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Long-term deployment of Wave Glider for a real-time tsunami monitoring system using the Vector Tsunameter

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We have been developing a real-time tsunami monitoring system by using the Vector Tsunameter(VTM), in which we use an unmanned surface vehicle called Wave Glider, manufactured by Liquid Robotics Inc. The WG, equipped with both an acoustic and a satellite communication modems, can be used to transmit data messages from the VTM to shore. In order to investigate the feasibility for this type of station-keeping operation, we made a long-term deployment of the WG at sea area. We deployed the WG on September 22, 2013 at 38 14.99N, 143 35.13E, water depth = 3420.1 m. We set 6 waypoints along a circle (200m in diameter) centered at the above position, so that the WG trace the watch circle. The experiment had been continued until the WG was caught by a drift net and delivered to the Kesennuma port on December 6,2013.

The 75-days deployment of WG gives valuable information on the performance of the WG. As for the feasibility of WG for the station-keeping operation, two problems become apparent. During the experiment, the WG sporadically escaped from the watch circle and drifted away following the ambient water current, and it returned to the circle after several days of trip. Four excursions occurred during the first 50 days, and the total of the excursion period is 20 days. For monitoring slow activities such as crustal deformation, this performance is acceptable. However, some improvements are required for monitoring the short period signals such as tsunami. The other problem is the reduction of speed over water occurred after about 2 months operation. In the middle of November, the speed abruptly decreased to less than 0.5 knots and remains low until the end of the experiment.

Based on the detailed analyses of the navigation data sets and inspection of the WG, we conclude that the twist of the umbilical cable, which connects the surface float to the sub-surface glider, triggered both the excursion and the speed reduction. The small size of the watch circle and the short distance between the waypoints (about 100 m) are main cause of the twist. The short distance causes large and frequent changes of glider heading. Since the float can not follow the abrupt changes of heading, differential rotation of the glider relative to the float arises and enhances the twist of the cable. This twist of the cable increases water drag to the WG, and the stress of the cable due to the twist inhibit the rotation of the WG. These effects reduce the movability of WG, and the speed reduction start the drift of WG following the ambient current motion. The twist of the cable mainly occurs while the WG follows the path along the watch circle. On the other hand, during the excursions, glider heading is fixed and rewinding of the cable was observed. This rewinding reduces the drag force to the WG and assist the WG in returning to its home circle.

Extreme reduction of the speed is observed after 2 months of deployments. Inspection of the WG right after the recovery indicates that the propulsion system of the sub-glider had been working well until the end of the experiment, whereas the float suffered by the biofouling of eboshi-gai (goose barnacle). The biofouling seems responsible for the speed reduction, but theoretical estimate suggests that the hydrodynamic drag due to the biofouling is not sufficient to explain the observed speed reduction. The twist of the cable and the biofouling both contribute to the speed reduction. These analyses suggest larger size of the watch circle may improve or solve the present two problems of the excursion and the speed reduction.

Keywords: tsunami, tsunameter, real-time observation, seafloor observatio