

Challenge of Unmanned Ocean Exploration Competition "Shell Ocean Discovery XPRIZE" by GEBCO-NF Alumni Team

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To challenge the unmanned ocean exploration competition "Shell Ocean Discovery XPRIZE", a few active alumnus of Nippon Foundation-GEBCO training program led to form a team for XPRIZE, GBCO-NF Alumni Team.

The objective of our team is to establish the solution of acquiring the very wide-area and high-resolution ocean bathymetry at the depths of 2000-4000 m deep within the limited time, by using the innovative unmanned/autonomous technologies, such as combination of Unmanned Surface Vessel (USV) and Autonomous Underwater Vehicle (AUV). Our established solution may also contribute to the NF-GEBCO Seabed 2030 project, which is an international collaborative project between GEBCO and the Nippon Foundation with the aim to facilitate the complete mapping of the ocean floor by the year 2030.

We designed and developed the USV SEA-KIT of size to fit in a 40 ft. container, which can install the AUV HUGIN inside. The main purposes of the USV SEA-KIT are to carry the AUV HUGIN to the survey site areas and to launch and recover the AUV HUGIN without any crews. The other purpose is to determine the AUV HUGIN positioning by Ultra Short Base Line (USBL) acoustic positioning system HIPAP.

In order to map the seafloor, the multibeam echosounder of EM2040 and the synthetic aperture sonar HISAS operated in the Wide Area Mode are used at AUV altitude 60 m from the seafloor, which are equipped on the AUV HUGIN. The EM2040 data are necessary to fill the big nadir gap of approximately +/- 45 degrees of HISAS bathymetry. In order to identify the seafloor features by the high-resolution images, the HISAS operated in the Standard HISAS Mode are used at AUV altitude 40 m.

The semi-automated data processing workflows for bathymetry and imagery are made by CARIS HIPS and SIPS, as well as FOCUS (HISAS special software for the bathymetric surface and mosaic imagery), NavLab (HIPAP post-processed positioning software), and HydrOffice QCTools (ancillary quality control software for the bathymetric surface). The manual processing workflows are made by FOCUS and REFLECTIONS (HISAS special software for HISAS spot imagery). The bathymetry and imagery are analyzed and submitted by ArcGIS Desktop and online.

The Round-1 Technology Readiness Test has been held in the place where each team selected, instead of Round-1 in Puerto Rico, due to the tremendous damage of the huge hurricane Maria. Our Round-1 Technology Readiness Test decided to be held on 20-23 November, 2017 in Horten, Norway. In order to prepare our Round-1, for more than 5 weeks, we had conducted the final internal test to check the cooperation operation between USV SEA-KIT and AUV HUGIN, and to verify the horizontal and vertical resolutions of the bathymetry and imagery by the EM2040 and HISAS.

In our Round-1 Test on 20-23 November, 2017, we succeeded the unmanned launch and recovery of AUV HUGIN from the USV SEA-KIT. We made the combined bathymetric surface with 2 m resolution from EM2040 and HISAS operated in the Wide Area Mode, and made more than 10 spot imageries with approximately 2 cm resolution from HISAS operated in the Standard HISAS Mode. In this paper, we show

the wide-area bathymetry and high-resolution imagery products which we achieve in our XPRIZE Round-1 Test.

Keywords: Shell Ocean Discovery XPRIZE, Unmanned/Autonomous Technologies (USV, AUV), Ocean Bathymetric Survey, Synthetic Aperture Sonar (SAS)