



Presented at the FIG Working Week 2023,  
28 May - 1 June 2023 in Orlando, Florida, USA

# FIG WORKING WEEK 2023

28 May - 1 June 2023 Orlando Florida USA

Protecting  
Our World,  
Conquering  
New Frontiers

## Subsea Pipeline Tracking Using a Forward-Looking Imaging Sonar for Autonomous Underwater Vehicle

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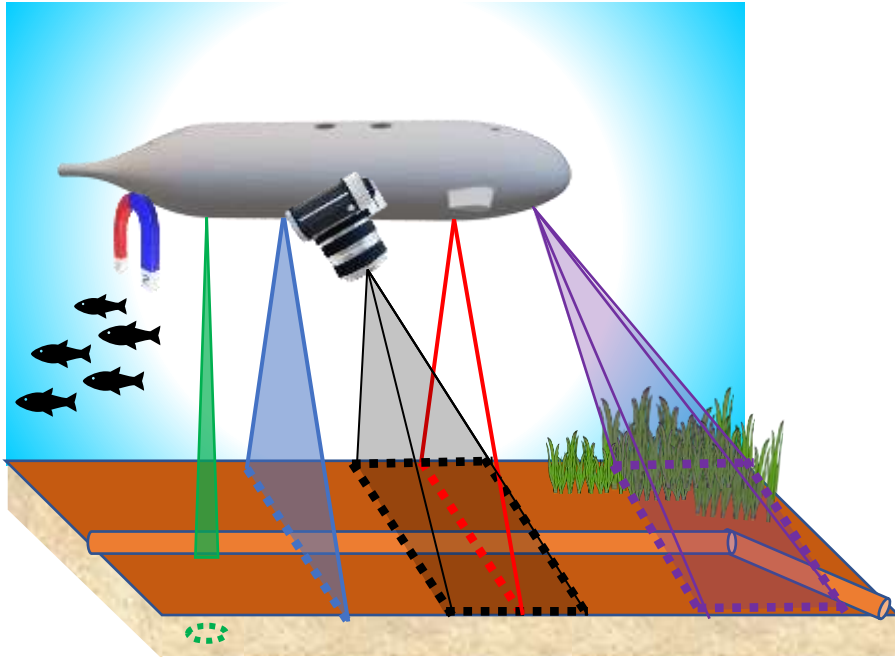




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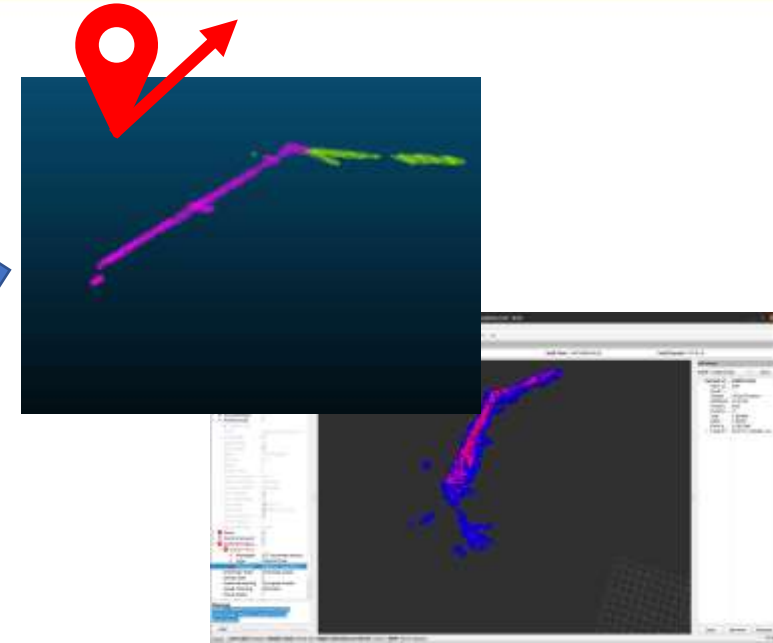
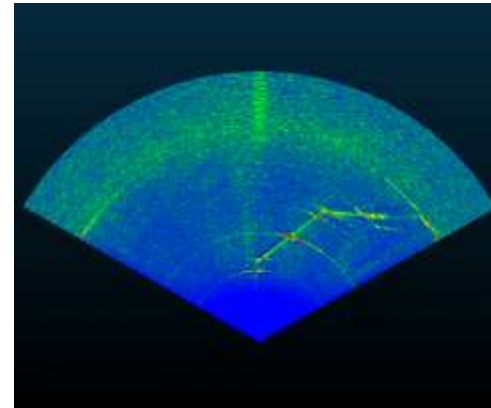
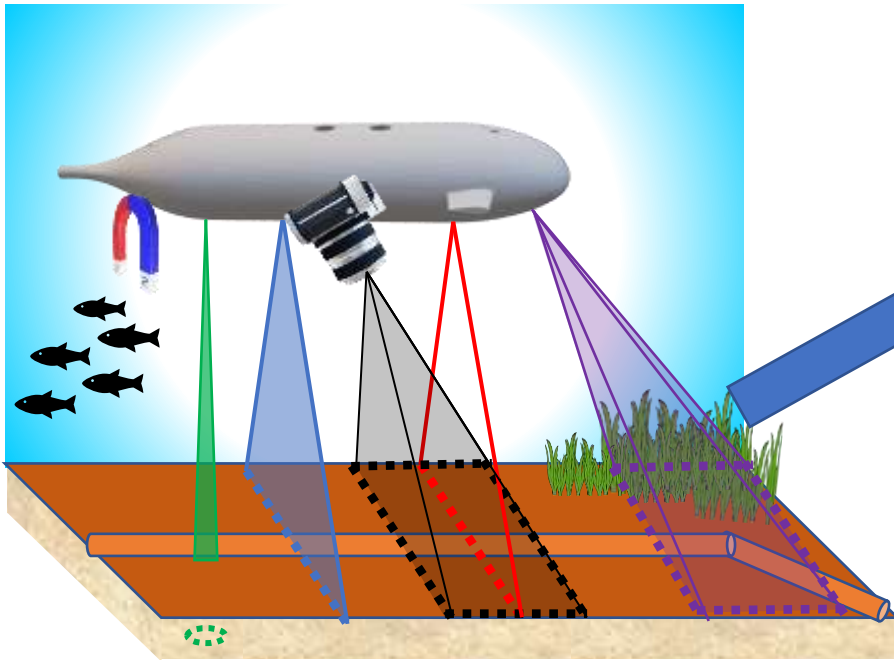


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**How can a pipeline be detected in imaging sonar data?**

- Automatic
- Reliable
- Real time





## Why pipelines???

- continuous transport of crude oil or natural gas

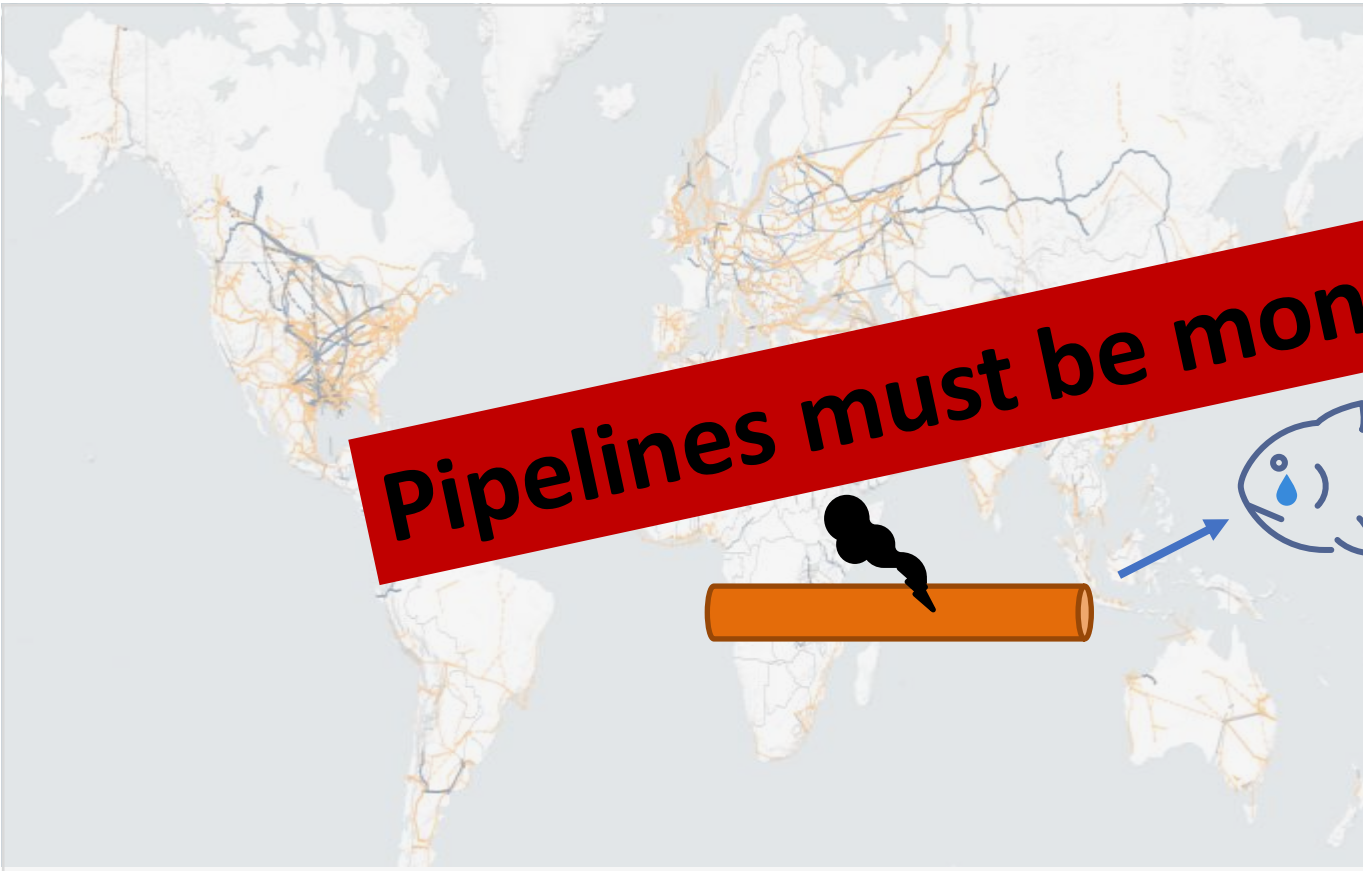
## Why Monitored?

- Leakages lead to enormous ecological and economic damage

## Hazards

- natural → (Water movement, corrosion, sediment movement,...)
- Human-caused → (Anchor, fishing,...)
- Pipelines older than 40 years

[<https://interaktiv.tagesspiegel.de/lab/globaler-pipeline-atlas-das-unsichtbare-netz-der-weltweiten-energieversorgungs/>]



**Pipelines must be monitored regularly**

Why pipelines???

– continuous transport of crude oil or natural gas

– Leakages lead to enormous ecological and economic damage

Hazards

– natural → (Water movement, corrosion, sediment movement,...)

– Human-caused → (Anchor, fishing,..)

– Pipelines older than 40 years

[<https://interaktiv.tagesspiegel.de/lab/globaler-pipeline-atlas-das-unsichtbare-netz-der-weltweiten-energieversorgung/>]



## Use of an survey vessel:

- Weather dependent
- Inflexible
- Expensive
- inaccurate



## CIAM - COMPREHENSIVE INTEGRATED AND FULLY AUTONOMOUS SUBSEA MONITORING



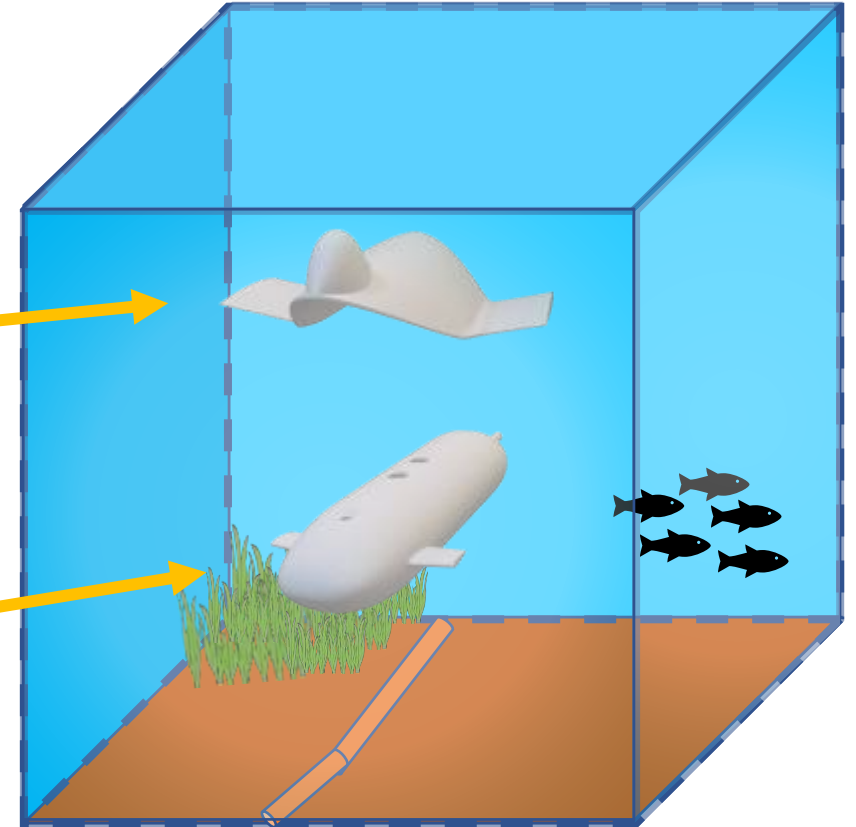
Use of an survey vessel:

- Weather dependent
- Inflexible
- Expensive
- inaccurate



Autonomous Underwater Vehicle (AUV)

Docking Roboter

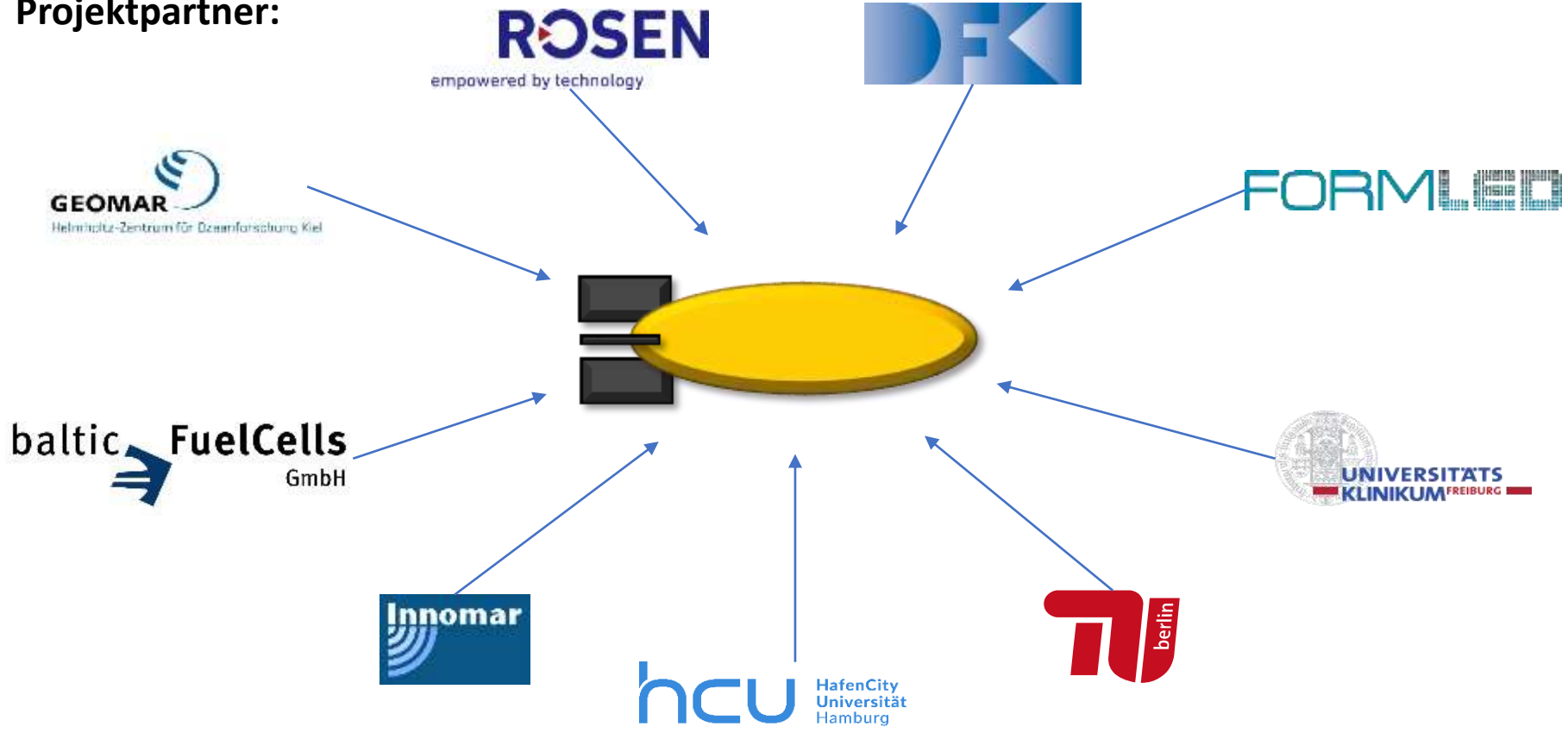


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**Projektpartner:**



2021-2024

**Finanziert durch:**



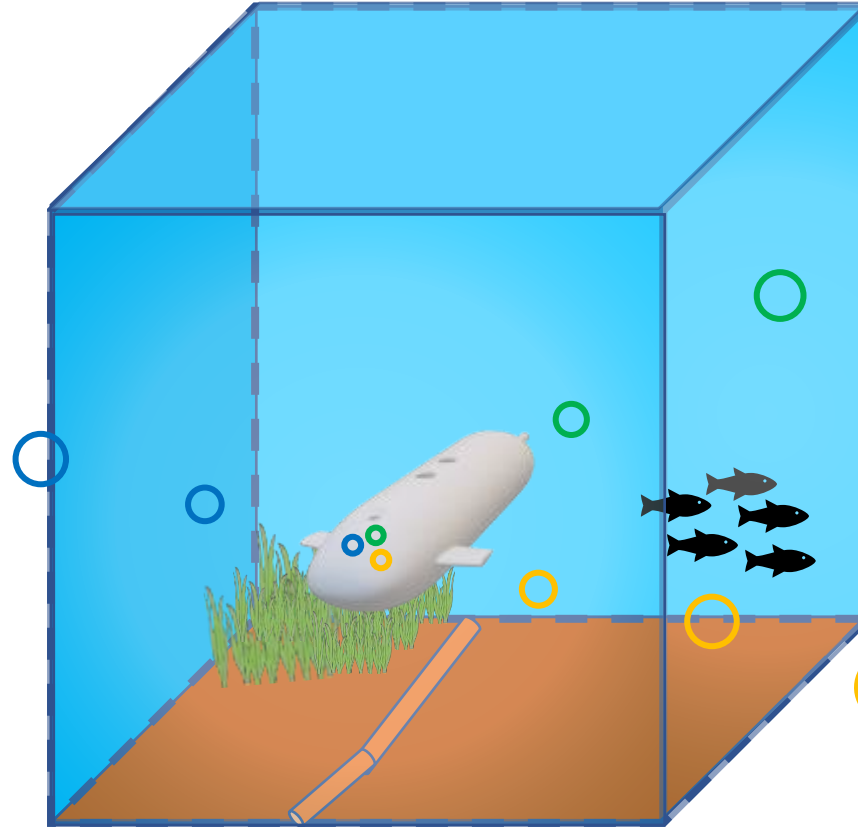


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Where do I have to go?



Where am I?

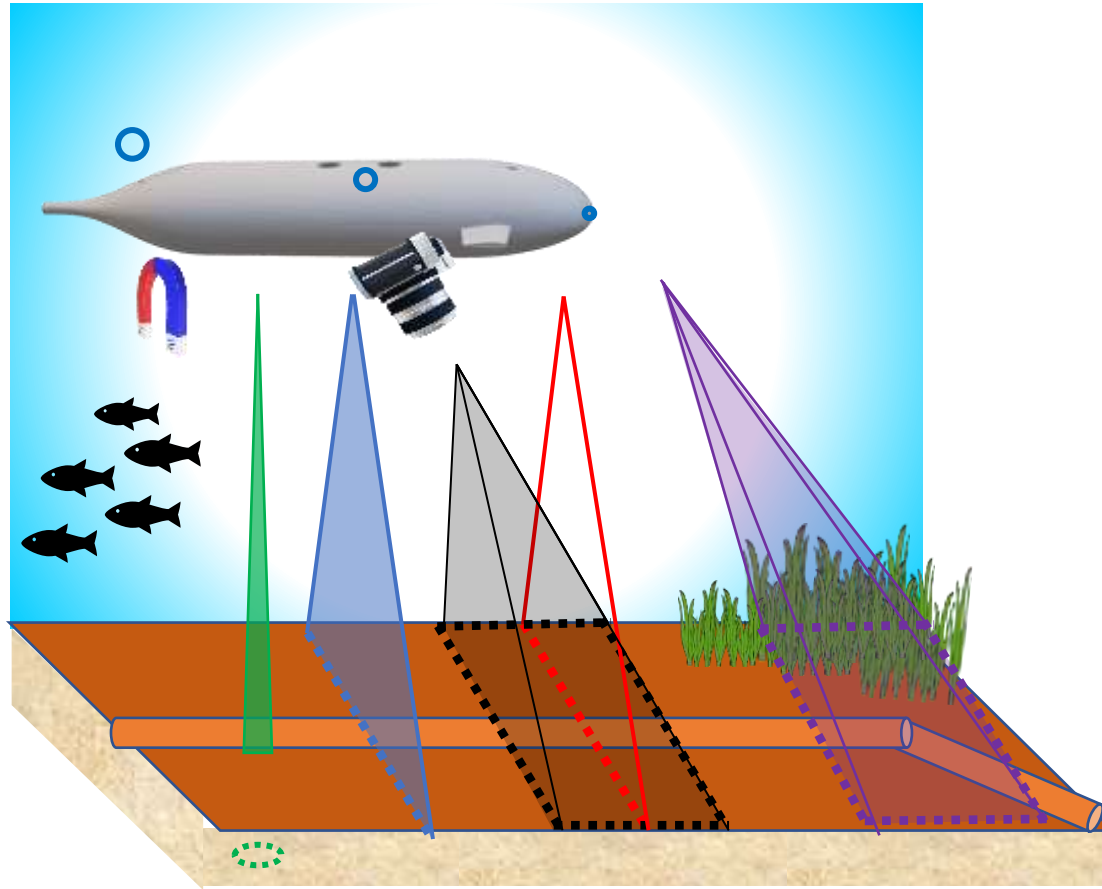
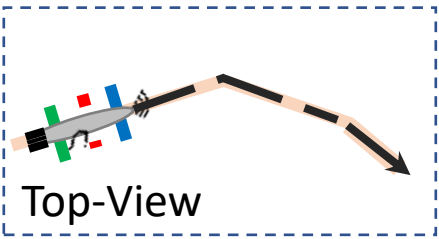
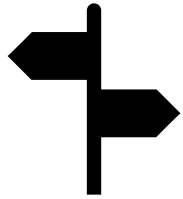
What does my environment look like?

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Where do I have to go?

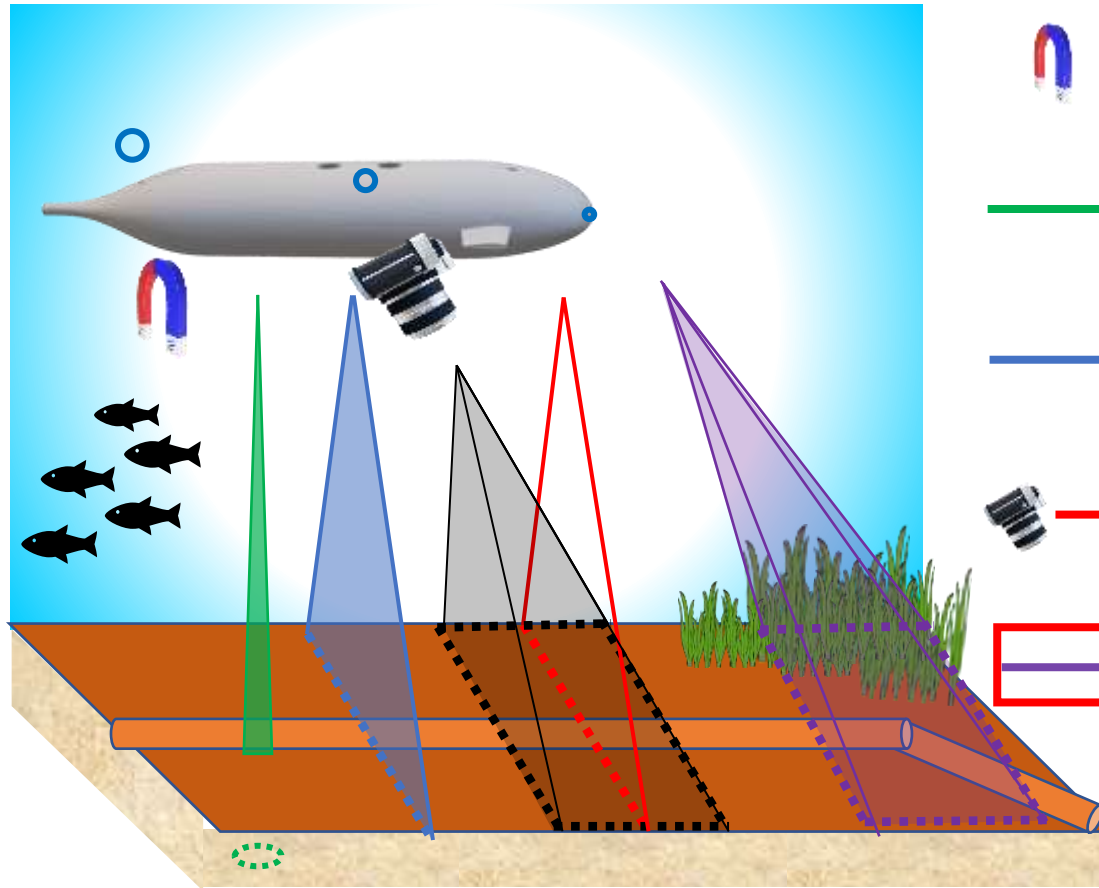
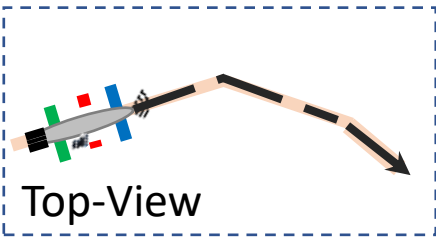
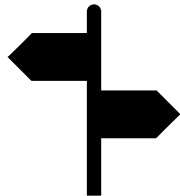







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Where do I have to go?



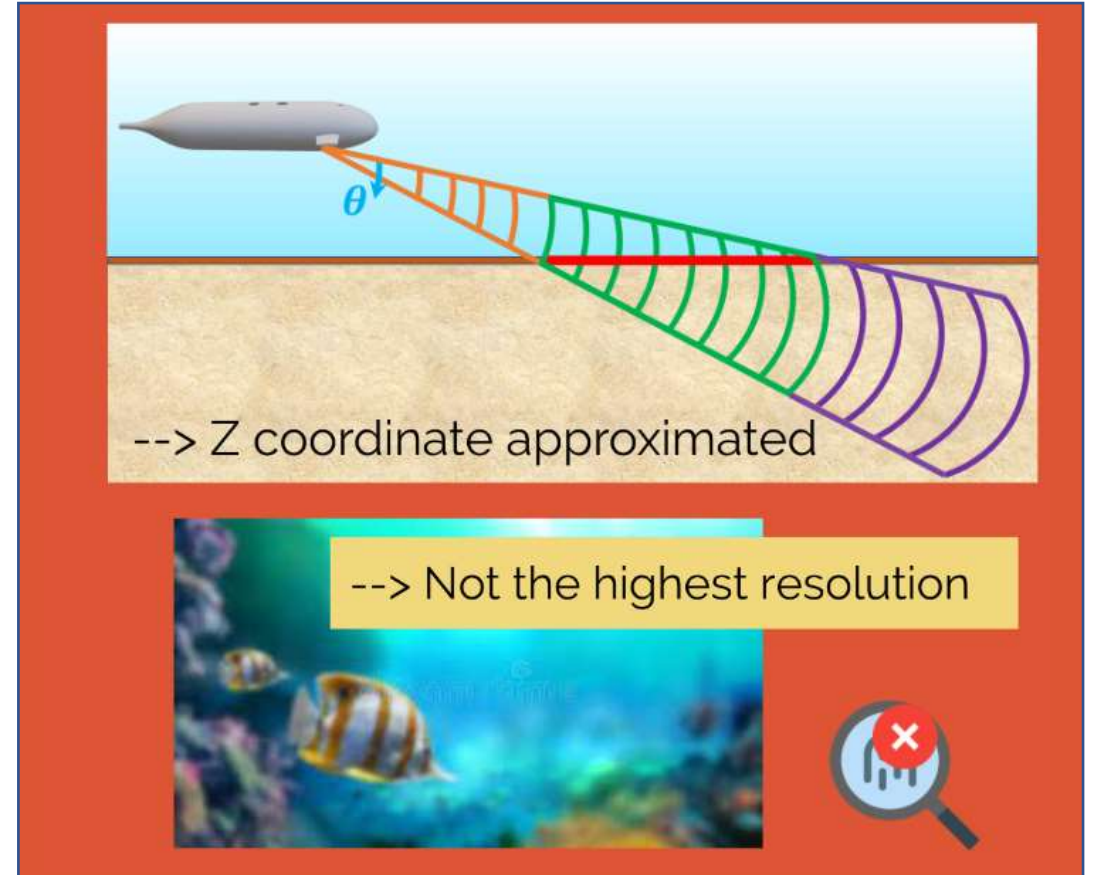
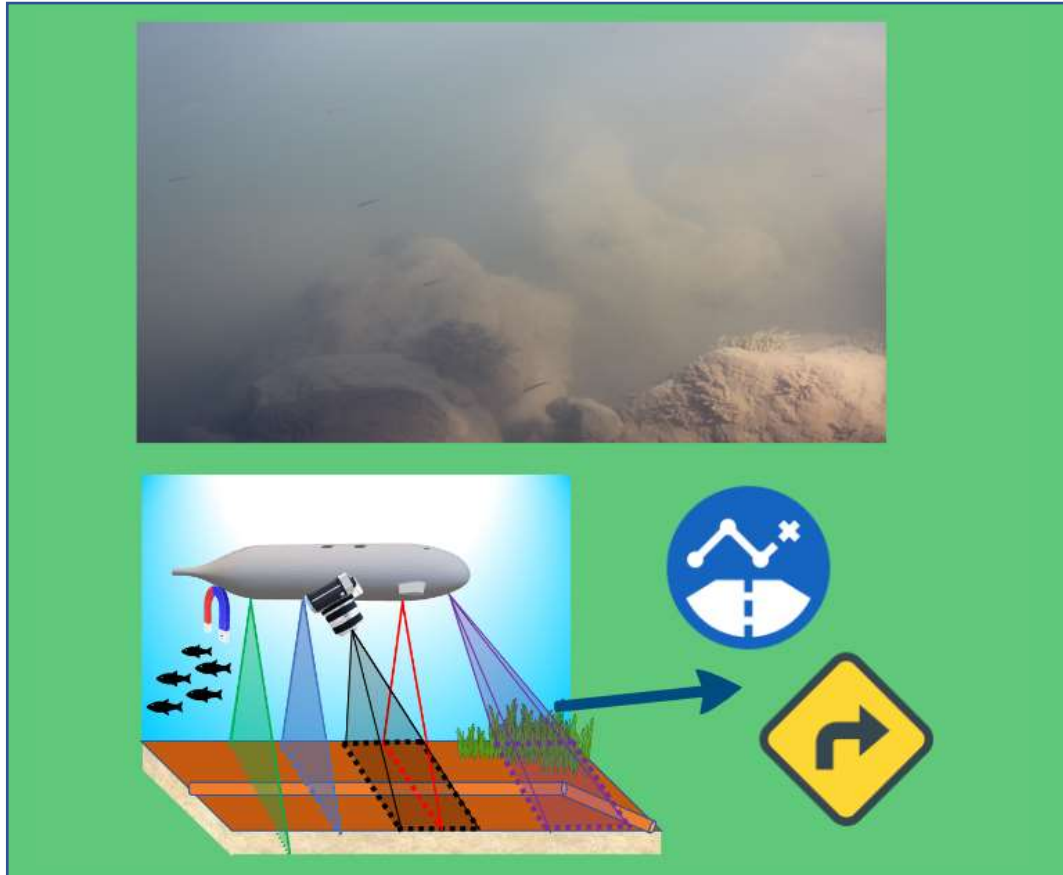
-  Magnetometer
-  Sub-Bottom Profiler
-  Multibeam Echosounder
-  Kamera-Laser System
-  Forward Looking Imaging Sonar



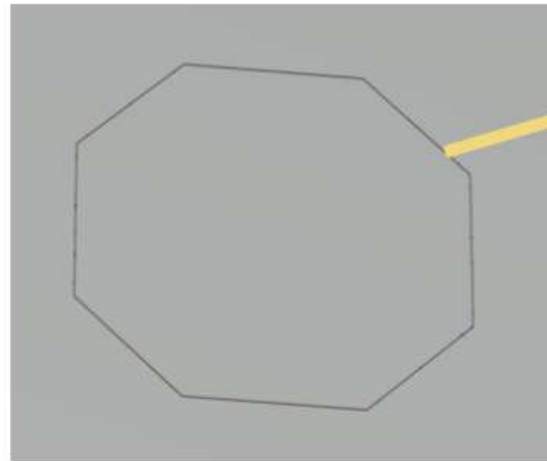
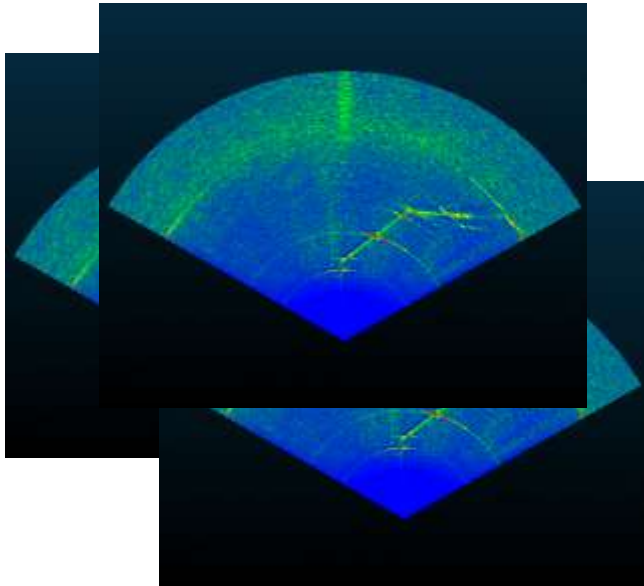
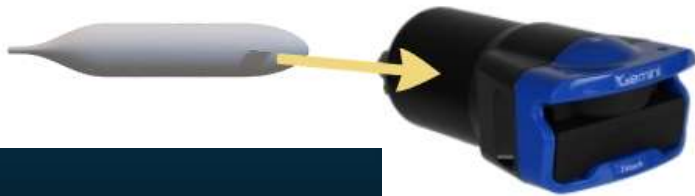
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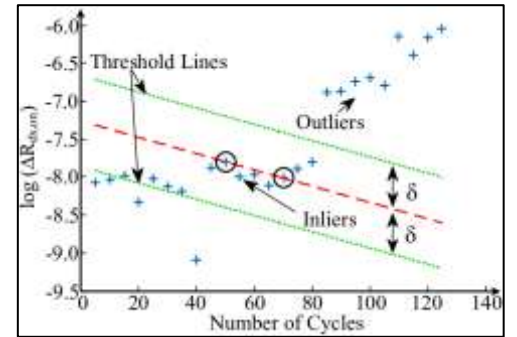
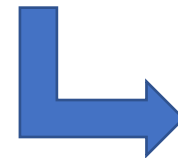
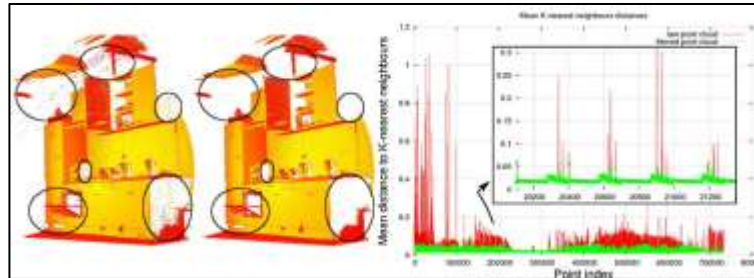
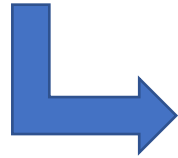
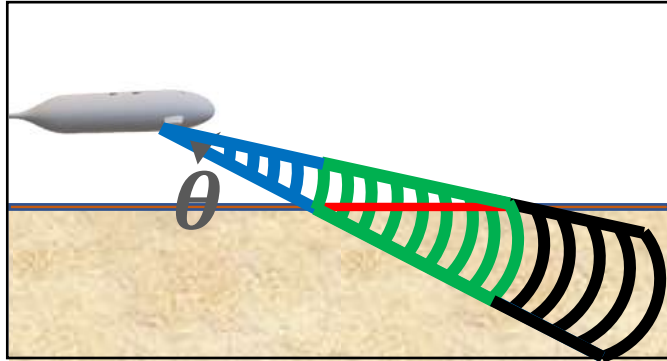
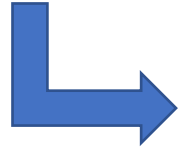
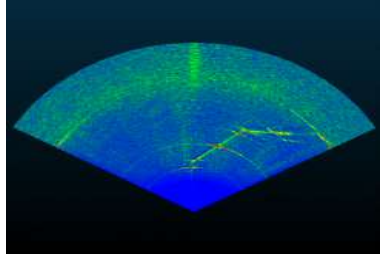


## Gemini 720IS





Input:



Output:

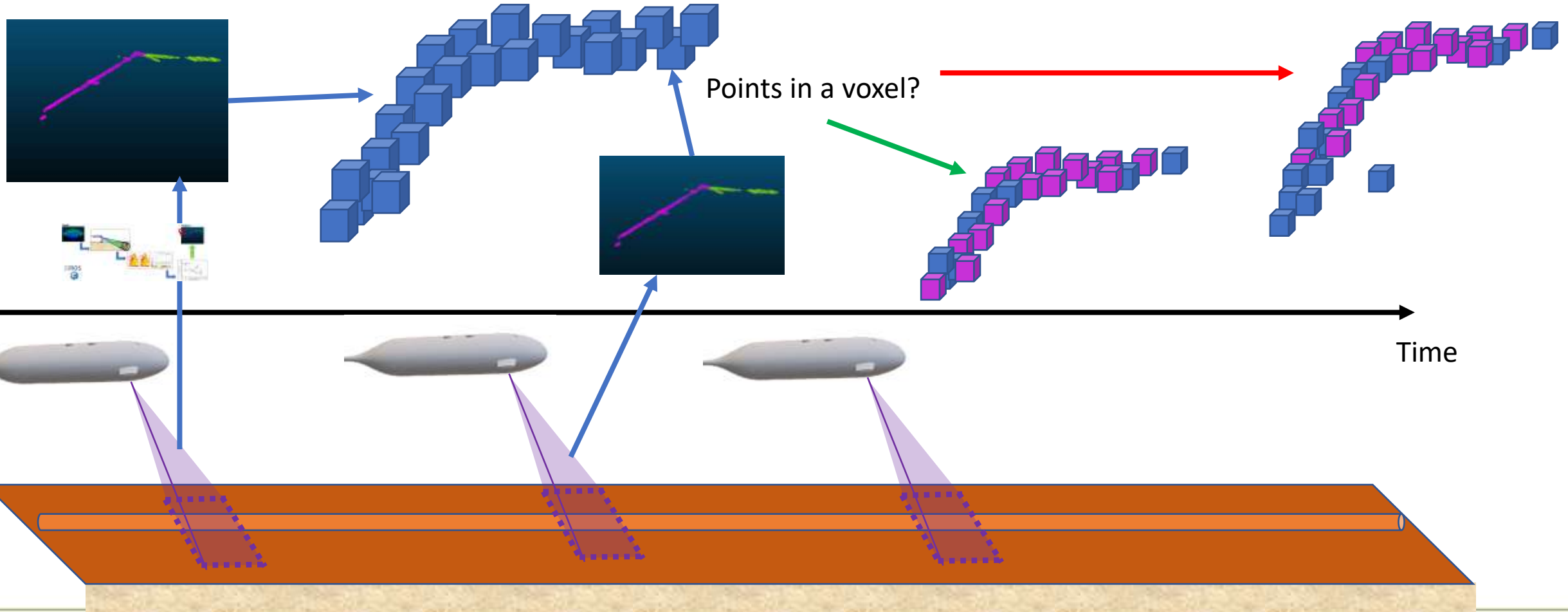




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**SimpleScreenRecorder**

Recording

Enable recording hotkey  Enable sound notifications

Hotkey:  Ctrl +  Shift +  Alt +  Super +

Information

Total time: 0:00:00  
 FPS in: 0.00  
 FPS out: 0.00  
 Size in: 1920x1080  
 Size out: ?  
 File name: ?  
 File size: 0 B  
 Bit rate: 0 bit/s

Preview

Preview frame rate:

Note: Previewing requires extra CPU time (especially at high frame rates).

Log

[PageRecord::StartPage] Starting page ...  
 [PageRecord::StartPage] Started page.

**ocot\_gut.rviz\* - RViz**

2D Nav Goal Publish Point

ROS Elapsed: 3354.70 Wall Time: 1680531063.98 Wall Elapsed: 3354.67

31 fps

Min. Height Dis... -3.40282e+38

**ColorOccupancyGrid**

Displays 3D occupancy grids generated from compressed color octomap messages.





### SimpleScreenRecorder

**Recording**

Enable recording hotkey     Enable sound notifications

Hotkey:  Ctrl +     Shift +     Alt +     Super +    R

---

**Information**

Total time: 0:00:00  
 FPS in: 0.00  
 FPS out: 0.00  
 Size in: 1920x1080  
 Size out: ?  
 File name: ?  
 File size: 0 B  
 Bit rate: 0 bit/s

**Preview**

Preview frame rate: 10

Note: Previewing requires extra CPU time (especially at high frame rates).

---

**Log**

```
[PageRecord::StartPage] Starting page ...
[PageRecord::StartPage] Started page.
```

### ocot\_gut.rviz\* - RViz

2D Nav Goal    Publish Point

ROS Elapsed: 1069.42    Wall Time: 1680528778.70    Wall Elapsed: 1069.36

Min. Height Dis... -3.40282e+38

**ColorOccupancyGrid**

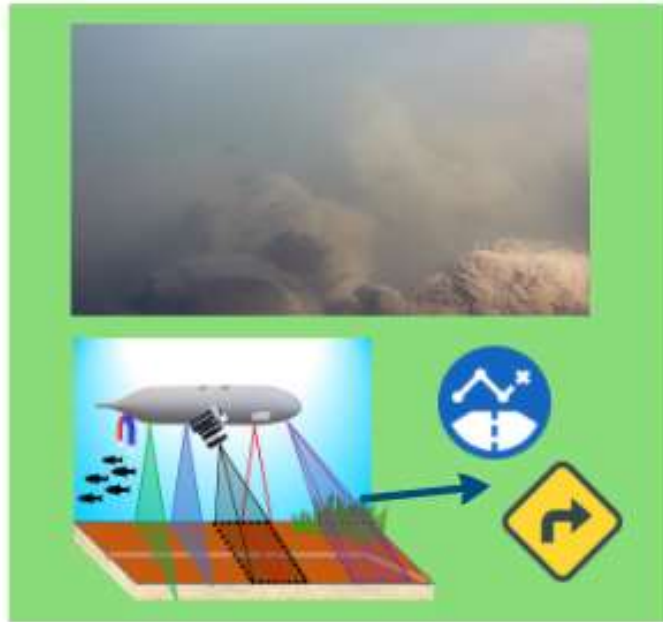
Displays 3D occupancy grids generated from compressed color octomap messages.





## Conclusion

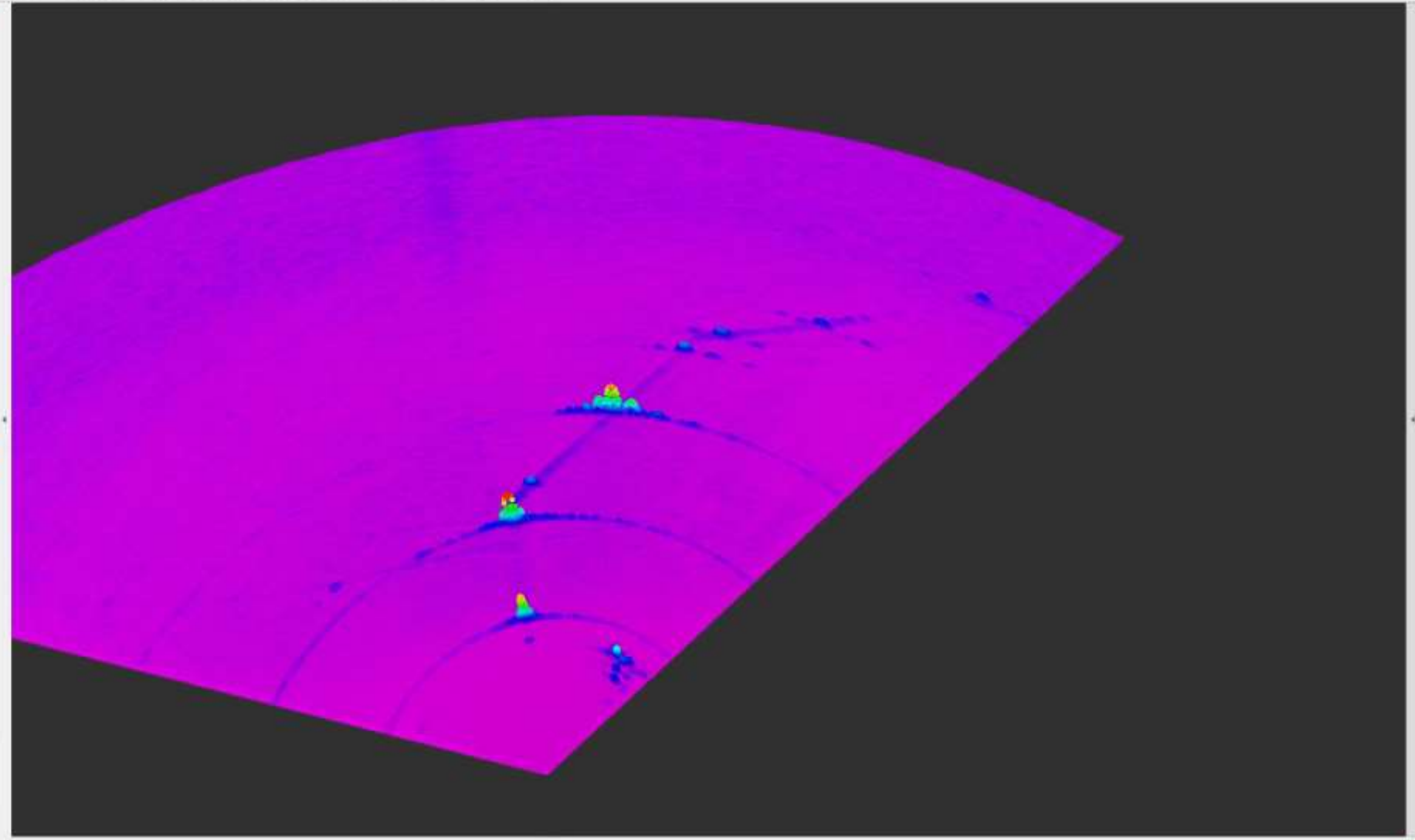


File Panels Help

Interact Move Camera Select Focus Camera Measure 2D Pose Estimate 2D Nav Goal Publish Point

**Displays**

- Global Options
  - Fixed Frame: local\_nwu\_0
  - Background Color: 48; 48; 48
  - Frame Rate: 30
  - Default Light:
- Global Status:  OK
  - Fixed Frame:  OK
- Grid:
- PointCloud2:
- PointCloud2: 
  - Status:  OK
  - Topic: /img\_sonar/pipe\_can...
  - Unreliable:
  - Queue Size: 10
  - Selectable:
  - Style: Boxes
  - Size (m): 0.05
  - Alpha: 1
  - Decay Time: 10
  - Position Transf...: XYZ
  - Color Transfor...: AxisColor
  - Axis: Z
  - Autocompute V...:
  - Use Fixed Frame:
- PointCloud2:
- SonarDisplay**:



**SonarDisplay**

Displays rosen\_auv\_msgs/Sonar messages.

Add Duplicate Remove Rename

**Time**

Pause Synchronization: Off ROS Time: 1673442948.49 ROS Elapsed: 2153.50 Wall Time: 1673442948.52 Wall Elapsed: 2153.47

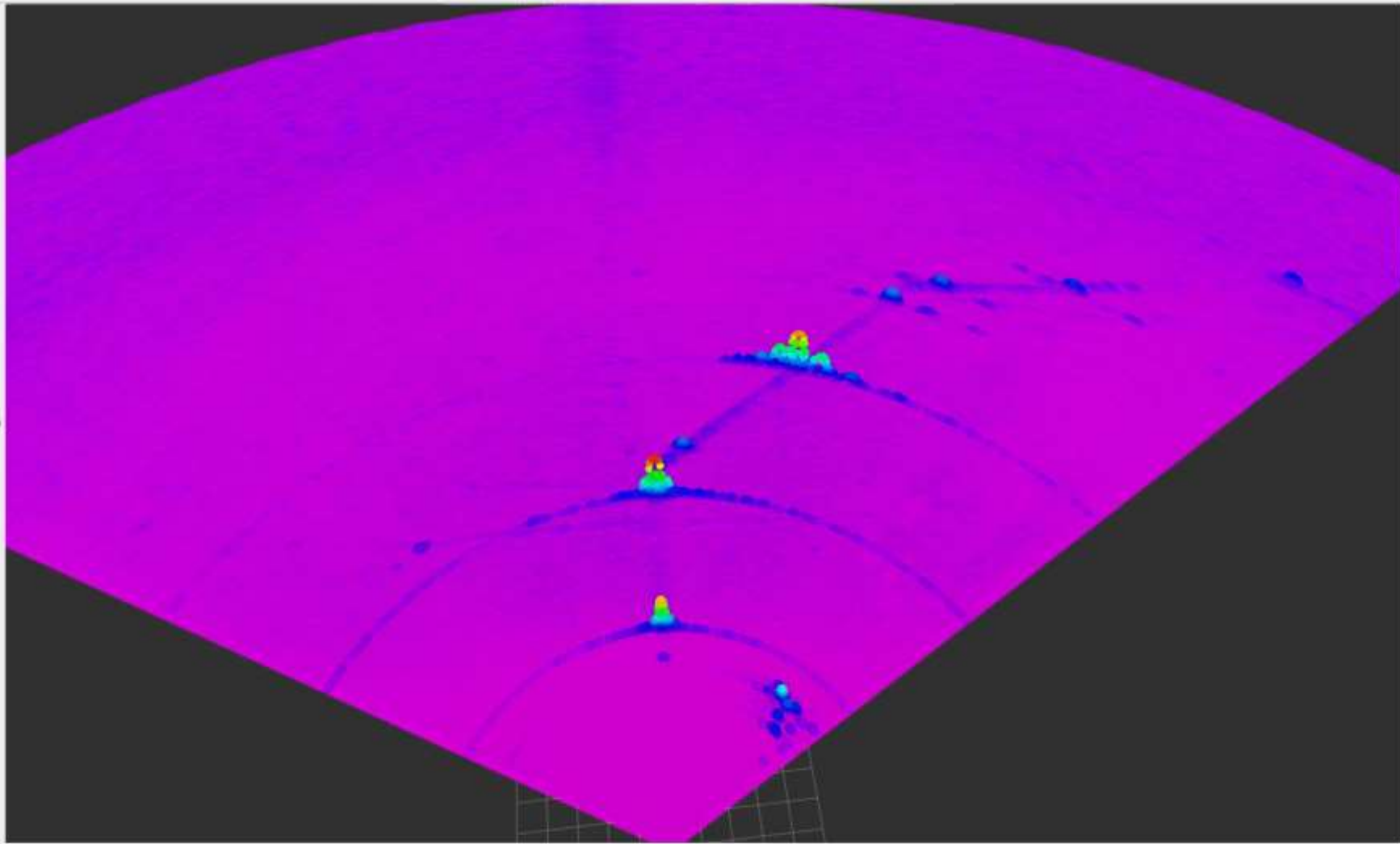
Reset Left-Click: Rotate. Middle-Click: Move X/Y. Right-Click/Mouse Wheel: Zoom. Shift: More options. 31 fps

File Panels Help

Interact Move Camera Select Focus Camera Measure 2D Pose Estimate 2D Nav Goal Publish Point

**Displays**

- Default Light
- Global Status: Ok
  - Fixed Frame OK
- Grid
- PointCloud2 
  - Status: Ok
    - Topic /img\_sonar/pipe\_ca...
    - Unreliable
    - Queue Size 10
    - Selectable
    - Style Boxes
    - Size (m) 0.05
    - Alpha 1
    - Decay Time 0
    - Position Transf... XYZ
    - Color Transfor... AxisColor
    - Axis Z
    - Autocompute V...
    - Use Fixed Frame
- PointCloud2 
  - Status: Ok
    - Topic /img\_sonar/p3d\_cut
    - Unreliable
    - Queue Size 10
    - Selectable
    - Style Flat Squares
    - Size (m) 0.01
    - Alpha 1
    - Decay Time 0
    - Position Transf... XYZ
    - Color Transfor... Intensity
      - Charaset Name intensity
      - Use rainbow
      - Insert Rainbow
      - Min Color 0, 0, 0
      - Max Color 255, 255, 255
      - Autocompute i...
      - Min Intensity 0
      - Max Intensity 4096
- SonarDisplay



**Color Transformer**  
Set the transformer to use to set the color of the points.

Add Duplicate Remove Rename

Time

Pause Synchronization: Off ROS Time: 1673441931.74 ROS Elapsed: 1136.75 Wall Time: 1673441931.77 Wall Elapsed: 1136.68



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512 beams

