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JAMSTEC

Prototype of New Underwater Laser Ranging System Demonstrates Promising Results

Introduction
A prototype of a new laser ranging system, developed by Hiroshi Yoshida and his team at the Marine Technology Center of JAMSTEC, has successfully achieved high-accuracy underwater ranging in sea trials. The new ranging system was developed based on the underwater laser propagation traits obtained by the team. Equipped with automatic laser beam alignment and ranging resolution of less than 1 mm, the system achieved measurement accuracy, consistent with its designed value. The results are expected to help develop technology for high-precision ranging at the deep sea floor, where conventional acoustic ranging can not produce reliable data due to errors caused by water pressure and temperature. Researchers will continue improving the system's ranging accuracy and pursue its use for a variety of applications in deep sea research and projects.

Results
With the aim of improving accuracy in underwater ranging, JAMSTEC researchers have been working to develop a ranging method using a laser beam (*). The laser beam is especially useful for applications requiring high-precision measurements.

The study saw the following operations and results:
(1) Characterizing underwater laser propagation
Researchers manufactured an in-situ laser propagation measuring system (ILPMS) (Fig. 1) to characterize the attenuation of the laser beam in underwater environments. The results showed that the laser beam attenuation (propagation loss) was quite large in the surface layer; but it decreased rapidly with water depth, and leveled off at depths more than 100 meters (Fig. 2) . This indicates that, when the water is less clouded with materials that block or absorb the laser beam (e.g. plankton, yellow substance or suspended particles), and therefore less turbid, the laser beam can travel through the water with a stable intensity (Fig. 2).

(2) Sea trail of the prototype ranging system
A prototype of the underwater laser ranging system was developed and tested in waters, 500 meters off the southern coast of Kohama-jima island, Okinawa, at a depth of 5 meters. The area is home to a variety of coral reefs, where the laser beam is minimally attenuated by the water column. The results proved successful in the automatic laser axis adjustment between the transmitter and the receiver. The prototype was also capable of measuring distances up to 10 meters. The range error of the prototype was between 3 and 10 cm.

Future studies
The sea trials of the prototype revealed larger range errors than previously projected. The margin of error involved in ranging was designed to be within 1cm. The larger values of error could have resulted from the heat generating from the laser beam or in the receiver circuit. Further analysis is now underway to solve this problem.

With the encouraging results from the prototype tests, researchers will further work on technical challenges in implementing the system, including the attainment of higher accuracy, and enhance the system's capability towards practical applications.

*The laser beam attenuates significantly in sea water due to suspended particles and plankton, making it difficult to use in underwater applications. The details of deep sea laser attenuation had not yet been fully understood.

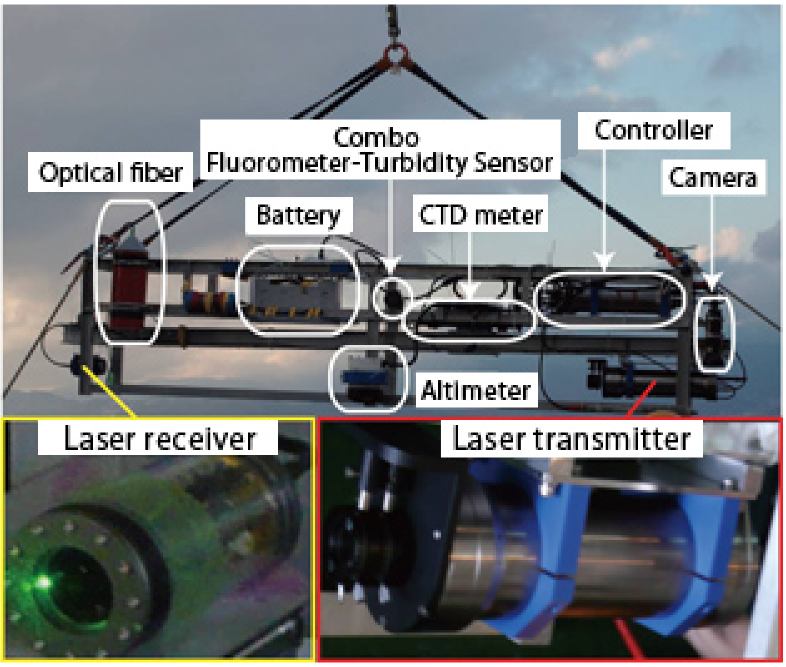

Figure 1. In-situ propagation measuring system (ILPMS)
The system, measuring 3 meters in width, consists of a laser transmitter (TX), a receiver (RX), and sensors to measure water parameters. The configuration of these instruments is designed to reduce deformation of the frame and thus ensure the alignment of the optical axis. The laser beam intensity is measured between the TX and RX.

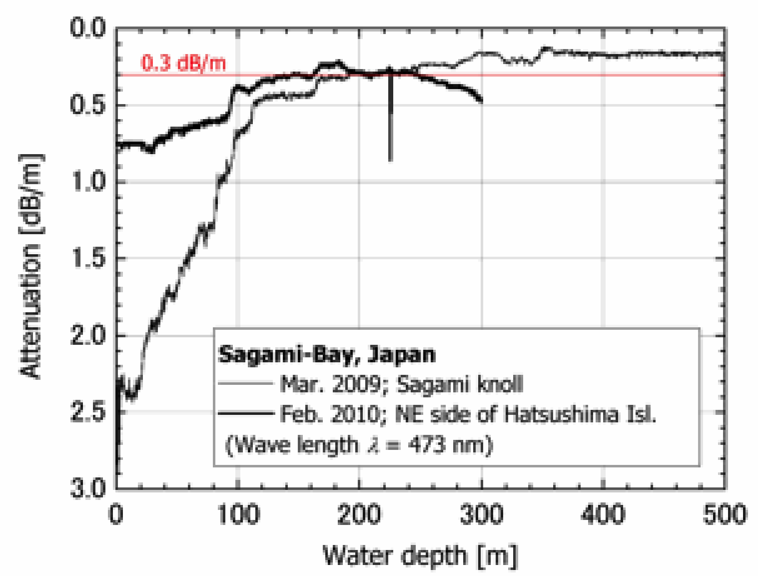

Figure 2. Characteristics of underwater laser propagation (from sea trials in Sagami Bay in 2009 and 2010)

The laser beam is significantly attenuated in the surface layer but is much less attenuated at depths more than 100 meters. This could be attributed to a smaller amount of suspended matter in deep see, such as phytoplankton or inflow sediment from rivers. The attenuation in the surface layer varies depending on the season and location.

Figure 3. Transmitter (TX) and receiver (RX) of the underwater laser ranging system

Both units measure 90cm in height, width and length, and their weight-in-air is approximately 70 kg. The laser unit and receiver are housed in the pressure hulls of the TX and RX, respectively. The hulls have acrylic windows to allow for the penetration of the laser beam. In each pressure hull, the device module is set on a platform equipped with actuators, which allow for azimuth motion of 360 degrees and the elevation angle of plus or minus 30 degrees. When the TX and RX are placed on the seafloor, the actuators are automatically activated to align laser beam. The distance between the TX and

RX is calculated from the phase difference between the laser beam and the synchronous signal (Fig.4).

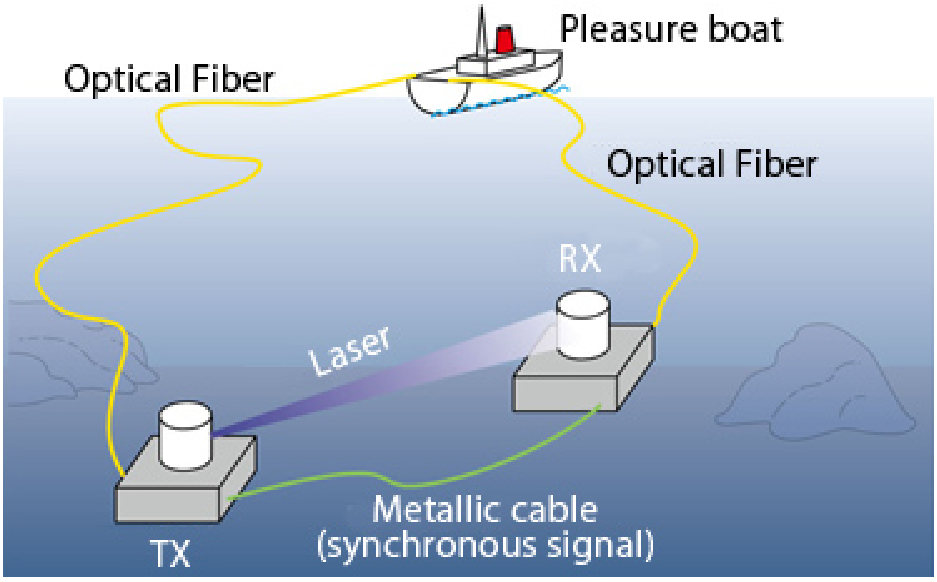

Figure 4. A typical configuration of the sea trial.
The transmitter (TX) and receiver (RX) are both connected by an optical fiber to the shipboard controller. The TX and RX are connected to each other by a metallic cable to synchronize the signal.

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