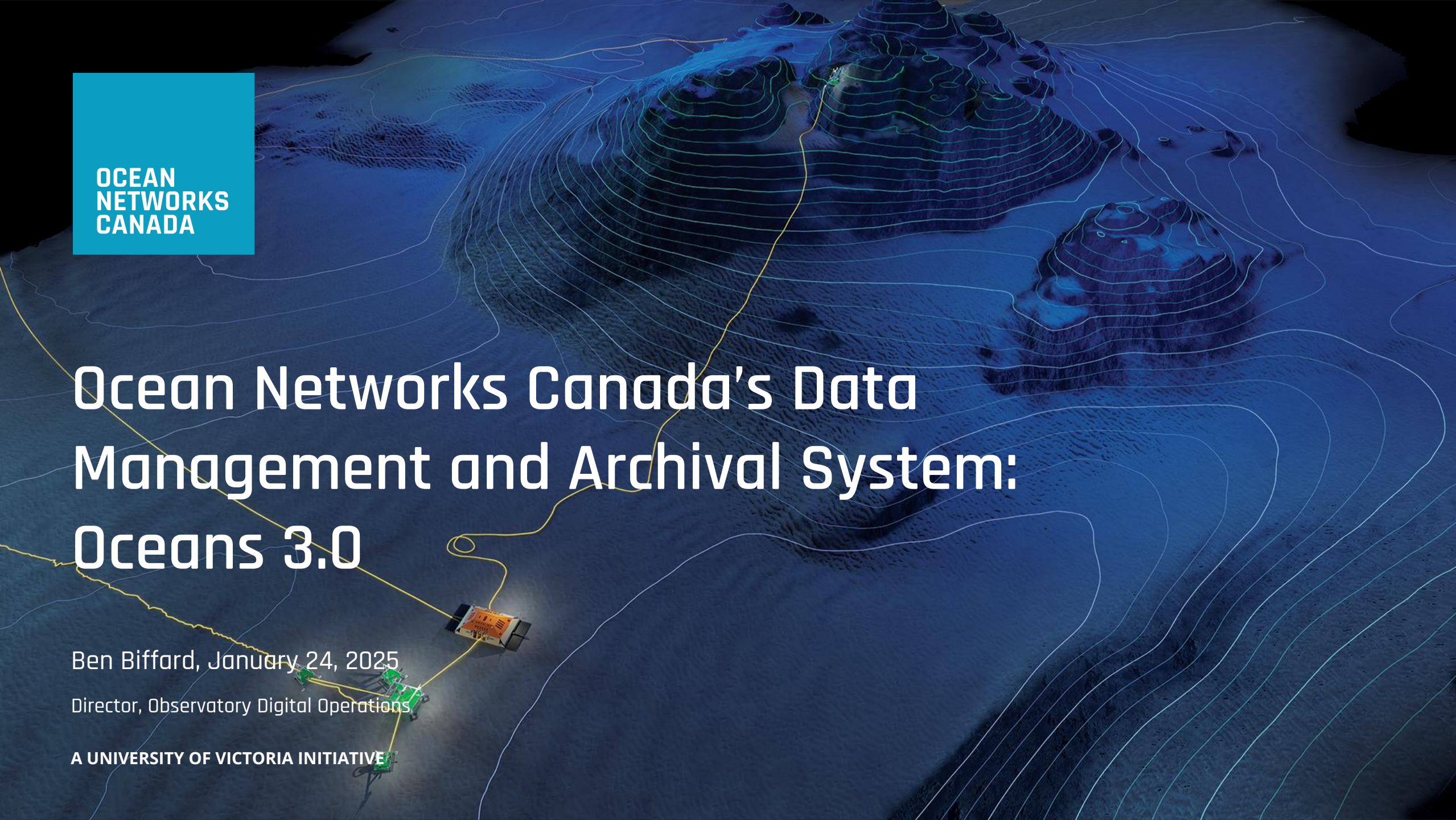




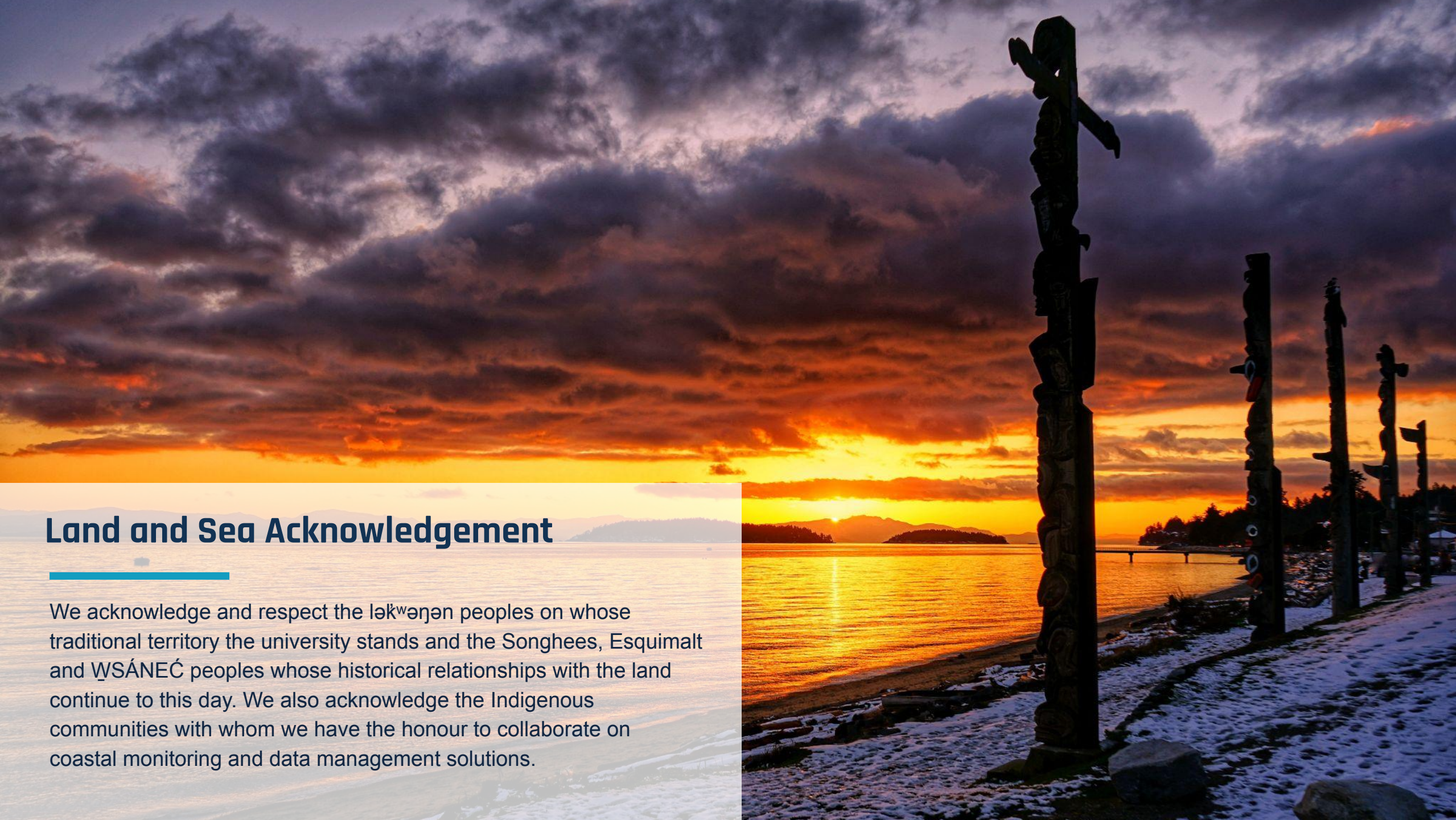
OCEAN  
NETWORKS  
CANADA

# Ocean Networks Canada's Data Management and Archival System: Oceans 3.0

Ben Biffard, January 24, 2025

Director, Observatory Digital Operations

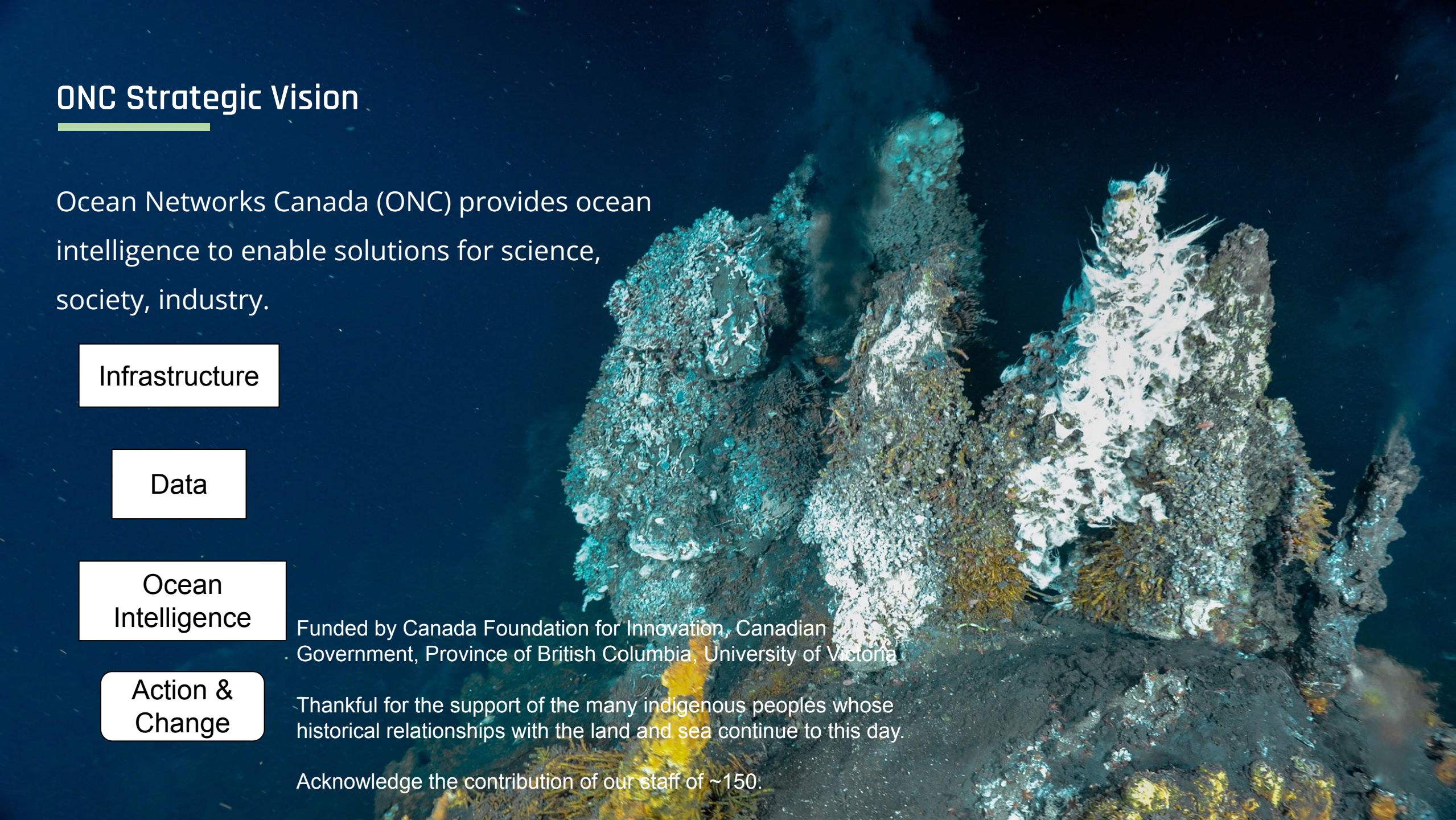
A UNIVERSITY OF VICTORIA INITIATIVE



## Land and Sea Acknowledgement

We acknowledge and respect the ləkʷəŋən peoples on whose traditional territory the university stands and the Songhees, Esquimalt and W̱SÁNEĆ peoples whose historical relationships with the land continue to this day. We also acknowledge the Indigenous communities with whom we have the honour to collaborate on coastal monitoring and data management solutions.

# ONC Strategic Vision



Ocean Networks Canada (ONC) provides ocean intelligence to enable solutions for science, society, industry.

Infrastructure

Data

Ocean  
Intelligence

Action &  
Change

Funded by Canada Foundation for Innovation, Canadian Government, Province of British Columbia, University of Victoria

Thankful for the support of the many indigenous peoples whose historical relationships with the land and sea continue to this day.

Acknowledge the contribution of our staff of ~150.



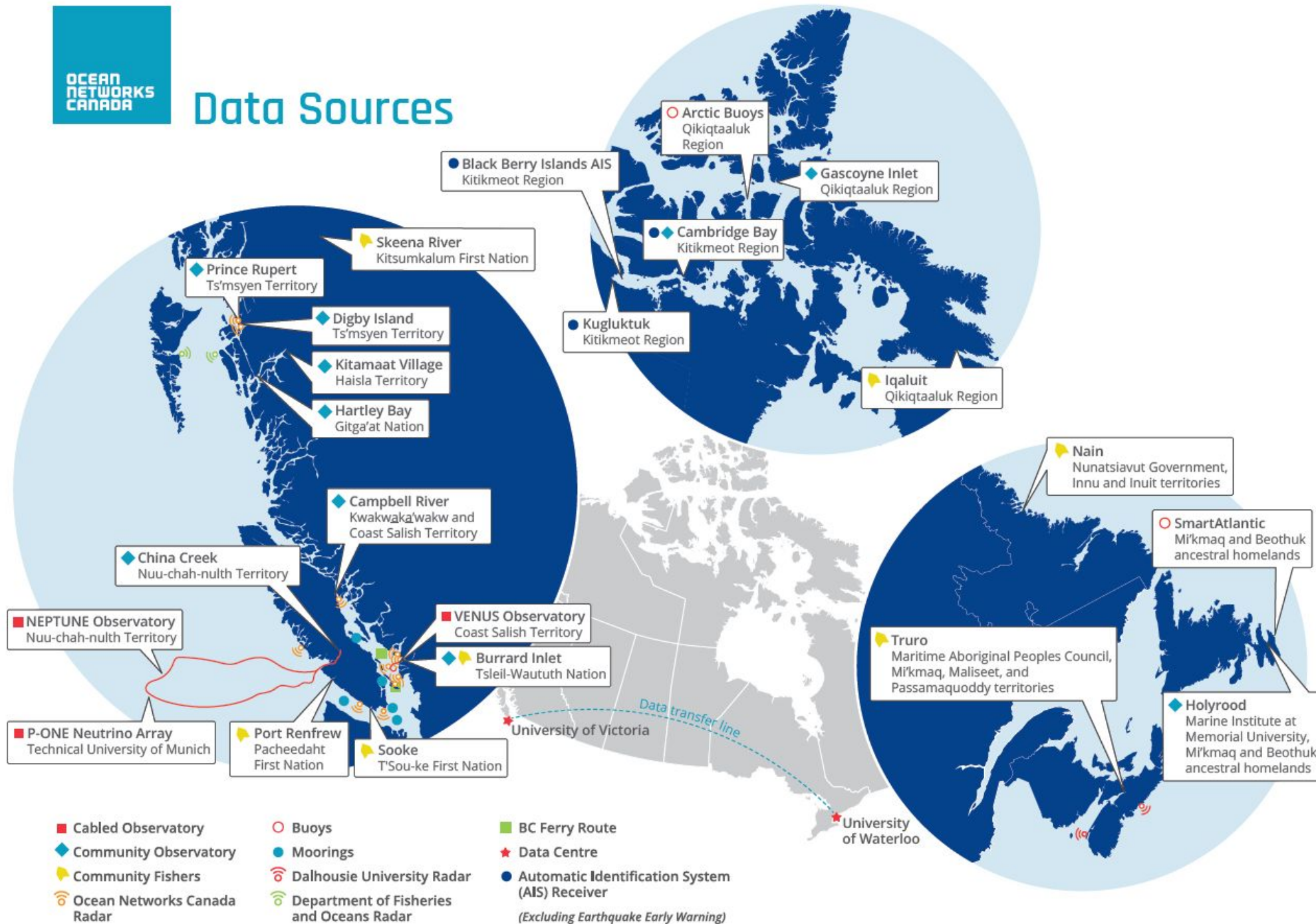
## OCEANS 3.0 DATA MANAGEMENT PORTAL

- Ocean Health Monitoring
- Scientific Discovery
- Tsunami Preparedness
- Climate Change Mitigation
- Blue Economy
- Neutrino Detection
- Arctic Observing
- Maritime Safety
- Ocean Health Monitoring
- Forensics
- Marine Mammal Avoidance
- Ocean Soundscapes
- Underwater Imagery
- Community-Based Monitoring
- Tectonic Plates Monitoring
- Earthquake Early Warning
- Inform Incident Response
- Ocean Sciences Education

## DATA SOURCES

- Major Observatory
- Coastal Community Observatory
- Coastal Observatory
- Geo-Seismic Sensor (ONC)
- Geo-Seismic Sensor (Natural Resources Canada & ONC)
- Neutrino Array
- Community Fishers Mobile Assets
- Subsea Fibre Optic Cable
- Mooring/Buoy
- Data Center
- Mobile Asset
- AIS Receiver
- RADAR (Fisheries and Oceans Canada)
- RADAR (ONC)
- RADAR (Dalhousie University)

# Data Sources



# EARTHQUAKE EARLY WARNING STATIONS



- Node
- Shore Station
- Ocean Networks Canada (ONC) Geo-seismic Sensors
- Natural Resources Canada + ONC Geo-seismic Sensors
- Fibre-optic Cable
- Fault Line
- Subduction Zone
- Spreading Centre

Bathymetry (m)



50 km

AN INITIATIVE OF University of Victoria



**Data Sources:** Plate margins estimated from fig. 2 in Hyndman, 1995, Can. J. Earth Sci.; Digital Elevation Model derived from Smith and Sandwell Global Altimetry, Natural Resources Canada topography, Canadian Hydrographic Service (CHS) bathymetry.

This product has been produced by the University of Victoria based on CHS data, pursuant to CHS Direct User License No. 2019-1007-1260-ON. The incorporation of data sourced from CHS in this product shall not be construed as constituting an endorsement by CHS of this product. This Product does not meet the requirements of the Charts and Nautical Publications Regulations, 1995 under the Canada Shipping Act, 2001. Official charts and publications, corrected and up-to-date, must be used to meet the requirements of those regulations.

Last Updated: 16 January 2025

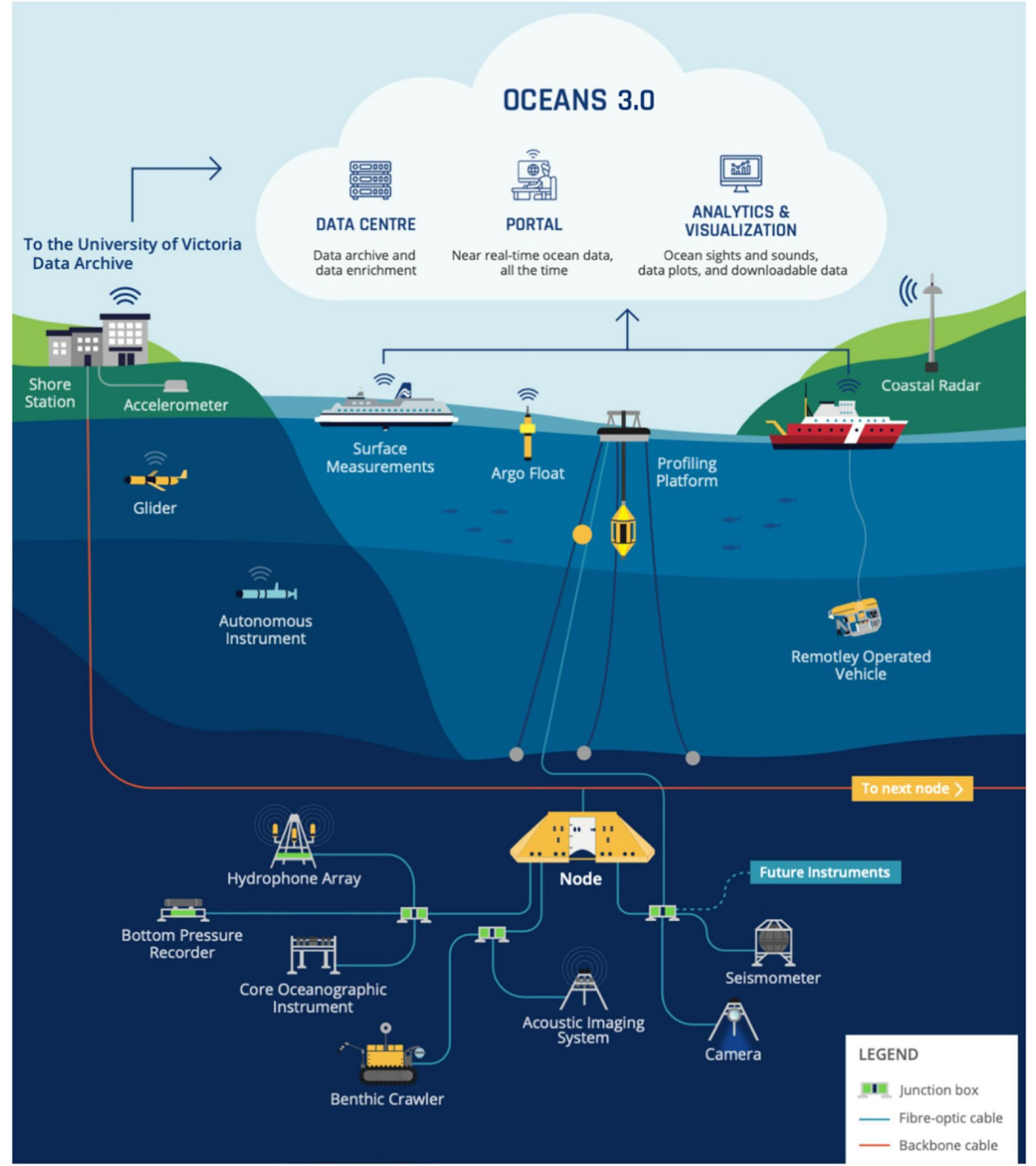
# Oceans 3.0 runs the *Network* in Ocean Networks Canada

Began 20 years ago powering world's first large-scale internet-connected ocean observatory.

Originally called DMAS: Data Management and Archival System, but it does more than that now.

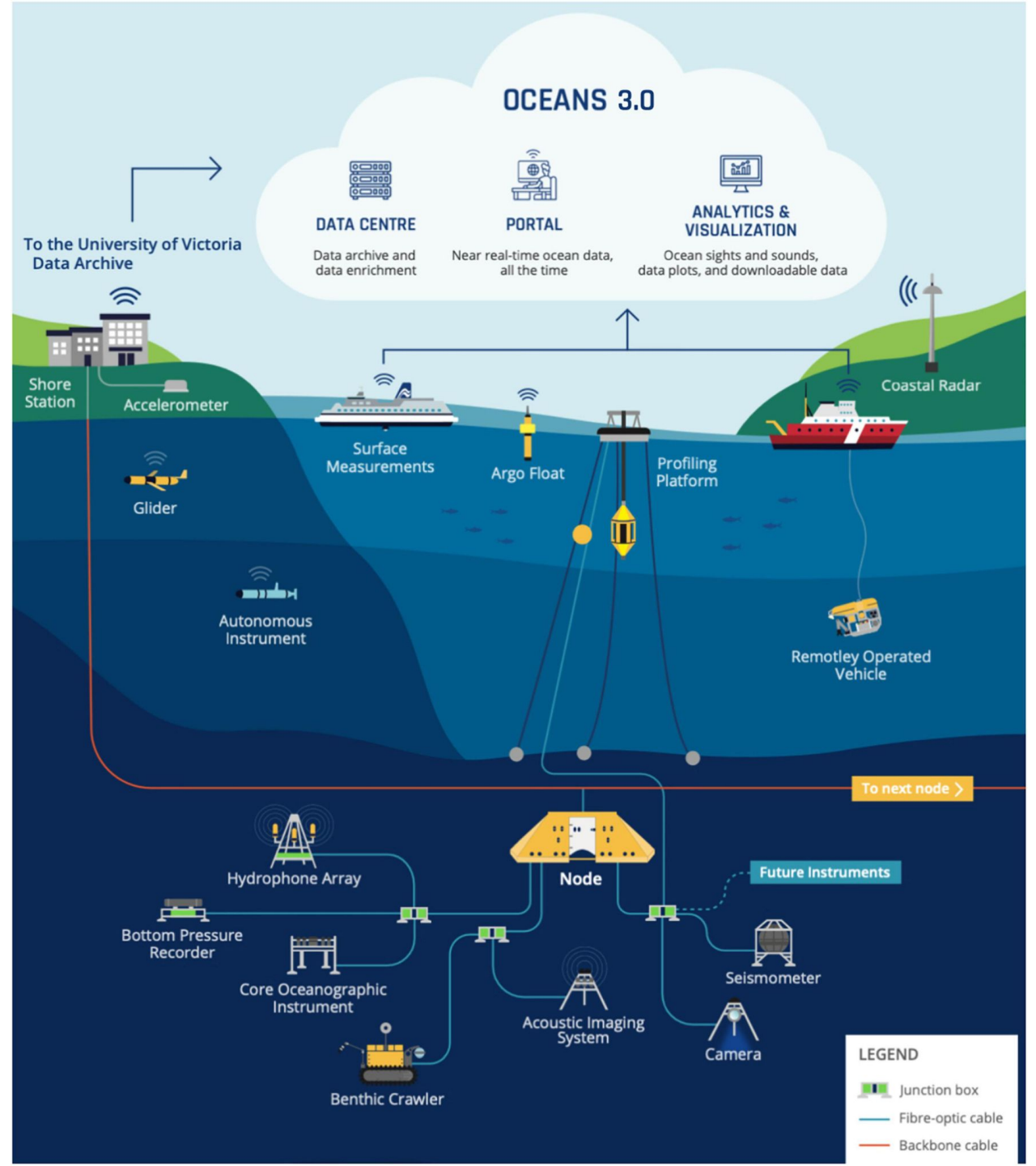
Enables continuous, near real-time ocean observation, data collection, and communications.

Data collected from cabled, autonomous, and mobile instruments in deep-sea, coastal, and land-based locations.



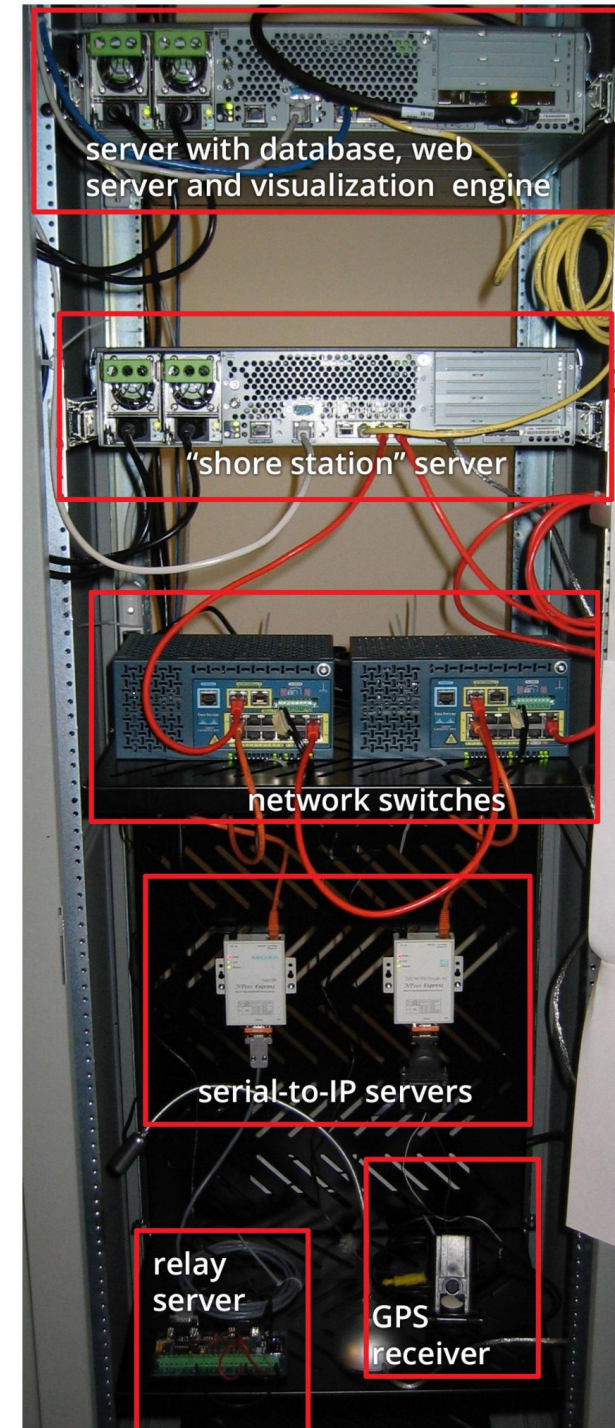
# Oceans 3.0 in Numbers

- 12500+** Active sensors producing data;
- 977** Instruments producing data daily;
- 284** Unique file-based data products\*;
- 9921** Average pre-generated plots produced daily;
- 9654** Average daily data requests;
- 300** GB Average volume of uncompressed data archived per day;
- 1.74** PB Total uncompressed volume of archived data.

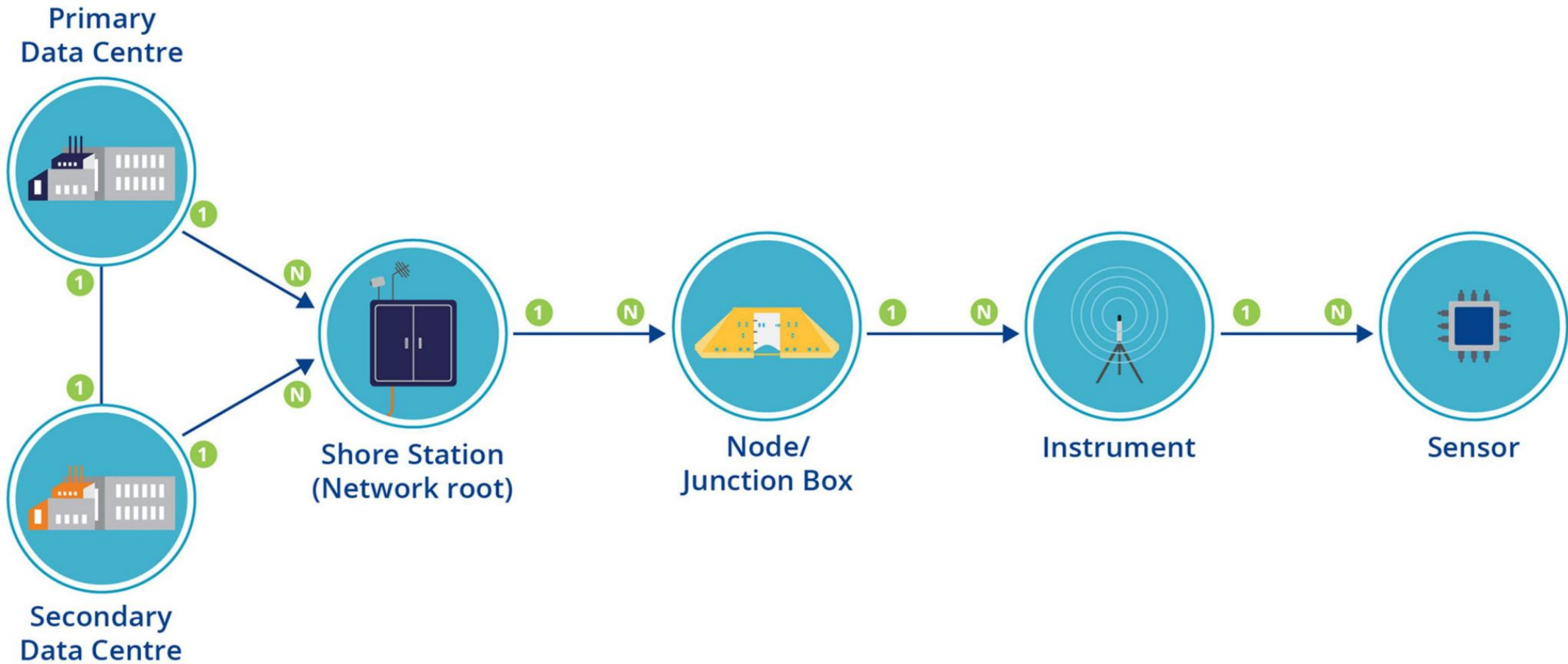


# Prototype DMAS Hardware

1. Server for running data repository (database, web server, visualization software); the “data centre”
2. Shore station server with drivers that implement communication protocols for each instrument (configure, control, parsing and pre-processing)
3. Network equipment for tree topology of infrastructure, including switches
4. Serial-to-IP servers for interfacing with instruments
5. Relay server to control instrument power

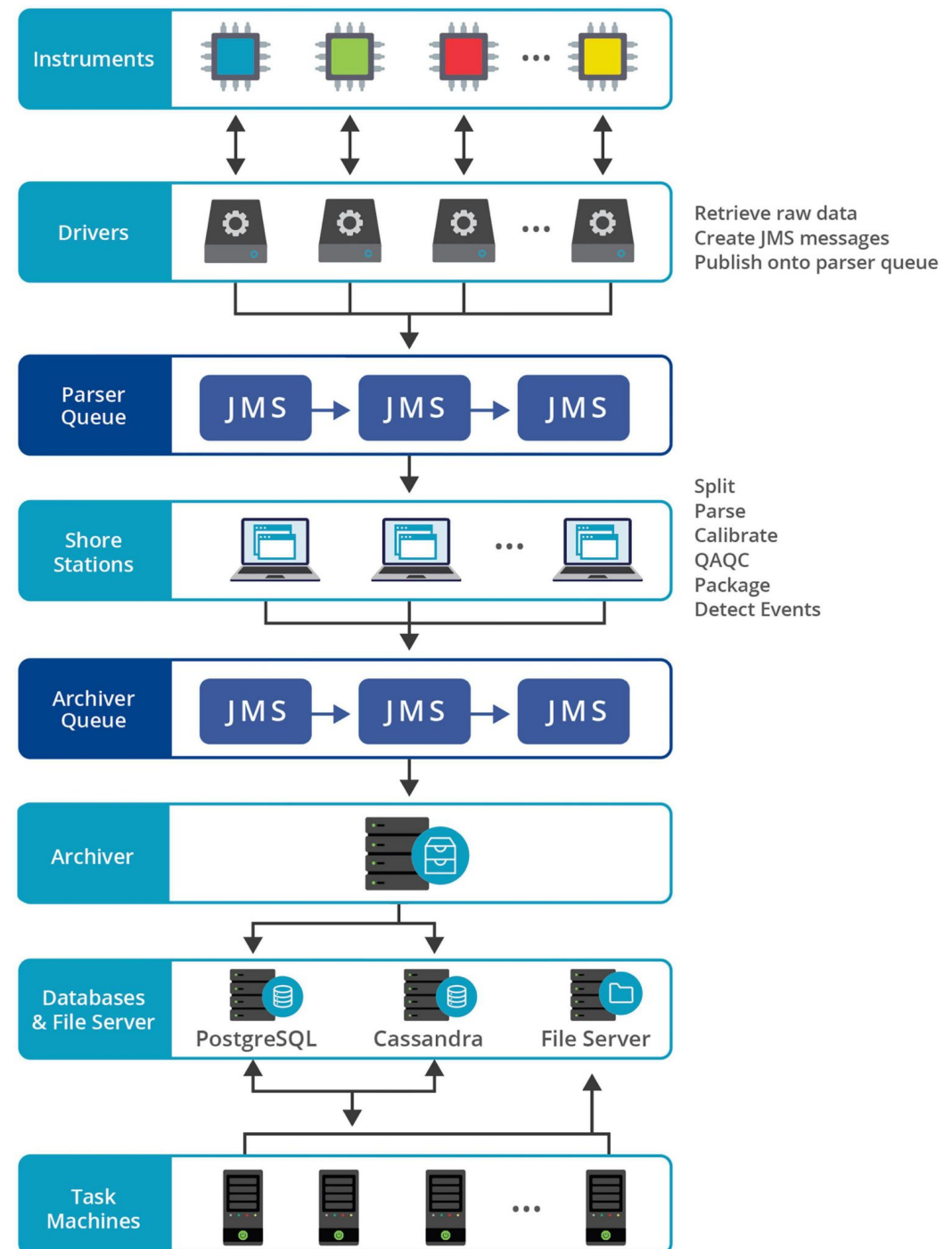


# Infrastructure Hierarchy from Data Center to Sensor

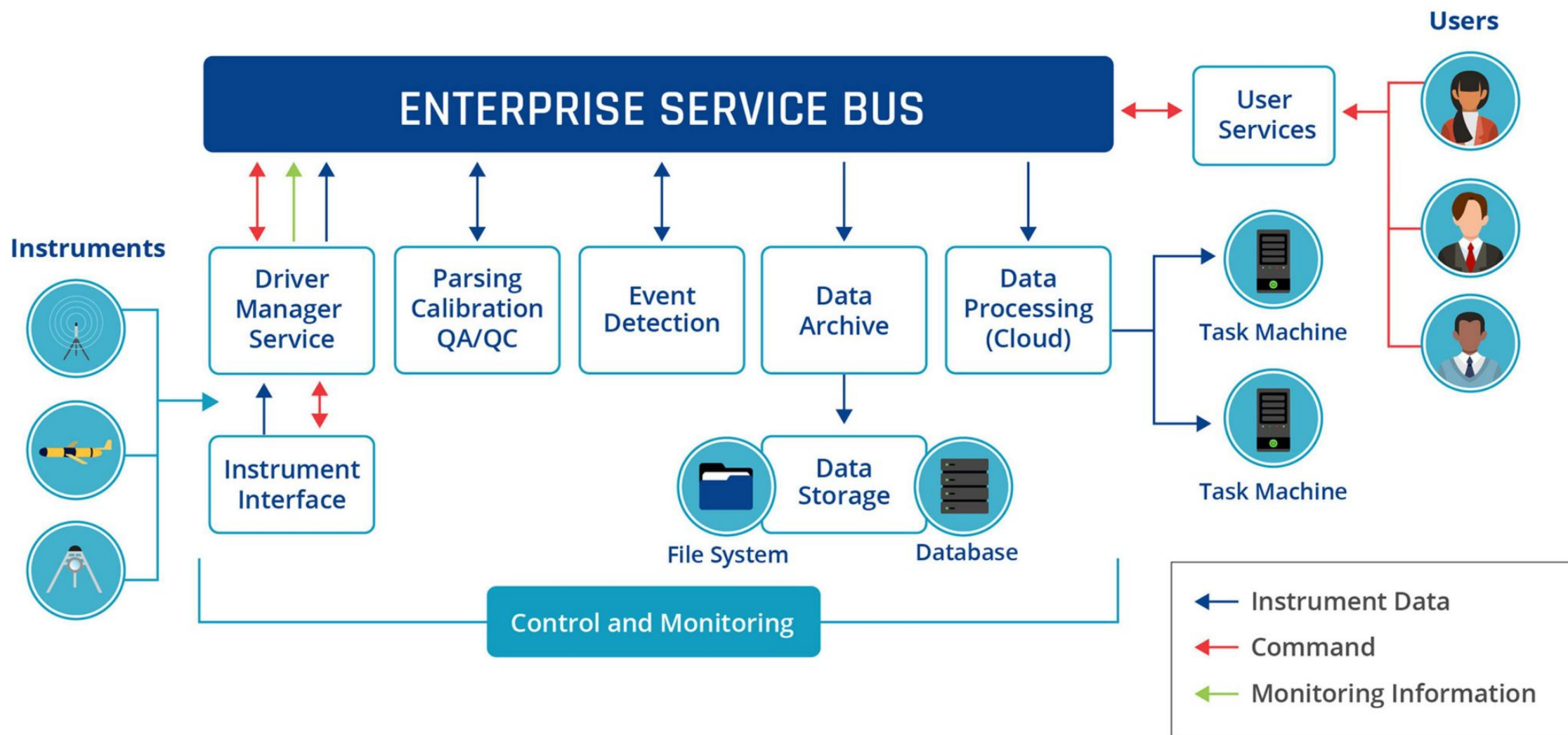


# Data Acquisition Process

1. Acquiring data readings
  2. Publishing onto parser queue
  3. Processing by shore station
  4. Publishing onto archiver queue
  5. Archival of raw and processed data
  6. Task machines for value-added processing and data products
  7. Available on the Oceans 3.0 data portal, 100% live!
- Latency ranges from milliseconds (driver acquisition) to minutes (file acquisition).



# System Architecture: How the Network works



# Technologies

Metadata database: PostgreSQL

Raw data holding tank: Cassandra

File archive: "AD" (NetAPP and Synology)

Value add data:

- Scalar data: Cassandra
- Complex data:
  - Generate on-the-fly
  - Pre-generate and store in the file archive
- Interoperability: ERDDAP
  - Scalar data: custom cassandra driver
  - Complex data: NetCDF store



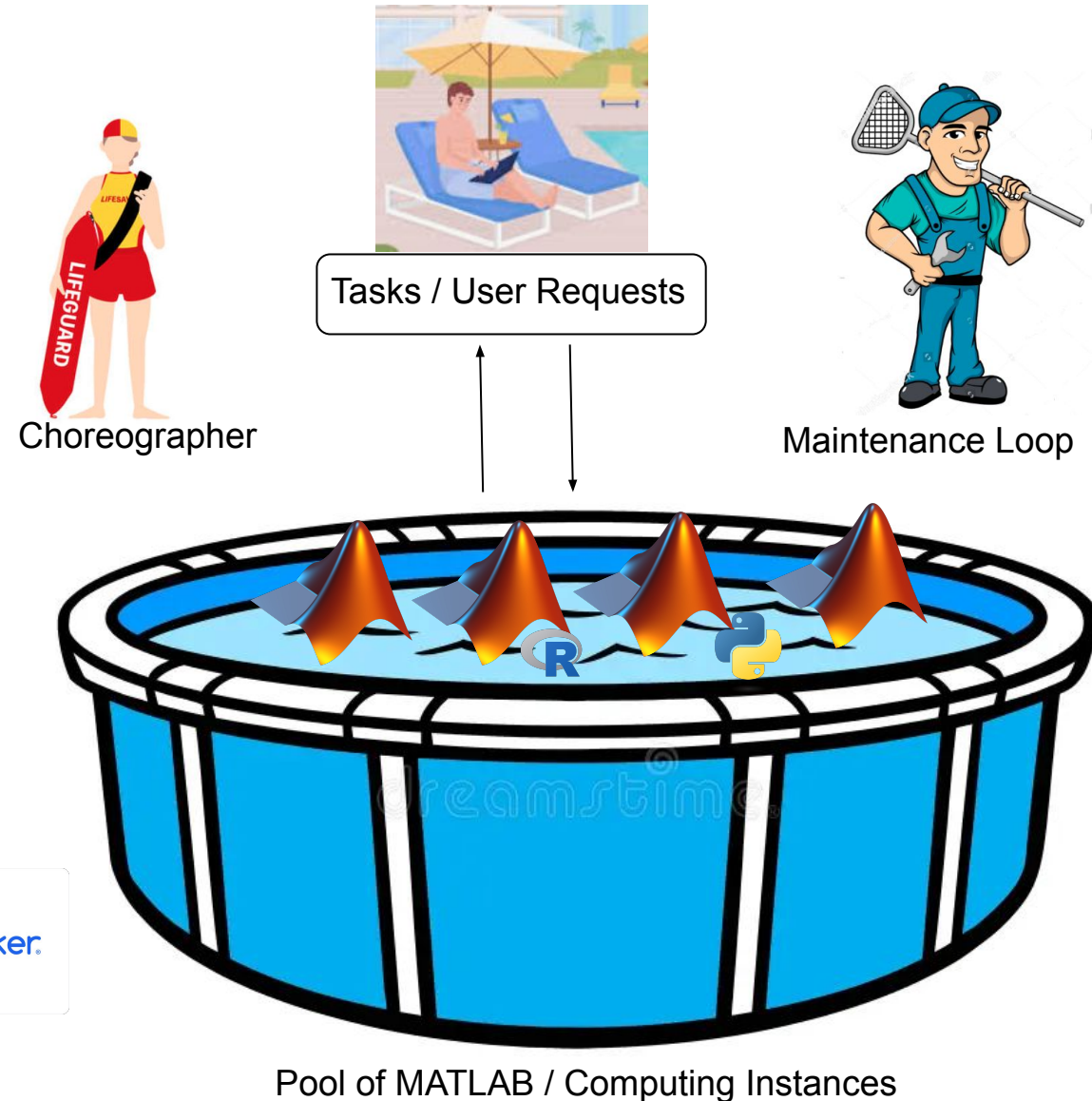
## File Formats and Data Products

---

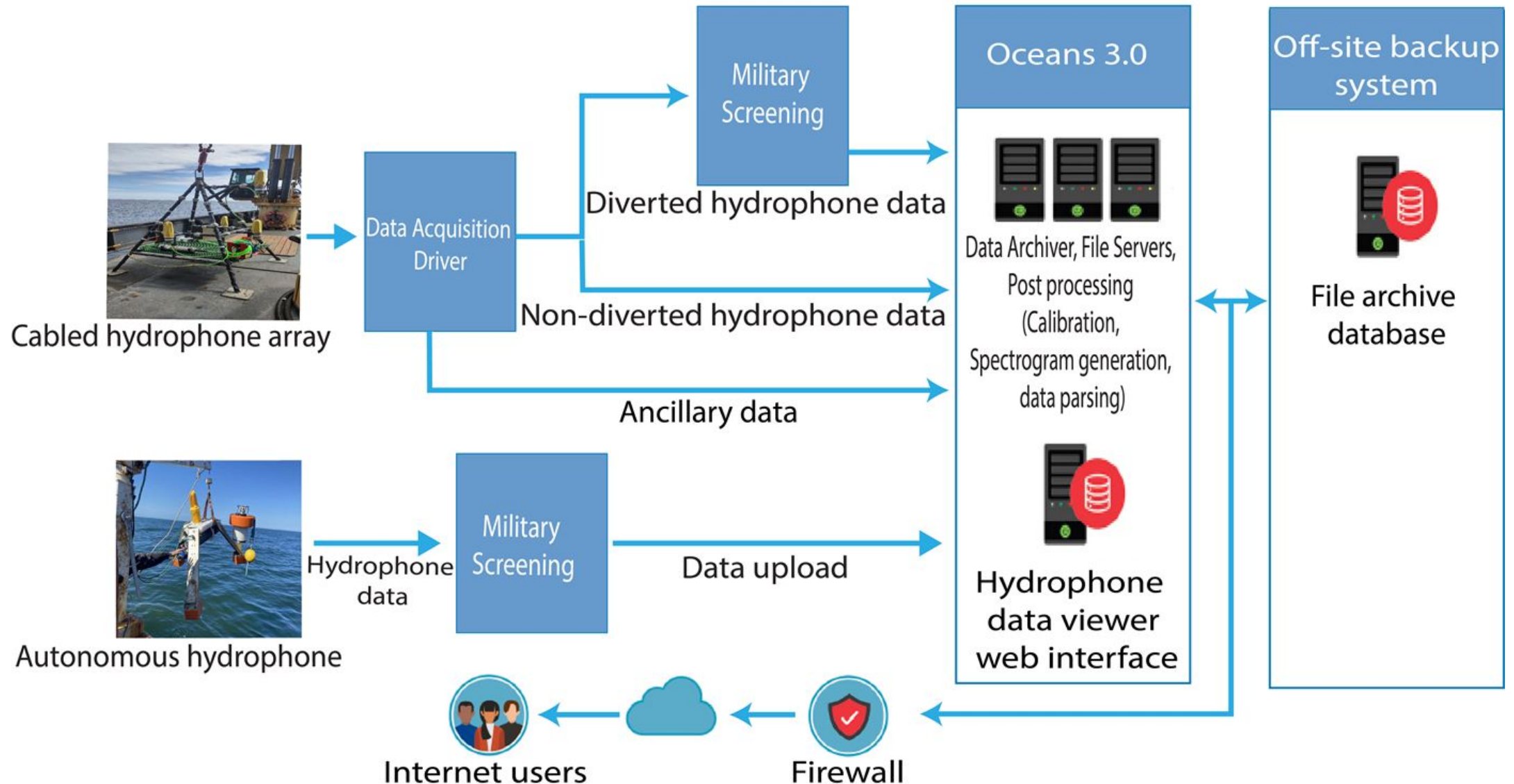
- Anything goes as long as it has appropriate metadata and documentation
- Support manufacturer's original formats
- Maintain a list of preferred formats: FLAC for audio, MP4/264 for video
- Raw data collected in a flexible raw log hex format
- Support compression
- Minimal requirements: raw format, manufacturer's original format, accessible data format and a visualization (plot). Over 300 types of instruments.
  
- > 400 different data product formats available
  - Examples: NetCDF, CSV, MAT, HDF5, FLAC Audio, MP4 Video
- Generated within Oceans 3.0 by Java, MATLAB or Python
- On-the-fly generation is easier to maintain, allows us to support option sets
- Support citations and persistent identifiers, allowing reproducibility
- Encourage P.I.'s to contribute code
- In-progress: citable code and complete provenance

# Challenges: generating data products on-the-fly: *MATLAB-as-a-service* Low Latency System

- Eliminates start-up latency and resource use. Instances can be re-used hundreds of times!
- On-demand latency can be as low as 1 second for a simple plot or small data file.
- Average data search request completion time and computation resource utilization reduced by >60%. Even greater gains for nightly processing tasks such as preview generation and automated testing.
- Fully integrated with task management features such as error handling, reporting, task scheduling and cancellation.
- Extensible to Docker images (in-progress).



# Challenges: Handling Sensitive Data (Hydrophones, Seismometers, etc)



# Challenges: Multi-point Synchronized Live Data and Annotations

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Ocean Networks Canada Dive Log

Oceans 3.0

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[Request Support](#)

NA154 - Ala 'Aumoana Kai Uli in Papahānaumokuākea Marine National Monument (PMNM) - T1002 - Akagi

Dive Video

03:59:00 / 25:13:06

2023-09-10 23:47:04

Annotation List

131 of 131

23:47 Gun Tub [ARC]  
gun tub likely 12.7 cm AA guns, port midships, barrels were blown of mount, barrels upside down

23:56 Deck [ARC]  
poss starboard flight deck outboard limit

00:05 Armament [ARC]  
UXO: 12.7cm

Annotation Entry

Drafts

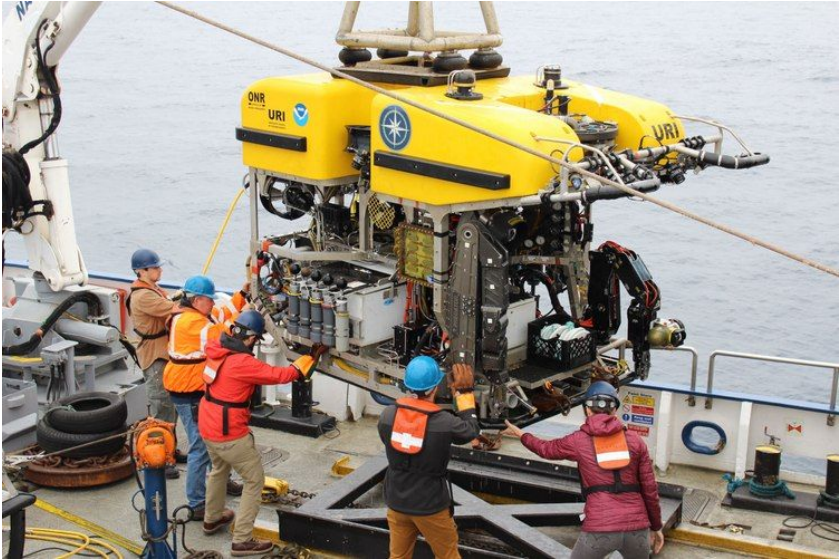
New Annotation

Device Data: Insite Pacific Mini Zeus HD Camera on At...

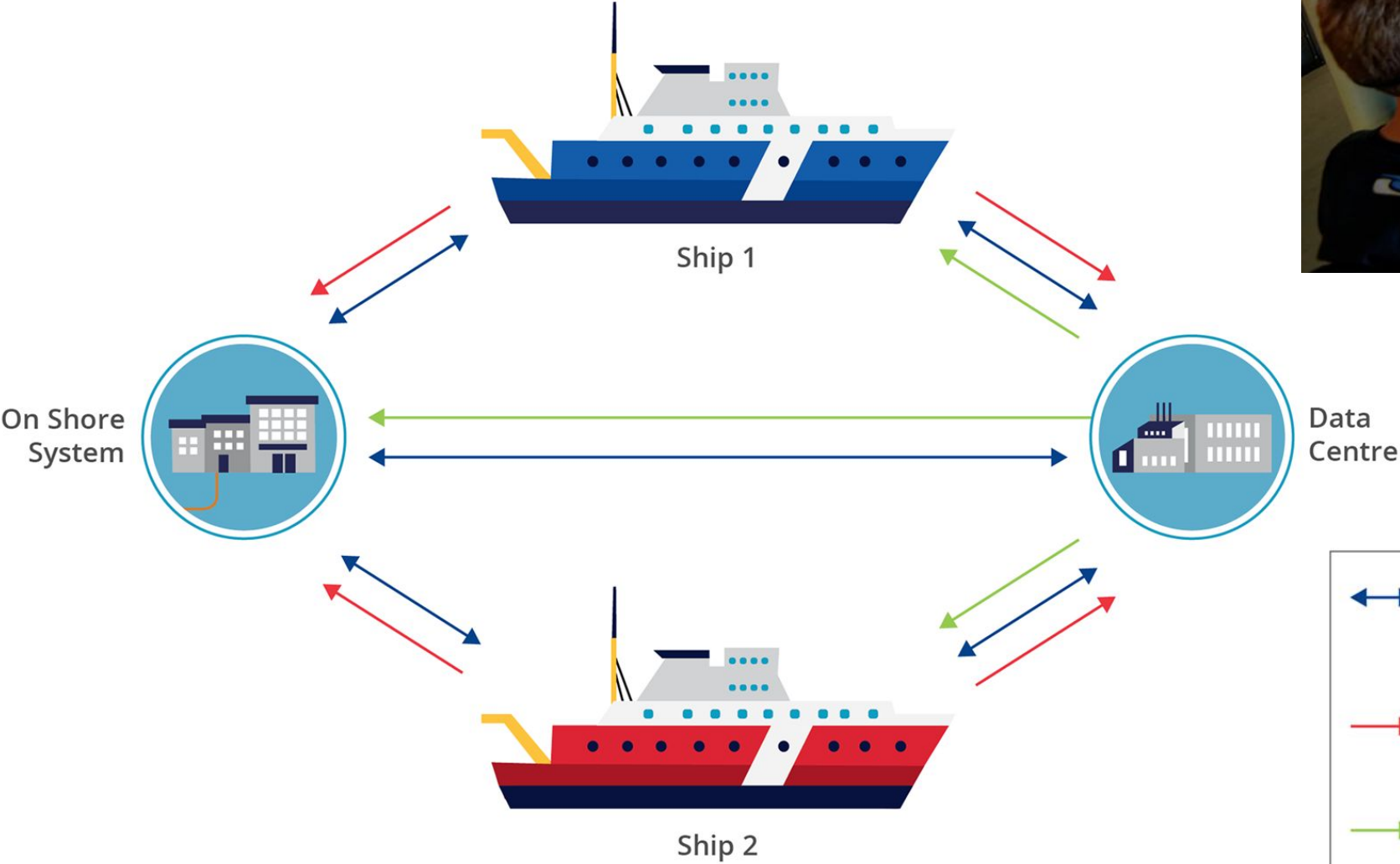
General

Date

CAPTURE TIME



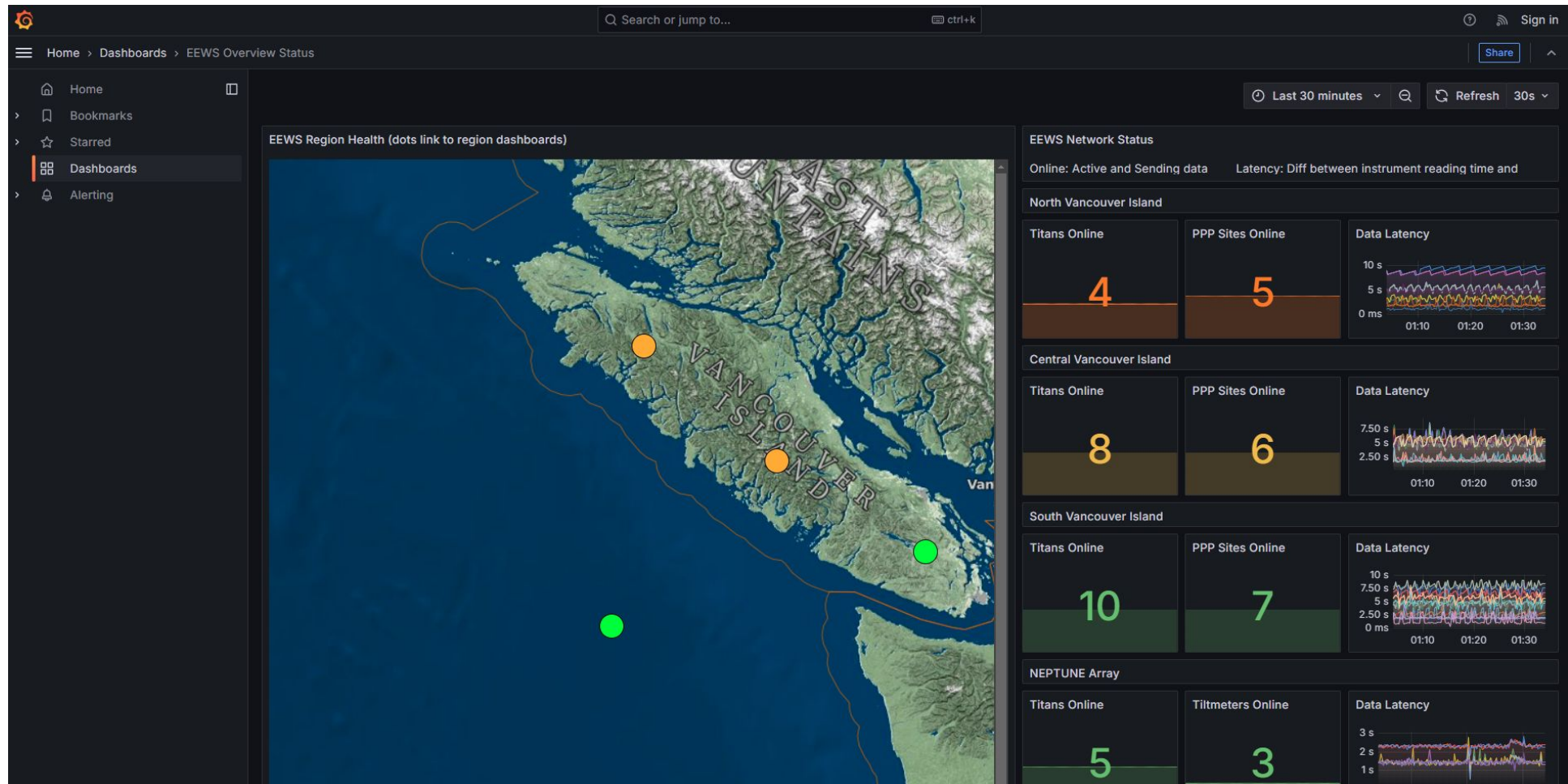
# Challenges: Multi-point Synchronized Live Annotations



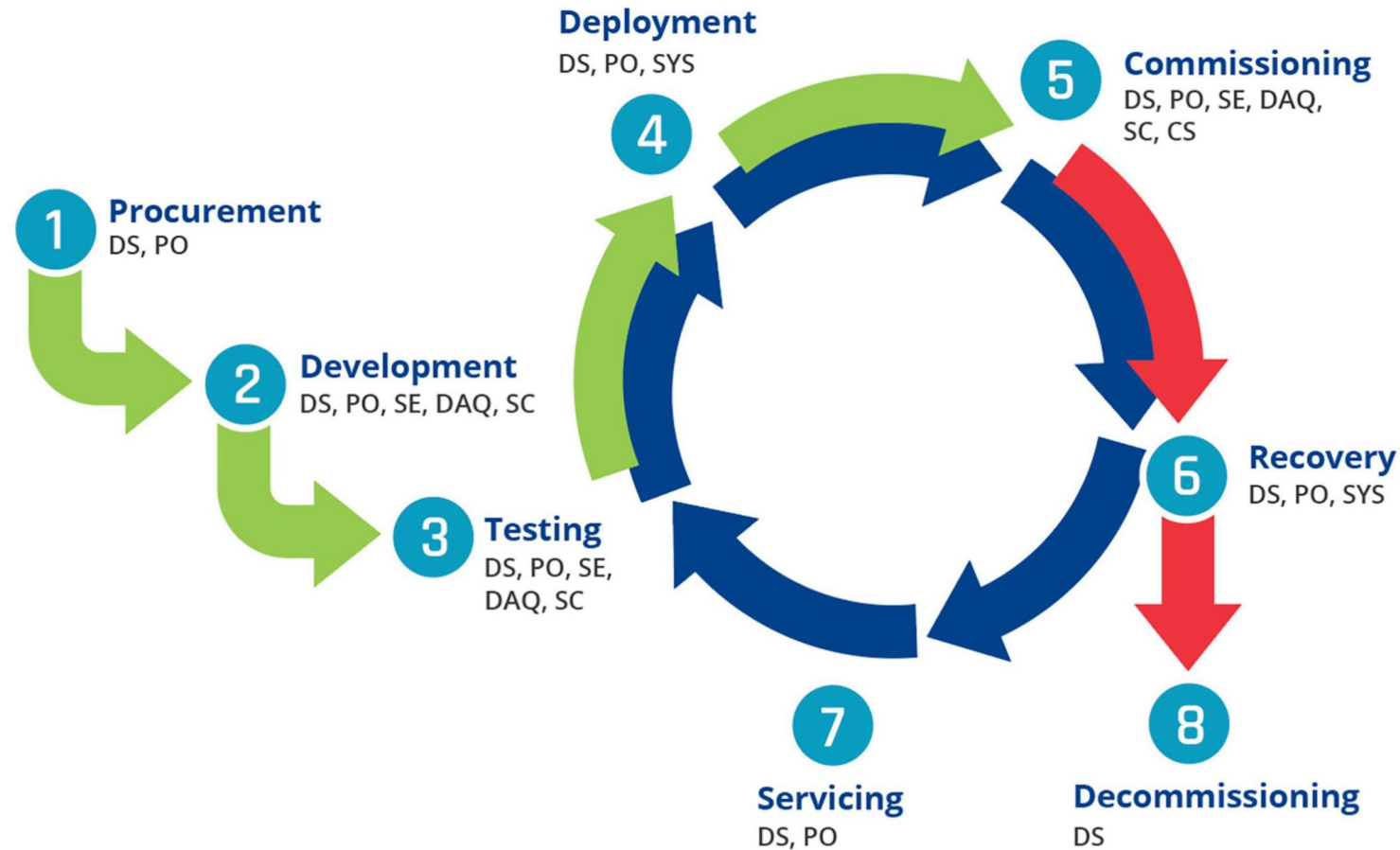
- ↔ Two-way flow of user information, dive & annotation data, and taxonomy and button set data
- Device and sensor data flowing from ship to shore system and data centre
- Expedition data flowing from data centre to ships and on-shore system

# Lessons Learned: Monitoring Tools

- 24/7 monitoring and alerting with on-call staff
- We use Grafana:



# Lessons learned: instrument life cycle + quality control/assurance



DS: Data Stewardship  
PO: Physical Operations  
SYS: Systems  
SE: Software Engineering

DAQ: Data Analytics & Quality  
SC: Science Team  
CS: Client Services

# Workflow Tool

Oceans 3.0 supports the full instrument lifecycle

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Oceans 3.0

Data Preview

Data Search

Plotting Utility

SeaTube

Digital Fishers

Endeavour Earthquakes

Cameras

More

Admin

Device Id: 64100

Device Name: AML-6 RT A60002

Nameplate

Port

Physical Characteristics

Device Action

Site

Procurement

Additional Attributes

Workflow

SeaScript

Parser Definition

Resource R

Antarctica 2024-01: Polar Iridium Device Installation

(Process Group)

Acquisition

Complete: 8/8

| Task                               | Area of Responsibility | Status   | Comment | JIRA          | Modified Date        | Modified By   |
|------------------------------------|------------------------|----------|---------|---------------|----------------------|---------------|
| Device - create                    | Data Stewardship       | Complete |         | NEPDATA-16517 | 09-Mar-2021 00:19:40 | Mitchell Wolf |
| Instrument Documentation - collect | Data Stewardship       | Complete |         | NEPDATA-16517 | 09-Mar-2021 00:19:40 | Mitchell Wolf |
| Instrument Documentation - publish | Data Stewardship       | Complete |         | NEPDATA-16517 | 09-Mar-2021 00:19:40 | Mitchell Wolf |
| Device Actions - update            | Data Stewardship       | Complete |         | NEPDATA-16517 | 09-Mar-2021 00:19:40 | Mitchell Wolf |
| Bench Test - complete              | Marine Operations      | Complete |         | EN-4495       | 18-Jul-2023 20:25:58 | Grant Francis |
| Depth Rating - assign              | Data Stewardship       | Complete |         | NEPDATA-16517 | 09-Mar-2021 00:19:40 | Mitchell Wolf |
| Device Owner - update              | Data Stewardship       | Complete |         | NEPDATA-16517 | 09-Mar-2021 00:19:40 | Mitchell Wolf |
| Instrument Point People - assign   | Data Stewardship       | Complete |         | NEPDATA-16517 | 09-Mar-2021 00:19:40 | Mitchell Wolf |

Edit

Polar Iridium Device Development

Complete: 10/10

| Task    | Area of Responsibility | Status   | Comment | JIRA    | Modified Date | Modified By   |
|---------|------------------------|----------|---------|---------|---------------|---------------|
| Sensors | Data Stewardship       | Complete |         | NEPDATA | 10-Aug-2023   | Mitchell Wolf |

OCEAN NETWORKS CANADA World Leader

# QAQC

QAQC tests and flags fully integrated

Ocean Networks Canada

Oceans 3.0

Home

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Data Search

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SeaTube

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Endeavour Earthquakes

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QAQC Auto Tests Finder

Logged in as Ben Biffard | Profile | Help | Logout

Search by Device and Sensor IDs

Device Selection

AML-6 RT A60002 (64100)

Sensor ID(s)

FIND

CLEAR

Active Only ☒

Search...

+ ADD QAQC AUTOTEST

| QAQC Id | Effective Date From (UTC) | Effective Date To (UTC) | Description                                                     | Device Id             | Sens |
|---------|---------------------------|-------------------------|-----------------------------------------------------------------|-----------------------|------|
| 5334    | 2023-08-17 00:00:00       |                         | <a href="#">AML6RTA60002 Instrument Temperature Range Test</a>  | <a href="#">64100</a> | Temp |
| 5335    | 2023-08-17 00:00:00       |                         | <a href="#">AML6RTA60002 Instrument Pressure Range Test</a>     | <a href="#">64100</a> | Pres |
| 5336    | 2023-08-17 00:00:00       |                         | <a href="#">AML6RTA60002 Instrument Conductivity Range Test</a> | <a href="#">64100</a> | Conc |

1-3 of 3

# Data Distribution

- Foundational infrastructure needs to be designed and scalable to facilitate all phases of data acquisition, storage and distribution.
- Distribution includes video players, scrolling image viewers, data preview, search, plot and download.  
Best of all: **API** →
- Putting it all together is a game changer, enabling solutions such as earthquake early warning, tsunami warning, observations of climate change, biodiversity, etc.



**Ocean Networks Canada** OpenAPI  
Oceans 3.0

Logged in as **Dwight Owens** | [Profile](#) | [Help](#)

[Home](#) | [Data Preview](#) | [Data Search](#) | [Plotting Utility](#) | [SeaTube](#) | [Digital Fishers](#) | [Cameras](#) | [More](#) | [Admin](#) | [System Status](#) | [Request](#)

**Oceans 3.0 Public API**

▼ ▲

OPERATIONS

**Discover Locations**

▼

[GET](#) Returns locations

[GET](#) Returns a location tree

**Discover Device Categories**

▼

[GET](#) Returns a list of device categories

**Discover Deployments**

▼

[GET](#) Returns a list of device deployments

**Discover Properties**

▼

[GET](#) Returns a list of properties

**Discover Devices**

▼

[GET](#) Returns a list of devices

**Discover Data Products**

▼

[GET](#) Returns a list of data products

**Scalar Data**

▼

[GET](#) Returns data from a specific location

## Oceans 3.0 Public API 1.0.0

For support and help email: [info@oceannetworks.ca](mailto:info@oceannetworks.ca)

The Oceans 3.0 API allows users to programmatically access Ocean Networks Canada vast data archive via user-defined code. The API is backward compatible and provides a number of RESTful webservice services following the OpenAPI specification. The services in the API are split into two groups:

- Discovery Services to find the data
- Delivery Services to retrieve data

### Before you get started

Ocean Network Canada's RESTful web services return JSON formatted data. We recommend installing a JSON formatter/interpreter extension or using an online JSON formatter for example <https://jsonformatter.org/> to make the api responses more human readable.

### Additional Resources

- [https://en.wikipedia.org/wiki/OpenAPI\\_Specification](https://en.wikipedia.org/wiki/OpenAPI_Specification)
- [https://en.wikipedia.org/wiki/Representational\\_state\\_transfer](https://en.wikipedia.org/wiki/Representational_state_transfer)
- <https://wiki.oceannetworks.ca/display/O2A>

## For More Information

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### Frontiers in Marine Science publications:

- Canada's Internet-Connected Ocean

<https://www.frontiersin.org/articles/10.3389/fmars.2021.805134/full>

- The Oceans 2.0/3.0 Data Management and Archival System

<https://www.frontiersin.org/articles/10.3389/fmars.2022.806452/full>

<https://www.oceannetworks.ca/>

<https://data.oceannetworks.ca/>

[bbiffard@oceannetworks.ca](mailto:bbiffard@oceannetworks.ca)

The logo for Ocean Networks Canada, featuring the text "OCEAN NETWORKS CANADA" in white, uppercase letters on a solid teal square background.

OCEAN  
NETWORKS  
CANADA

Thank you  
Questions?