir

History of this glider:

- Delivered October 2022 (R126831-R NOAA)
- Glider never deployed
- Glider returned to TWR for WISPR/DMON bay integration November 2024 (CSM#24-012)
    - Science bay - had flbbcd and par added, and wiring for DMON and WISPR
    - Glider ballasted and pond flown
- February 2024 used in glider training at NOAA in La Jolla
    - **Found small oil leak in forward section (SN 691)** - Cordie decided it was okay to deploy for short period of time
- Deployed off San Diego 2025-02-24
    - Standard rechargeable battery, WISPR stack on bay, 1000m pump
    - Diving to 300m for most of the day of Feb 25
    - Stepped to 400m for two yos
    - stepped to 600m for four yos
    - Leaked for aft leak on 6^{th} yo (CRO 00014634 ; PI-00496)
    - Surfaced drifted overnight
        - Desiccant seemed dry up the water, aft leak detect returned to normal reading after sometime on the surface.
    - Recovered the next day
- Inspected in the NOAA lab by Cordie
- **Photos attached from oil seeping after deployment**
    - Oil seems to be coming from aft seam of the reservoir
    - Dripping down and landing on the forward hull just below where motor sits
    - Have cleaned up the oil a few times and it always returns

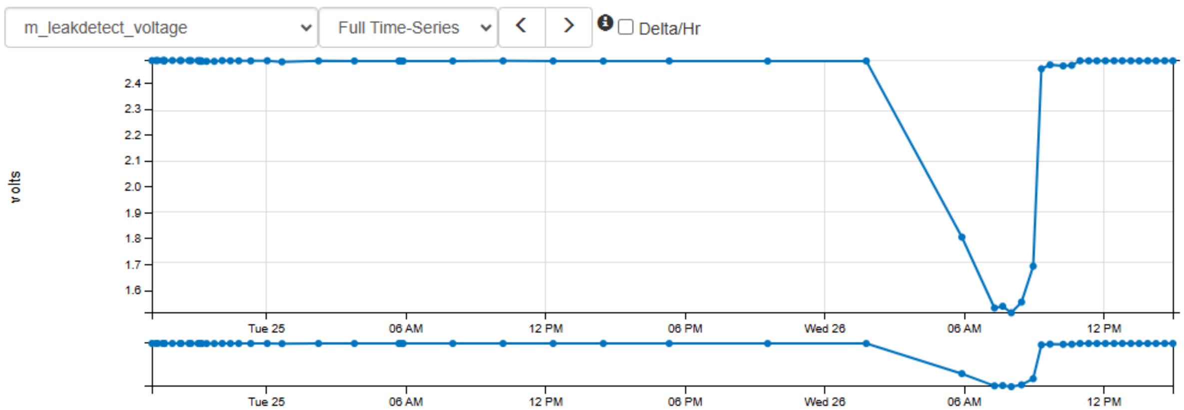

Figure 2. Aft leakdetect readings from unit_1024, showing the drop in voltage when the leak occurred.

Figure 3. Dried salt behind aft battery

Figure 4. Dried salt on aft battery.

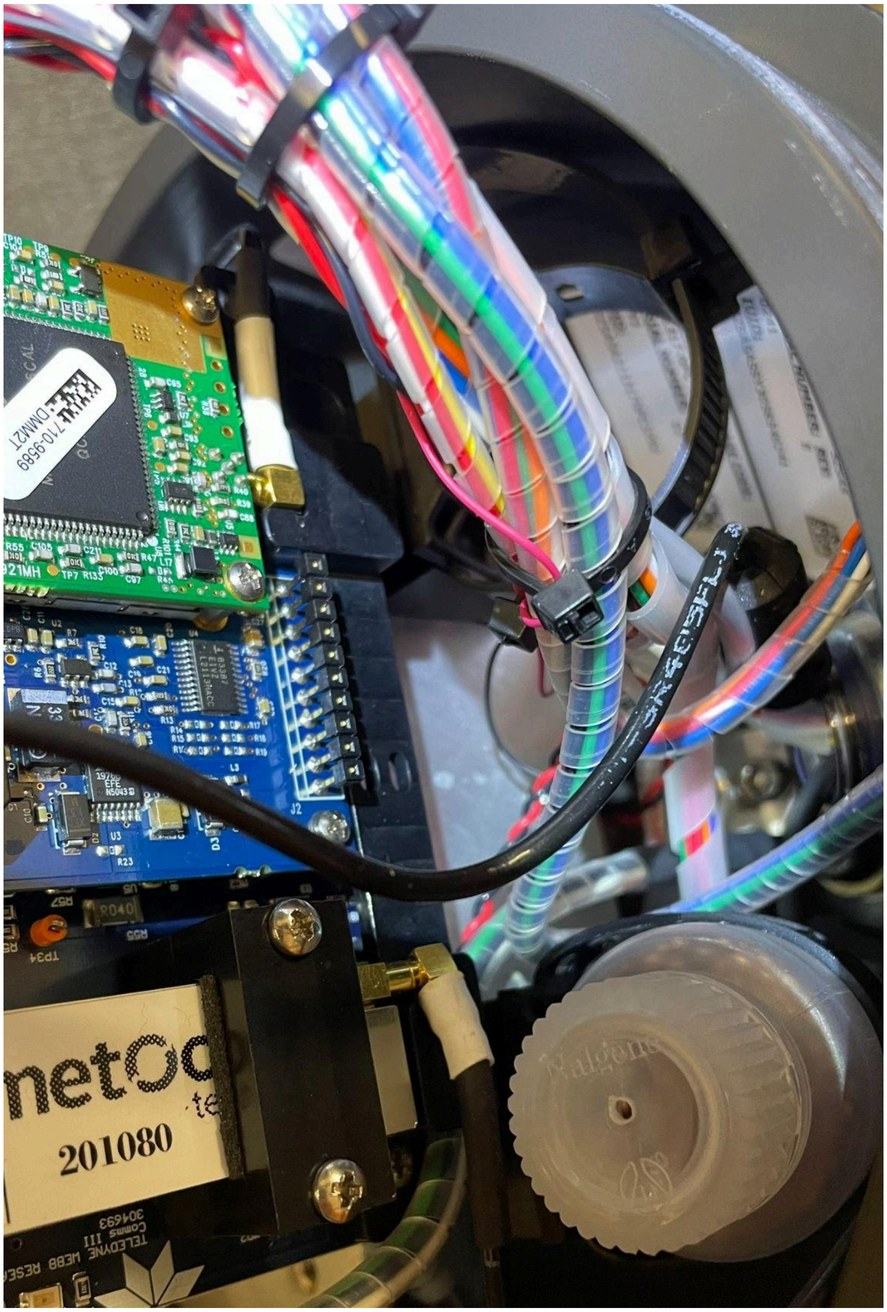

Figure 5. Dried salt on metal plate behind main board.

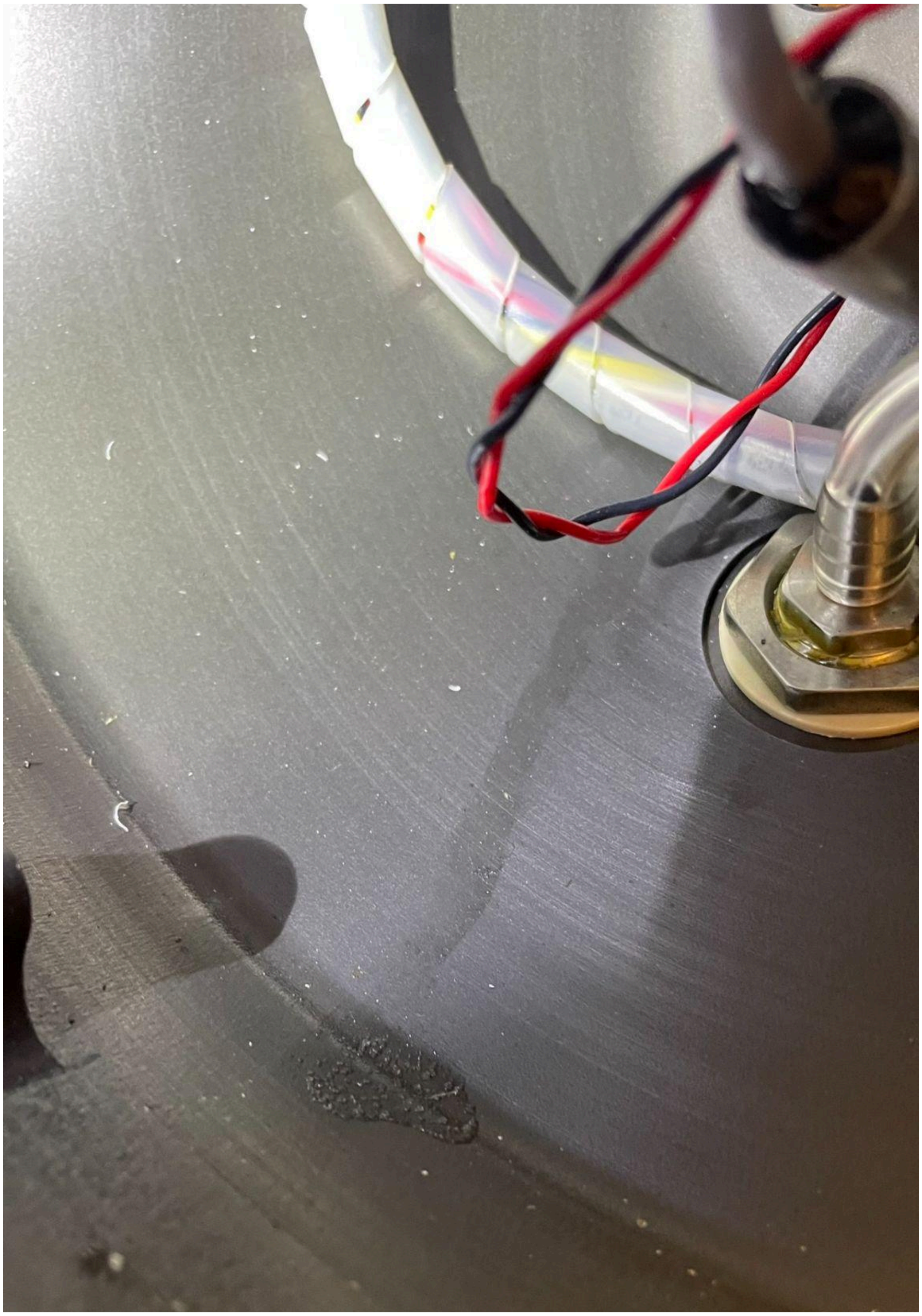

Figure 6. Dried salt from MCBH connector.