

# High-rate underwater acoustic communication system for image transmission with a manned submersible SHINKAI6500

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(JAMSTEC)

# Agenda

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## 1. Brief introduction about us

About us, Example of research, Example of development

## 2. Background

Shinkai6500, image transmission, UWA comm. Data rate, conventional system

## 3. New Communication System

improvement policy, specification

## 4. At-sea Experiment

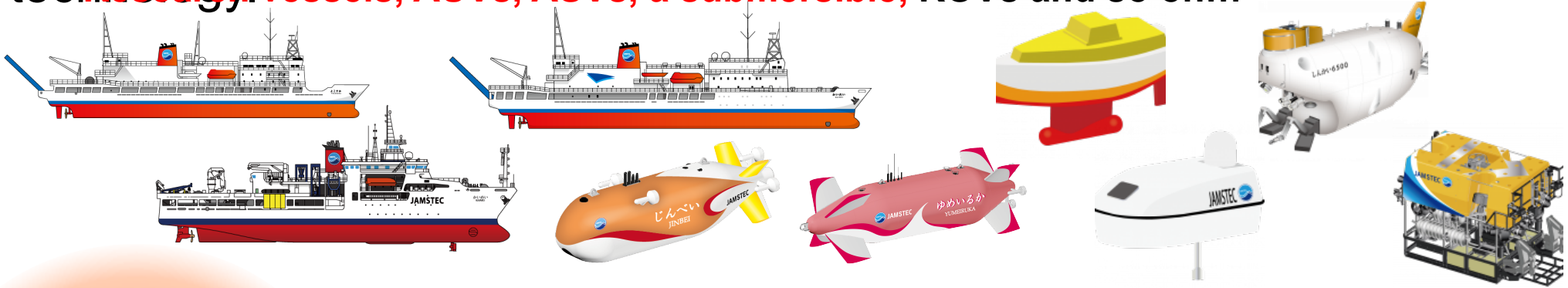
experiment sites, at a depth of 1200m, at a depth of 6500m

## 5. Summary

# 1-1: Introduction about us

JAMSTEC is a national research institute,  
focused on marine-earth science and  
technology. **Research vessels, AUVs, ASVs, a submersible, ROVs and so on...**

Many Facilities



Research Development

Acoustic scientists & engineers :  
5 people (including managers)

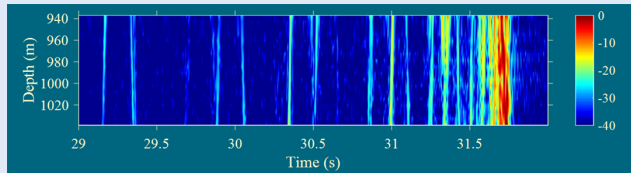
We research and develop  
Underwater Acoustic communication and localization systems!  
(UWA)

# Research!

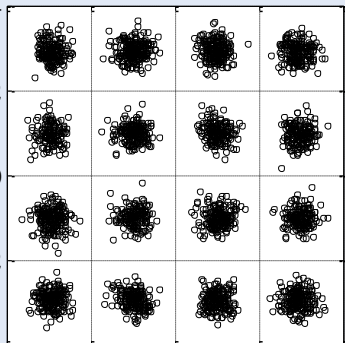
## 1-2:UWA communication with Time-reversal

### Long - range

1000km communication



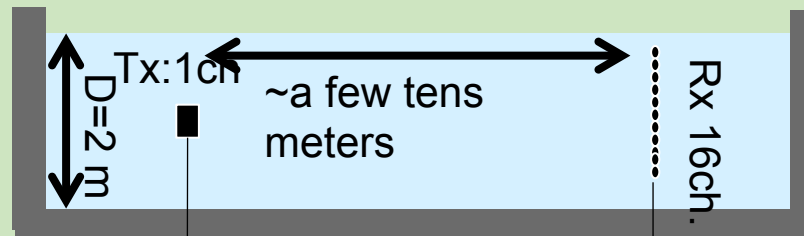
Mod. :16QAM  
Rate :400 bps  
Range :600 km



Output SNR : 20.0 dB  
Symbol error : 0 / 2700

### High rate in a Tank

Small Tank : rich multipath environment



Signal spec.

- Fc:59kHz,
- BW:24kHz,
- Modulation: 16QAM
- Data rate: 96kHz

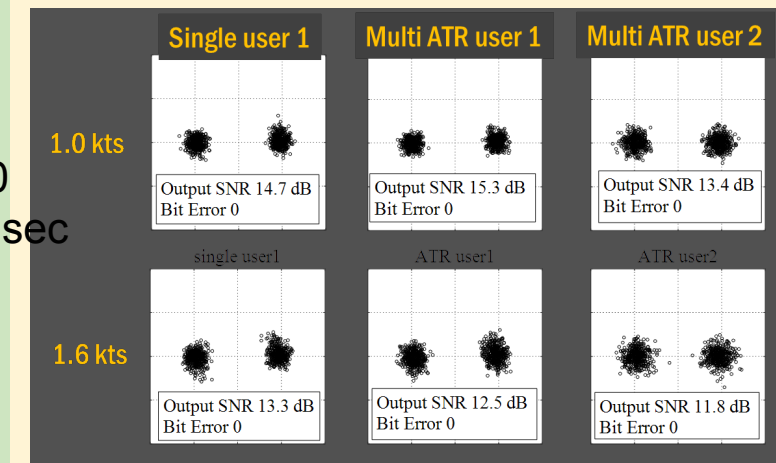
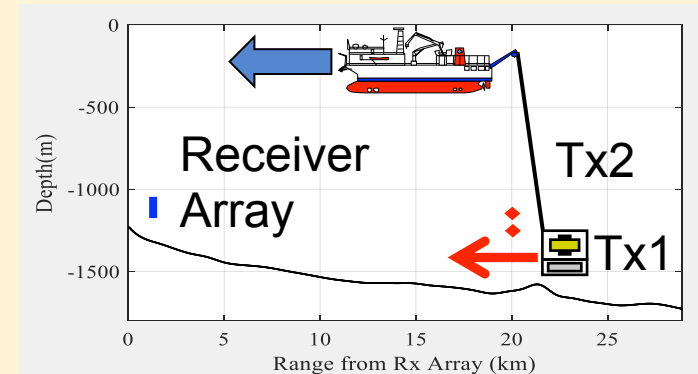
Image spec.

- Image size : 640x480
- Interval : every 2 sec

\* This experiment was conducted as demonstration for

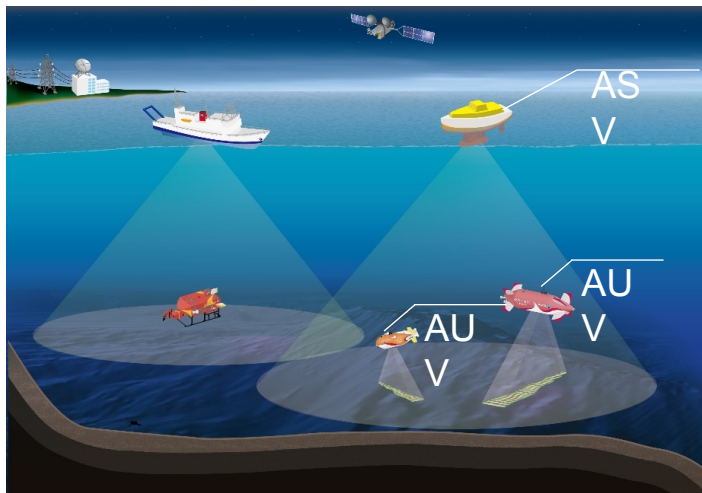
### Multuser (mobile)

Multuser mobile communication



Development!

# 1-4: multiuser communication & localization



Multiple AUVs operation with an ASV

## concepts

1. Unified modem for multiple communication and localization
2. Downlink signals avoid to overlap transmission of uplink signals automatically.



A prototype of an ASV



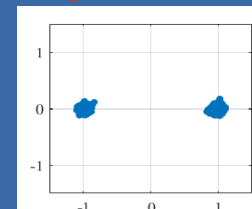
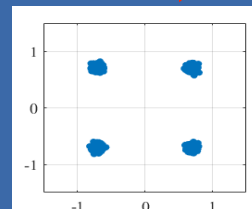
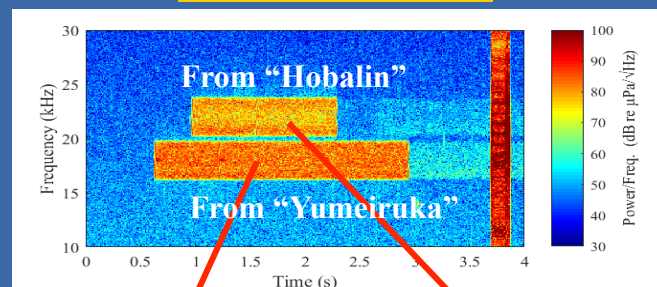
AUV "Hobalin"

(National Maritime Research Institute)

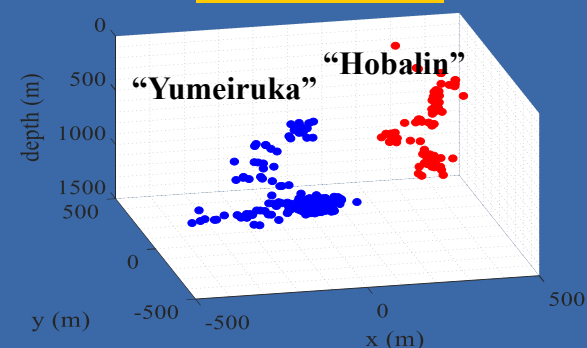


AUV "Yumeiruka"

## multiple simultaneous communication



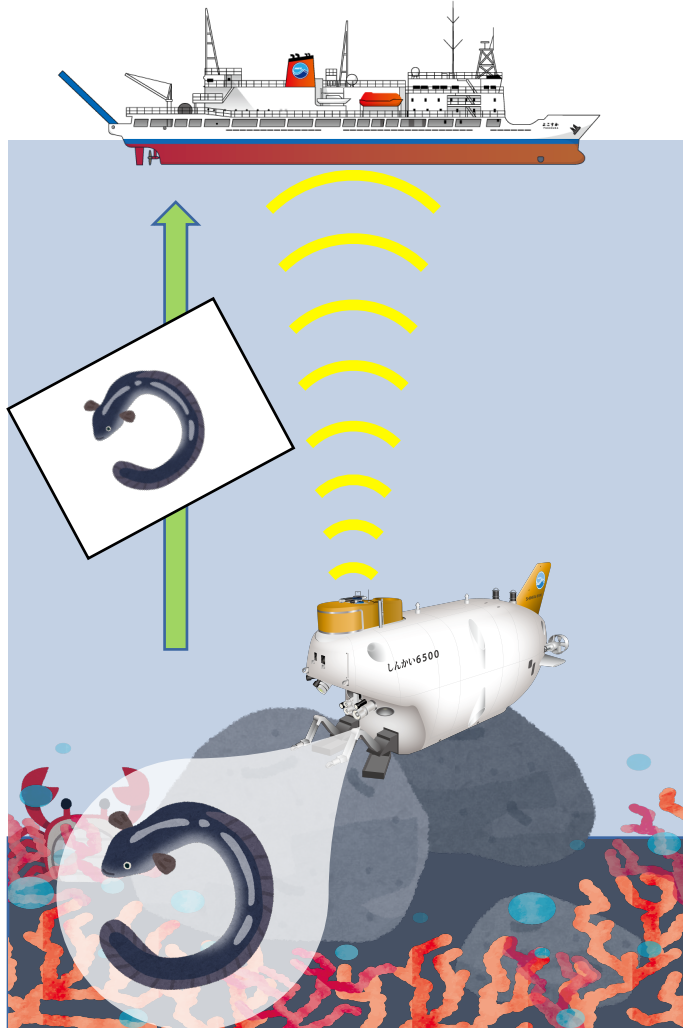
## multiple simultaneous Localization



The good performance as expected!

Development!

# 1-5: image transmission system for submersible

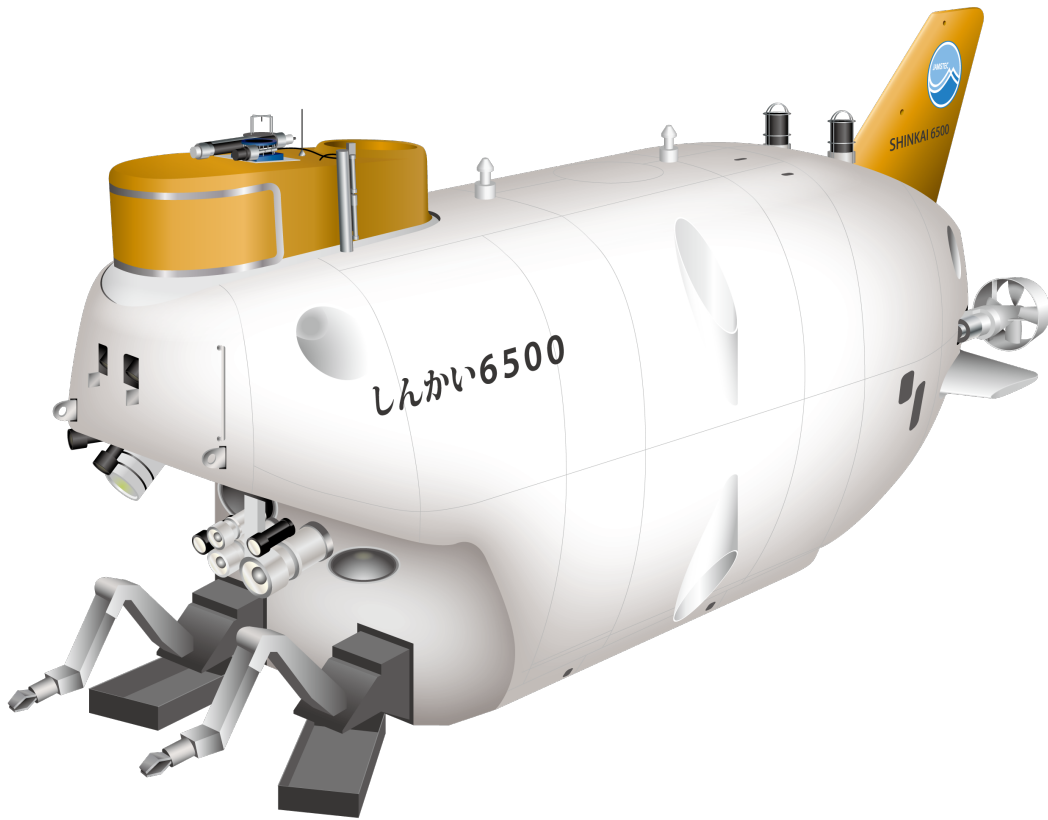


Today's Topic!



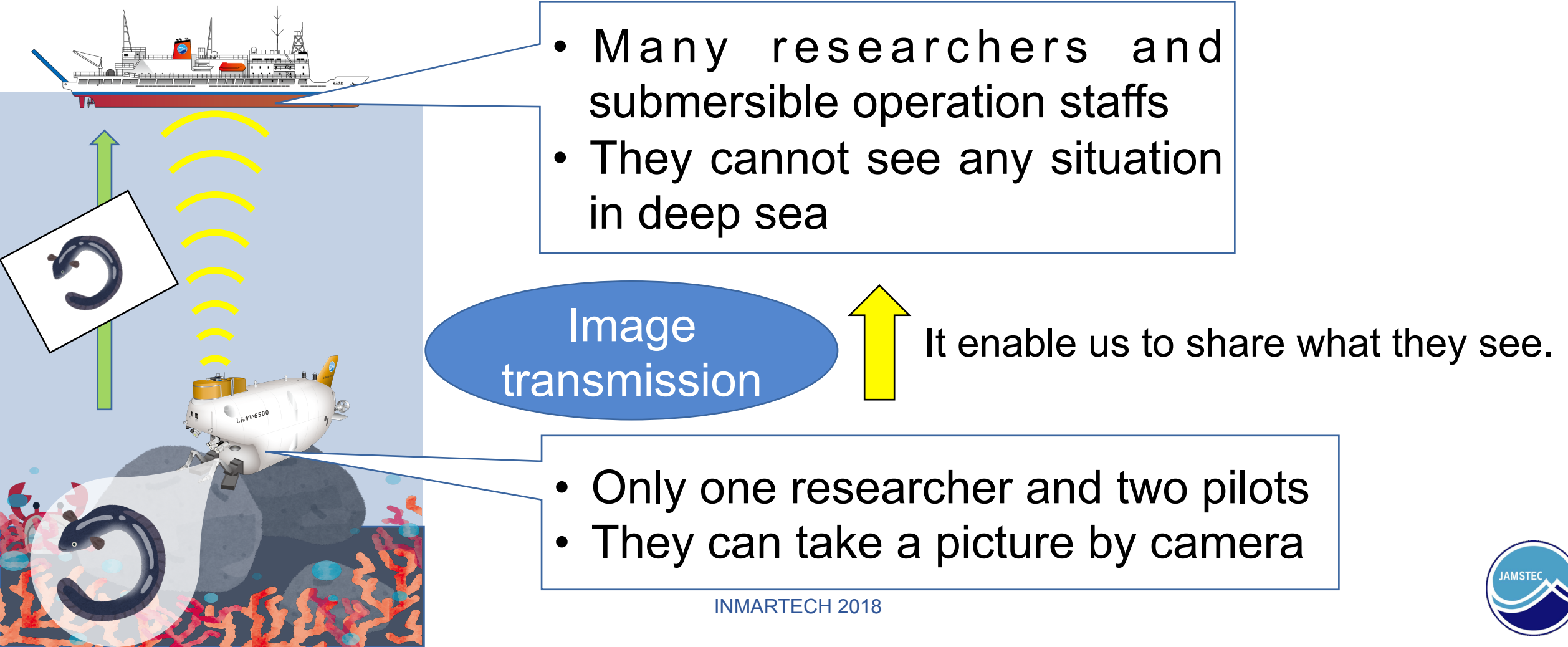
# 2-1:Shinkai 6500

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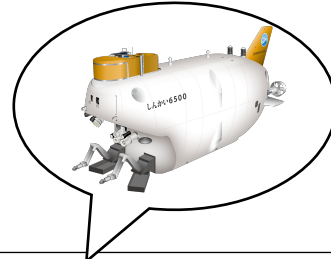
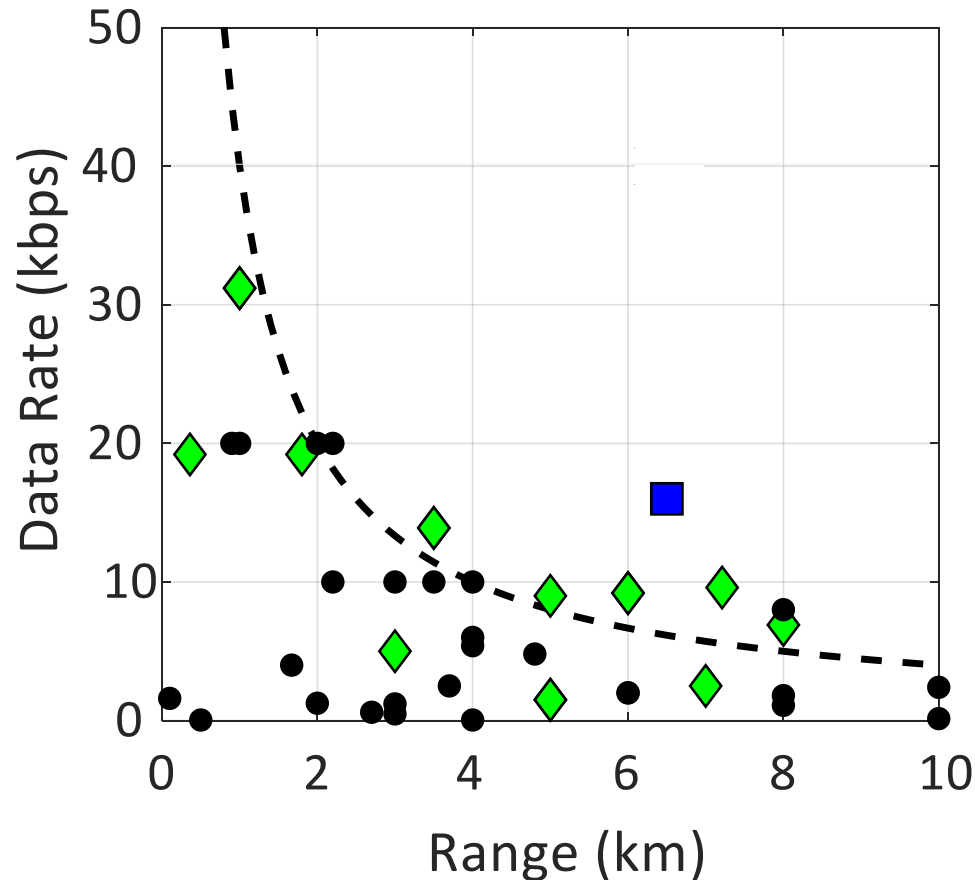
Name	:	Shinkai 6500
Size	:	9.7mx2.8mx4.1m
Weight in the air	:	26.7tons
Accommodation	:	3 (2pilots & 1 researcher)
Maximum speed	:	2.7 knots
Instruments	:	2 HD video cameras underwater telephone 1 CTDO 1 digital camera 2 mobile sample baskets

## 2-2:Necessary of image transmission





## 2-3: UWA comm. : data rate & range

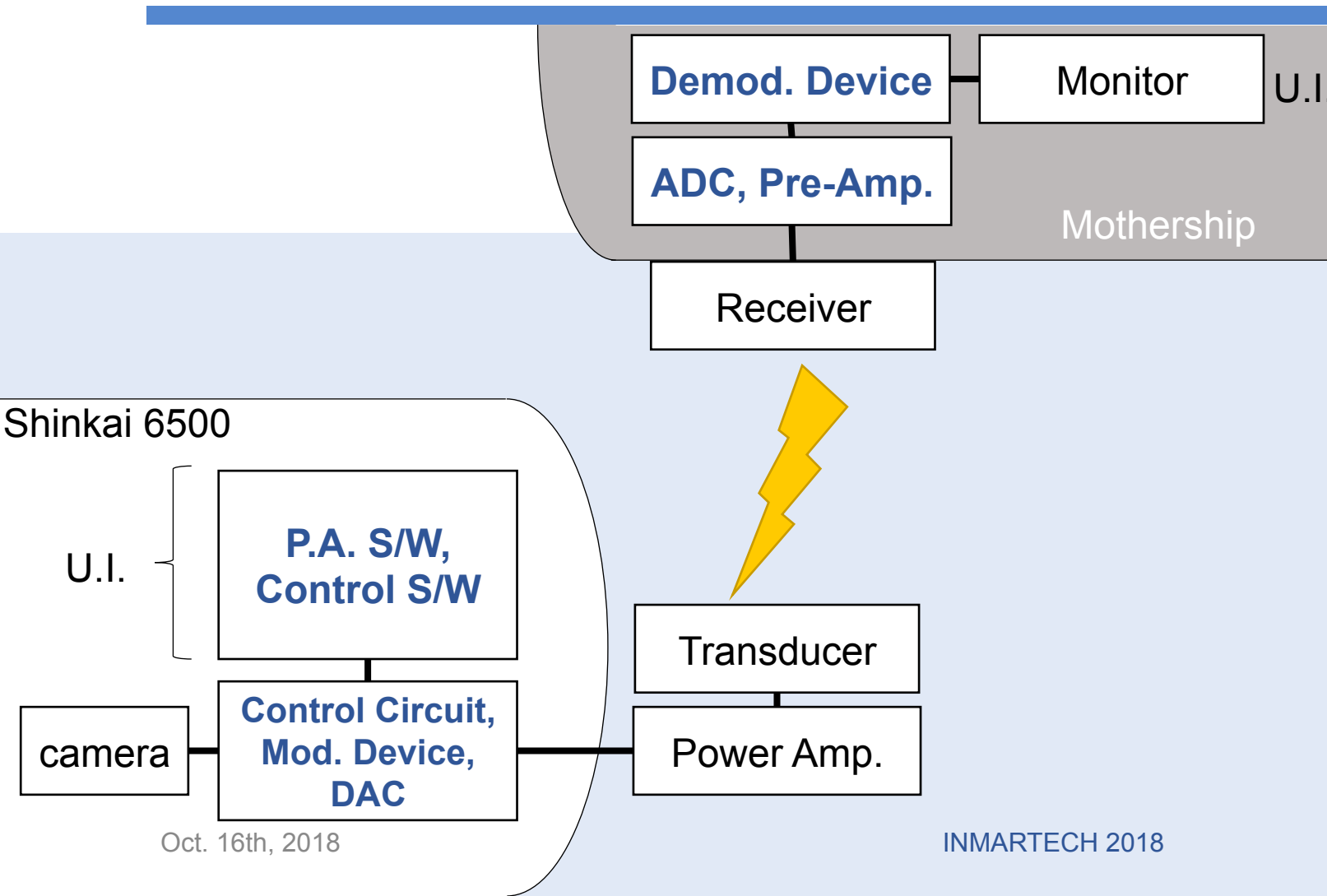


- Old one
- ◆ Major Products
- Others

- ✓ For UWA communication, data rates depend on ranges. (Absorption, noise, maximum Tx level,...)
- ✓ Empirical formula in a paper:  
 $\text{Data rate} \times \text{Range} = 40 \text{ kbps} \cdot \text{km}$
- ✓ Many products follow the formula.

*"The state of the art in underwater acoustic telemetry"*  
Kilfoyle, D.B.; Baggeroer, A.B.; MIT & Woods Hole Oceanogr.  
Instn. Joint Program in Oceanogr. Eng., Woods Hole Oceanogr.  
Instn., MA IEEE Journal of Oceanic Engineering, Jan 2000

## 2-4:Background – Conventional system -



It was developed in 1991.

### Maintenance

- Some parts are unavailable.

### Improvement

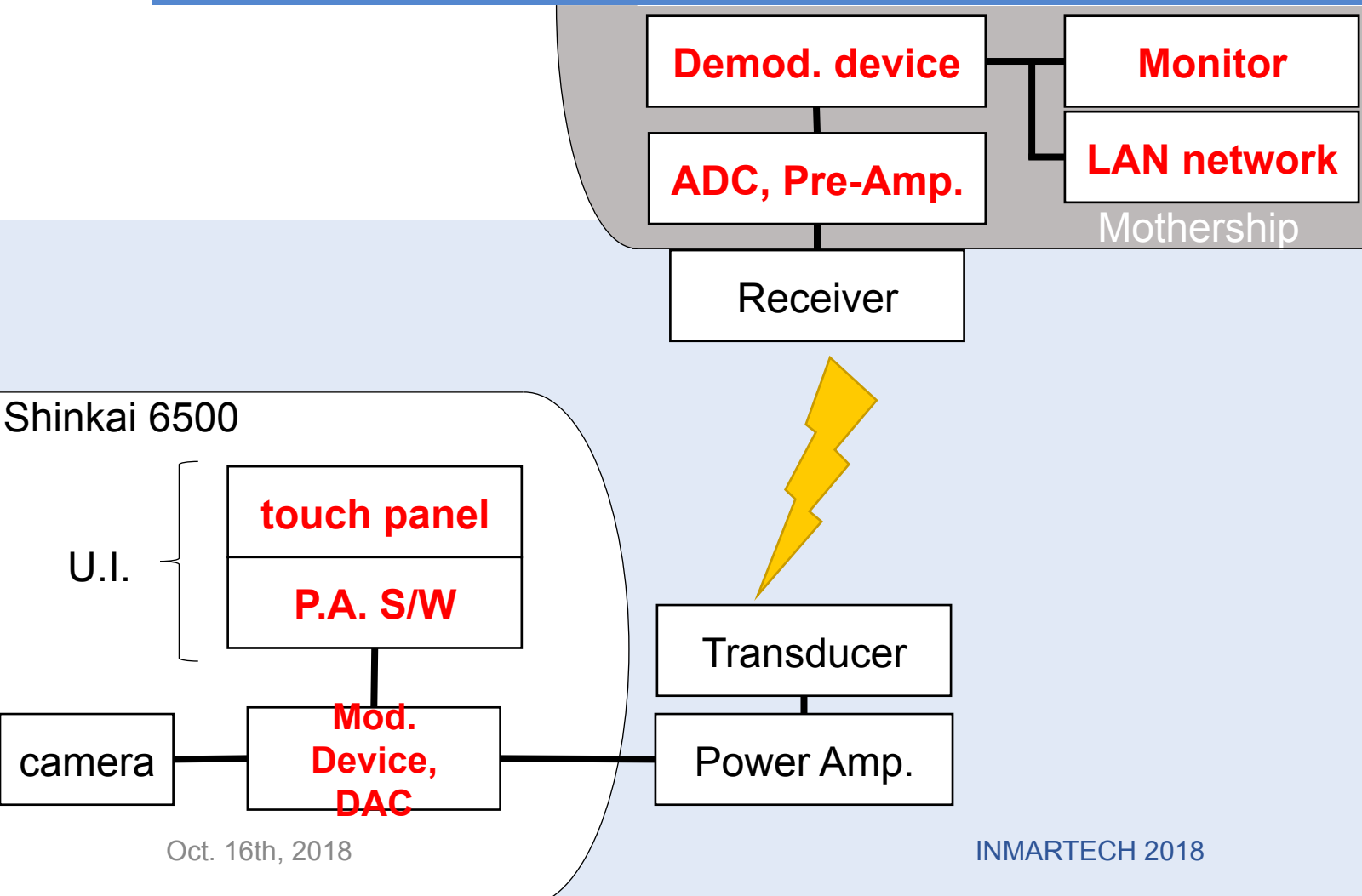
- Sophistication of signal processing technology and electronics

### Conventional system's specification

- ✓ Frequency : 16 – 24 kHz
- ✓ Data rate : 16kbps
- ✓ Tx Power @ 20kHz :
  - 205 dB re.1 $\mu$ Pa @1m (High)
  - 195 dB re.1 $\mu$ Pa @1m (Middle)
  - 185 dB re.1 $\mu$ Pa @1m (Low)
  - 165 dB re.1 $\mu$ Pa @1m (Test)

# 3-1:New image transmission system

## Improvement policy

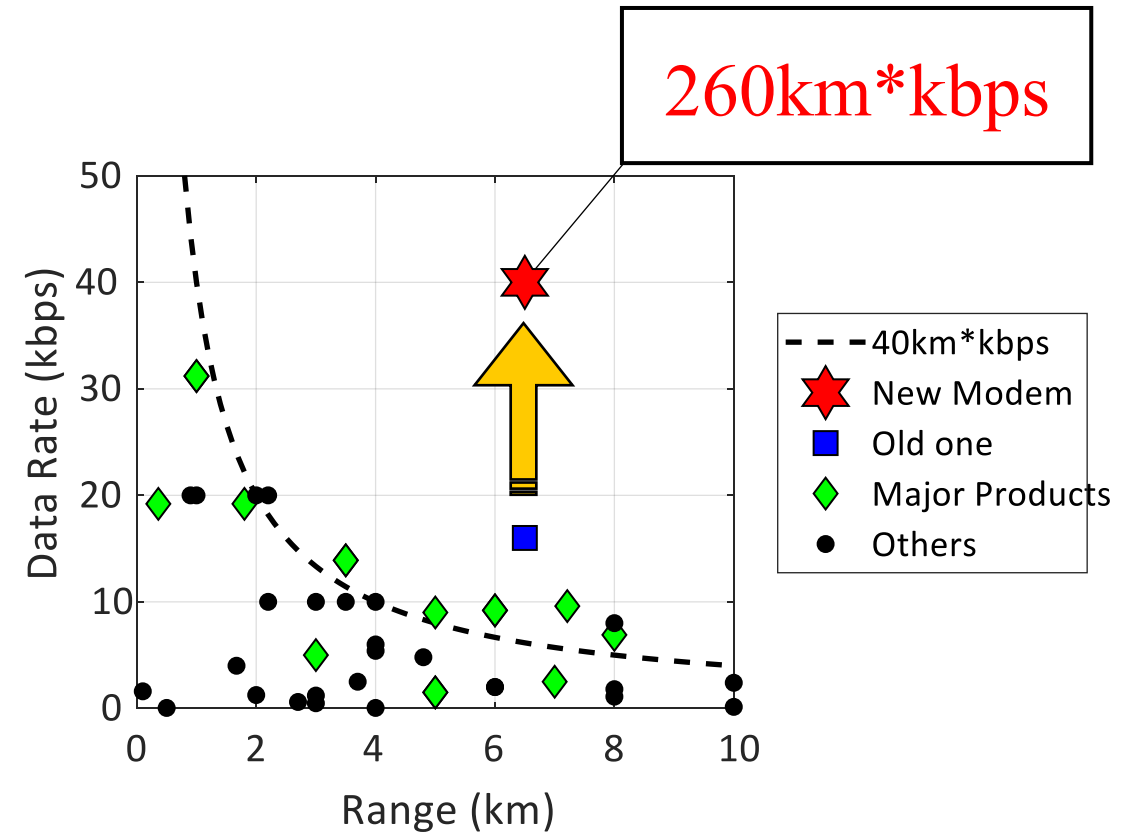


## Improvement policy

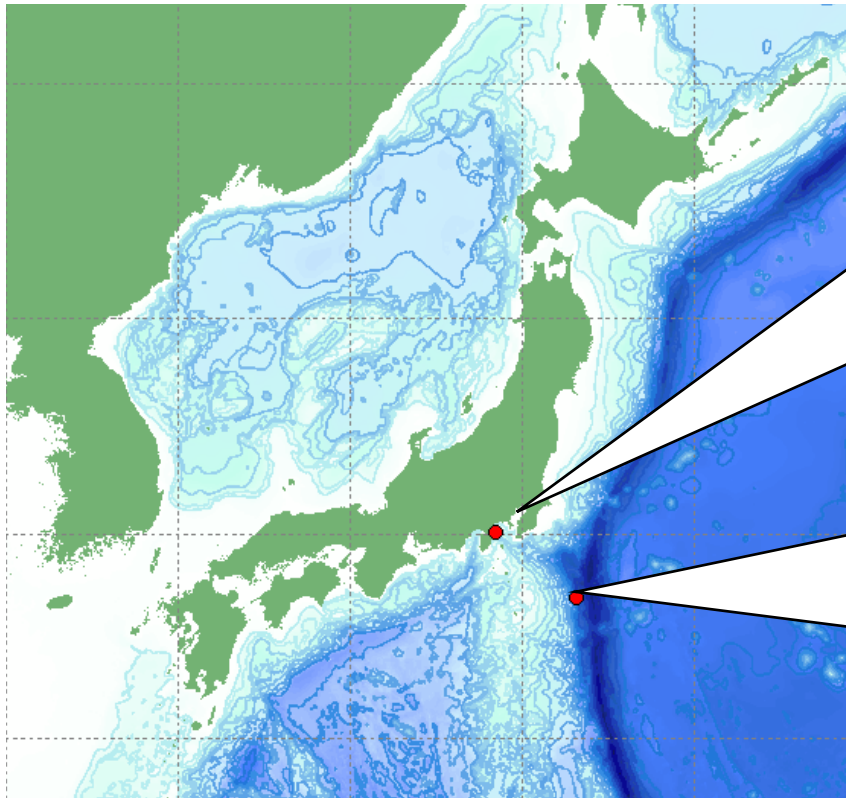
- ✓ The conventional transducer and power amp. are utilized.
  - ➔
    - Reduce Development schedule
    - Reduce necessary expenses
- ✓ An image transmission interval is **shortened dramatically**.
- ✓ Robust and high data-rate communication
  - ➔
    - Modulation and demodulation methods should be redesigned from the beginning.
    - **Research results** and **experiences of AUV communication** are expected to contribute to this development.

# 3-2:New Communication system - specification -

	Old one	New One
Center Frequency	20kHz	20kHz
Bandwidth	8 kHz	8 kHz, 10kHz
Number of Tx, Rx	1x1(SISO)	1x1(SISO)
modulation	4-DPSK	QPSK, 16QAM
Data rate	16kbps	16kbps ( 8kHz, QPSK) 32kbps ( 8kHz,16QAM) <b>40kbps</b> (10kHz,16QAM)
Image transmission interval	10s	<b>2, 3, or 5 s</b> (selectable)
Image size	256x240	<b>320x420 or 480x320</b> (selectable)

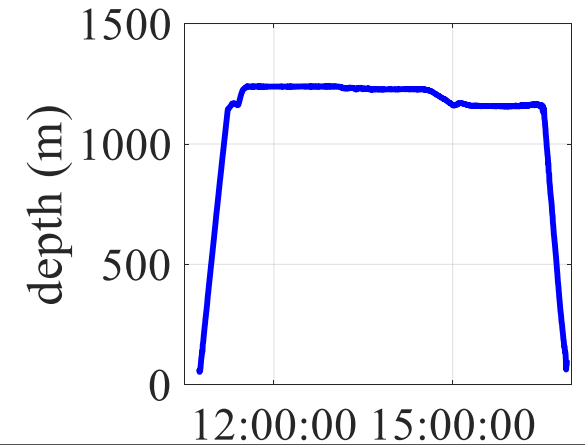
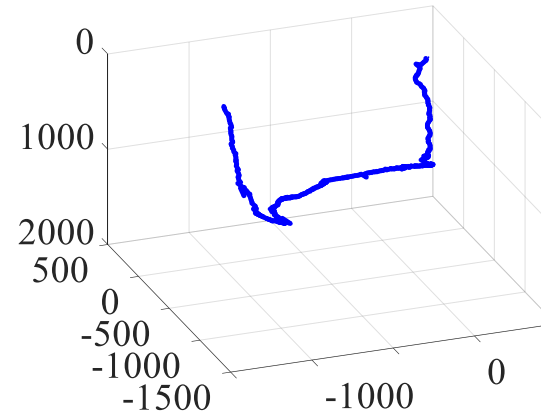


# 4-1:At-Sea Experiment



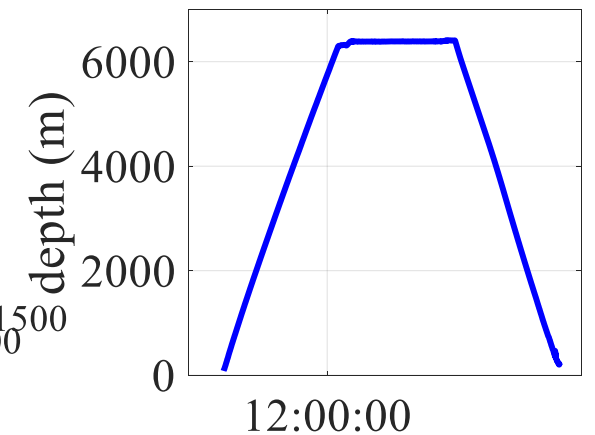
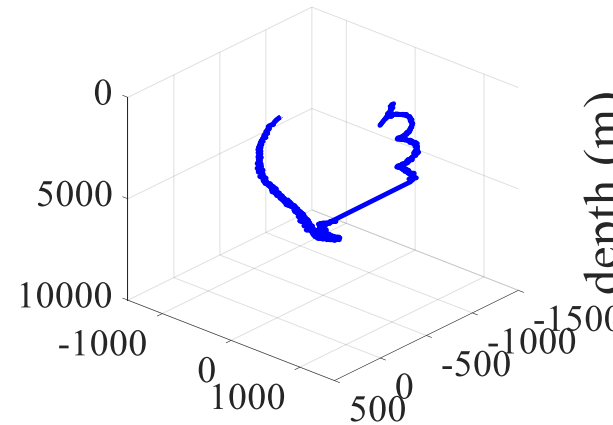
Depth:1200m

System Check



Depth:6500m

System Check  
Challenge



## 4-2: At-Sea Experiment at depth of 1200m

- System confirmation test



Tx Level : Low ( $\sim 2W$  @ transducer)

Size : 320x240

Interval : 2sec

Frequency : 16 – 24 kHz

Mod type : 16QAM

Data rate : 32kbps



# 4-3:At-Sea Experiment at depth of 6500m

- System confirmation test

\*This example is updated every 4 sec



Tx Level : Middle (~ **20W** @ transducer)

Size : 320x240

Interval : 2sec

( image and test signals were transmitted alternately.)

Frequency : 15 – 25 kHz

Mod type : 16QAM

Data rate : 40kbps

# 5:Summary

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Images when Shinkai 6500 landing at 6300m , X10 play



## Summary

- ❑ Our image transmission system was renewed.
- ❑ New one gives us clearer images.
- ❑ The data rate is so high  
that we monitor images like movie.
- ❑ It is utilized for actual operation with Shinkai 6500.