



R/V KIREI Cruise Report

KR21-18C

Verification test
of underwater optical wireless communication technology
that achieves BL product of 1 Gbps x 100 m

Nov. 26, 2021 - Nov. 30, 2021

Japan Agency for Marine-Earth Science and Technology
(JAMSTEC)

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1. Cruise Information

- Cruise ID: KR21-18C
- Name of vessel: R/V KAREI
- Title of the cruise:

Verification test of underwater optical wireless communication technology that achieves BL product of 1 Gbps x 100 m.

- Cruise period: November 26, 2021 - November 30, 2021
- Ports of departure / call / arrival: Yokosuka Port Section No.4 – Nissan Port No.6
- Research area: Sagami Bay.
- Research Map

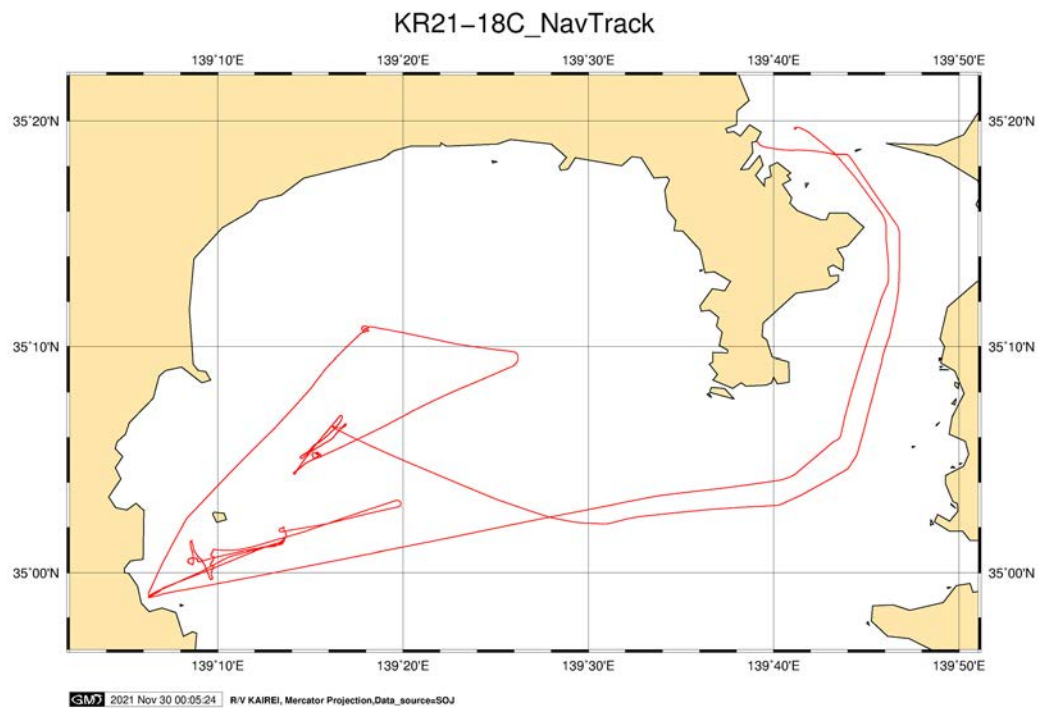


Fig.1 Cruise track of KR21-18C

2. Researchers

- Chief scientist [Affiliation]: Kenji NAGAHASHI [JAMSTEC]
- Representative of the Science Party [Affiliation]: Shojiro ISHIBASHI [JAMSTEC]
- Onboard scientist [Affiliation]:
 - Kenji NAGAHASHI [JAMSTEC]
 - Kenichi Suzuki [Trimatiz Limited]
 - Seigo Takahashi [Trimatiz Limited]
 - Hiroki Okuzawa [Trimatiz Limited]
 - Ryo Kimura [NME]

3. Results of Observations.

- Overview

This voyage will be carried out as part of the "Research on Underwater Optical Wireless Communication Technology that Achieves a BL Product of 1 Gbps x 100 m" adopted as a commissioned research project of the 2019 Security Technology Research Promotion System under the jurisdiction of the Acquisition, Technology and Logistics Agency. This is a sea area verification test, and the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) is participating as a subcontractor (Main contractor: Trimatiz Limited.).

JAMSTEC is currently working on "(5) Challenging and original research and development and development of advanced basic technology" in the medium- to long-term goals and medium- to long-term plans. Development and operation | In "Optical electromagnetic wave technology", we are proceeding with basic research on optical propagation characteristics in the sea. In this commissioned research, we are in charge of background parameter measurement and deep-sea application technology by providing knowledge and elemental technologies for the propagation of laser light in the sea.

ROV "KAIKO" was applied for the purpose of confirming the practicality of the optical wireless communication device (demonstration machine) constructed in "Research on underwater optical wireless communication technology that achieves BL product of 1 Gbps x 100 m" in a deep sea environment. An optical wireless communication test was conducted. In this test, an optical wireless communication device is installed in each of the ROV "KAIKO" launcher and vehicle, and an optical wireless communication link is established between the launcher and the vehicle to improve communication accuracy, communication distance, and communication speed. evaluated.

As a result, we achieved 1 Gbps Underwater communication at a distance of 100 m, which confirms the practicality of the optical wireless communication device (demonstration machine), and also obtained the distance attenuation curve of this device.

- Test outline diagram

Outline of the test A communication test will be conducted with the aim of achieving a "BL product of 1 Gbps x 100 m" by stopping the vehicle dive at the point where the depth difference between the vehicle and the launcher is 100 m or more. At this time, as in the case of descending, if necessary, the vehicle is moved horizontally while maintaining the vehicle depth to align the optical axis. In the optical axis alignment, the vehicle operation is controlled based on the image of the lower camera (surveillance camera) mounted on the launcher and the change in the reception intensity detected from the reception / signal processing unit (equipped with the launcher or vehicle).

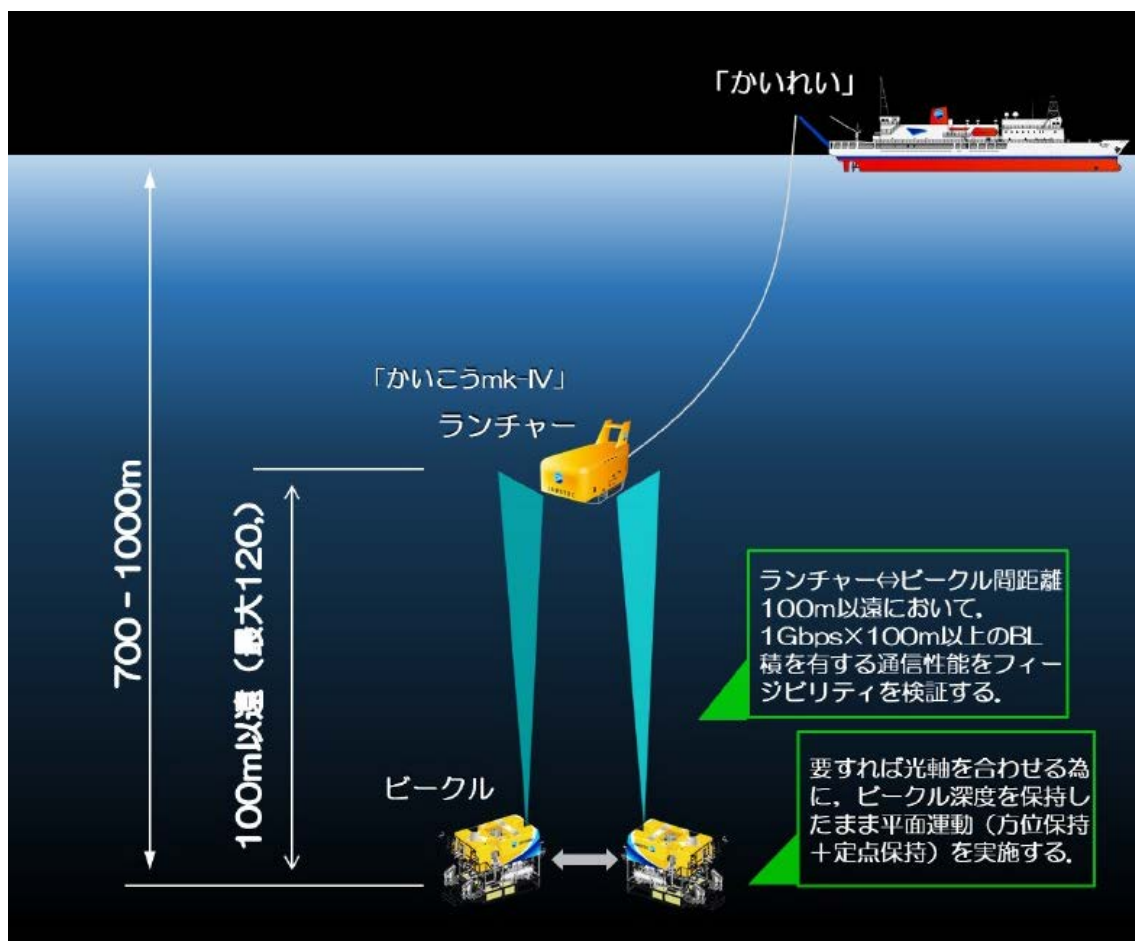


Fig.2 Test outline diagram

- Test Site

The test site was conducted at points 1 and 4 below.

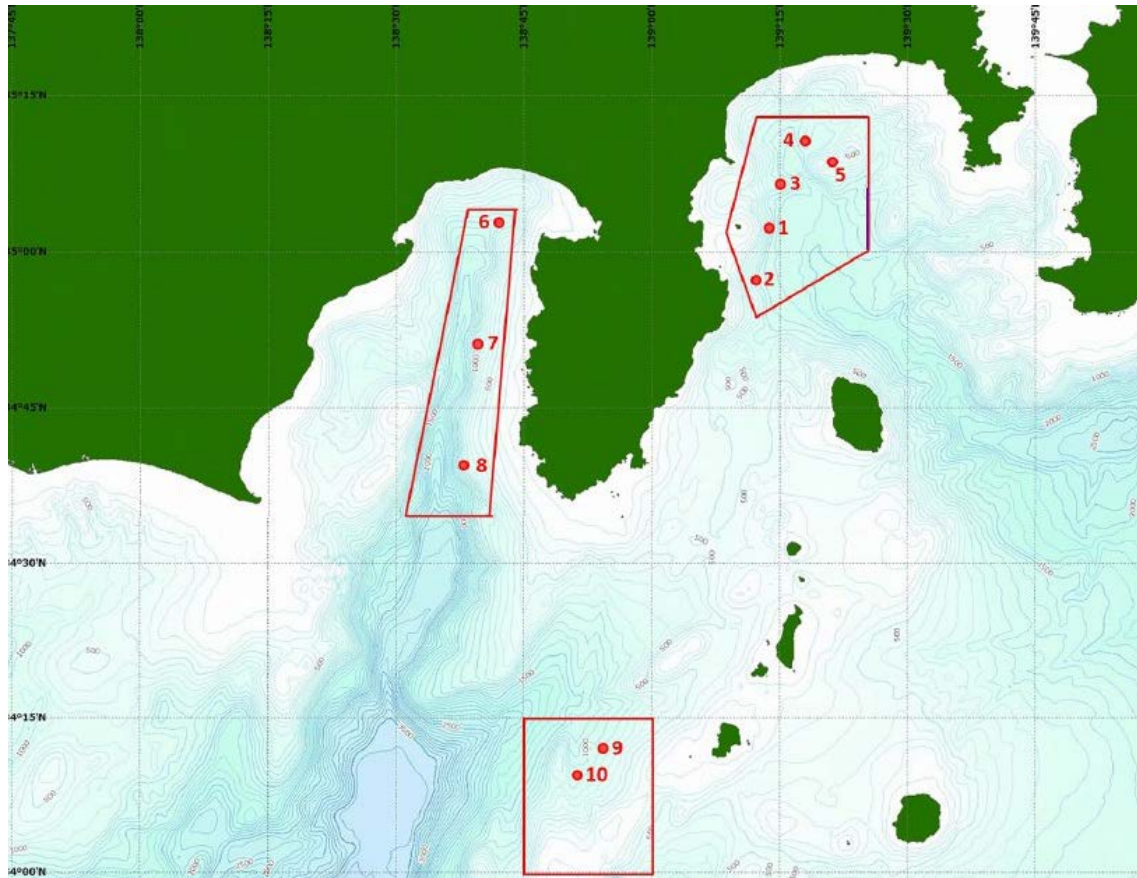


Fig.3 Test Site

Point 1: 35° 01.00 'N 139° 14.00 'E (Depth About 900-1000m) (Nov.27 and Nov.28)

Point 4: 35° 10.50 'N 139° 18.00 'E (Depth About 900-1000m) (Nov.29)

- Optical wireless Communication system - Laser transmitter (Trimatiz Limited carry-on item)

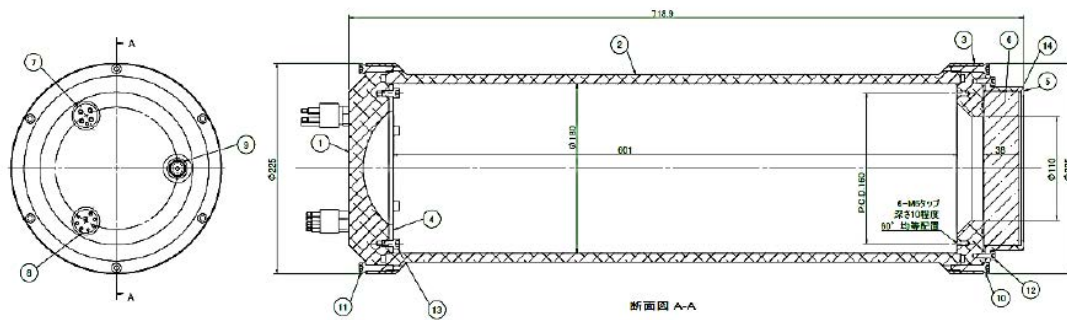


Fig.4 Optical wireless Communication system - Laser transmitter

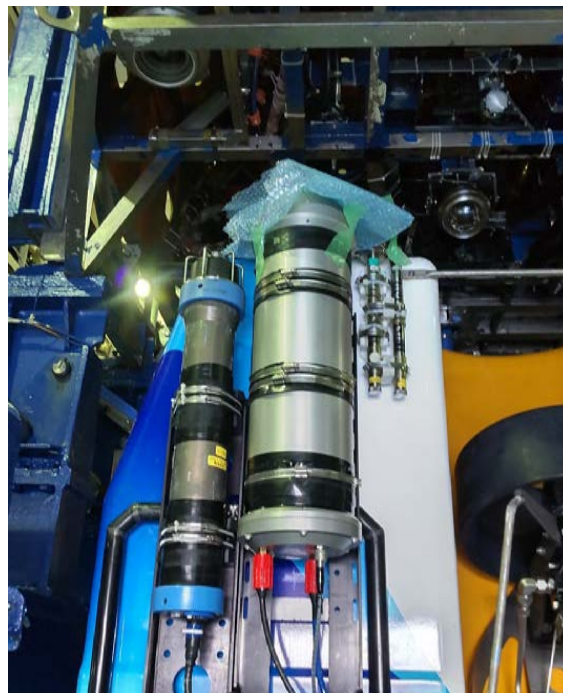


Fig.5 Optical wireless Communication system - Laser transmitter

Table 1 Specifications of Optical wireless Communication system - Laser transmitter

Size[D×H] (mm)	φ 180 x 600
Mass in air(kg)	20kg
Max. operation depth (m)	1000
Com.Range (m)	100

- Optical wireless Communication system - Laser Receiver and Signal Processing unit (Trimatiz Limited carry-on item)

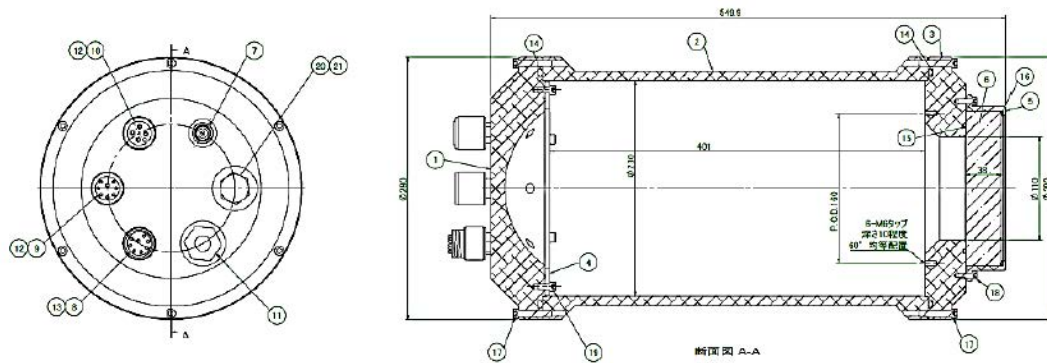


Fig.6 Optical wireless Communication system - Laser Receiver and Signal Processing unit

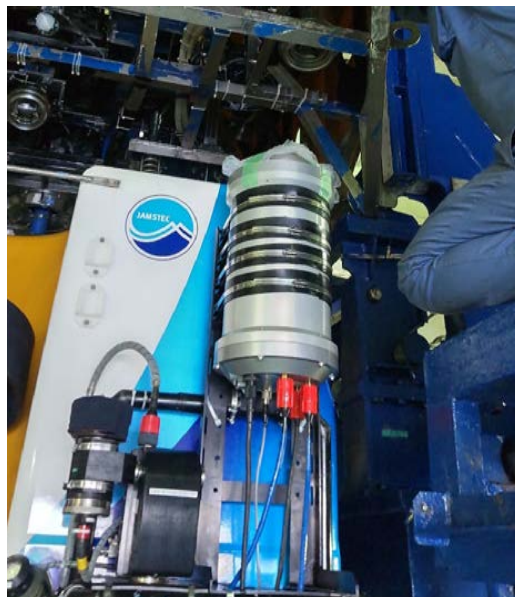


Fig.7 Optical wireless Communication system - Laser Receiver and Signal Processing unit

Table 2 Specifications of Optical wireless Communication system

- Laser Receiver and Signal Processing unit

Size[D×H] (mm)	φ 230 x 550
Mass in air(kg)	30kg
Max. operation depth (m)	1000
Com.Range (m)	100

- Activities

Table 3 shows the activities of the cruise.

Table 3 Schedule of KR21-18C cruise

2021/11/26 Fri.	
08:40	Onboard "KAIREI" at YOKOSUKA port Section No.4
09:00	Heaving anchor, left at YOKOSUKA port Section No.4
10:00-10:40	Carried out education & training for scientists
10:40-11:30	"KAIKO Mk-IV" briefing and meeting
13:30	Let go anchor, arrived at off ITO port
18:00-18:30	Research meeting
2021/11/27 Sat.	
06:50-06:55	Research meeting
07:45	Heaving anchor, left at off ITO port
08:30	Arrived at Research Area
10:55	Launched and commenced "KAIKO Mk-IV" dive #879 operation
11:55	Separated Launcher and Vehicle
14:26	Combined Launcher and Vehicle
15:09	Refloated
15:15	Recovered "KAIKO Mk-IV"
18:00-18:30	Research meeting
2021/11/28 Sun.	
05:55-06:00	Research meeting
08:42	Launched and commenced "KAIKO Mk-IV" dive #880 operation
09:43	Separated Launcher and Vehicle
14:03	Combined Launcher and Vehicle
14:43	Refloated
14:52	Recovered "KAIKO Mk-IV"
16:20	Let go anchor, arrived at off ITO port
18:00-18:15	Research meeting
2021/11/29 Mon.	
07:00	Heaving anchor, left at off ITO port
07:30-07:35	Research meeting

10:00	Launched and commenced "KAIKO Mk-IV" dive #881 operation
10:55	Separated Launcher and Vehicle
14:25	Combined Launcher and Vehicle
15:09	Refloated
15:16	Recovered "KAIKO Mk-IV"
17:55-18:15	Research meeting
2021/11/30 Tue.	
9:00	Sent out 1st shore line, arrived at Nissan Pier No.6 at Yokosuka Port
13:00	Scientists disembarked, then completed voyage KR21-18C

- Results

The observation results of KR21-18C are shown below.

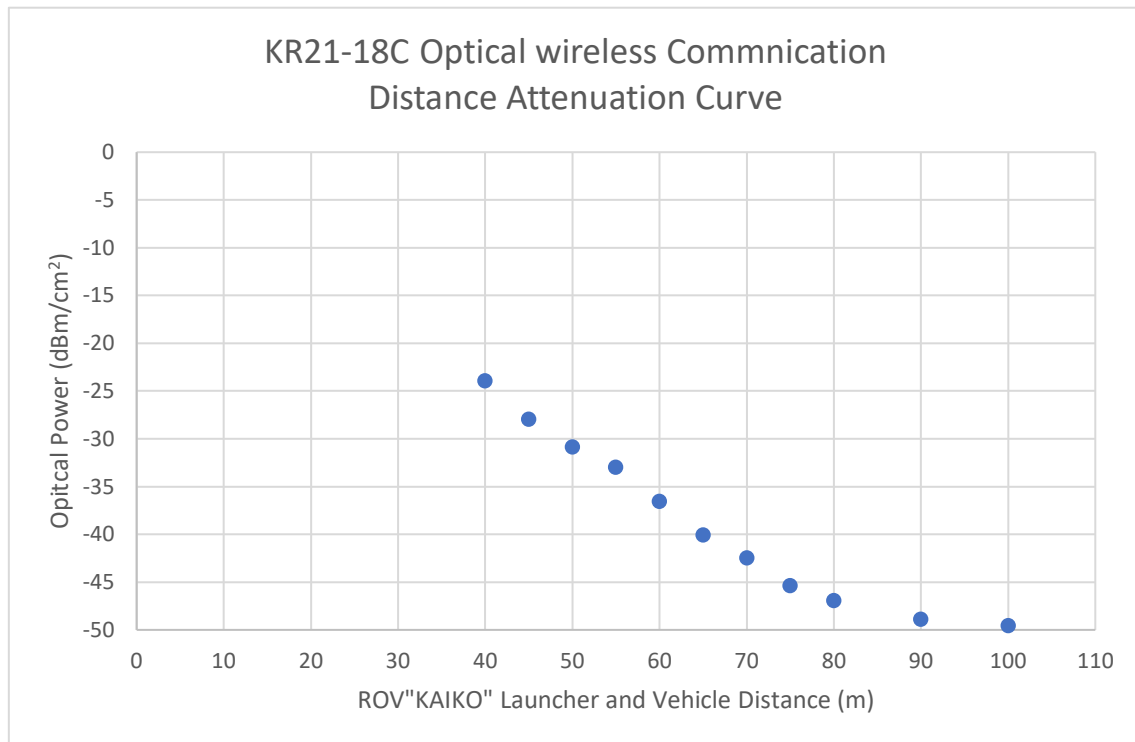


Fig.8 Distance Attenuation Curve

4. Notice on Using

This cruise report is a preliminary documentation as of the end of cruise.

This report is not necessarily corrected even if there is any inaccurate description (i.e. taxonomic classifications). This report is subject to be revised without notice. Some data on this report may be raw or unprocessed. If you are going to use or refer the data on this report, it is recommended to ask the Chief Scientist for latest status.

Users of information on this report are requested to submit Publication Report to JAMSTEC.

<http://www.godac.jamstec.go.jp/darwin/explain/1/e#report>

E-mail: submit-rv-cruise@jamstec.go.jp

Acknowledgement

We would like to thank the captain Takafumi AOKI and his crew of the R/V KAIREI, and Seiji SHIGETAKE and the ROV “KAIKO Mk-IV” technical support team (Nippon Marine Enterprises, Ltd.) for safe operation and great support during the cruise.

5. Appendix

Research Vessel KAIREI

R/V “KAIREI” is the exclusive mother ship for the 7,000m class remotely operated vehicle “KAIKO7000II” which entered service in 2006. In addition, R/V “KAIREI” is equipped with geophysical instruments such as a 444 channel seismic profiler. The major instruments installed in KAIREI are a multi-narrow beam batymetric mapping system (Sea Beam3012), and integrated sub-bottom profiler, gravity meter, proton magnetometer and three components magnetometer, and various kinds of sampling devices such as piston corer and dredge. There are several onboard laboratories for data recording, and data and sample analysis. These are the Research Room, Mission control & Computer Room, Wet laboratory (chemistry and biology), Dry laboratory (Geophysics), Gravimeter room, KAIKO Operation’s Center, Rocks and sediment laboratory, Library, Video Room and Personal computer Room. The ship also has an aft wheel house which overlooks the entire aft operations deck for the operation of the ship, winches, A-frame and cranes during station work such as dredge hauls, piston coring and sampling, launch and recovery operations.

The general specifications of R/V KAIREI

Length overall	106.0 m
Beam overall	16.0 m
Depth	7.3 m
Draft	4.5 m
Gross tonnage	4,517 tons
Service speed	16.7 knot
Main propulsion system Diesel engines	2,206kW x 2
Main propulsion method	Controllable pitch propeller x 2

R/V KAIREI MBES / magnetometers / gravity meter

KAIREI is equipped with various kinds of underway geophysical equipment, a multi narrow beam echo sounder (Type SeaBeam 3012, L-3 ELAC Nautik GmbH.), a sub bottom profiler (Type BATHY-20101, SyQwest, Inc.), a gravity meter (Type KSS31, BODENSEEWERK PERKIN-ELMER), a portable gravity meter (Type CG-3M, SCINTREX Inc.), a shipboard three components magnetometer (Type SFG-1214, Tierra

Technica Inc.), and a proton magnet meter (Type PM-217, Kawasaki Geological Engineering Co., Ltd.). The specifications of these instruments are listed below.

The specifications of SeaBeam 3012

Technical Data	
Operating frequency	12 kHz
min. depth	50m below transducers
max. depth	11,000 m (full ocean depth)
number of Beams	301 equi-distance
Accuracy	< 1 % of water Depth (Average Across Swath)
Side scan	12-Bit Resolution to maximum 2000 pixels
Average Footprint Resolution	2° x 1.6°
Max. Vessel Speed	6 knots (100 % Coverage @ 140° swath) 12 knots (100 % Coverage @ 120° swath)
Workstations	Computer with Windows 7 operating system
measurement method	Swept beam technique
Environmental limits for compensation	
Roll	±10°
Pitch	±7°
Yaw	±5°

The specifications of BATHY-2010

Depth Ranges	10, 20, 40, 80, 150, 300, 500, 750, 1000, 2000, 5000, 12000 Meters
Strata Resolution	Up to 6 cm with 200 Meter of bottom penetration bottom type dependant
Depth Resolution	0.1 Meters
Depth Accuracy	±0.3% to 6000 m
Frequency Output	3.5 KHz

The specifications of Gravity meter

Accuracy on Profile	DYNAMIC* (mgal RMS)	EFFECTIVE** (mgal RMS)
Vertical Acceleration (mgal RMS)		
< 15,000	0.5	0.2
15,000 - 80,000	1	0.4

80,000 - 200,000	2	0.8
Accuracy during Turn	DYNAMIC*** (mgal RMS)	EFFECTIVE*** (mgal RMS)
Vertical Acceleration (mgal RMS)		
15,000 - 80,000	2.5	1
Drift Rate (mgal/month) 		

* Accuracy without applying data reduction

** Accuracy applying data reduction procedures

*** Depending on accuracy of navigation data

The specifications of portable Gravity meter

Reading Resolution 0.001 mgal

Minimum Operating Range	7000 mgal,without resetting
Residual Long-term Drift	Less than 0.02 mgal /day
Typical Repeatability in field use	Less than 0.05 mgal standard deviation
Range of Automatic Tilt correction	±200 arc sec.

The specifications of 3 axis magnet meter

System	ring core fluxgate
Number of component directly	3 axes
Cable length (m)	50
Sensor dimension (mm)	φ280×130H
Measurement range (nT)	±100,000
Resolution (nT)	1

The specifications of Proton magnet meter

Measurement range (nT)	$3 \sim 7 \times 10^{**4}$
Resolution (nT)	0.01
Sampling rate	10sec, 20sec, 1min, manual, external
Time of applying field(sec.)	3 to 10
Sensor dimension (mm)	φ200×1050
Weight (kg)	28.6(in the air), 6.2(in the sea)

Crew List

Ship's Crew

Position	Name
Master	Takafumi AOKI
Chief Officer	Hiroyuki KATO
2nd Officer	Akira SUZUKI
3rd Officer	Taiga YAMAMOTO
Chief Engineer	Eiji SAKAGUCHI
1st Engineer	Takahiro MORI
2nd Engineer	Yoshinobu HIRATSUKA
3rd Engineer	Keito SHIMADA
Chief Electronics Operator	Yoichi INOUE
2nd Electronics Operator	Kohei MAEDA
Boat Swain	Yoshiaki MATSUO
Quarter Master	Shuichi YAMAMOTO
Quarter Master	Kazumi OGASAWARA
Quarter Master	Saikan HIRAI
Quarter Master	Akira KURIHARA
Sailor	Kodai KAKUBARI
Sailor	Mizuki NAKANO
No.1 Oiler	Yukihiro YAMAGUCHI
Oiler	Sota MISAGO
Assistant Oiler	Ruki SAITO
Assistant Oiler	Kota MATSUMURA
Assistant Oiler	Fumiya NAKASHIMA
Chief Steward	Kazuhiro HIRAYAMA
Steward	Tsuyoshi NAGATOMO
Steward	Masaru SUGIYAMA
Steward	Tsugumi TANAKA
Steward	Hayato OKADA

“KAIKO” Operation Team

Position	Name
Submersible Operation Manager	Seiji SHIGETAKE
1st Submersible Tec. Officer	Tomoe KONDO
2nd Submersible Tec. Officer	Takuma GOTO
3rd Submersible Tec. Officer	Naoki SATO
3rd Submersible Tec. Officer	Atsushi KOGUMA
3rd Submersible Tec. Officer	Kunihiro IWATA
3rd Submersible Tec. Officer	Kai TAKEDA