

The logo for the National Oceanography Centre, featuring a white square with a black border. The text "National Oceanography Centre" is written in white, sans-serif font inside the square.

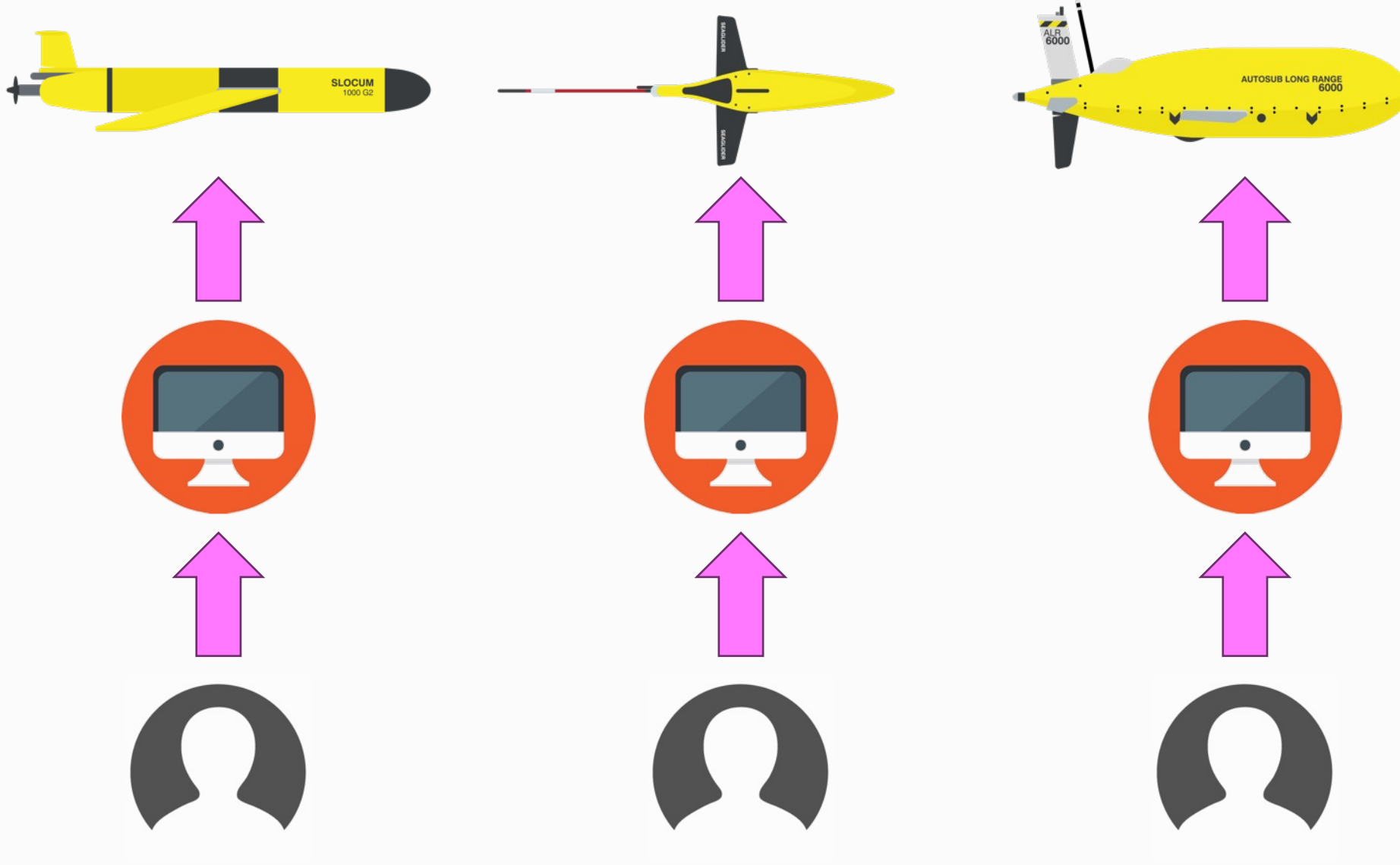
National  
Oceanography  
Centre

# **MODERN COMMAND AND CONTROL: THE FUTURE OF INTEROPERABILITY OF HETEROGENEOUS FLEETS OF MARINE AUTONOMOUS SYSTEMS**

**ASHLEY MORRIS**

**SENIOR SOFTWARE ENGINEER  
COMMAND AND CONTROL LEAD**

# THE PAST

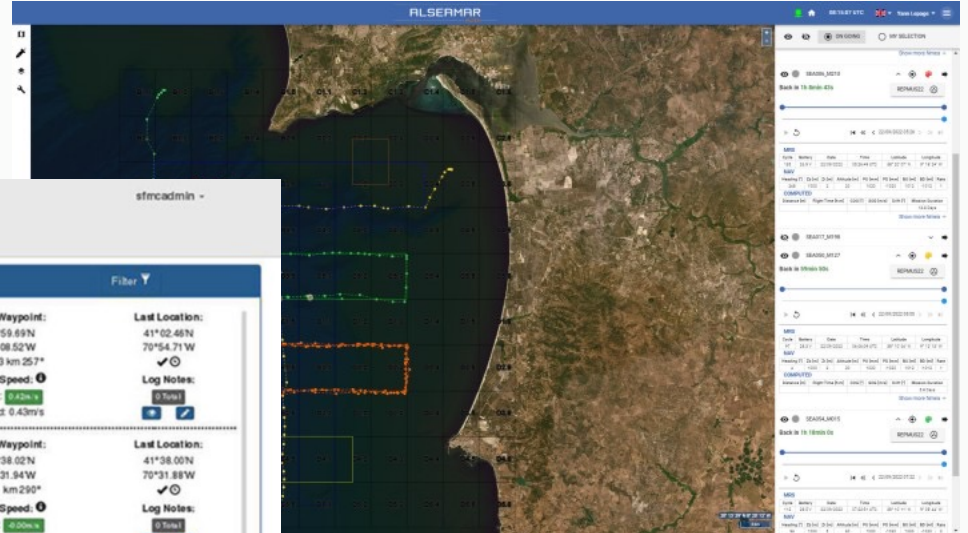
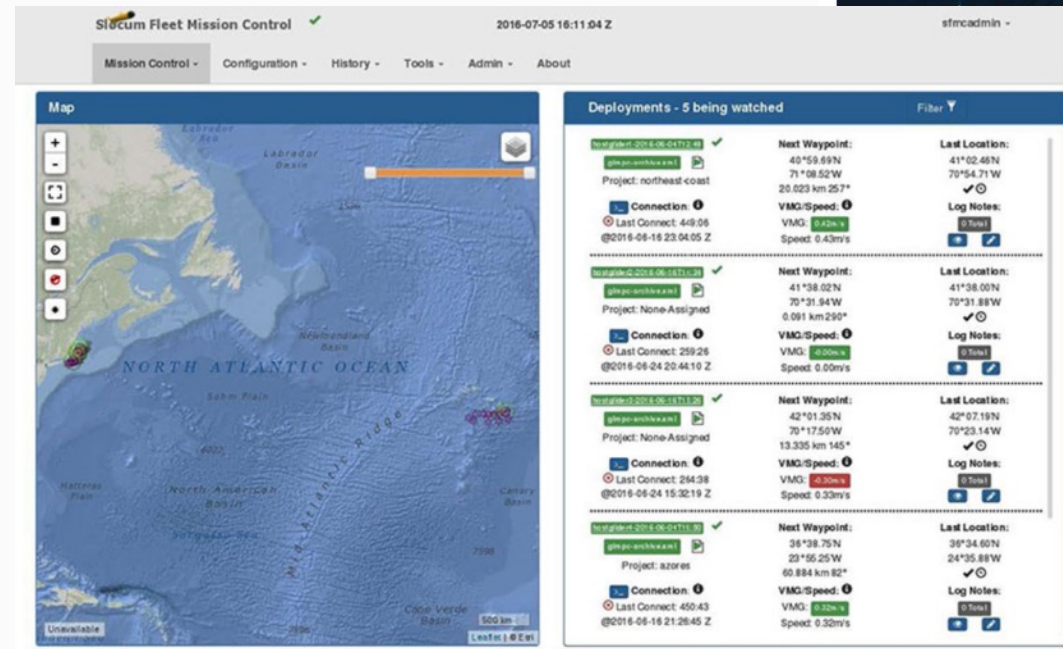
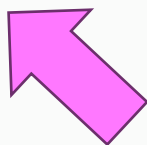
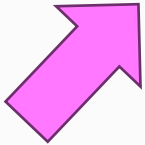
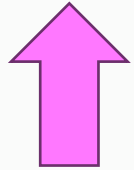


Pilots operated Marine Autonomous Systems on a one-to-one basis.

This model is unsustainable for operators with many vehicles or fleets with different platform types.

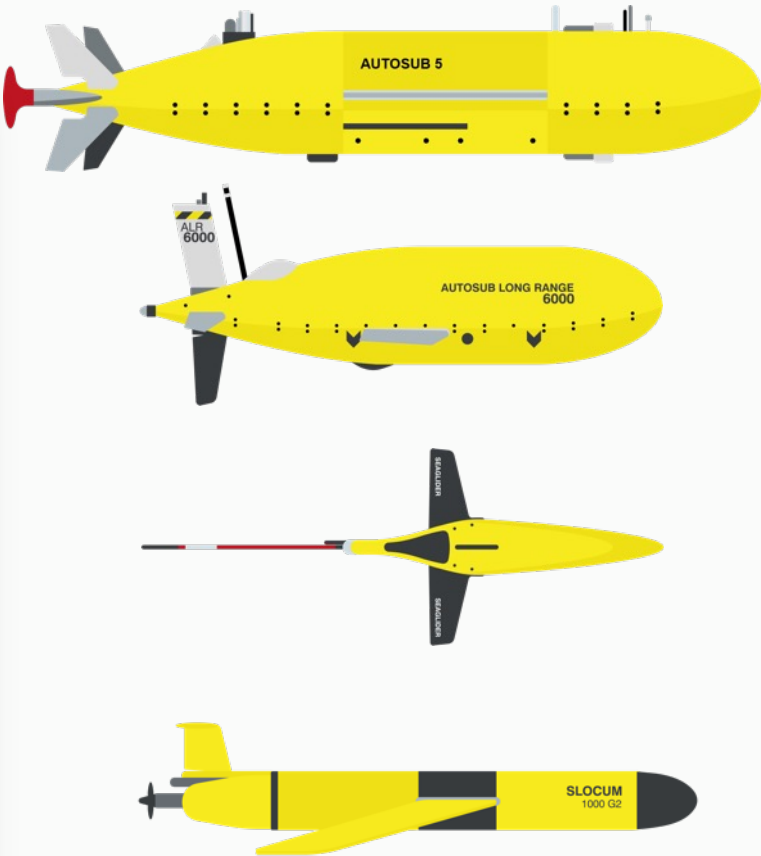
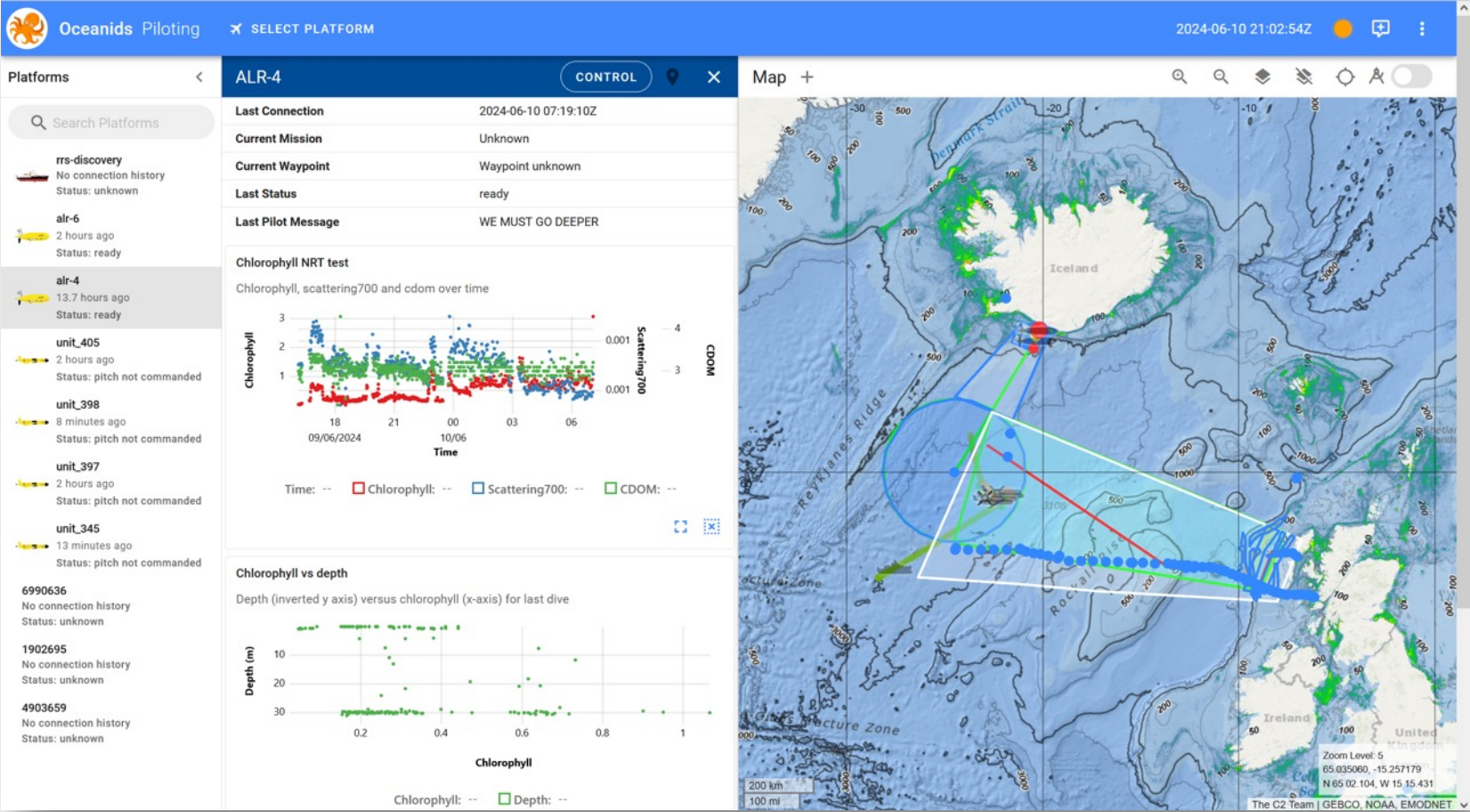


# RECENT C2 ADVANCEMENTS



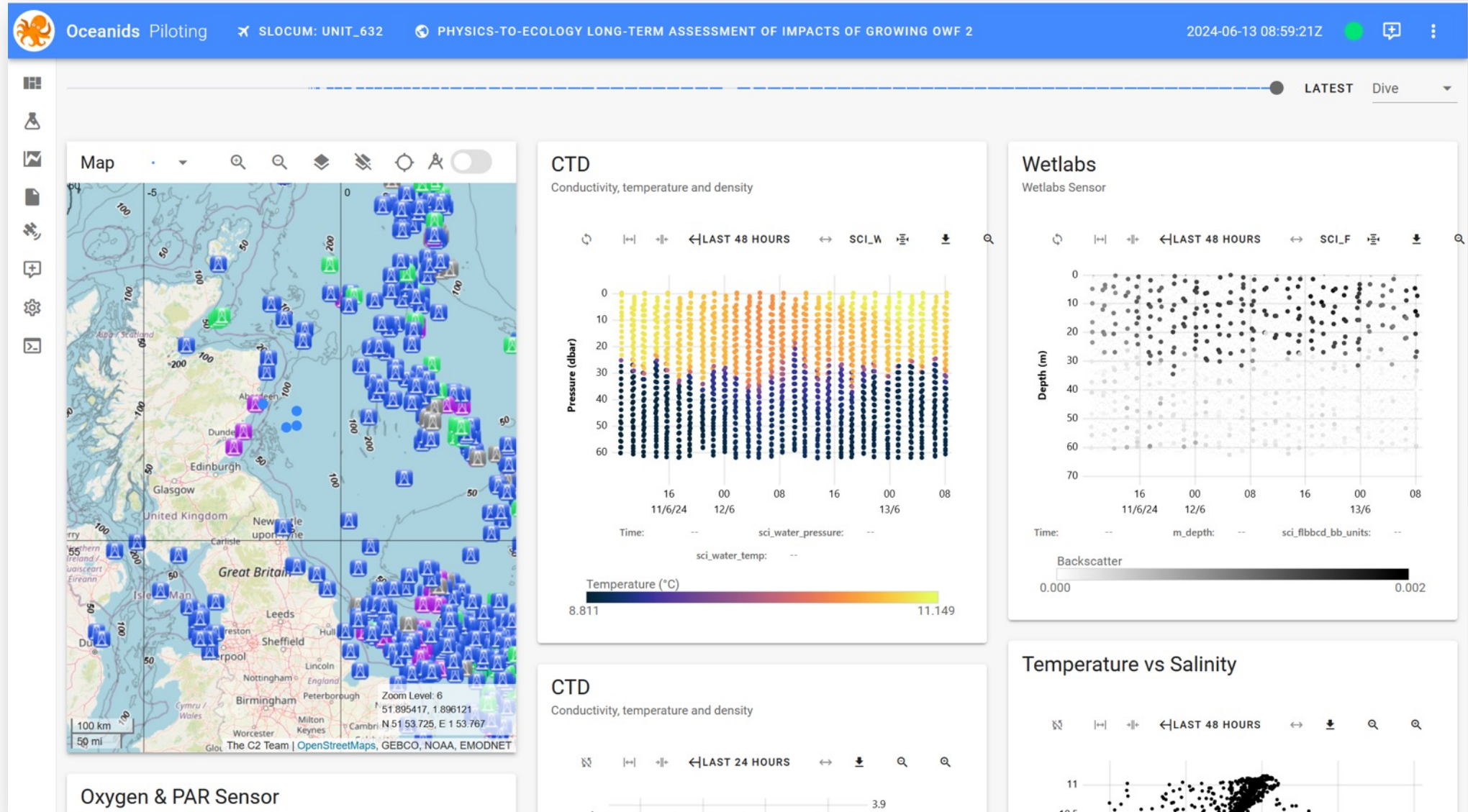
Modern web technologies and development techniques have allowed pilots command and control fleets of the same platforms from any internet connected device.

# MULTI-PLATFORM C2

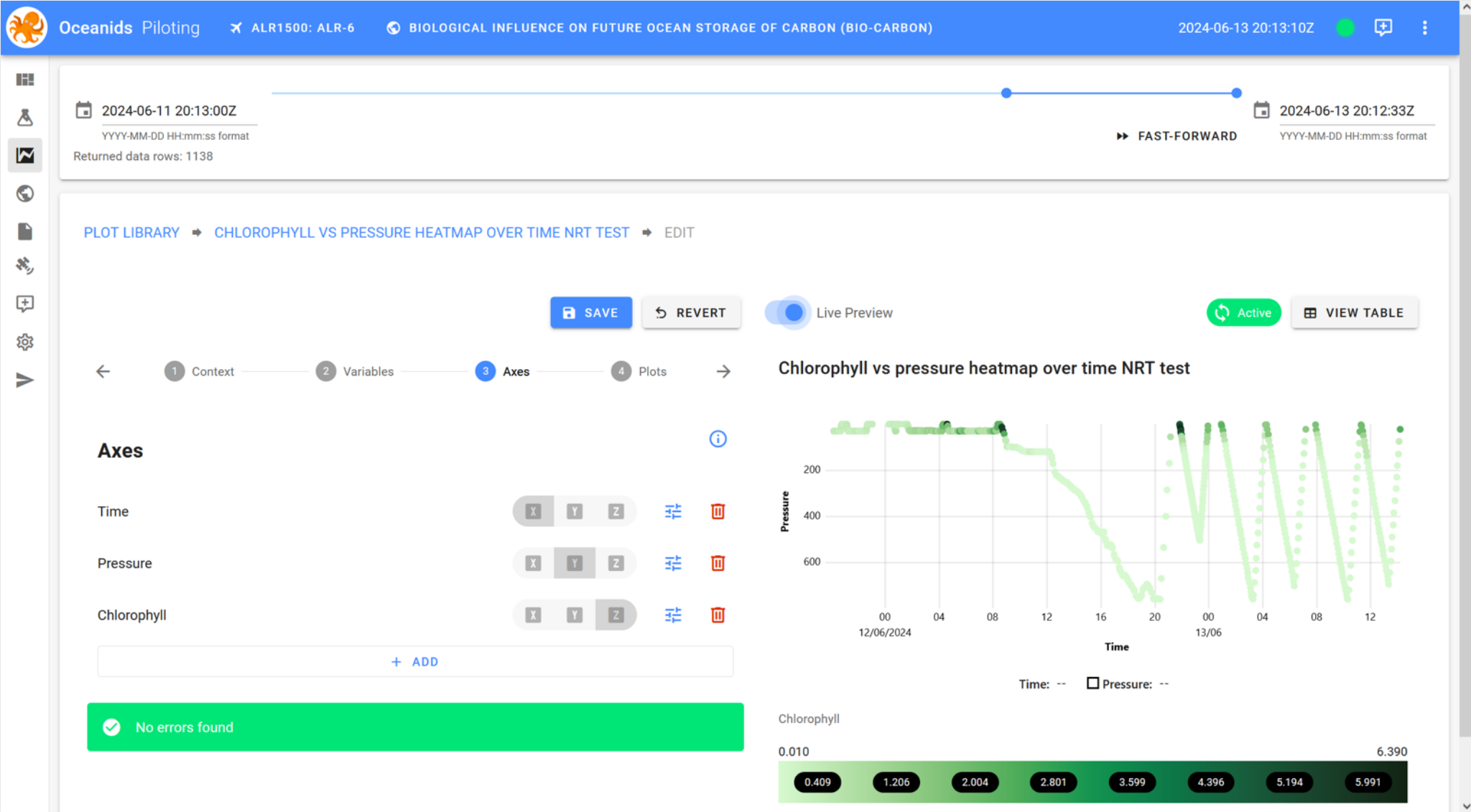




# MULTI-PLATFORM C2



# MULTI-PLATFORM C2



PLOT LIBRARY

➔

CHLOROPHYLL VS PRESSURE HEATMAP OVER TIME NRT TEST

➔

EDIT

💾

SAVE

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REVERT

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Live Preview

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Active

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VIEW TABLE

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Context

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+ ADD

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No errors found

Chlorophyll vs pressure heatmap over time NRT test



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Pressure: --

Chlorophyll

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5.991

# MULTI-PLATFORM C2



Piloting

✈️ ALR1500: ALR-4

🌐 BIOLOGICAL INFLUENCE ON FUTURE OCEAN STORAGE OF CARBON (BIO-CARBON)

2024-06-13 08:57:24Z

ALR / ... / ... / ... / Outline of transit from Ellet line to Harris / Version 4 (Latest)

STOP EDITING

COMMIT CHANGES

Map

+

ADD

GENERATE

IMPORT

Map

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Zoom Level: 7

57.883989, -6.209563

N 57 53.039, W 6 12.574

50 km

30 mi

The C2 Team | OpenStreetMaps, EMODNET

Plan Overview

EXPORT PLAN

SEND PLAN

- Plan contains 15 actions and can be sent via large buffer Iridium modems and WiFi ?
- Maximum planned depth 30 m
- Minimum planned altitude 25 m
- Estimated total distance 177.89 km ?
- Plan will timeout after 180:00:00 estimated plan time between 90:16:17 and 135:24:26 ?
- Dive 1 will timeout after 53:00:00 estimated dive time between 34:58:14 and 52:27:21 ?
- Dive 2 will timeout after 15:00:00 estimated dive time between 08:57:24 and 13:26:06 ?
- Dive 3 will timeout after 16:00:00 estimated dive time between 10:44:38 and 16:06:57 ?

+

ADD

GENERATE

IMPORT

Plan Settings

Outline of transit from Ellet line to ...

Flight Style: Dive To Waypoint

Dive to waypoint

Flight Style: Track Follow

Trackfollow

Flight Style: Loiter On Surface

Loiter on surface

Flight Style: Dive To Waypoint

Dive to waypoint

Flight Style: Track Follow

Trackfollow

Flight Style: Loiter On Surface

Loiter on surface

Flight Style: Dive To Waypoint

Dive to waypoint

Flight Style: Dive To Waypoint

Behaviour name

Dive to waypoint

Pilot Notes

Target Latitude

57.020552

Target Longitude

-9.084506

Minimum Altitude

25

Target Depth

30

Vertical Acceptance Tolerance

150

Horizontal Acceptance Tolerance

150

Descent Pitch Limit

-15

Ascent Pitch Limit

15

Min Run Up Speed Through Water

0.6

Run Up Speed Over Ground

0.6

Max Run Up Speed Through Water

0.6

Min Speed Through Water

0.55

Speed Over Ground

0.55

Max Speed Through Water

0.55

Run Up Timeout

90

Behaviour Time...

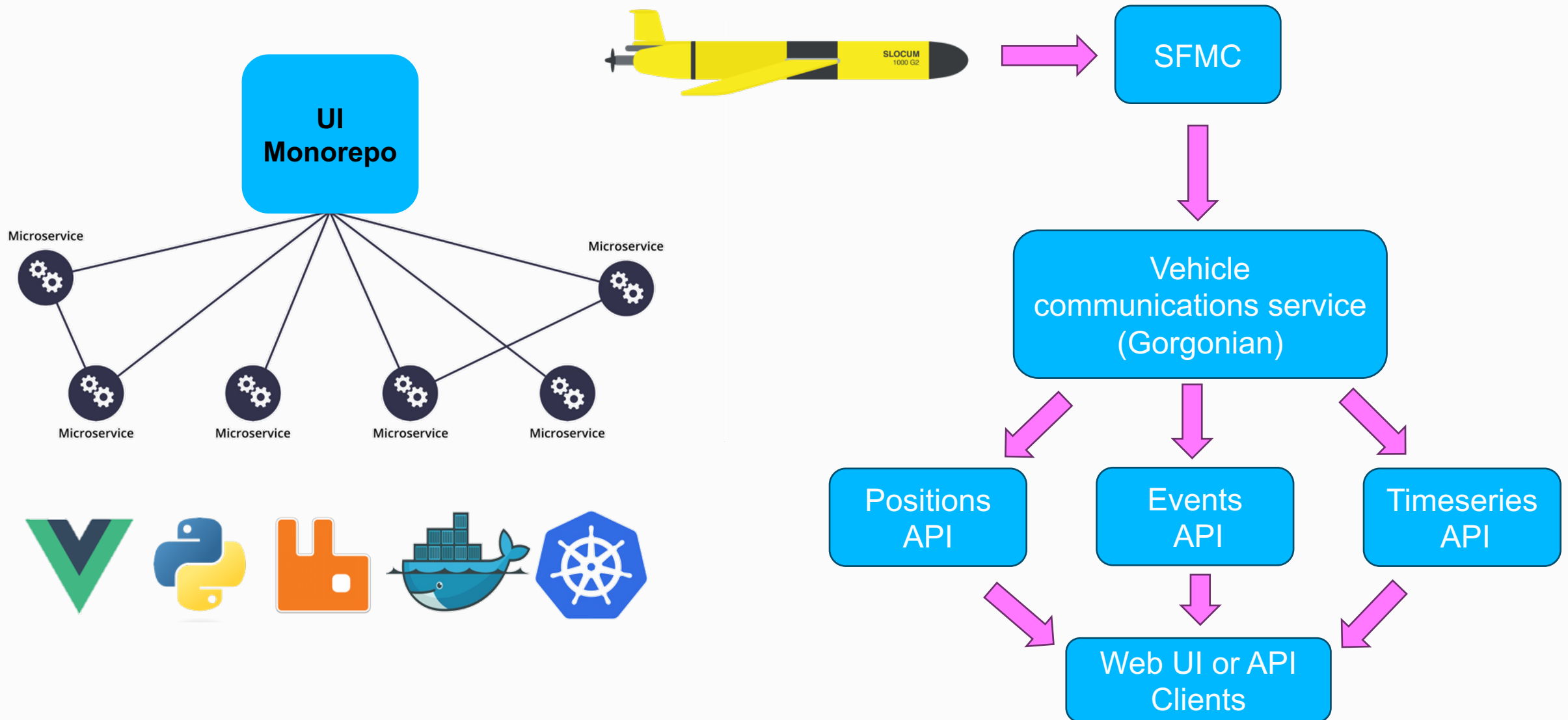
600 (00:10:00)

Dive Timeout

190800 (53:00:00)

Maximum time spent underwater

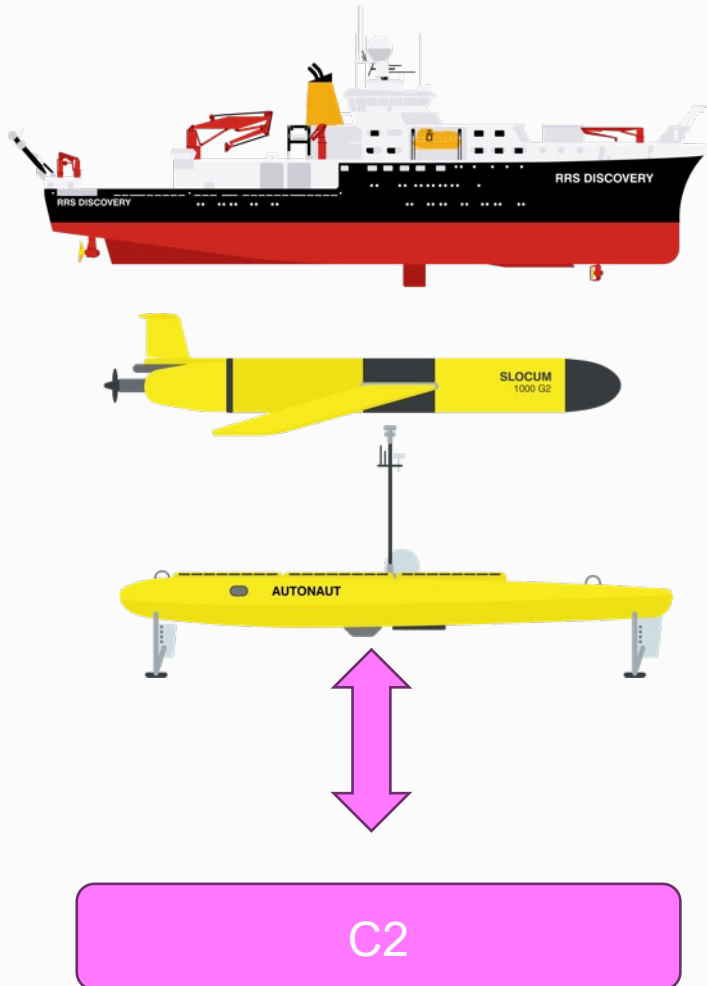
# NOC C2 ARCHITECTURE



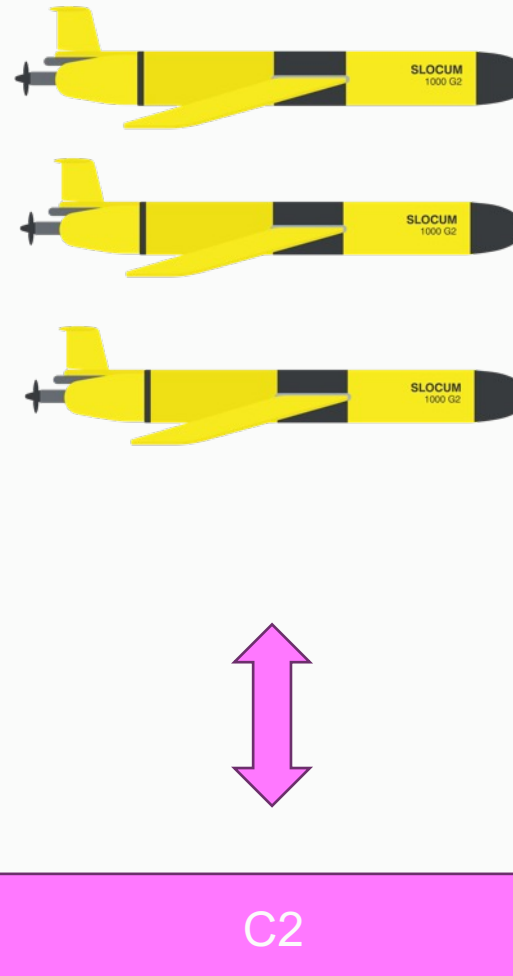


# VENDOR LOCK-IN BECOMES C2 LOCK-IN

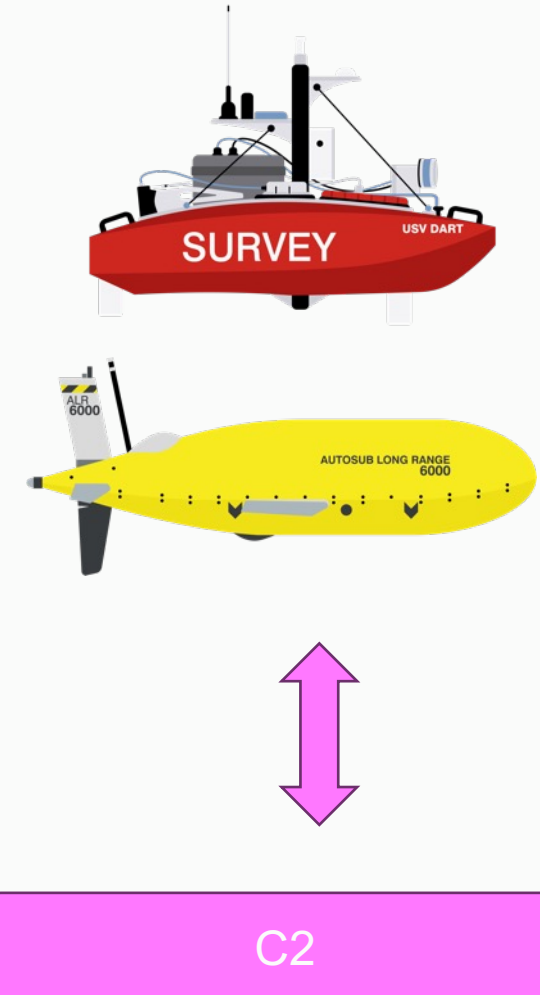
Organisation 1



Organisation 2



Organisation 3



# SOLUTION TO C2 LOCK-IN

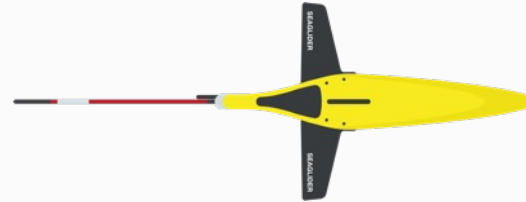
Organisation 1



C2



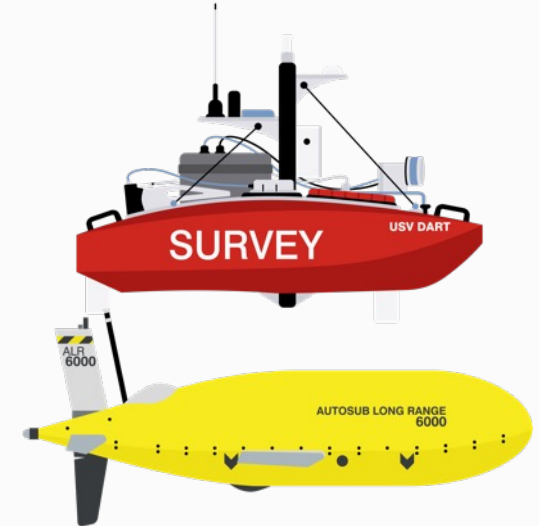
Organisation 2



C2



Organisation 3

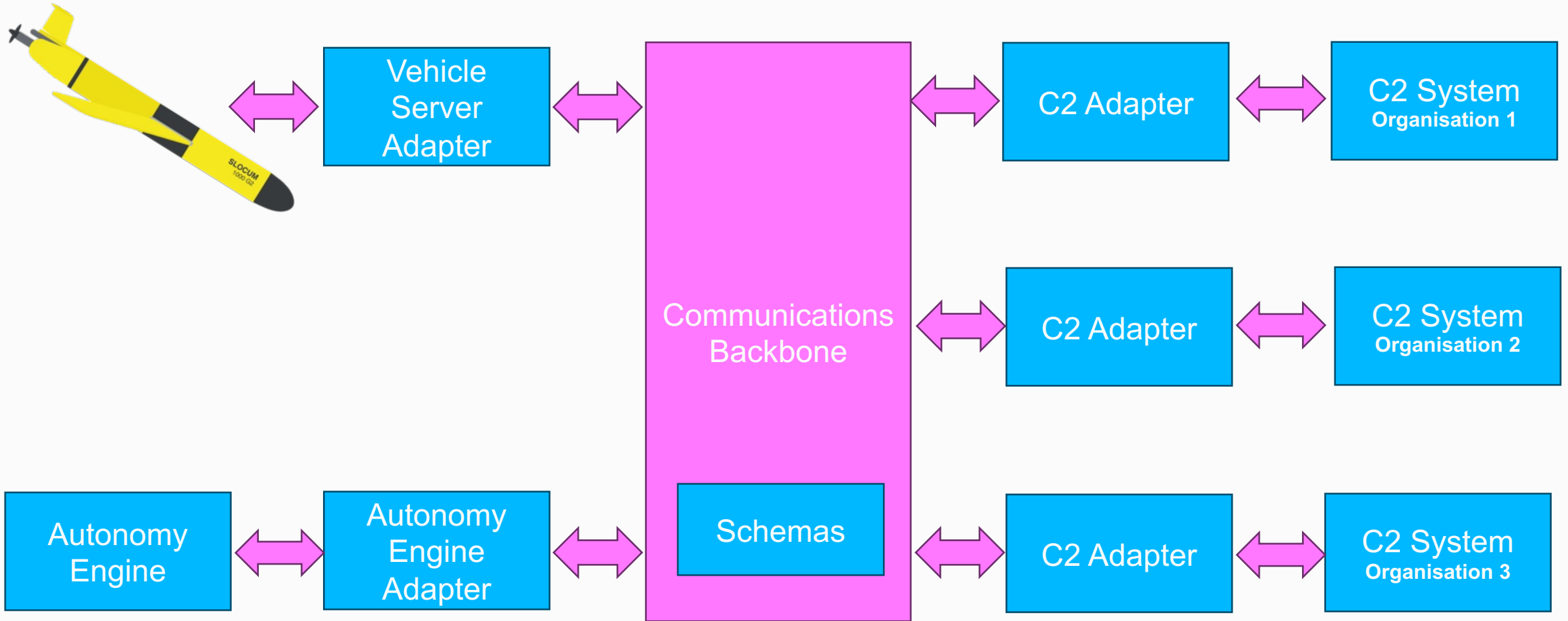


C2



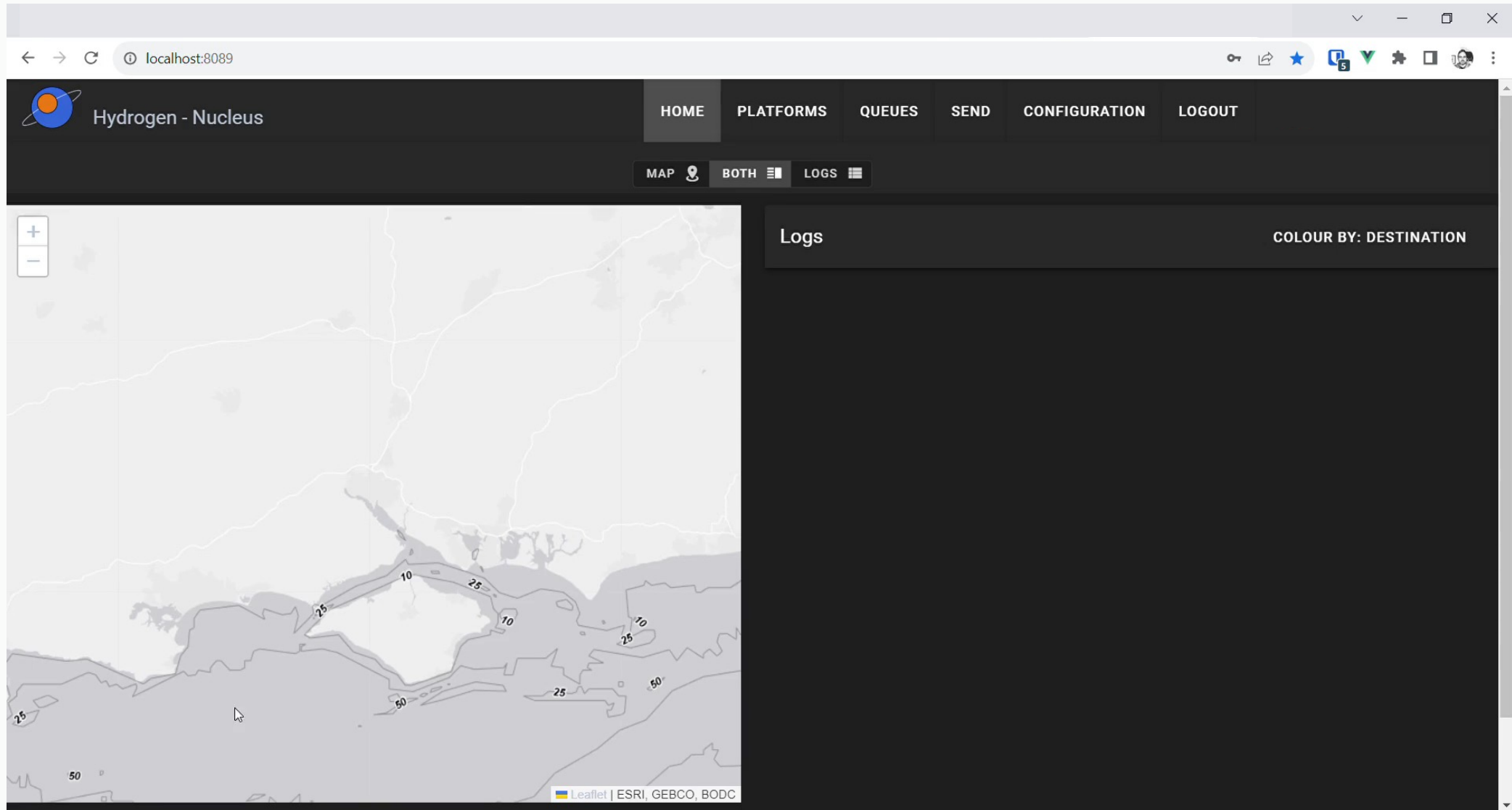
Communications Backbone

# SYSTEM OVERVIEW





# LET'S SEE IT IN ACTION



# LET'S GO DEEPER

JS sample\_adapter.js

```
import { GenericProtocol } from '~/modules/comms-adapter/protocol';

export class ExampleClientProtocol extends GenericProtocol {
  constructor(schema, services) {
    super(schema, services);
  }

  // Process a message received from the backbone
  decode(type, message) {
    switch (type) {
      case 'VehicleStatus':
        this.decodeVehicleStatus(message);
        break;
      case 'VehicleMission':
        this.decodeVehicleMission(message);
        break;
    }
    return message;
  }

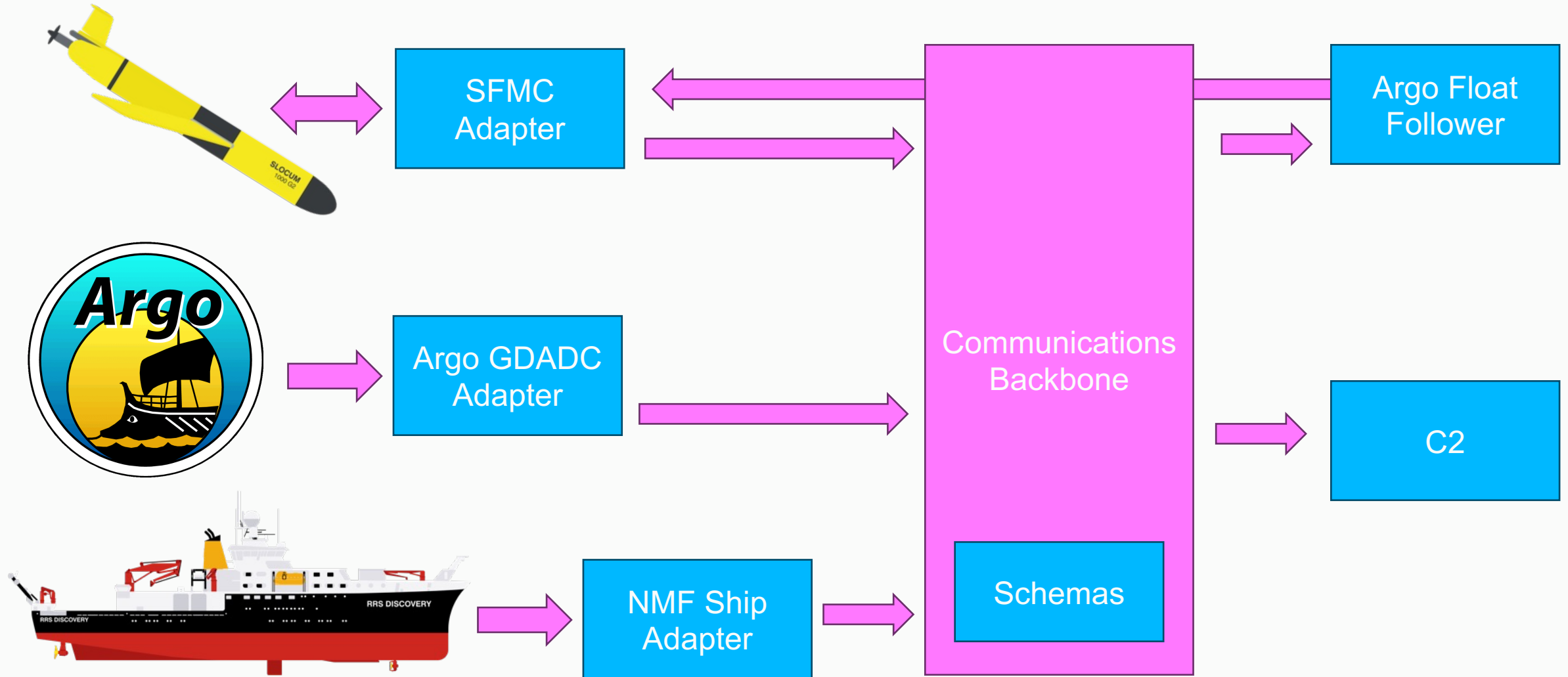
  // Transform local data into a message conforming to the protocol schema
  encode(type, message) {
    switch (type) {
      case 'MissionPlan':
        this.encodeMissionPlan(message);
        break;
      case 'Action':
        this.encodeMissionAction(message);
        break;
    }
  }

  return message;
}
```

platform\_status\_schema.py

```
platform_status_schema = {
  "type": "object",
  "properties": {
    "message_type": {
      "type": "string",
      "description": "Type of message",
      "example": "platform_status",
      "enum": ["platform_status"],
    },
    "platform_ID": {
      "type": "string",
      "description": "Unique identifier for this platform",
      "example": "reav-x-1",
    },
    "latitude": {
      "type": "number",
      "format": "float",
      "description": "Latitude (Y-coordinate) in decimal degrees.",
      "example": 178.2,
    },
    "longitude": {
      "type": "number",
      "format": "float",
      "description": "Longitude (X-coordinate) in decimal degrees.",
      "example": -10.122,
    },
    "depth": {
      "type": "number",
      "format": "float",
      "description": "Target depth in metres",
      "example": 50.0,
      "default": 0.0,
    },
    "altitude": {
      "type": "number",
      "format": "float",
      "description": "Target altitude in metres",
      "example": 20.0,
    }
  }
}
```

# ONGOING WORK – COMING SOON™







Follow our fleet!

<https://mars.noc.ac.uk>

National  
Oceanography  
Centre



View the code

<https://git.noc.ac.uk/communications-backbone-system>

**THANK YOU**

**ASHLEY.MORRIS@NOC.AC.UK**

NOC.AC.UK