R&D item

1. Development of Virtual Mooring (VM) Technology for Stormy Environments

Progress until FY2023

1. Outline of the project

We develop virtual mooring (VM) drone (VMD); sailboat-type uncrewed maritime surface vehicle (USV) that can operate around the center of typhoons and continuously obtain atmosphere-ocean data along their movement based on technologies that enable autonomous navigation and VM driven by winds and ocean currents.

In the first year (2022), we designed VM function and sailboat, built prototypes (#0 and #1) and tested them in full-scale tank and coastal waters in Japan to confirm hull strength, sail control, and navigation performance. In the current year (2023), we built protype #2 and conducted the first short-term open ocean test off the east coast of Philippines during R/V *Mirai* tropical ocean cruise to confirm sail control, satellite communication and navigation performance in the open ocean.

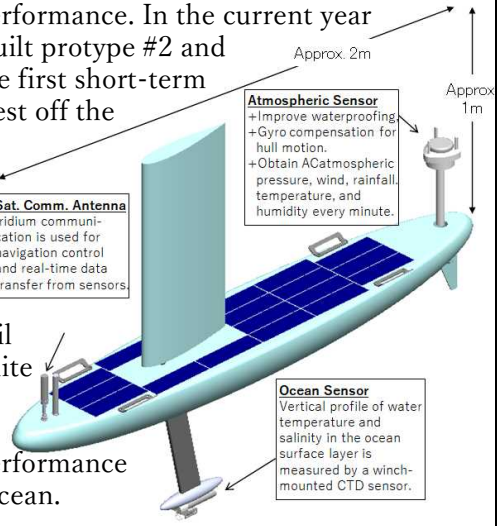

Fig. 1 Overview of the VM drone prototype. Specifications are subject to change by improvement through the project.

2. Outcome so far

1. Based on various test results in 2022, we built prototype #2 to improve hull structure, control software, and navigation performance and then tested it in coastal waters in Japan.
2. After several tests in coastal waters in Japan, we conducted the first short-term open ocean test off the east coast of Philippines in Summer (June-July) 2023 during R/V *Mirai* tropical ocean cruise to examine ship control, navigation performance, and satellite communication for data acquisition.
3. Because we encountered difficulty in ship control which must be due to malfunction with gyros and GPS, we continue to fix problems after the cruise.

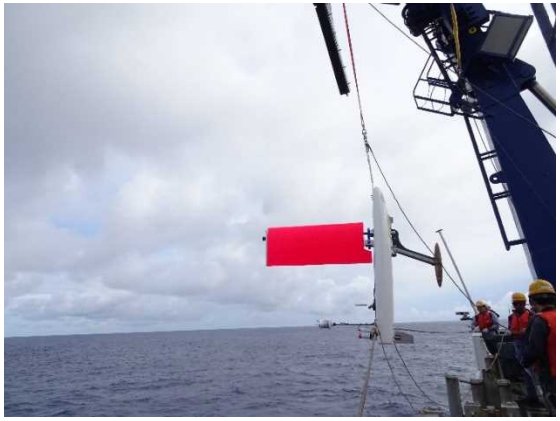

Fig. 2 Deployment of VMD prototype #2 from the A-frame crane (blue structure on the right side of the photo) on the aft deck of R/V *Mirai* during its tropical ocean cruise in the east of Philippines. Before the open ocean test, the hull structure, navigation equipment, satellite communications, and observation sensors are carefully inspected.

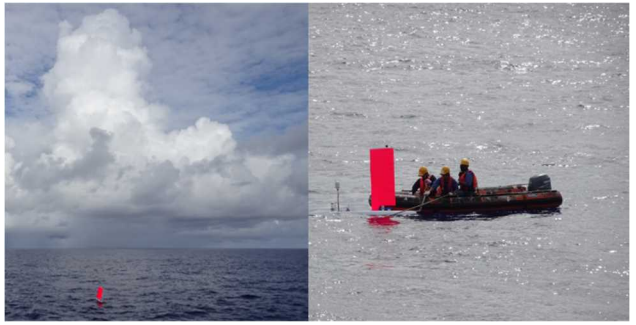

Fig. 3 VMD prototype #2 sailing under developing cumulonimbus clouds off the east coast of Philippines during R/V *Mirai* tropical ocean cruise (left). During the open ocean tests, the prototype #2 controlled from R/V *Mirai* via satellite communications, and simultaneously received both navigation and observation data. After completion of the open ocean test, prototype #2 was towed to vicinity of R/V *Mirai* by observation technicians aboard a Zodiac boat (right) and lifted onto the aft deck by the A-frame crane (Fig. 2), where it was serviced for the next test.

3. Future plans

We will build the final prototype #3 based on the test results in 2023 and test it at open ocean again during R/V *Mirai* cruise in 2024 to confirm ship control, navigation performance, and satellite communication as the final examination. 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 of the VMD.