

3. Test operation under stormy environment in the tropical northwestern Pacific Ocean

Progress until FY2023

1. Outline of the project

We conduct open ocean tests of virtual mooring drone (VMD) prototypes in the tropical Northwest Pacific Ocean, a region where many typhoons are generated and develop, during R/V *Mirai* (Fig. 1) tropical ocean cruises in 2023 and 2024 to validate hull control, navigation, communication, and accuracy of atmosphere-ocean sensors in stormy condition with strong wind and high waves.

In the current year (2023), we successfully conducted the first short-term open ocean test of VMD prototype #2 off the east coast of Philippines during R/V *Mirai* cruise. In addition, we submitted marine scientific research (MSR) application for the final open ocean test in 2024 after international coordination with relevant countries in advance.

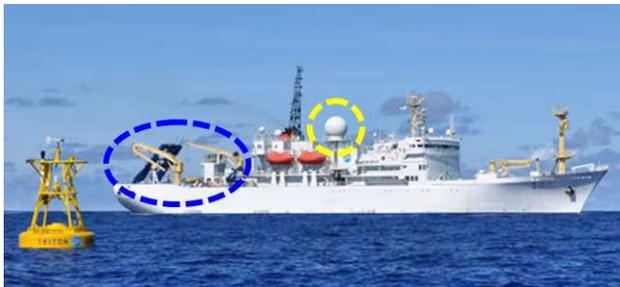


Fig. 1 R/V *Mirai* used for open-ocean tests of prototypes. A-frame crane on the aft deck (blue dashed circle) and other equipment used for deployment and retrieval of the VM drone prototypes. C-band radar (yellow dashed circle) and various atmosphere-ocean sensors equipped with the vessel are used to validate data obtained by the prototypes.

2. Outcome so far

1. We conducted the first short-term open ocean test of VMD prototype #3 off the east coast of Philippines in Summer (June-July) 2023 during R/V *Mirai* tropical ocean cruise (Fig. 2) to examine ship control, navigation, sensor accuracy, and satellite communication, etc. (Fig. 3).
2. We established safety procedures on the deck of R/V *Mirai* and ocean, including deployment and retrieval prototype #3 during the test period, and coordinated with research safety committee of the representative institution in advance. As a result, we completed the test without any loss, damage, or accidents.
3. We submitted MSR application, which is required to obtain consent from coastal states if we plan activities in waters under the jurisdiction of foreign state, to MEXT (and then, MOFA) for the final open ocean test in 2024 after international

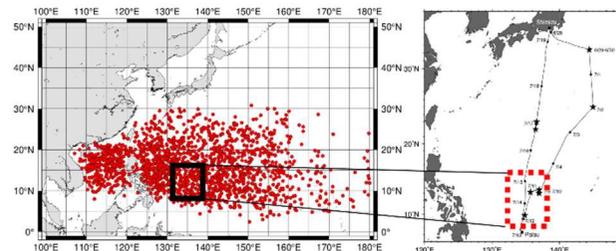


Fig. 2 Climatology of typhoon occurrence locations (red dots), 1951-2021, based on Digital Typhoon*1 (left). Track of R/V *Mirai* tropical ocean cruise in 2023 (MR23-05 Leg.1) and stationary points for open ocean test of VMD prototype #2 off the east coast of Philippines (right).

*1 <http://agora.ex.nii.ac.jp/digital-typhoon/reference/birthplace.html>

coordination with relevant countries concerning the test in advance.

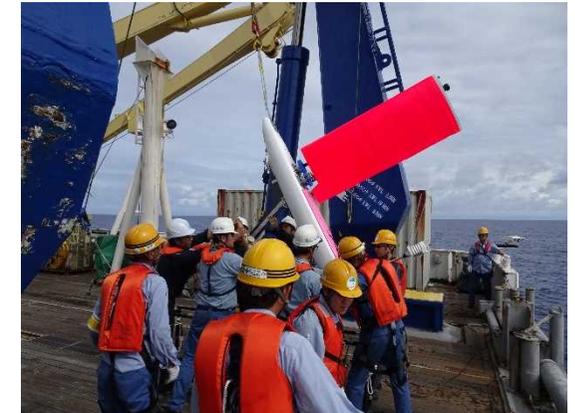


Fig. 3 Deployment of VMD prototype #2 from aft deck to the ocean surface during R/V *Mirai* tropical ocean cruise). After this, it is lifted by blue A-frame crane (Fig. 1) seen on both sides of the photo, and the crane arm is swung out to sea from the aft deck to safely and slowly land on the water.

3. Future plans

We will conduct the final open ocean test again during R/V *Mirai* cruise in 2024 with VMD prototype #3 to examine ship control, navigation, satellite communication, and sensor accuracy. The test was originally planned to be conducted at the tropical ocean in the summer season as same as that in 2023, but we will change the test schedule to *Mirai* Bering Sea cruise in autumn (October-November) because stormy conditions such as strong winds and high waves are expected, which is much suitable for the final test focusing on the weather resistance performance.