R&D Theme

Development of Virtual Mooring (VM) Technology for Stormy Environments

Progress until FY2022

1. Outline of the project

We develop virtual mooring (VM) drones; sailboat-type unmanned maritime surface vehicles (USVs) 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 virtual mooring driven by winds and ocean currents.

In the first year (2022), we designed VM function and built hulls which can be navigated in stormy environment with strong wind and high waves around typhoon centers. After improvements by testing prototypes in a lab, full-scale tank, and coastal waters in Japan to prepare a short-term (approx. one week) open-ocean test in 2023 in the east of Philippines, where typhoons are frequently generated, during R/V *Mirai* tropical ocean cruise.

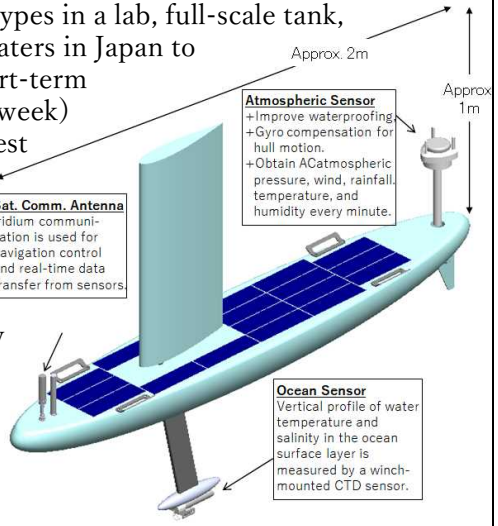

Fig. 1 Overview of the VM drone prototype. Specifications are subject to change by improvement through the project.

2. Outcome so far

The activities and results in 2022 are as follows.

1. We designed a sailboat-type USV based on computational fluid dynamics (CFD) simulations in collaboration with private sectors, and built prototypes #0 (hull structure only) and #1 (with mast, sail, keel, rudder, and electrical components).
2. To confirm the hull strength and the external forces around the hull during sailing under stormy environment with strong wind and high waves, we tested the prototype #0 in a multipurpose water tank (L 40 m x W 4 m wide x D 2 m). For example, it was repeatedly dropped into the tank from a height simulating stormy waves in typhoons to confirm hull deformation and damage, and it was towed in the tank at different speeds and angles to measure wave resistance and hexagonal stress around the mast during sailing.

Fig. 2 Water tank tests using VM drone prototype #0. It was lifted up to the ceiling by a crane (white dashed circle) and dropped into the water tank for a strength test (left). The prototype #0 with six-axis stress sensor equipped to its mast was towed at high speed over the water tank to measure wave resistance and stress around the mast (right).

3. After outfitting prototype #1 with atmosphere-ocean sensors developed by R&D Theme 2, it was tested twice in coastal waters of Suruga Bay (Mitsuhama, Numazu City, Shizuoka) for one weeks in December 2022 and February 2023 to confirm hull and navigation performance. Although both tests were conducted in fair weather and weak wind conditions, we were able to confirm basic sailing performance, hull control by sail and rudder, and radio communication, starting with checking a safety procedure of its deployment (landing on water) and retrieval by using an A-frame crane on the deck of measuring vessel (approx. 17 tons) that transported it from a port to the test area.

Fig. 3 Test in coastal waters by using prototype #1 in Suruga Bay, Japan (left). Operation check on land for sail and rudder control, and communication prior to the test (right).

3. Future plans

In the next year (2023), we build a prototype #2 which is improved based on tests in 2022, and conduct a short-term (approx. one week) open-ocean test in east of Philippines, where typhoons are frequently generated, during R/V *Mirai* tropical ocean cruise which is prepared by R&D Theme 3.

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