



# AUV PAUL3000

## Polar autonomous underwater laboratory

AWI's AUV project

Feb. 2021

FRAM



 ALFRED-WEGENER-INSTITUT  
HELMHOLTZ-ZENTRUM FÜR POLAR-  
UND MEERESFORSCHUNG

- Team

- Team

- Sascha Lehmenhecker
- Autun Purser (Scientific Lead)
- Michael Busack (Tech. Lead)
- Jonas Hagemann



- Team
- History

# Introduction

- History
  - Purchased in 2003

Bluefin Robotics Type Odysse III



- Team
- History

# Introduction

- History

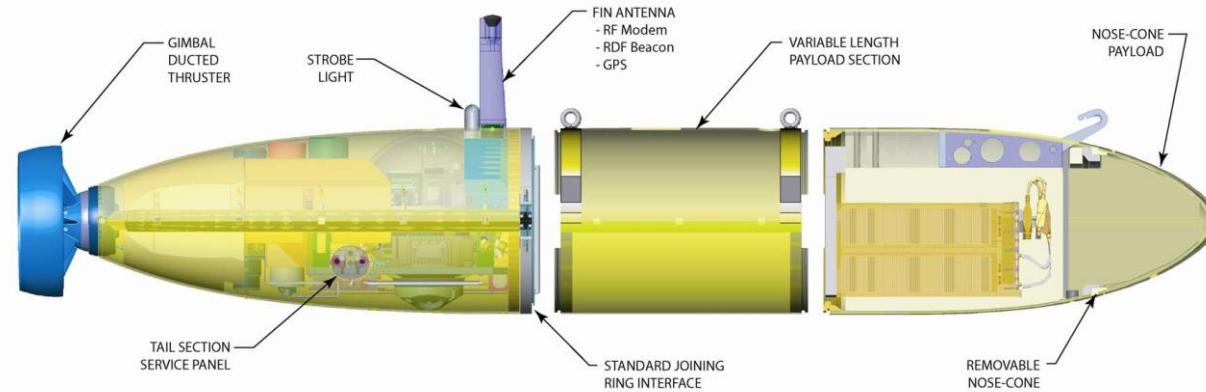
- 2003: Purchased

- Specs:

- Length: 3.2 – 4 m
    - Weight: 150 kg
    - Power: 2 kWh Li-Po
    - Depth: 3000 m

- Instruments

- 2 x magnetic compass
    - Forward-looking sonar
    - DVL



- Team
- History

# Introduction

- History
  - 2003 - 2007
    - Bad navigation
    - Problem with sensors



# Introduction

- History
    - 2008: Update
      - INS
      - Benthos-Modem

**U.S. Department of State  
UNITED STATES OF AMERICA**

**NONTRANSFER AND USE CERTIFICATE**

**3. Name of United States applicant  
Bluefin Robotics Corporation**

**4. Country of ultimate disposition  
Germany**

**5. This certificate is submitted in  
conjunction with export application  
no. 08-00000000000000000000000000000000**

**6. Article/Category  
We certify that we have placed an order with the person named in Item 2 for the following articles/items in the quantity and value shown below:**

<b>QUANTITY</b>	<b>ARTICLE/ITEM DESCRIPTION</b>	<b>VALUE (U.S. \$)</b>
1	Autonomous Underwater Vehicle ("AUV") - previously exported under Permanent License number 989760. Upgraded to include a Karto3 Internal Navigation System ("INS")	\$981,470

**7. Certification of foreign consignee  
We certify that the articles/items listed in Item 5 for delivery to the end-user in Item 3, except as specifically acknowledged by prior communication or in writing, will not be resold, re-exported, or otherwise disposed of in any manner, directly or indirectly, to any country or entity controlled by, or (2) any other person, including any government, that has imposed restrictions on the importation of such articles/items into that country or entity. We further certify that all of the facts contained in this statement are true and correct to the best of our knowledge and belief and we do not know of any reason that would cause any change of facts or intentions set forth here.**

**Type or print \_\_\_\_\_ Signature of Official, Foreign Consignee \_\_\_\_\_ Date Signed 0000-00-0000 Seal \_\_\_\_\_**

**Name and Title of Signer \_\_\_\_\_**

**8. Certification of foreign government  
We certify that we are the end-user of the articles/items in Item 5. Except as specifically authorized by prior written approval of the U.S. Department of State, we will not resell, re-export, or otherwise dispose of the articles/items in Item 5 to any other person, including any government, that has imposed restrictions on the importation of such articles/items into that country or entity. We further certify that all of the facts contained in this statement are true and correct to the best of our knowledge and belief and we do not know of any reason that would cause any change of facts or intentions set forth here.**

**Type or print \_\_\_\_\_ Signature of Official, Foreign Government \_\_\_\_\_ Date Signed 0000-00-0000 Seal \_\_\_\_\_**

**Name and Title of Signer \_\_\_\_\_**

**9. Certification of foreign government  
We certify that we are the end-user of the articles/items in Item 5. Except as specifically authorized by prior written approval of the U.S. Department of State, we will not resell, re-export, or otherwise dispose of the articles/items in Item 5 to any other person, including any government, that has imposed restrictions on the importation of such articles/items into that country or entity. We further certify that all of the facts contained in this statement are true and correct to the best of our knowledge and belief and we do not know of any reason that would cause any change of facts or intentions set forth here.**

**Type or print \_\_\_\_\_ Signature of Official, Foreign Government \_\_\_\_\_ Date Signed 0000-00-0000 Seal \_\_\_\_\_**

**Name and Title of Signer \_\_\_\_\_**

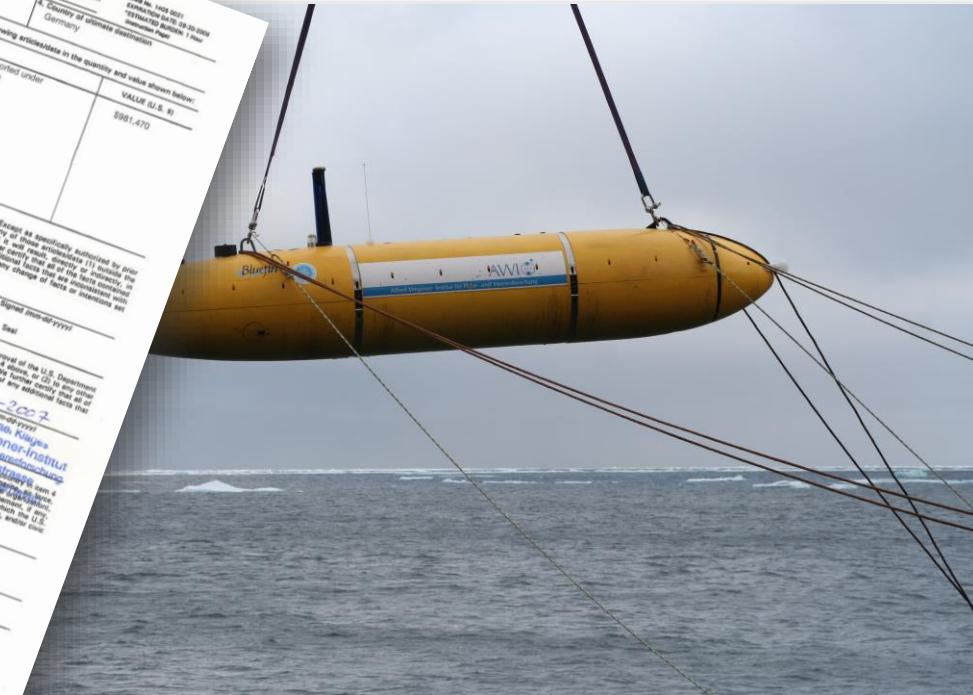
**10. We certify that no corrections, additions or alterations were made on this form by us after it was signed by the foreign consignee, foreign agent or foreign government.**

**Type or print \_\_\_\_\_ Signature of Applicant \_\_\_\_\_ Date Signed 0000-00-0000 Seal \_\_\_\_\_**

**Name and Title of Signer \_\_\_\_\_**

**11. This certificate is issued on  
EXPIRATION DATE: 00-00-2009  
Renewal date: 00-00-2009**

**Page 1 of 1**



## Introduction

- Team
  - History



- Team
- History

# Introduction

- History
  - 2011: Re-Design
    - Battery-Section
  - Ice shift tracking
    - Portable GPS tracker

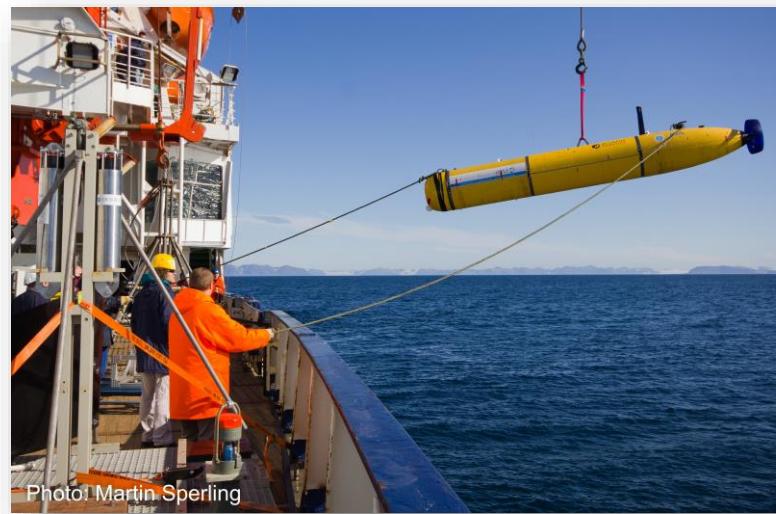


Photo: Martin Sperling



- Team
- History

# Introduction

- History
  - 2012: Additional Equipment
    - Orange fin
  - Ice shift tracking
    - Drone V1

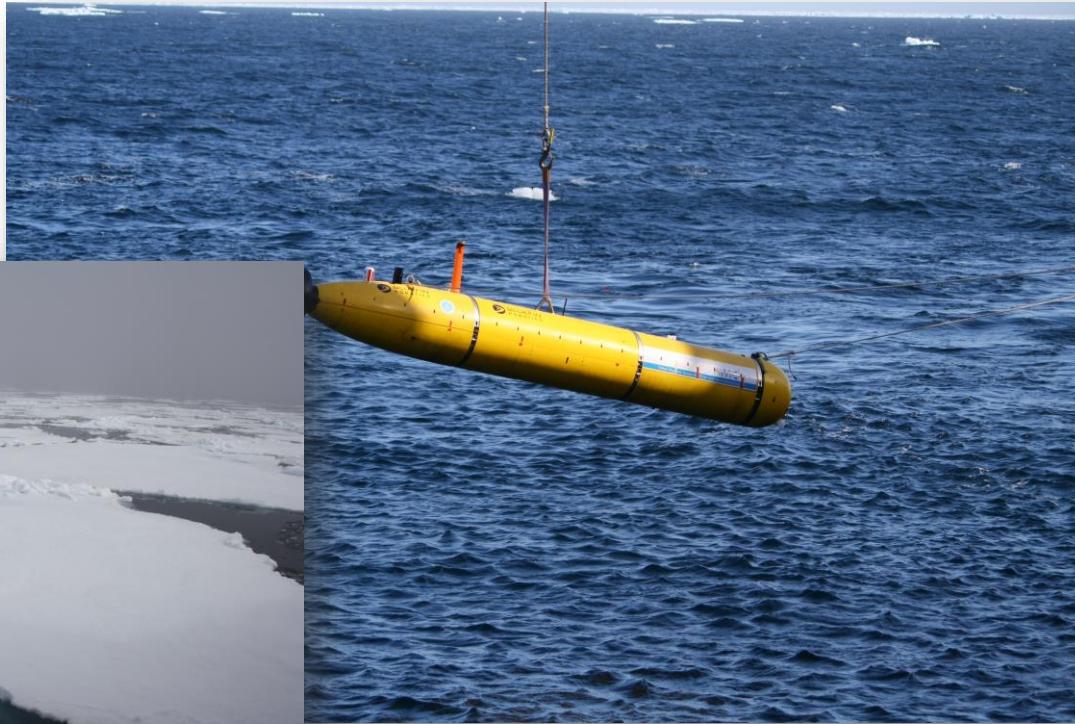


- Team
- History

# Introduction

- History

- 2013: Additional Equipment
  - Iridium
- Ice shift tracking
  - Drone V2



- Team
- History

# Introduction

- History
  - 2015: Additional Equipment
    - Drone V3



- Team
- History

# Introduction

- History
  - 2018



- Team
- History

# Introduction

- History
  - Today
    - Specs:
      - Length: 4.3 - 4.7m
      - Weight: 400 – 600 kg
      - Power: 7.5 kWh Li-Ion
      - Depth: 3000 m
    - Instruments
      - INS
      - DVL
      - 2 x Iridium / GPS
      - 2 x Strobe
      - USBL



# Payload

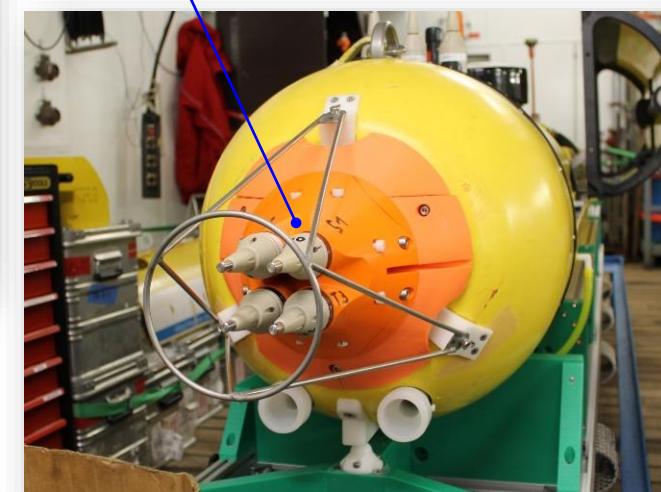
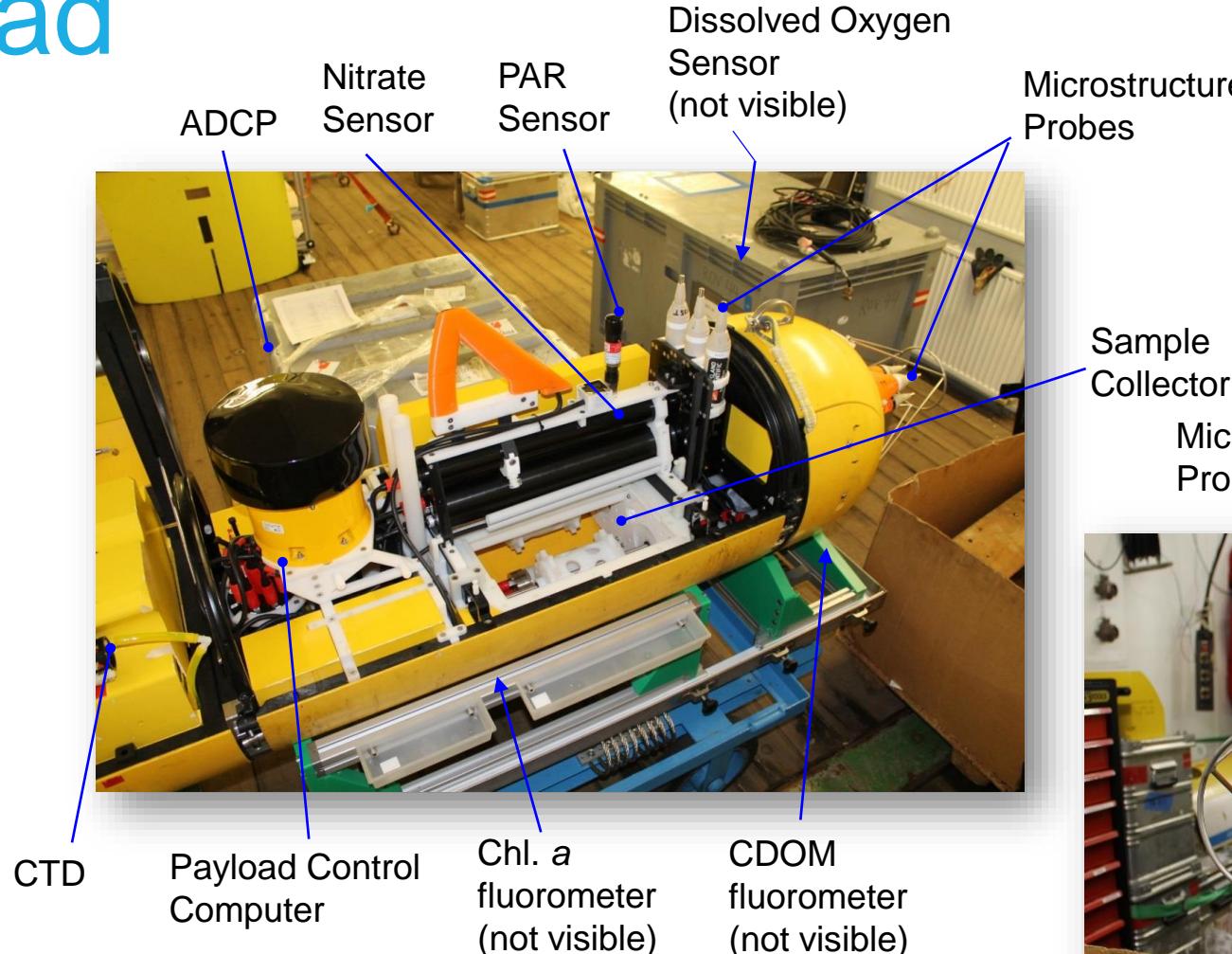
- Highly modular
- 2 different payloads
  - Pelagic
  - Benthic



- Team
  - History
- Payload
- Pelagic

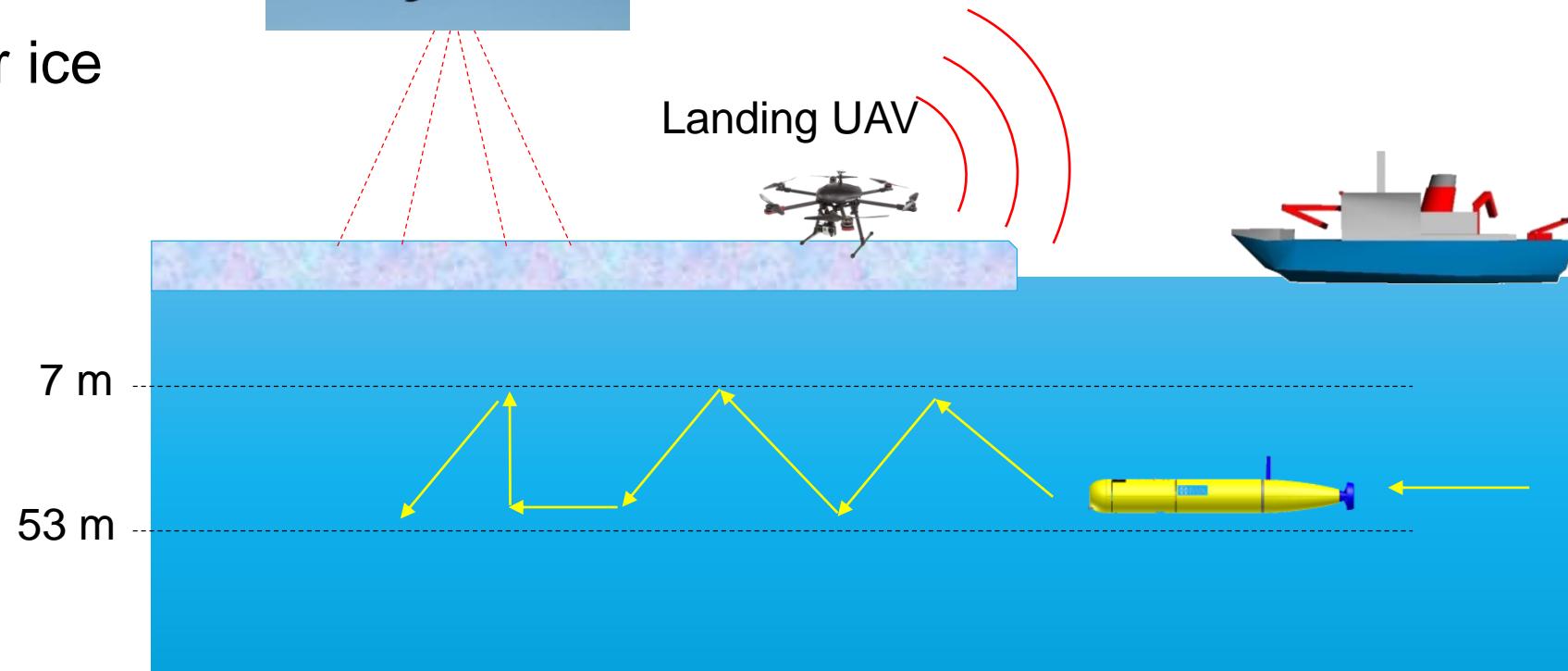
# Payload

- Pelagic



# Payload

- Pelagic
  - Under ice

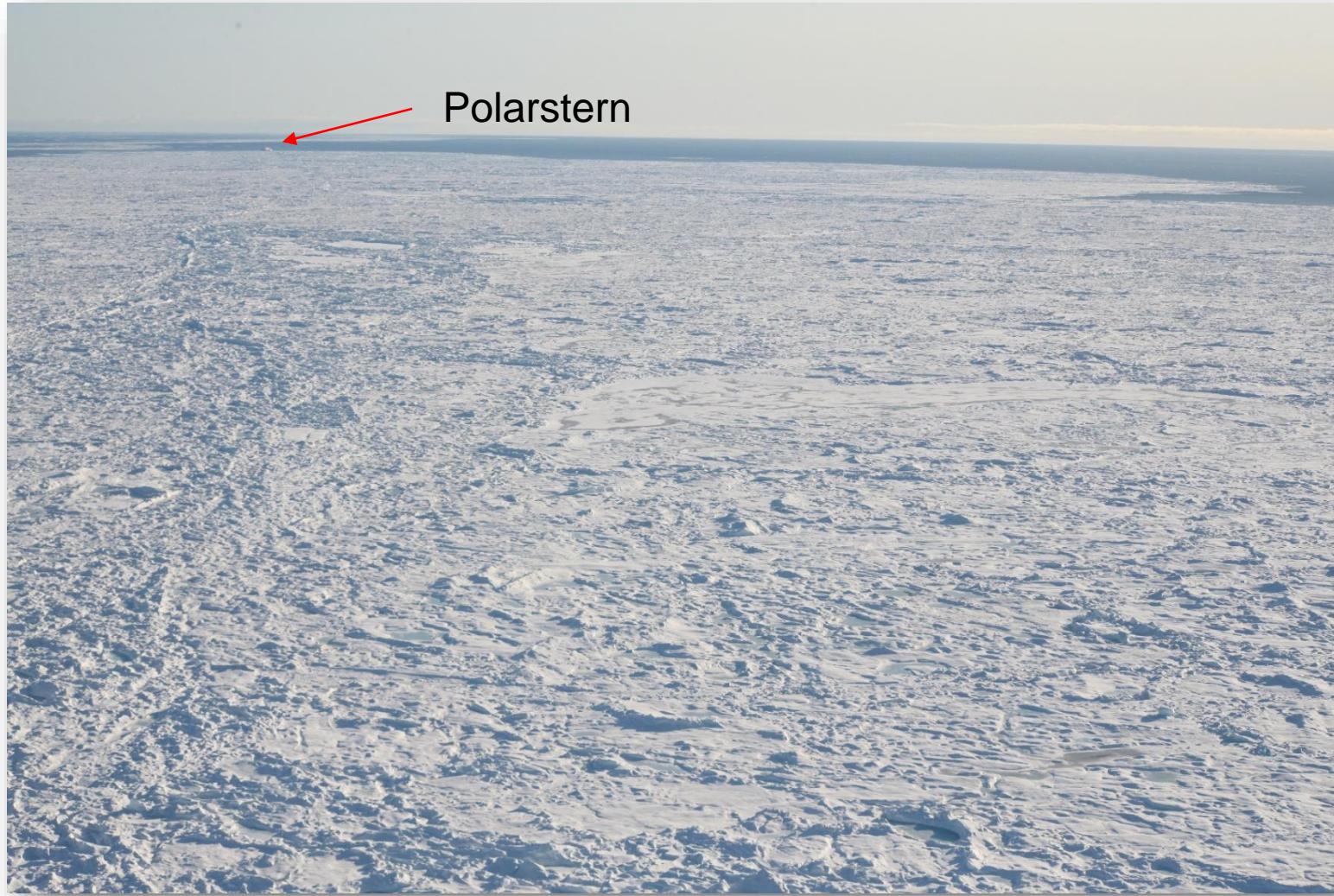


- Team
- History

## Payload

- Pelagic

- Pelagic
  - Under ice



- Team
- History

- Pelagic

- Pelagic
  - Under ice

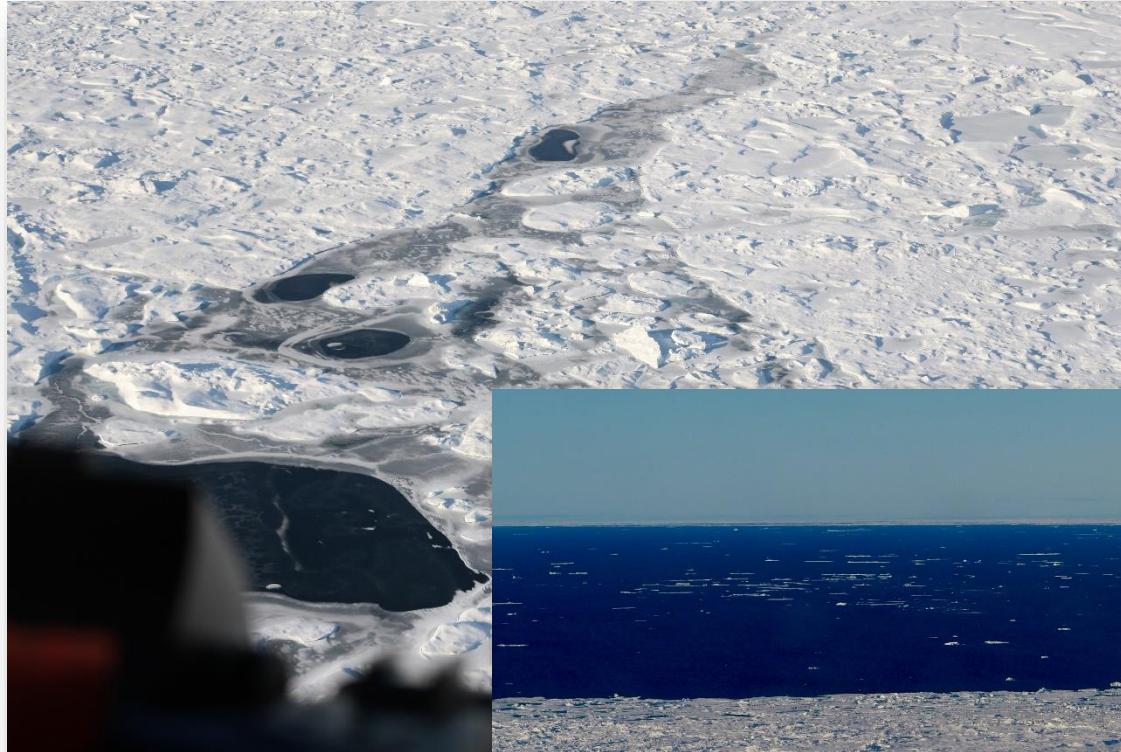


Foto: Jonas Hagemann

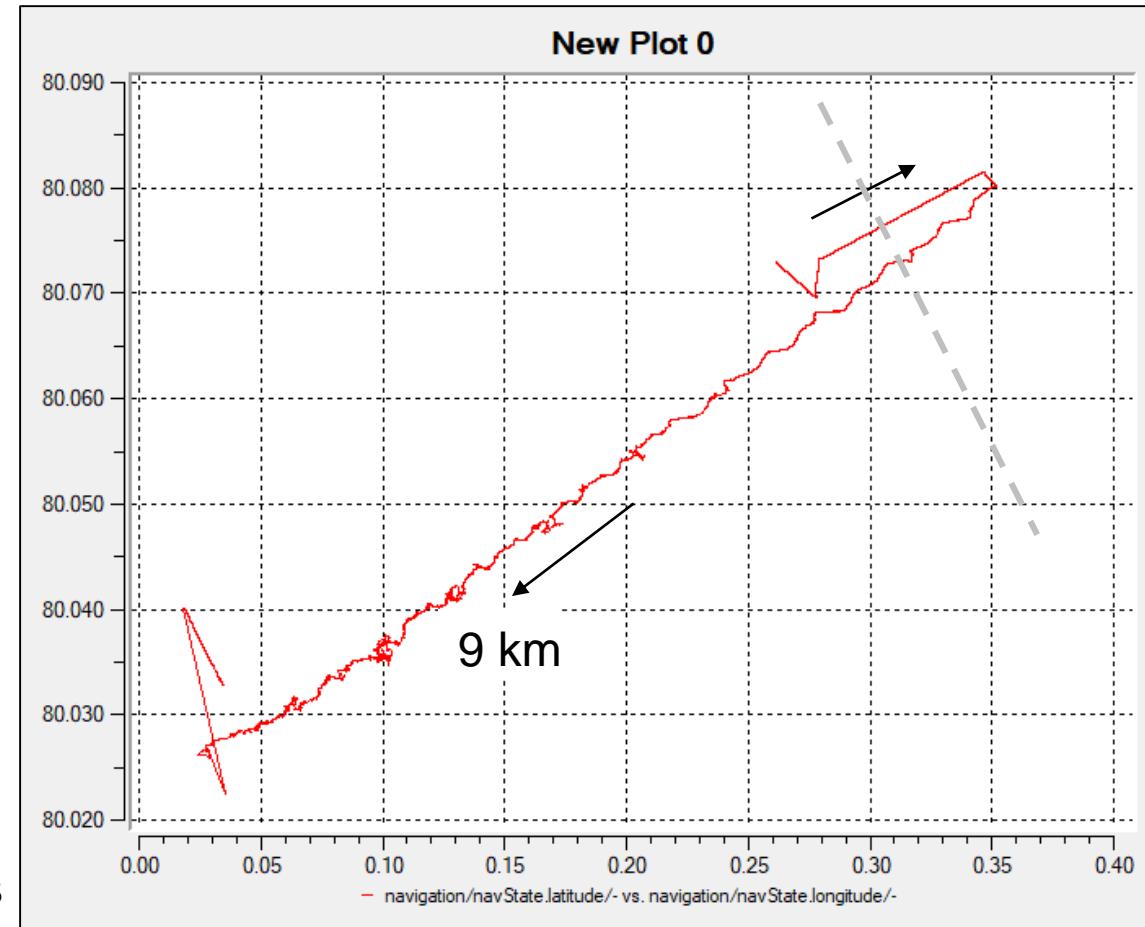
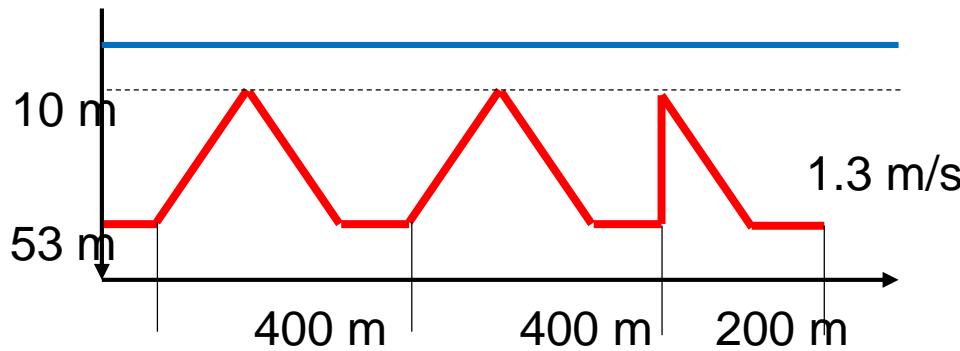


Foto: Sandra Tippenhauer



# Payload

- Pelagic
  - Under ice



- Team
- History

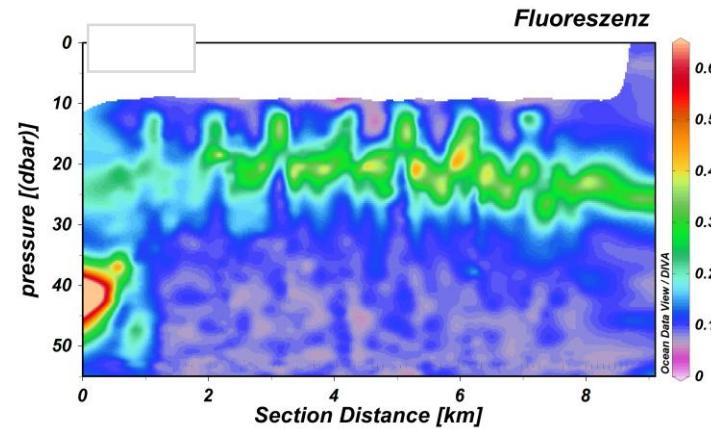
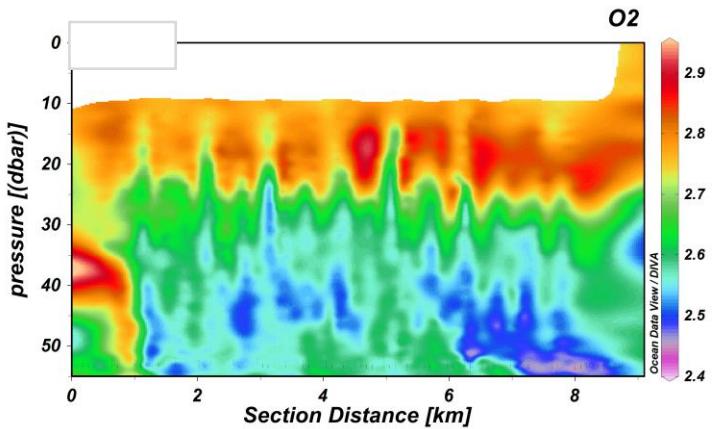
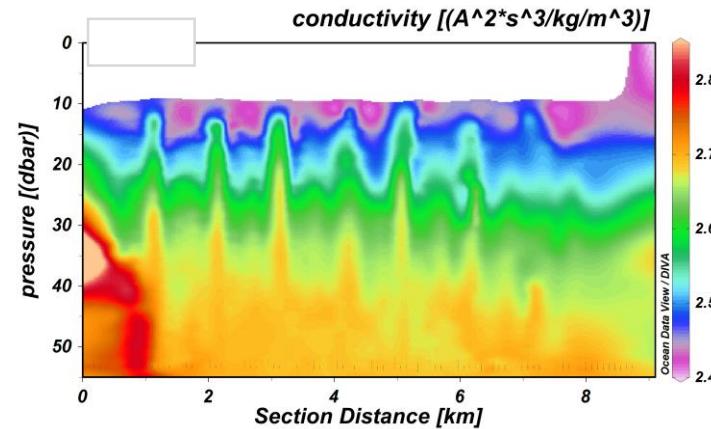
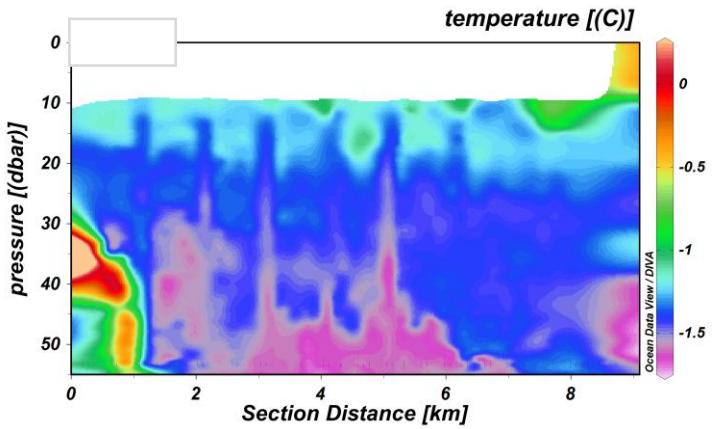
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- Pelagic

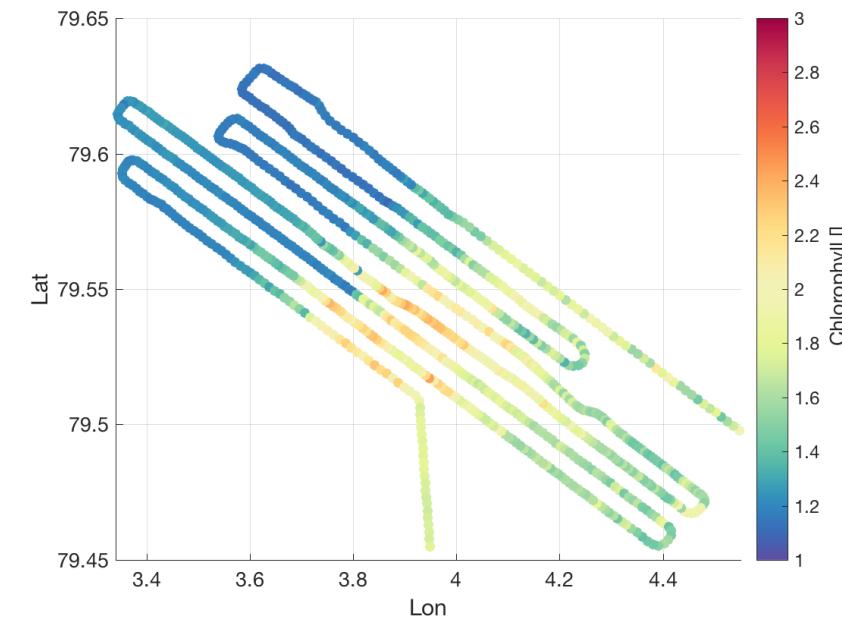
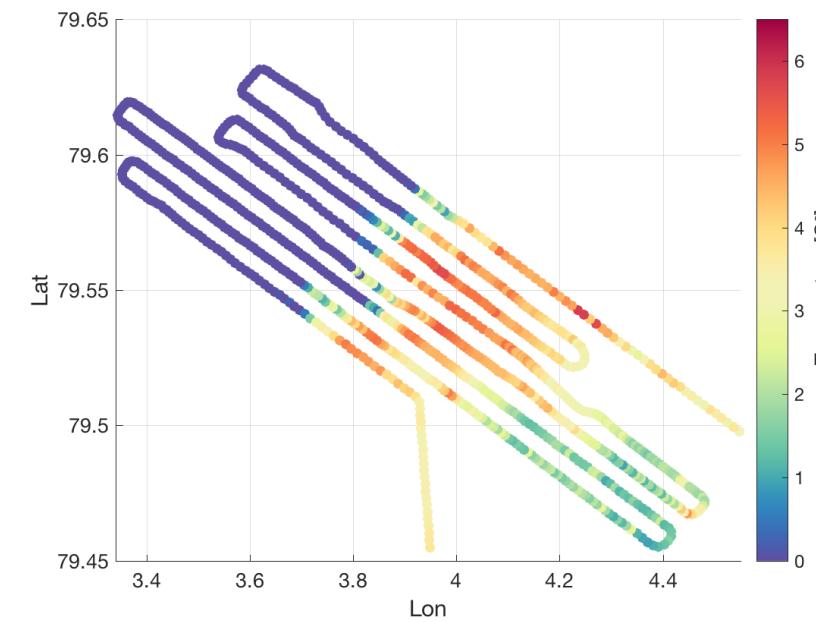
## • Under ice

# Payload

- Pelagic
- Under ice



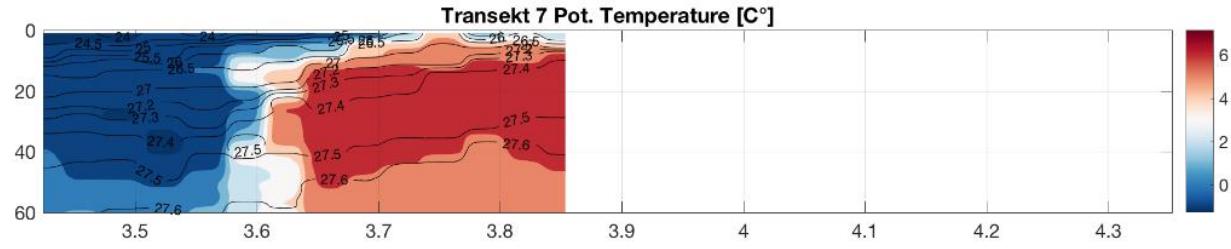
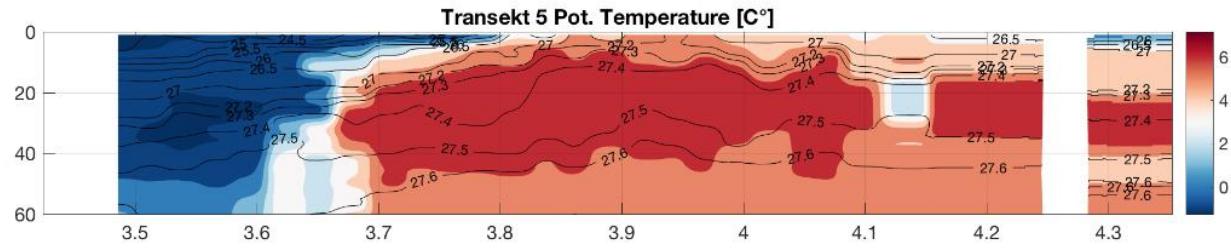
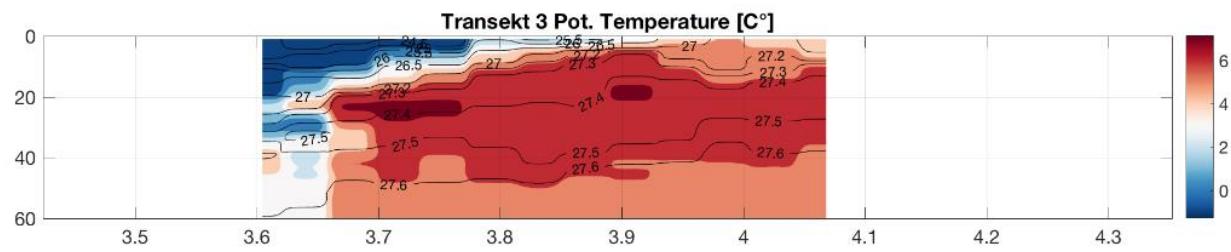
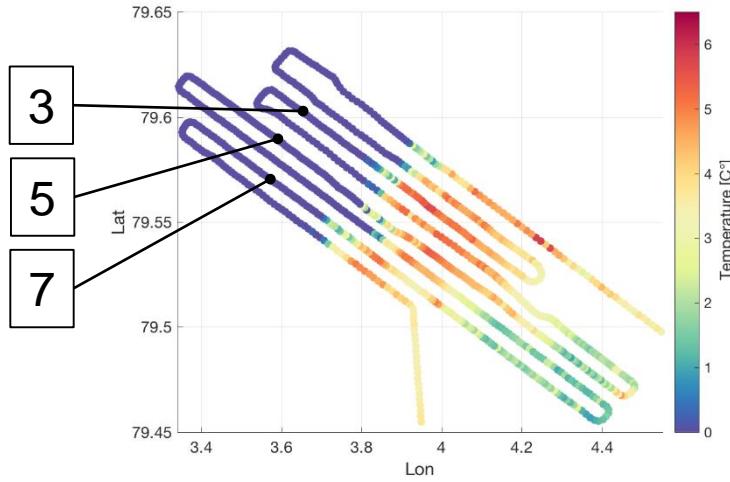
- Pelagic
  - Under ice
  - Ocean fronts



- Team
  - History
- Payload
- Pelagic

# Payload

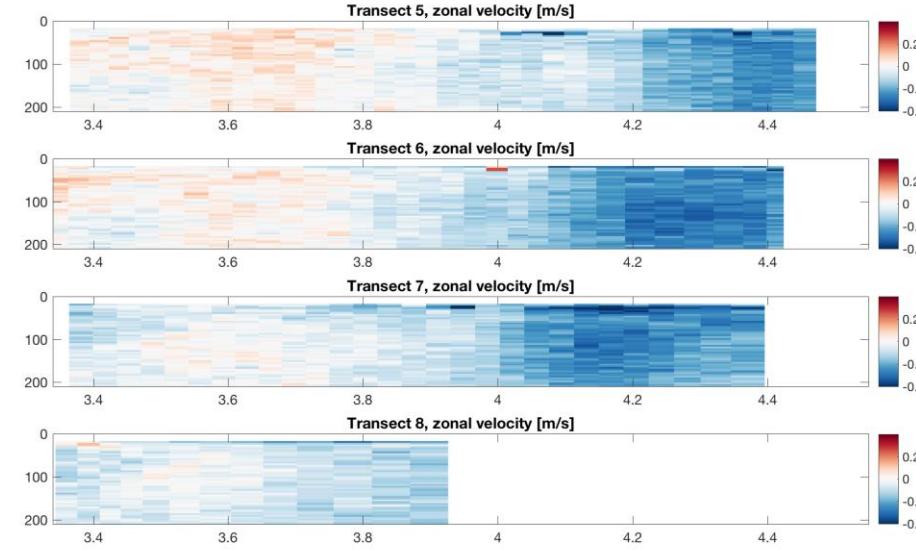
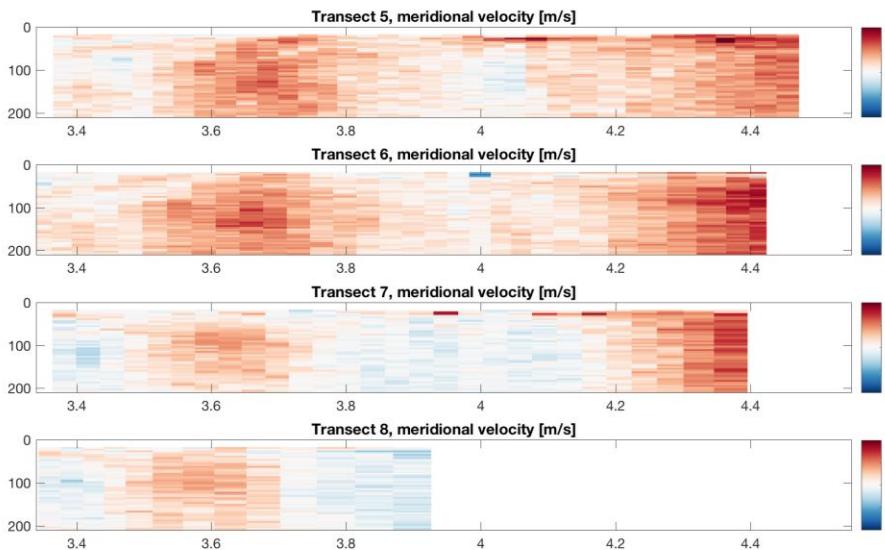
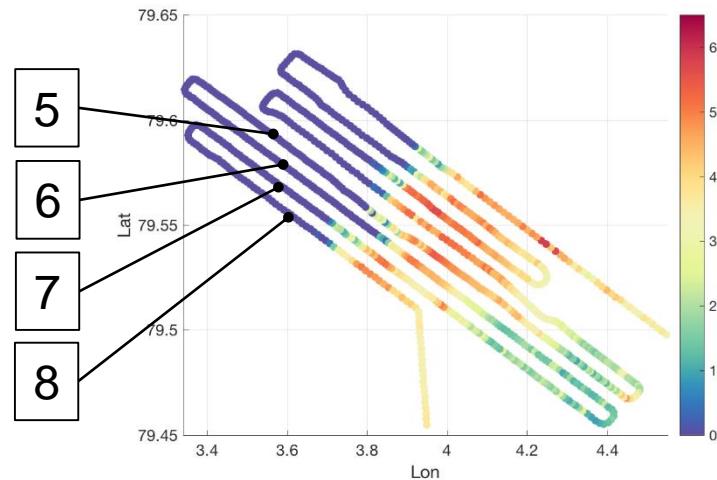
- Pelagic
  - Under ice
  - Ocean fronts



- Team
  - History
- Payload**
- Pelagic

# Payload

- Pelagic
  - Under ice
  - Ocean fronts

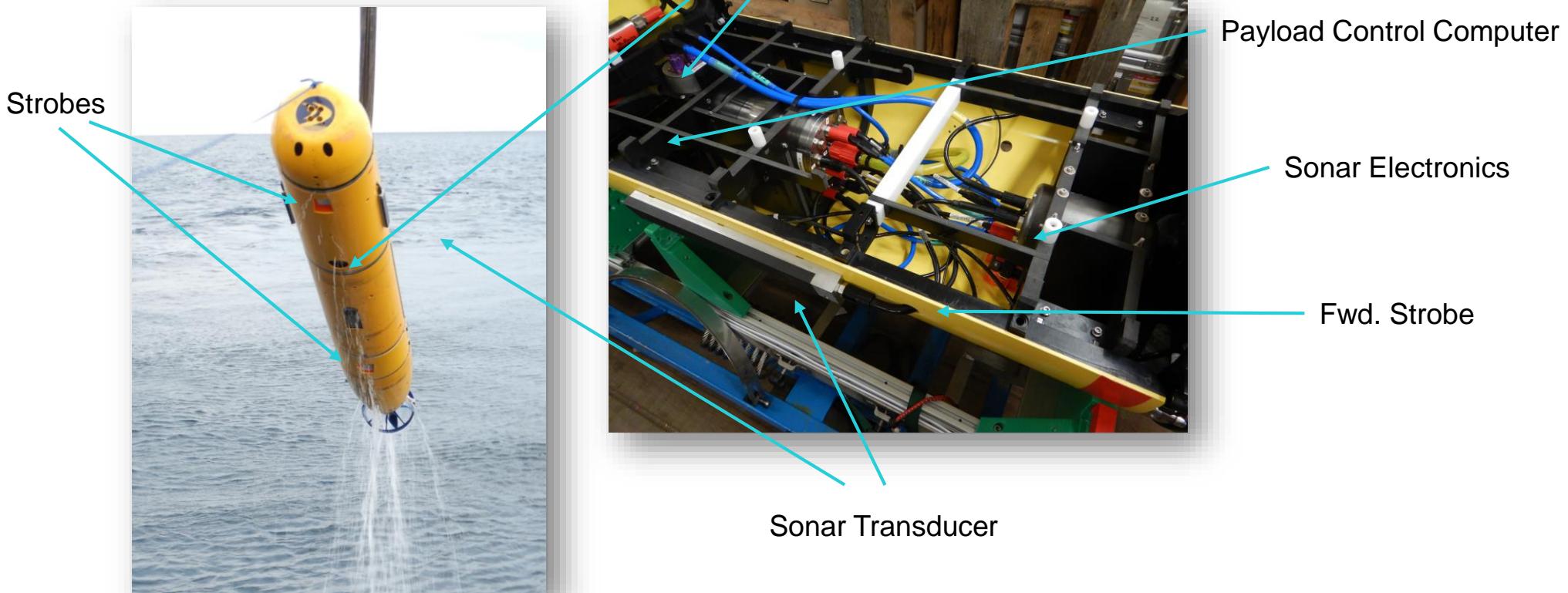


- Team
- History

- Pelagic
- Benthic

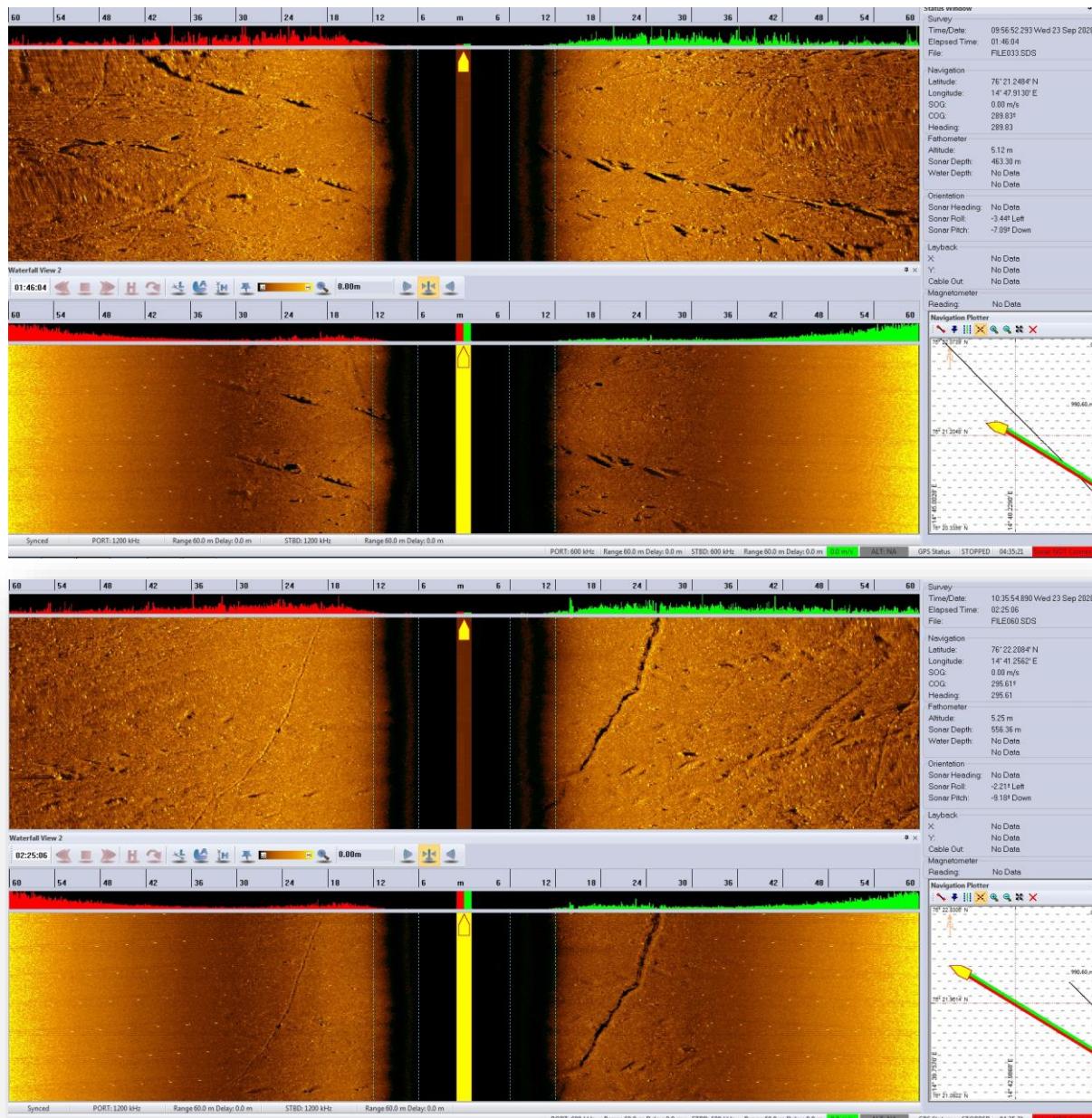
# Payload

- Benthic



# Payload

- Benthic
  - Sidescan sonar
    - 600 / 1200 kHz
    - Range 60 m / 30 m



## Introduction

- Team
  - History
- ## Payload
- Pelagic
  - Benthic

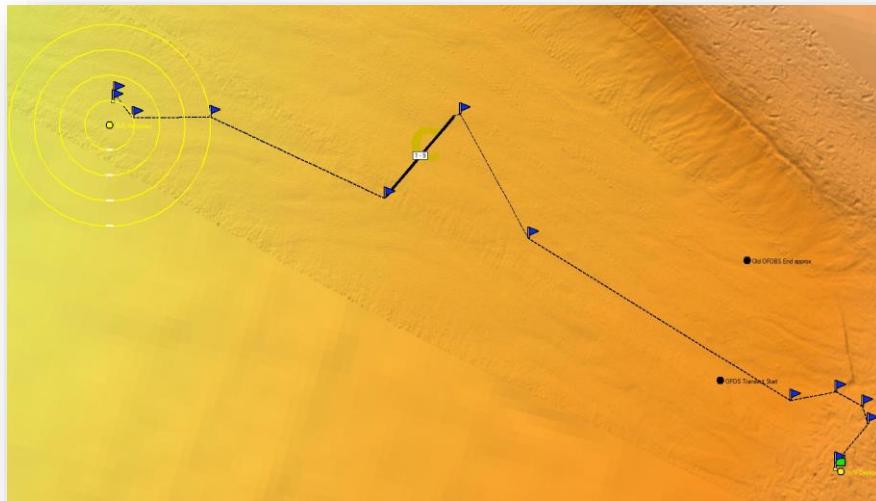


- Team
- History

- Pelagic
- Benthic

# Payload

- Benthic
  - Sidescan sonar
    - 1200 kHz
    - Altitude 6 m
    - 9 parallel transects

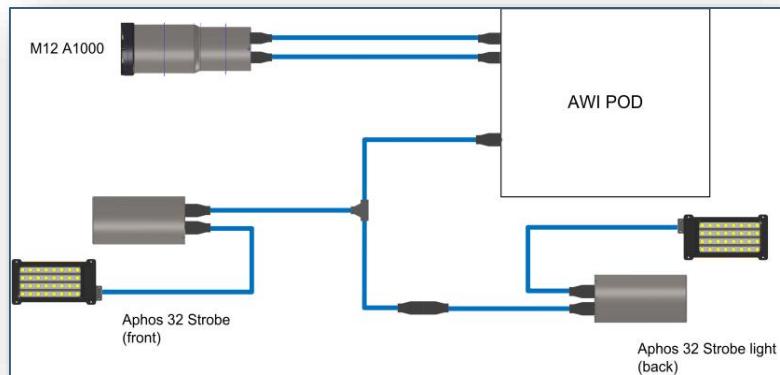


# Payload

- Benthic

- Camera system

- Stills camera (7fps, 12,5MP)
    - 2 Strobes (150.000 lumes)



4.5 m

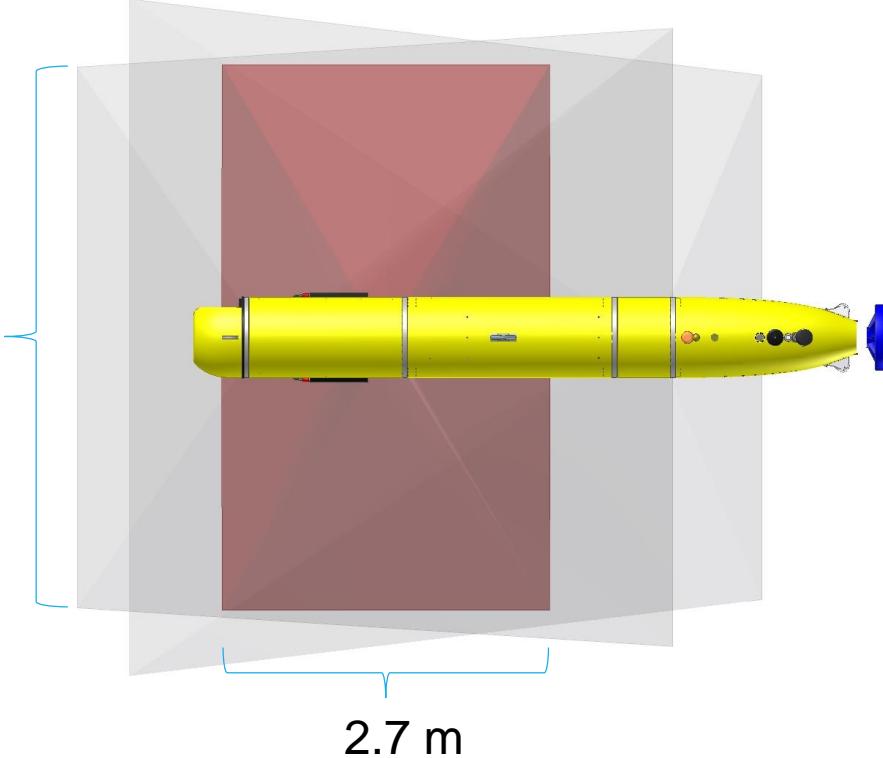


Image Area: 12.15 m<sup>2</sup> || Pixel Resolution (mm/pixel): 1.1

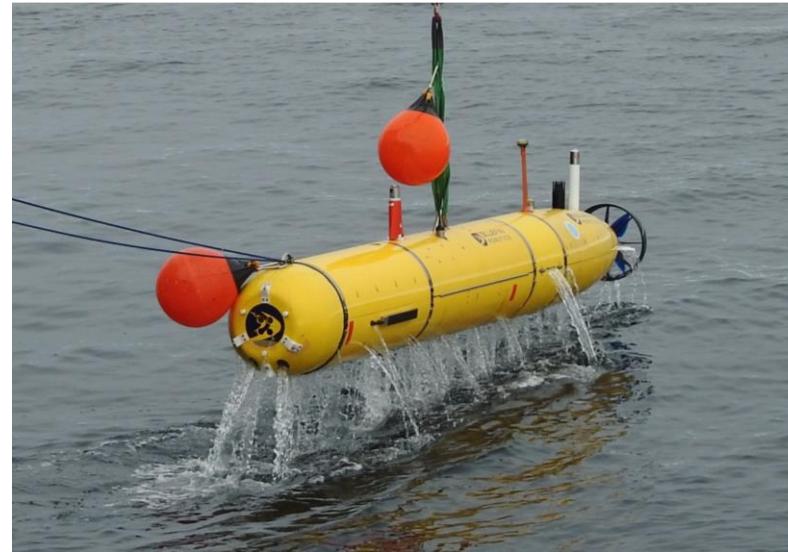
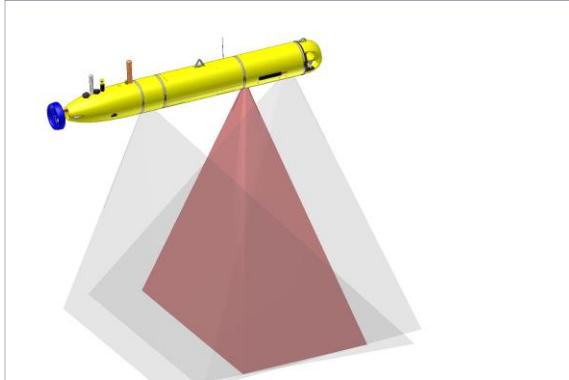


- Team
- History

- Pelagic
- Benthic

# Payload

- Benthic
  - Camera system
  - Strobe section

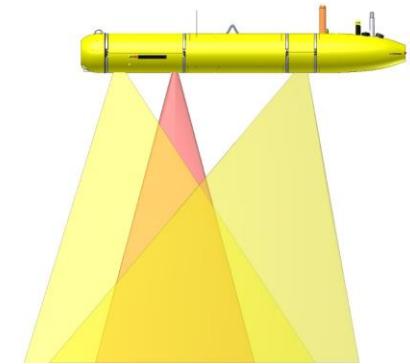


- Team
- History

- Pelagic
- Benthic

# Payload

- Benthic
  - Camera system
    - Altitude 5 m
    - Speed 1.5 m



- Team
- History

- Pelagic
- Benthic

# Payload

- Benthic
  - Camera system
    - Photomosaic

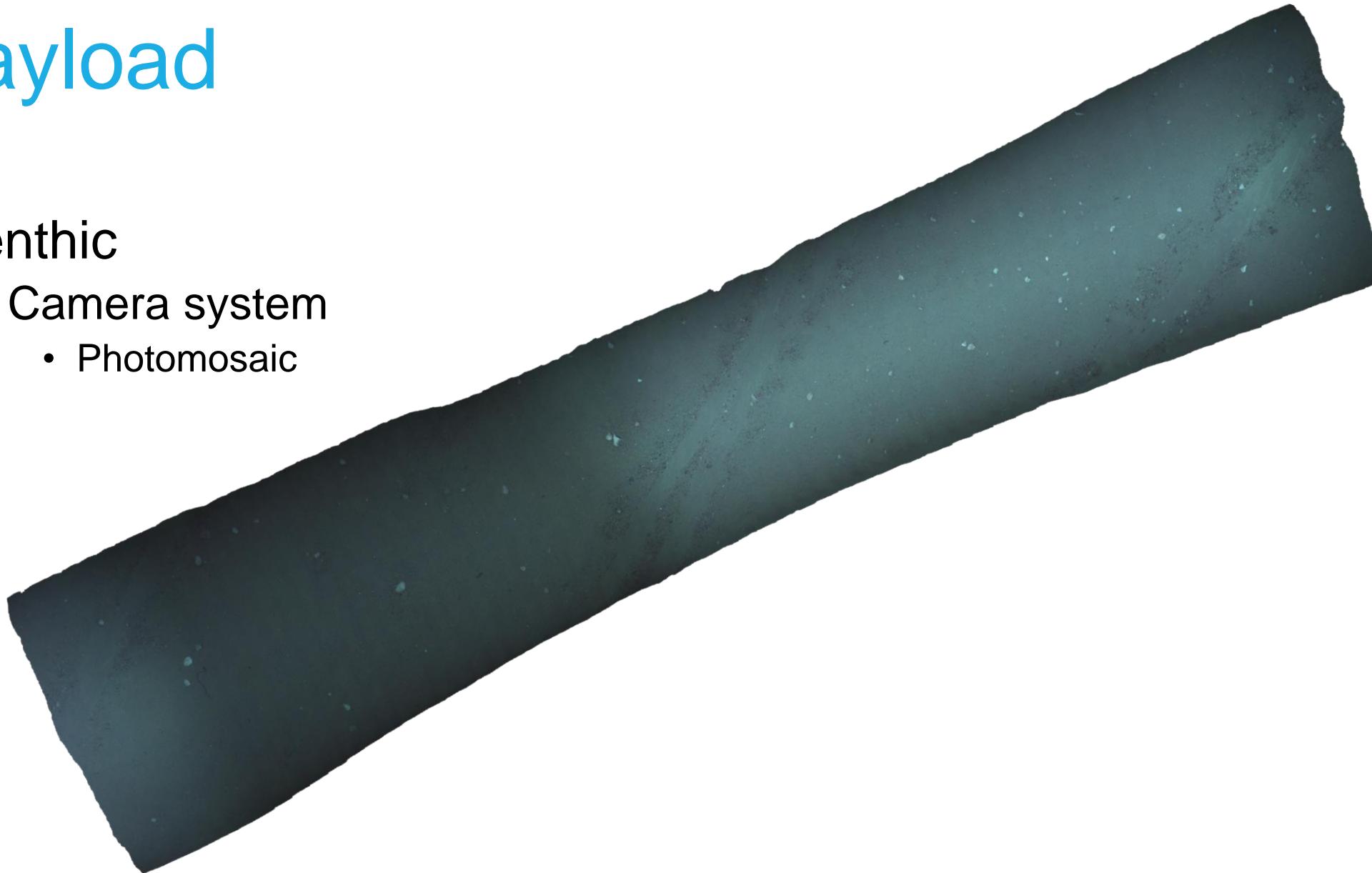


- Team
- History

- Pelagic
- Benthic

# Payload

- Benthic
  - Camera system
    - Photomosaic

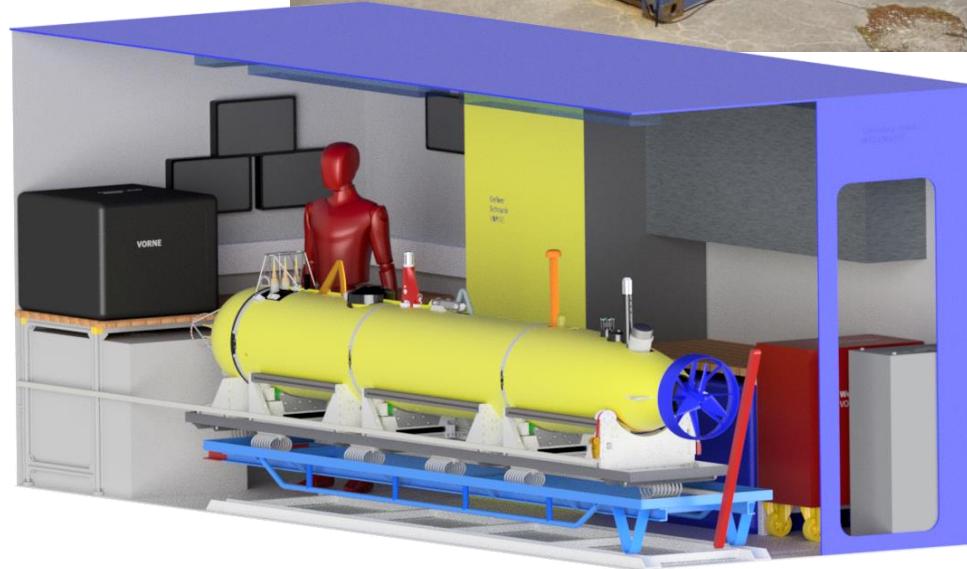


- Team
- History

- Pelagic
- Benthic

# Infrastructure

- Logistics
  - 20" Container
    - Transportation
    - Controlroom
    - Workshop
    - Store



- Team
- History

- Pelagic
- Benthic

# Infrastructure

- Logistics
  - Trolley
    - Vibration compensation
    - Section separation



- Team
- History

- Pelagic
- Benthic

# Infrastructure

- Logistics
  - Trailer
  - A-Frame
  - Tests in local lakes



- Team
- History

- Pelagic
- Benthic

# Infrastructure

- Accessories
  - Ballasting basin



- Team
- History

- Pelagic
- Benthic

# Infrastructure

- Accessories
  - Pressure tank



Introduction

- Team
- History

Payload

- Pelagic
- Benthic

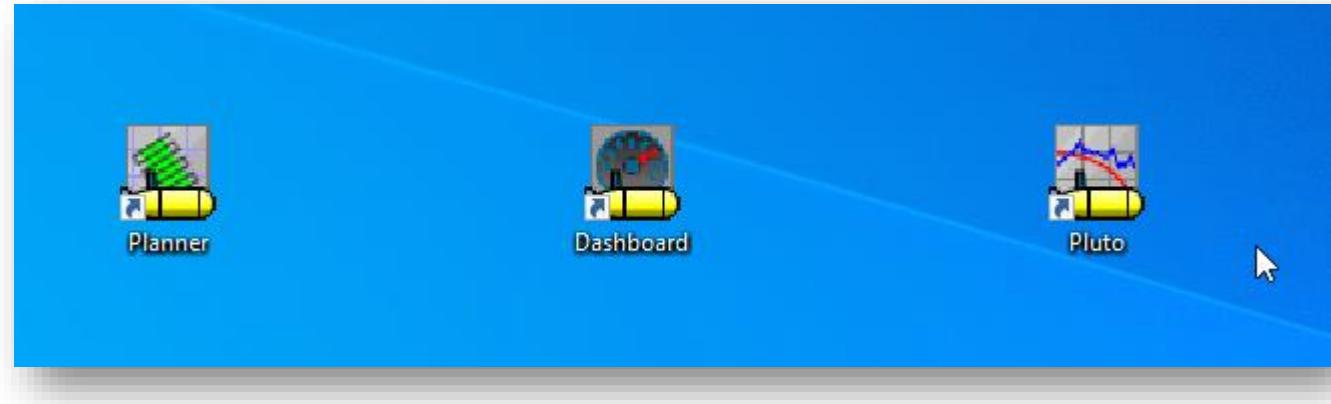
Infrastructure

# Infrastructure

- Accessories
  - Zodiac



# Operator Suite



- Introduction
- Team
- History
- Payload
- Pelagic
- Benthic
- Infrastructure
- Operator Suite

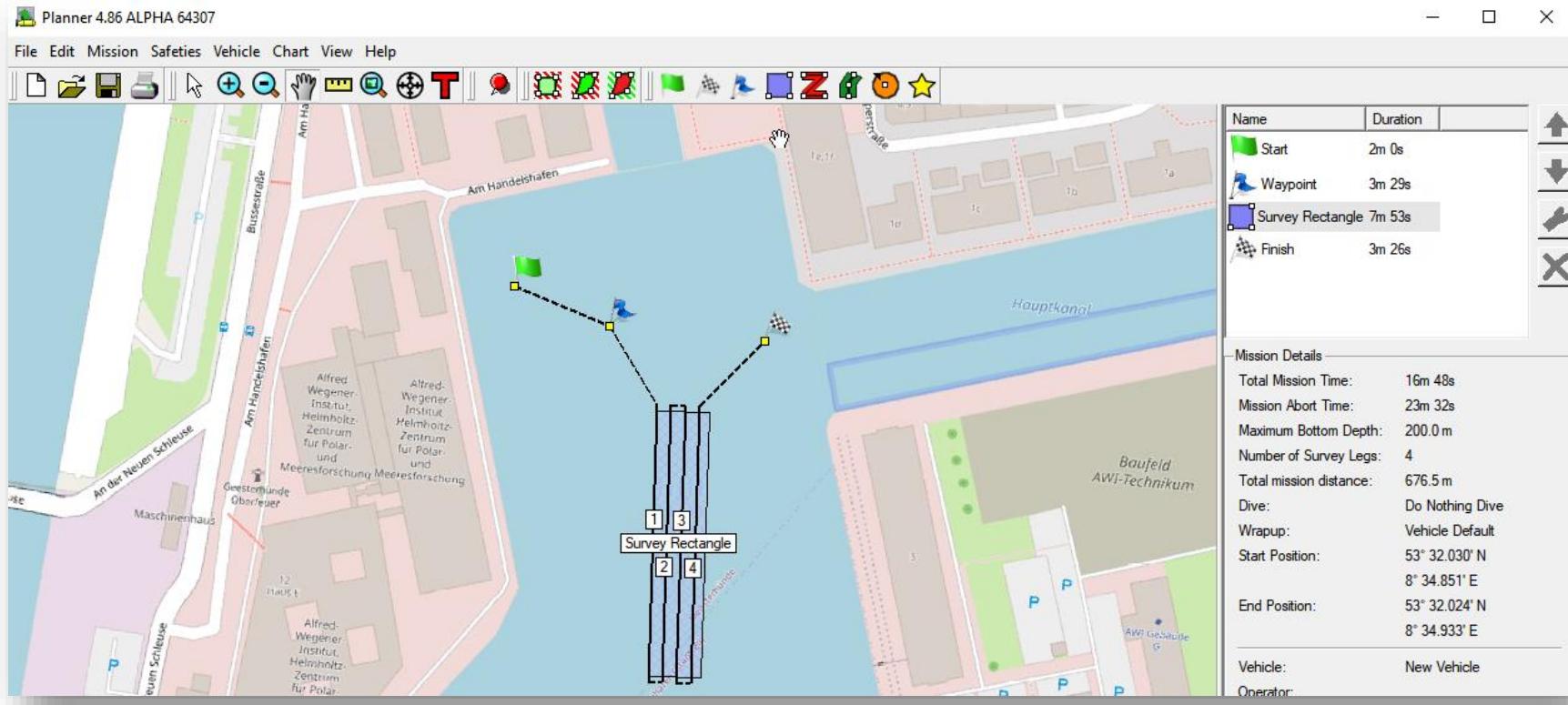


- Team
- History

- Pelagic
- Benthic

# Operator Suite

## • Mission Planner



- Team
- History

## Payload

- Pelagic

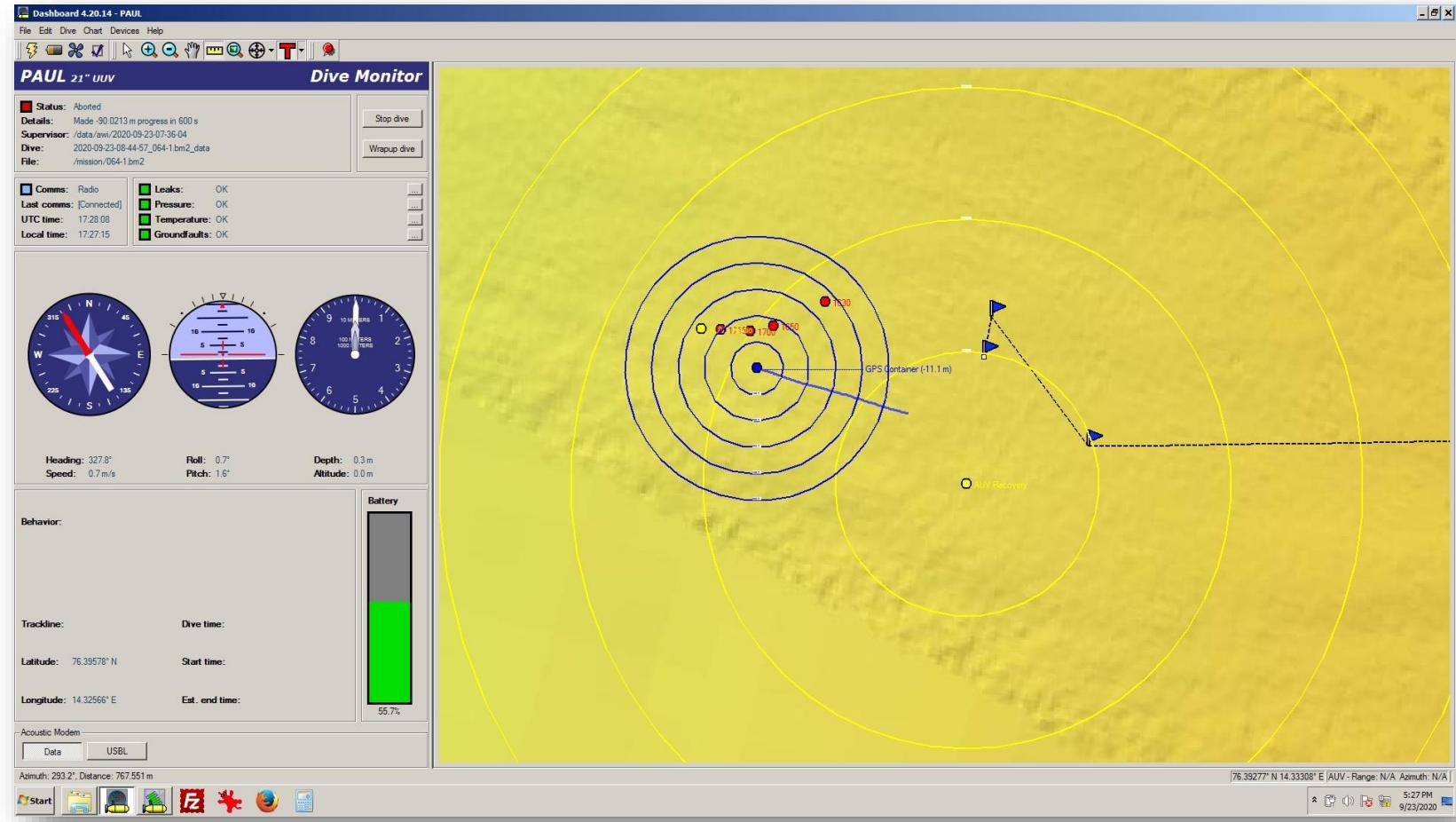
- Benthic

## Infrastructure

## Operator Suite

# Operator Suite

## • Dashboard



## Introduction

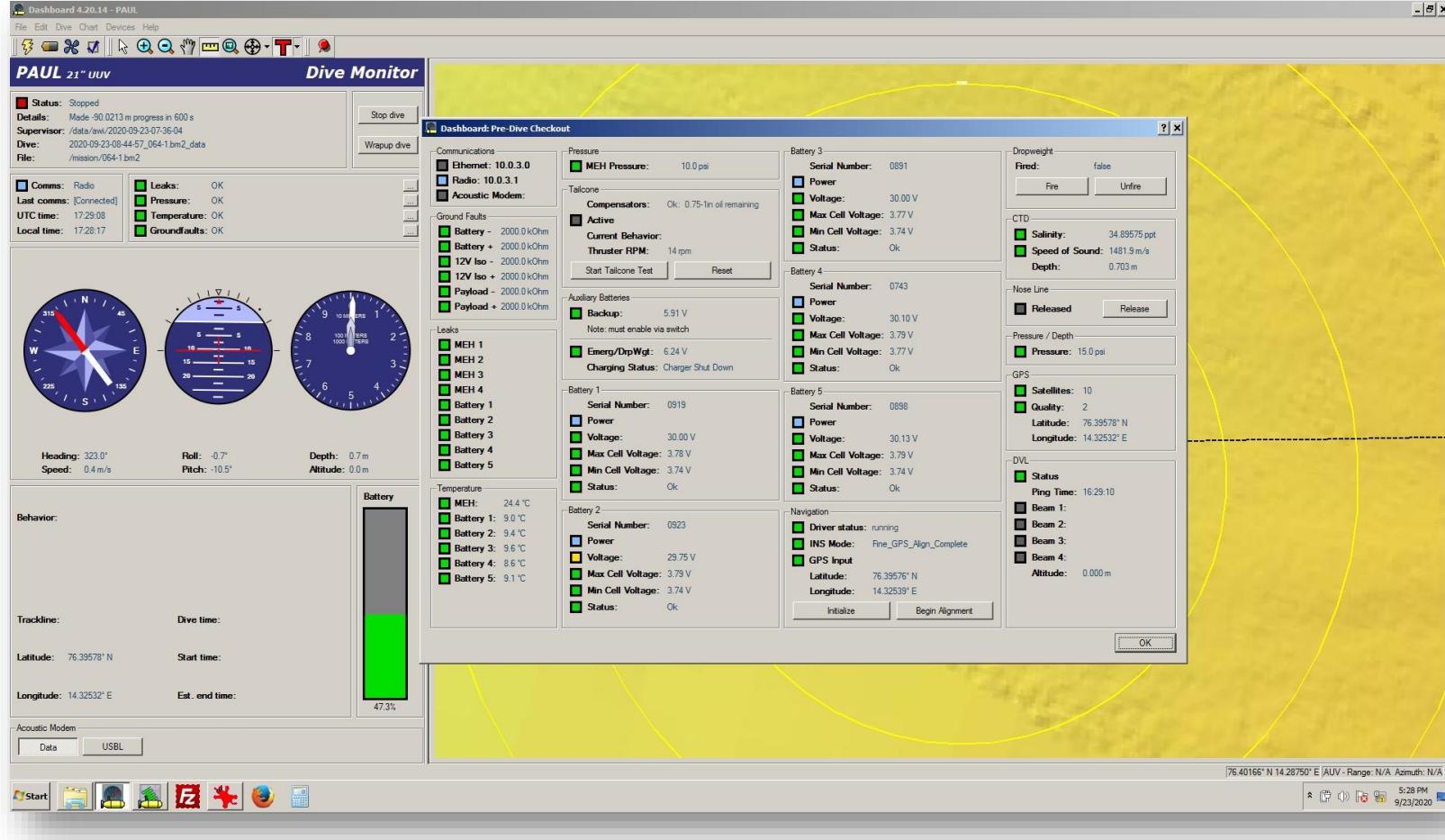
- Team
- History

## Payload

- Pelagic
  - Benthic
- ## Infrastructure
- ## Operator Suite

# Operator Suite

## • Dashboard



- Team
- History

## Payload

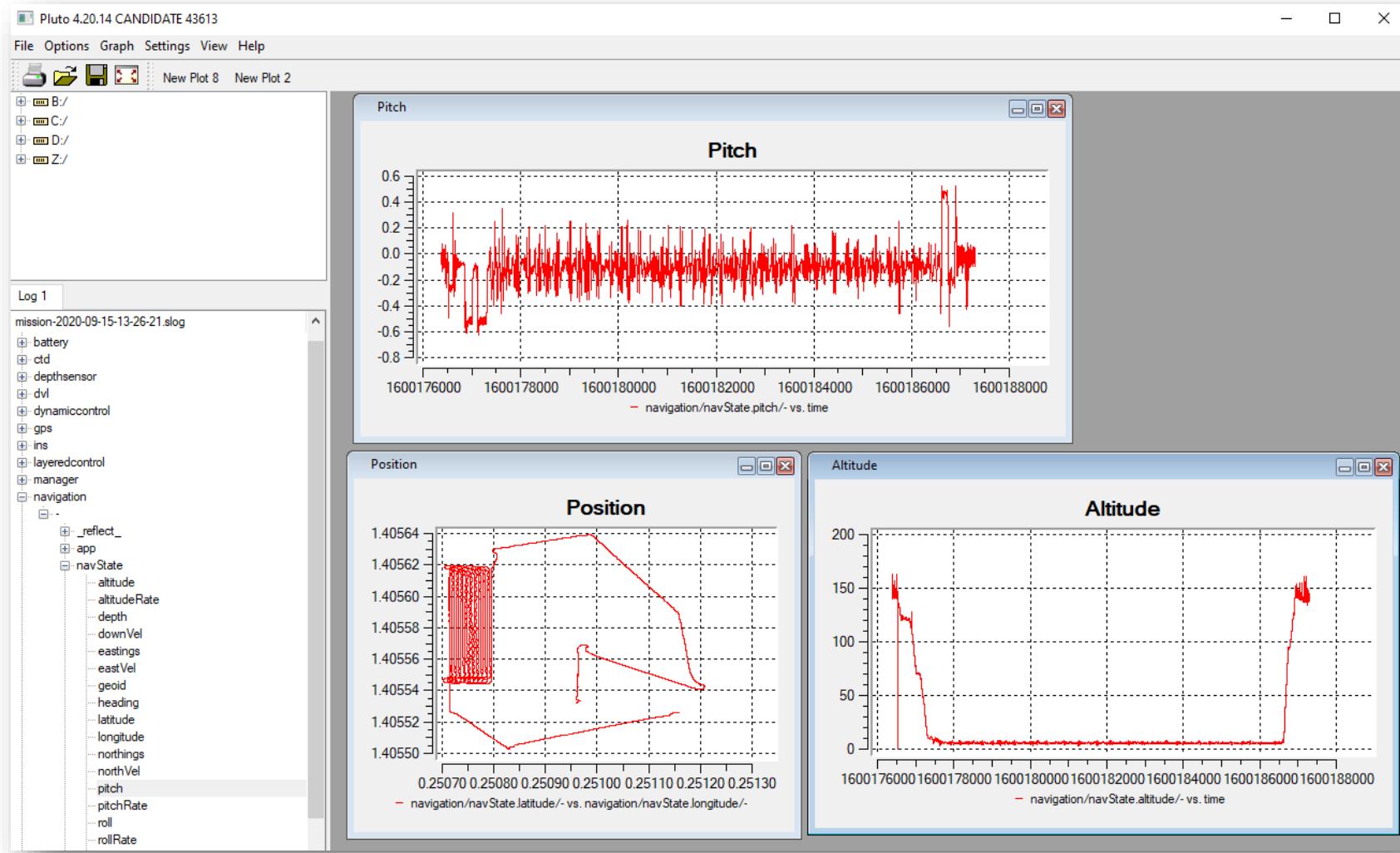
- Pelagic
- Benthic

## Infrastructure

## Operator Suite

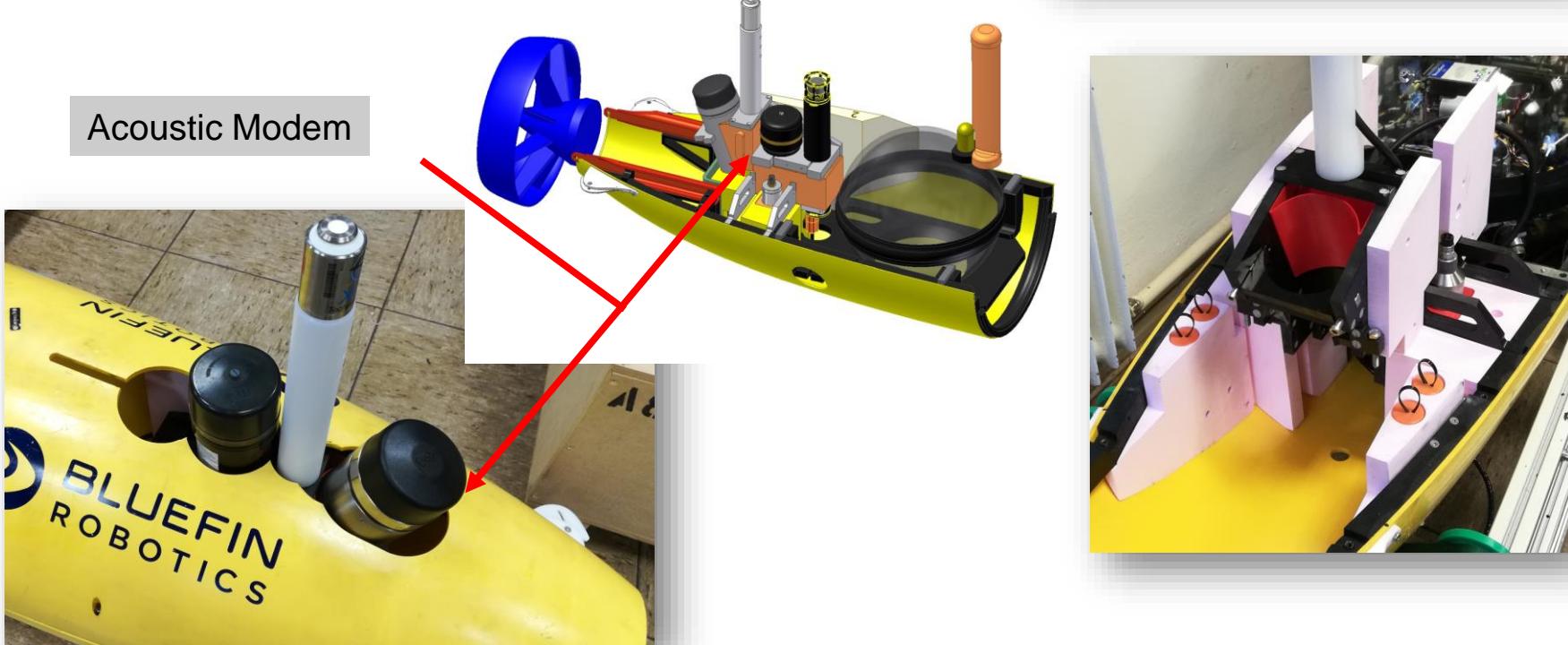
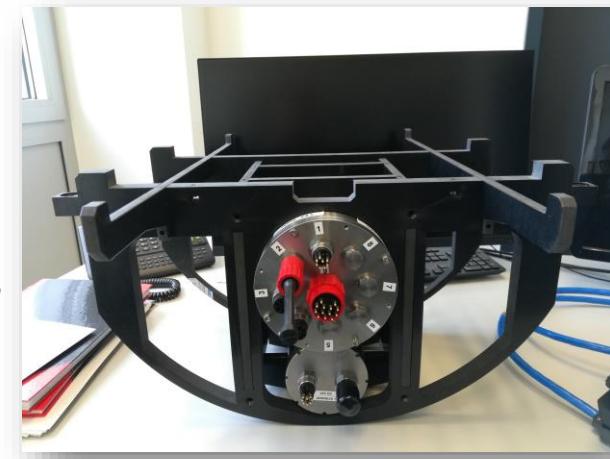
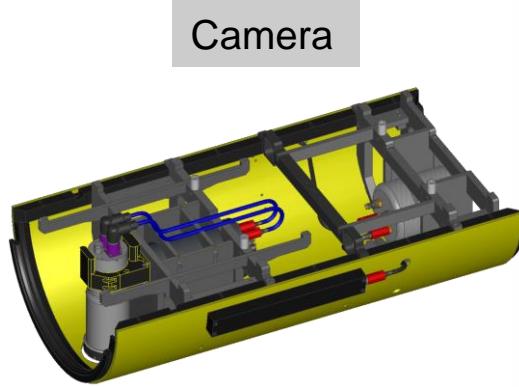
# Operator Suite

- Pluto



# Development

- Mechanical
  - Sensor implementation



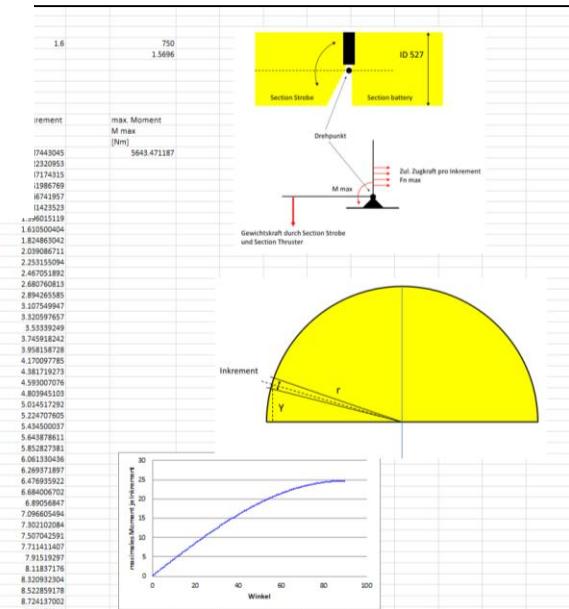
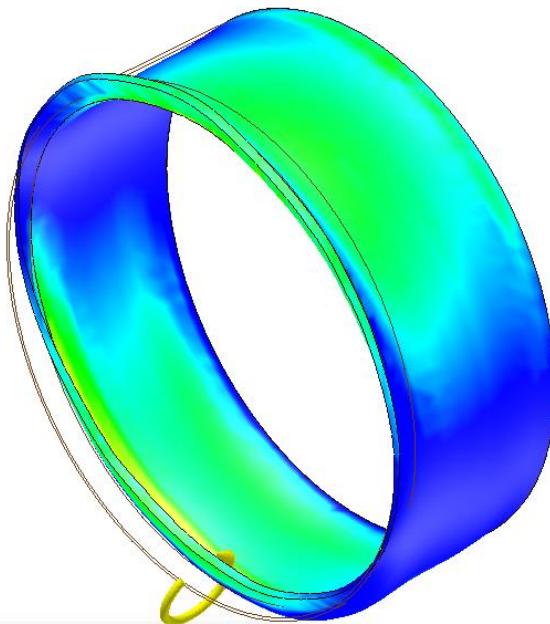
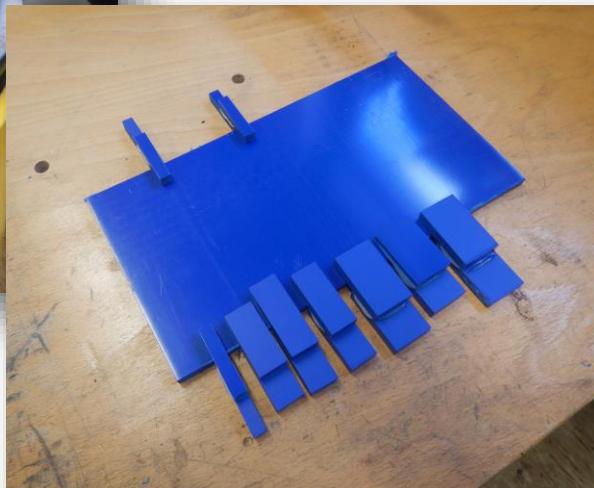
Introduction  
• Team  
• History  
Payload  
• Pelagic  
• Benthic  
Infrastructure  
Operator Suite  
Development

- Team
- History

- Pelagic
- Benthic

# Development

- Mechanical
  - Additional section



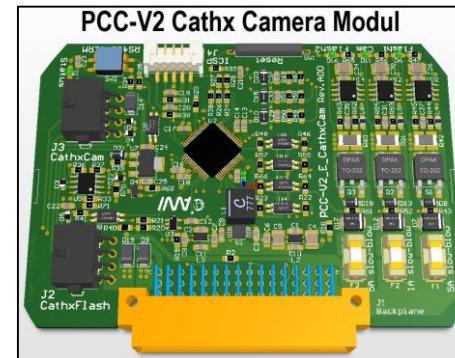
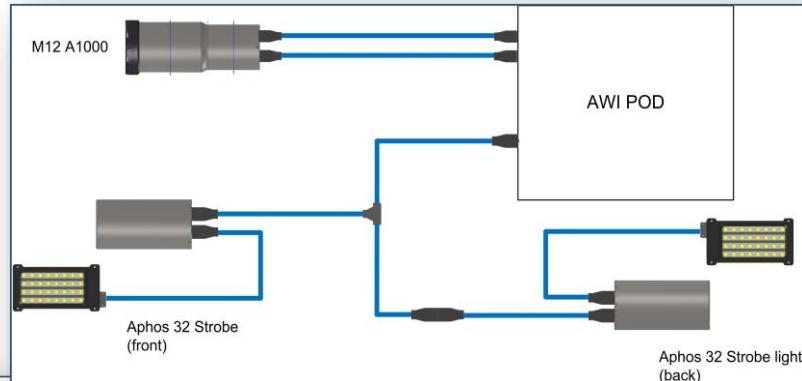
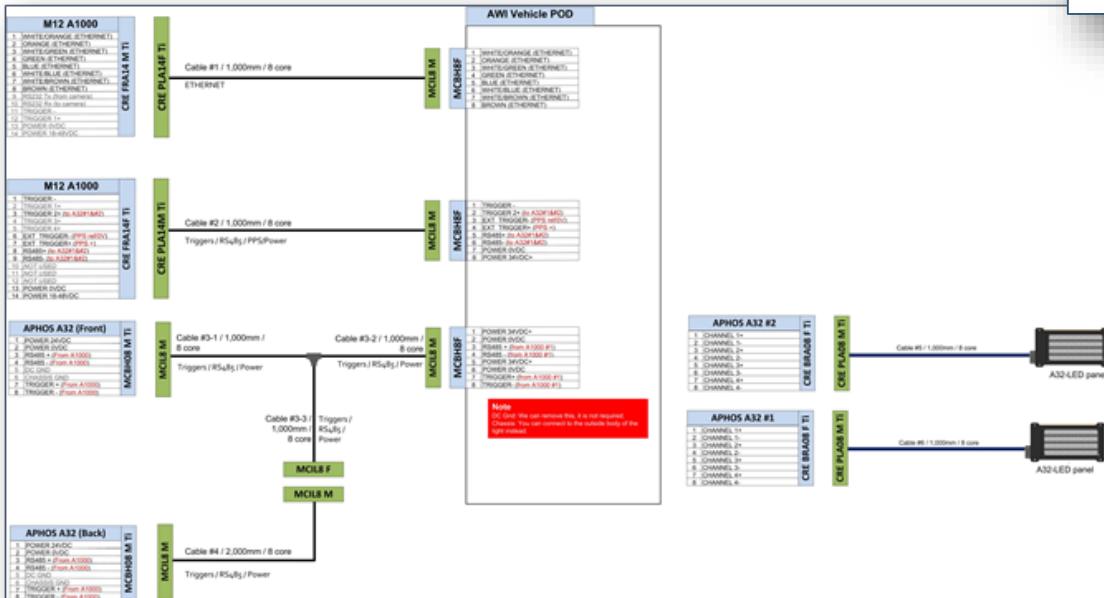
- Team
- History

- Pelagic

- Benthic

# Development

- Electrical
  - Sensor implementation



Introduction

- Team
- History

Payload

- Pelagic
- Benthic

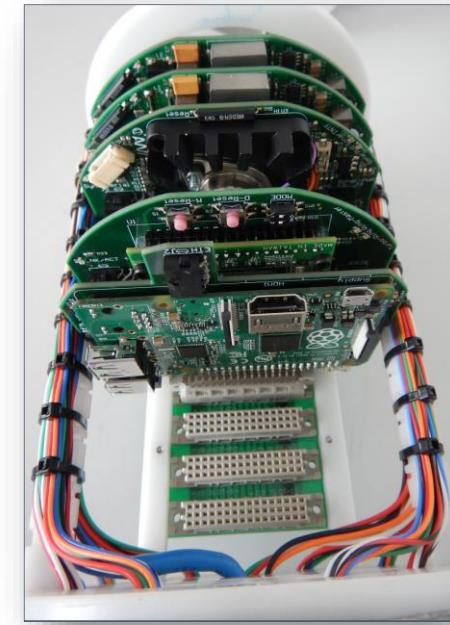
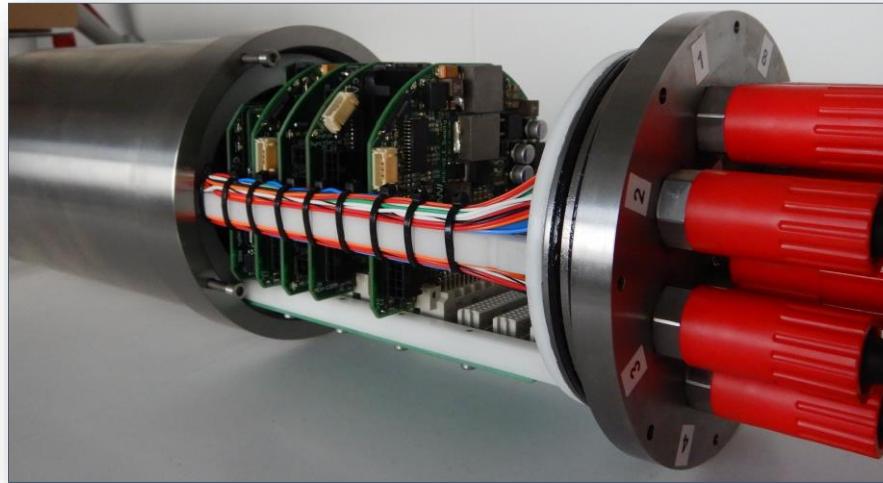
Infrastructure

Operator Suite

Development

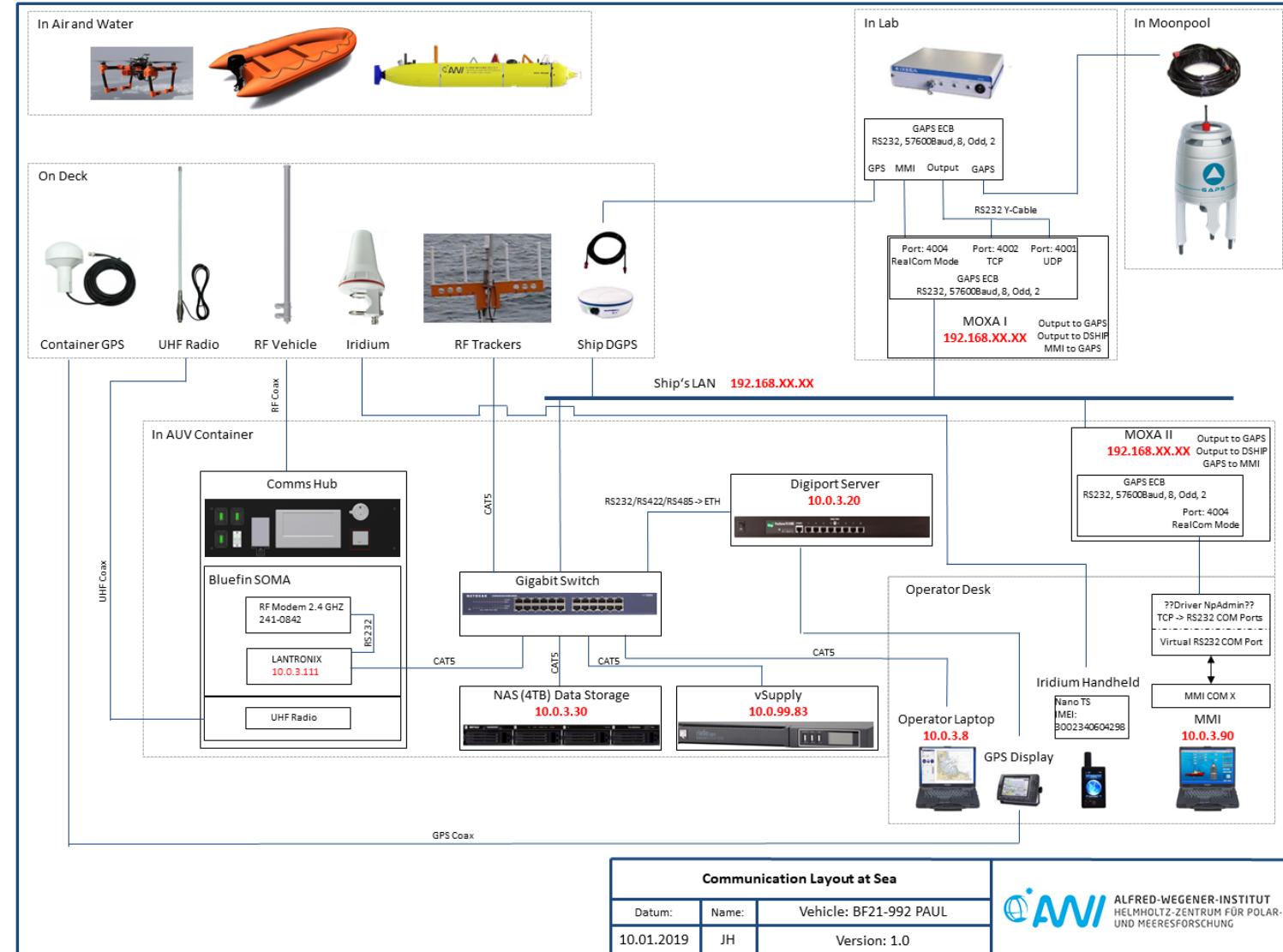
# Development

- Electrical
  - Electronic design



# Operation

- Communication



Introduction

- Team
- History

Payload

- Pelagic
- Benthic

Infrastructure

Operator Suite

Development

Operation



Introduction

- Team
- History

Payload

- Pelagic
- Benthic

Infrastructure

Operator Suite

Development

Operation

# Operation

- Pre-Dive



Introduction

- Team
- History

Payload

- Pelagic
- Benthic

Infrastructure

Operator Suite

Development

Operation

# Operation

- Launch

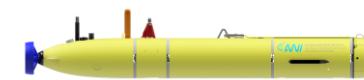


# Operation

- Dive

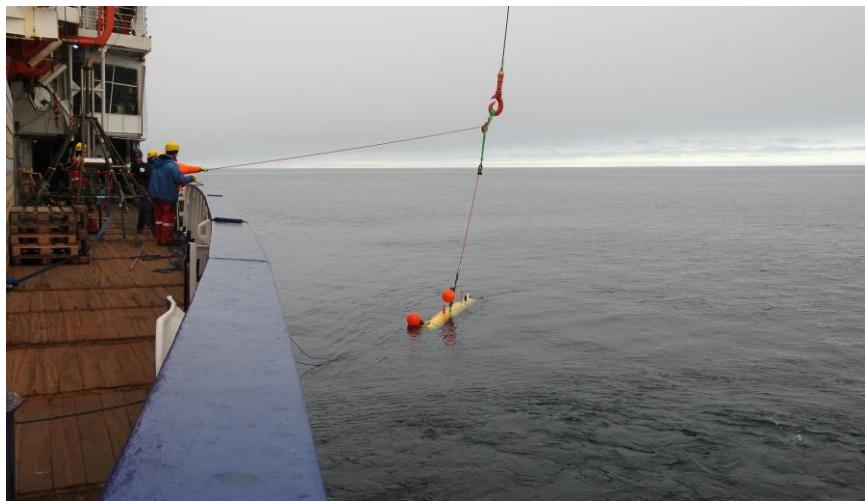
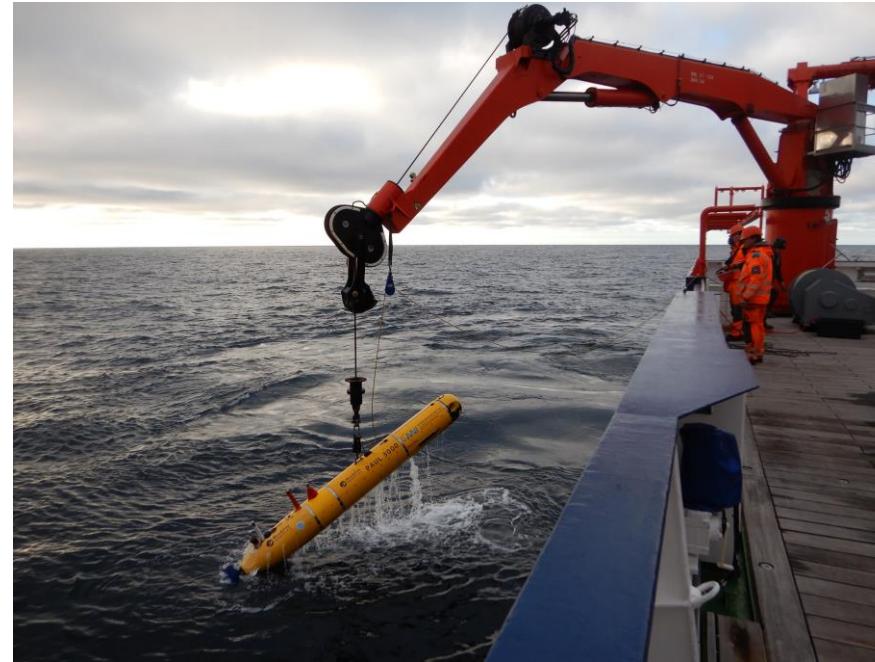


Introduction  
• Team  
• History  
  
Payload  
• Pelagic  
• Benthic  
  
Infrastructure  
  
Operator Suite  
  
Development  
  
Operation



# Operation

- Recovery



Introduction  
• Team  
• History  
  
Payload  
• Pelagic  
• Benthic  
  
Infrastructure  
  
Operator Suite  
  
Development  
  
Operation

Introduction

- Team
- History

Payload

- Pelagic
- Benthic

Infrastructure

Operator Suite

Development

Operation

# Operation

- Post-Dive



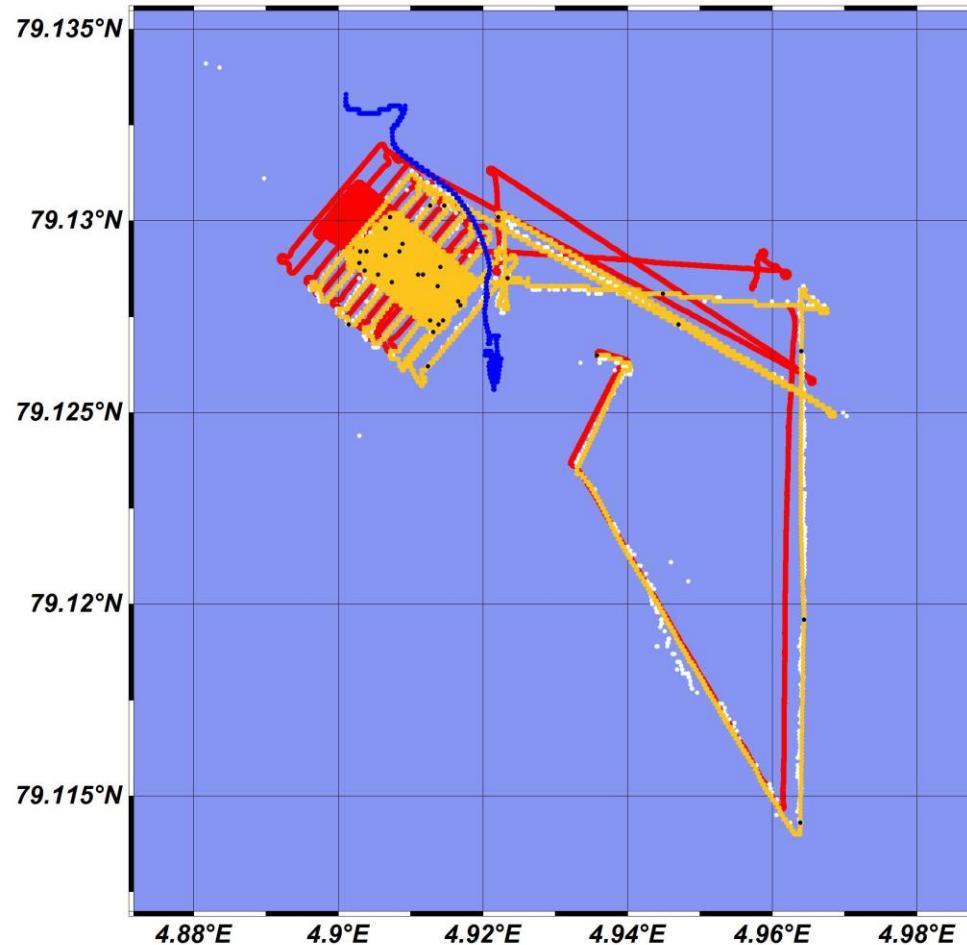
# Operation

- Processing
  - Data correction

**Water Depth:** 1500 m

**Time to descend:** 31 min

**Error:** 110 m



Introduction  
• Team  
• History  
  
Payload  
• Pelagic  
• Benthic  
  
Infrastructure  
  
Operator Suite  
  
Development  
  
Operation

# Q & A



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