UAV real time data acquisition, processing and visualization system:

current challenges and future developments

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Ocean Data Dojo Workshop

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MARITIME ROBOTICS

Maritime Robotics

- Established in 2005
- Located in Trondheim (HQ), Oslo and Eggemoen, Norway
- Main markets are geospatial mapping, environmental monitoring, transportation and defence/security

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UNMANNED SYSTEMS

COST EFFICIENT AND RISK-REDUCING
MARITIME DATA ACQUISITION

The Otter

easily deployable system for seabed mapping and monitoring of sheltered waters.

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The Mariner

multi-purpose unmanned vehicle for offshore and coastal applications.

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The Falk

multi-purpose unmanned aircraft system

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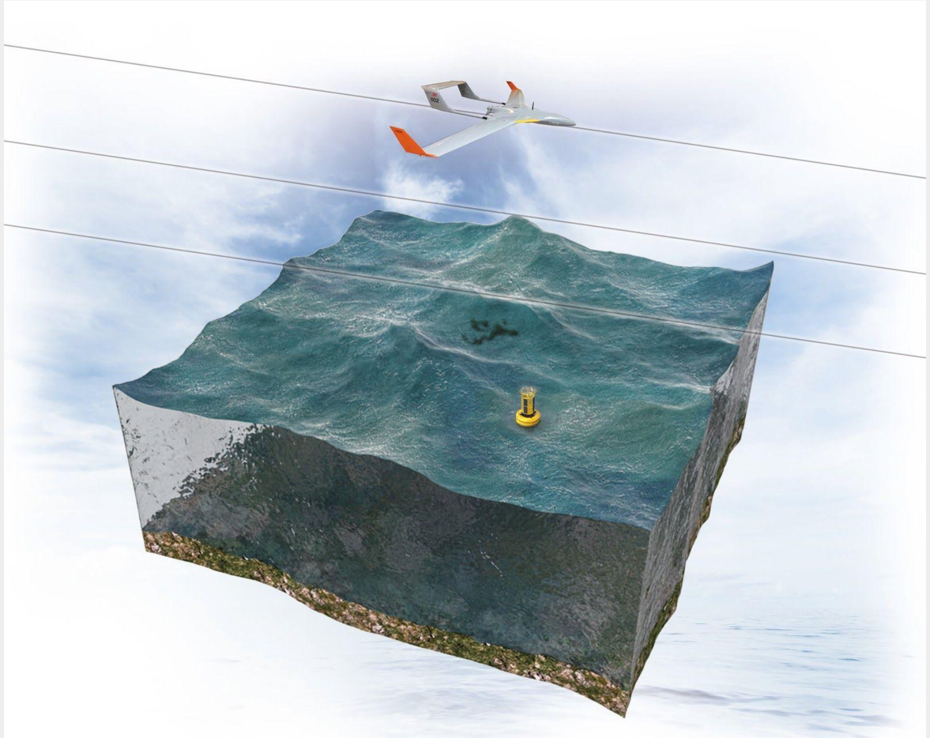
Why Unmanned Aerial Vehicles?

- **Monitoring the environment** by scanning huge maritime areas
    - Provide navigation support to operators
        - detecting objects/anomalies that might obstruct the navigability

- Using Unmanned Aerial Vehicles as a part of **Search and Rescue** operations:
    - EO + Thermal cameras with computer vision-based detection systems
    - monitor wide swaths of sea
    - during challenging weather conditions
    - without putting the lives of crew members at risk.

OceanEye NextGen - optimise route visibility



Route visibility can be improved by flying a UAVs way ahead the vessel to

Detect ⇨ Classify ⇨ Georeference ⇨ Report

objects/anomalies that might obstruct the navigability and/or the deployment of equipment at sea

Provide a common operational picture and situational awareness to relevant stakeholders in critical operations based on automatic analysis of data from unmanned systems.

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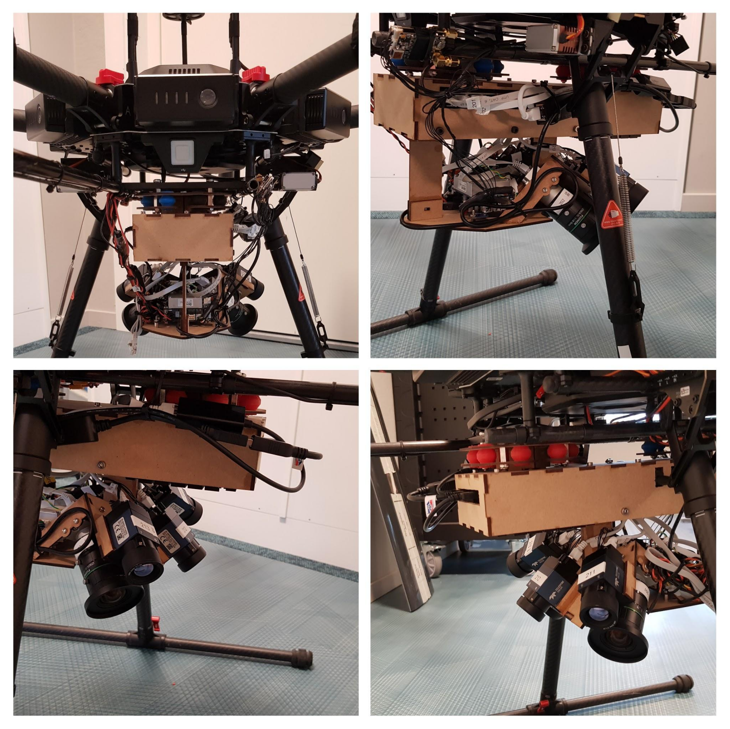
OceanEye NextGen - Payload camera system for sea surface objects detection

Challenges:

- choice of cameras:
    - coverage with minimal occlusions
    - camera mounting/positioning
    - resolution -> size of objects that can be detected
    - drastic changes in image quality
- camera interfaces:
    - USB3 interference
    - effect of drone vibrations on USB connectors
    - constraints on CPU/GPU/carrier boards



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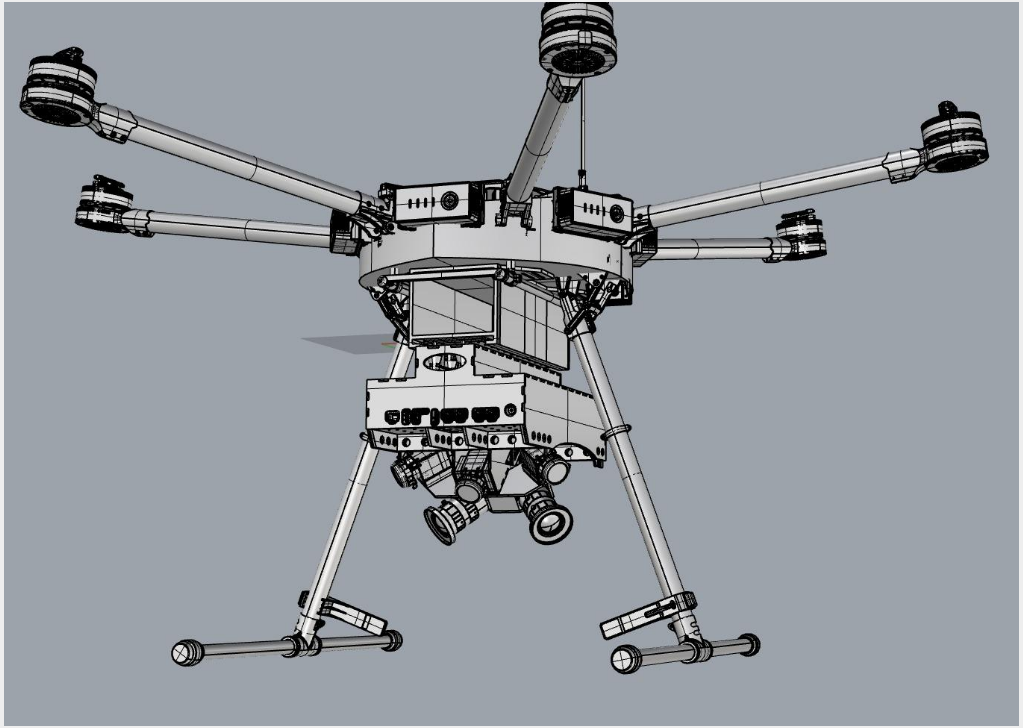
OceanEye NextGen - Payload camera system for sea surface objects detection

Challenges:

- if using multiple cameras
  - time synchronization
    - **between cameras**
    - **to navigation data for georeferencing**
  - Embedded computing boards
    - bandwidth (networking)
    - onboard computational power
    - CPU/GPU workload balance
  - carrier boards
    - number of interfaces required/available



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Arctic Challenges to UAV-based data acquisition system

Tough weather conditions and vast distance are challenges in the Arctic.

Definition of Arctic condition:

- temperatures below 0 degrees Celsius
- snow and/or sleet showers
- middle wind 12.5 m/s or higher
- rapid changes in wind and temperature (Polar lows)

The main goal a UAV producer should aim to for conducting surveys in the Arctic:

➔ improve the capacity to sustain extreme weather conditions and icing.

Arctic Challenges to UAV-based data acquisition system

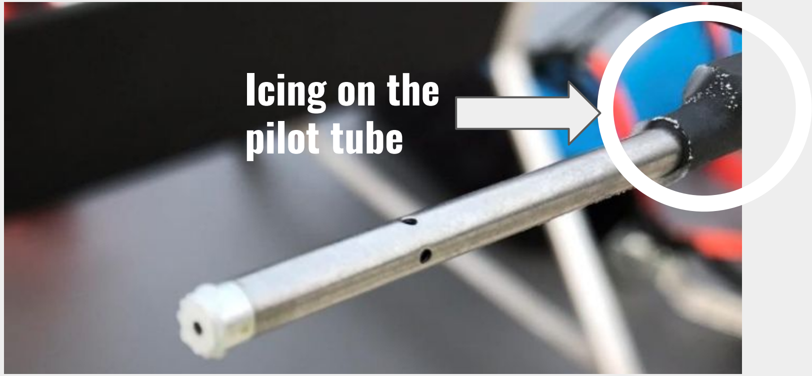
Arctic threats to take-off/landing:

- Loss of control due to rainwater in pitot tube
- Engine failure
  - due to battery malfunction in cold environments
  - carburetor icing
- Loss lift and not control on rotors/propellers
- Icing on wings.

Arctic threats to sensor/electronics:

- Sensor affected by snow/ice on landing
- Sensor electronics shutdown due to the low temperature
- Batteries require preheating to maintain high enough charge before launch.

Arctic Challenges to UAV-based data acquisition system



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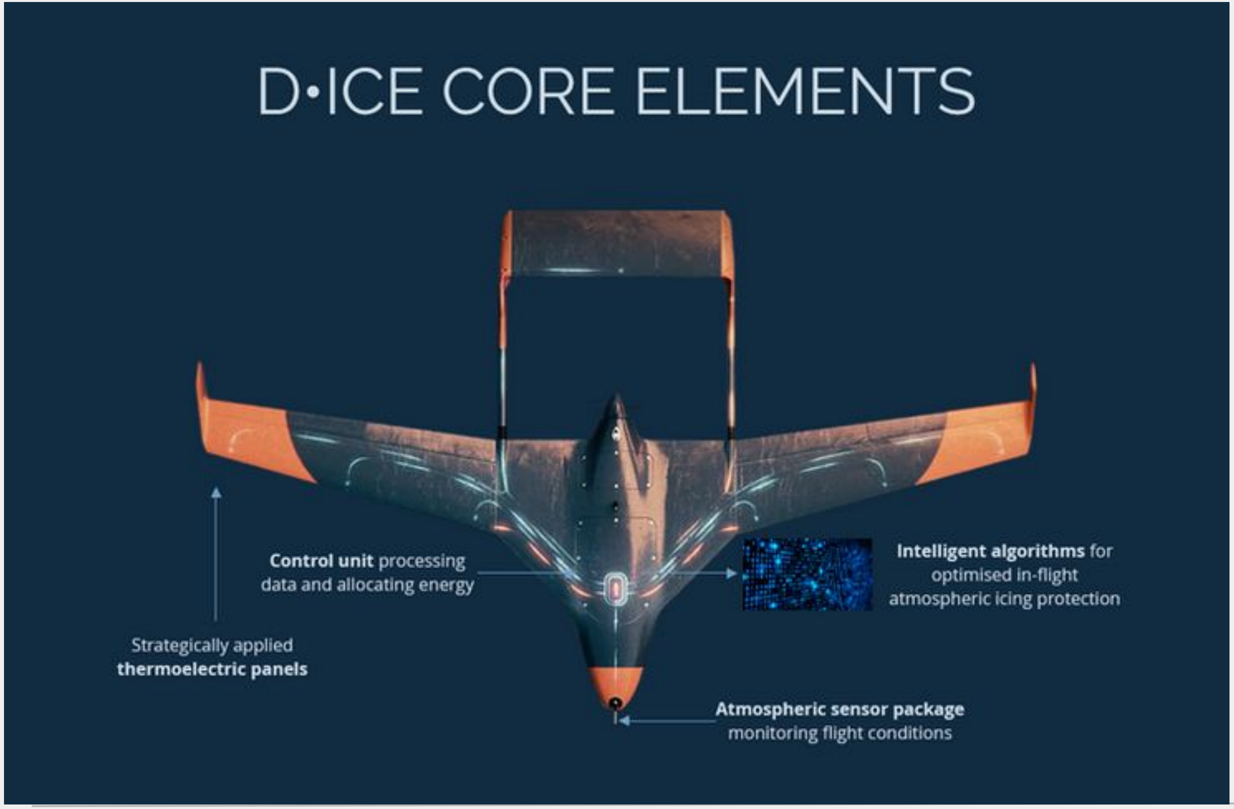
De-Ice system



- The wings are built by MR with Ubiq heating panels;
- The nose cone has a heated pilot tube and icing sensor;

- The sensor package and pilot tube is tested last year at Eggemoen
- The full system is going to be tested this fall.

Drone: Falk UAS, Maritime Robotics
D-ICE system: UBIQ Aerospace

Research project between Maritime Robotics, UBIQ Aerospace and NTNU, funded by Regionale Forskningsfond Trøndelag Forskningsfond Trøndelag

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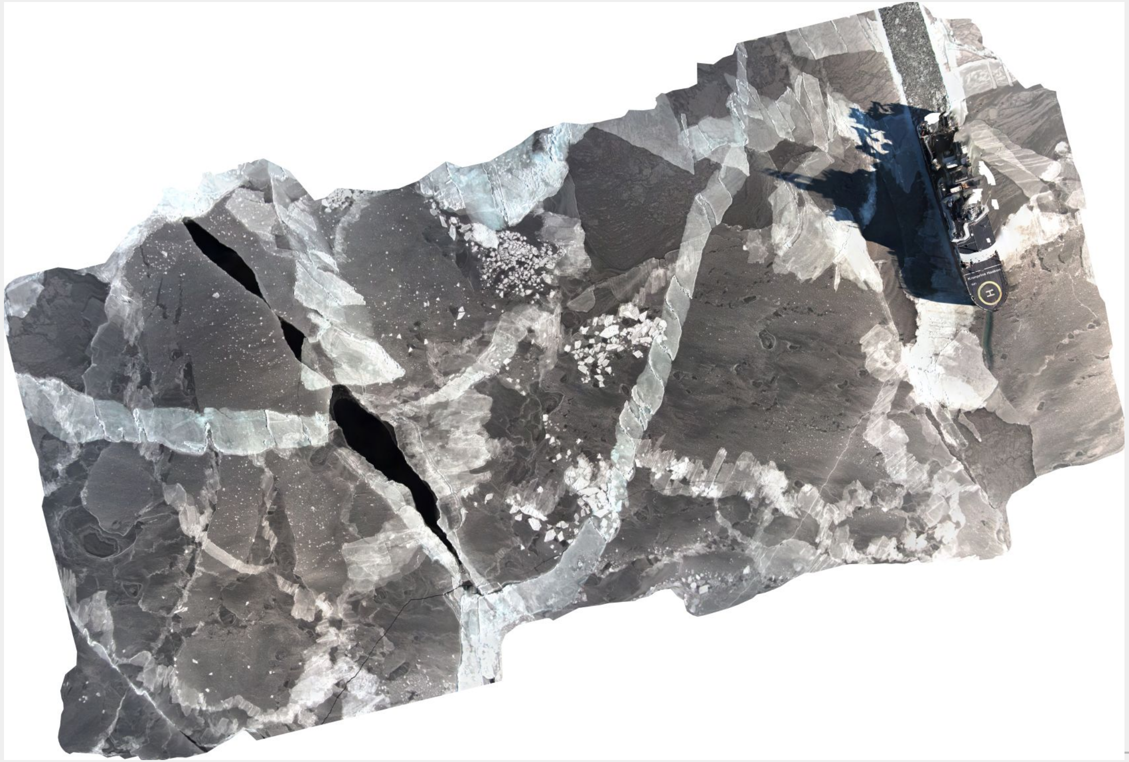
Digital Arctic Shipping - Ice monitoring using UAV



Develop new ice data products and visualisation services for navigation support towards Arctic shipping.

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DAS: Drone operations during the CIRFA 2022 cruise

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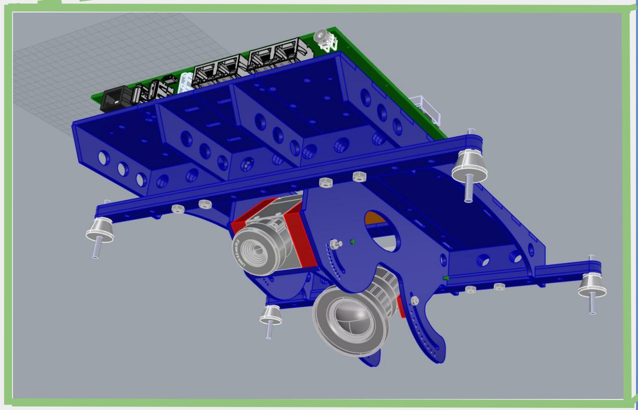
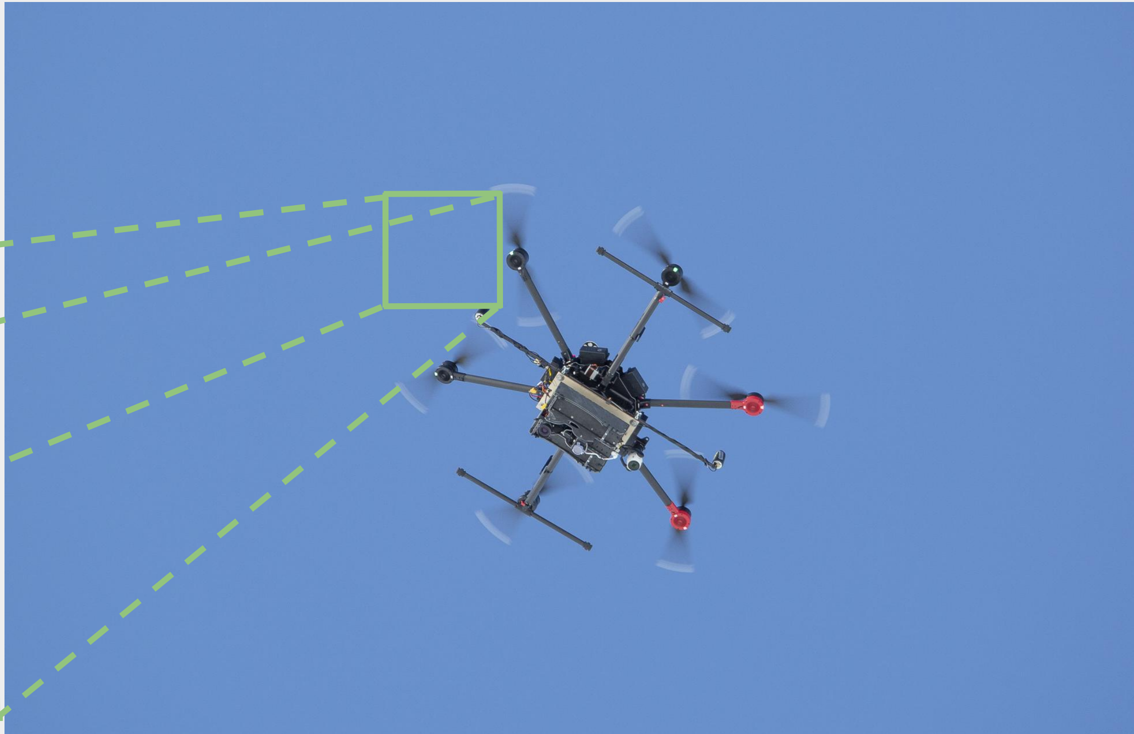
NERSC BERGEN ROBOTICS NORCE MARITIME ROBOTICS

DAS: Drone flights and data acquisition

- DJI Matrice 600
  - 1 x IR Teledyne Dalsa Calibir GXM
  - 1 x EO Teledyne Genie Nano C4040
  - NTNU/SentiSystem Sentiboard

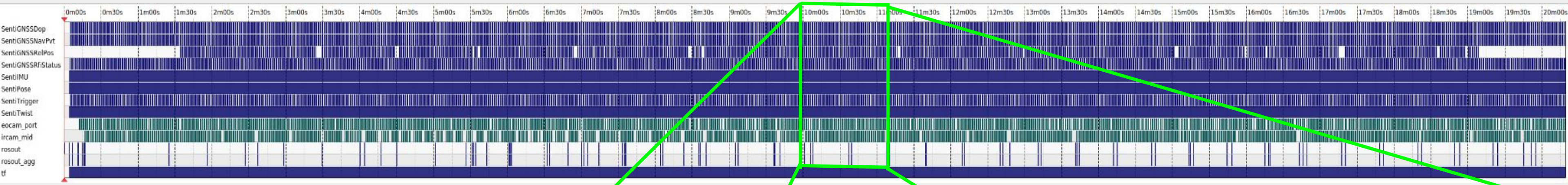
- Polar bears guards support
- Situational Awareness support
- Drones helping drones





DAS: Drone flights and data acquisition

Example of ROS bagfile collected during the CIRFA 2022 cruise (80 06.083’ N, -07 69.177 W)

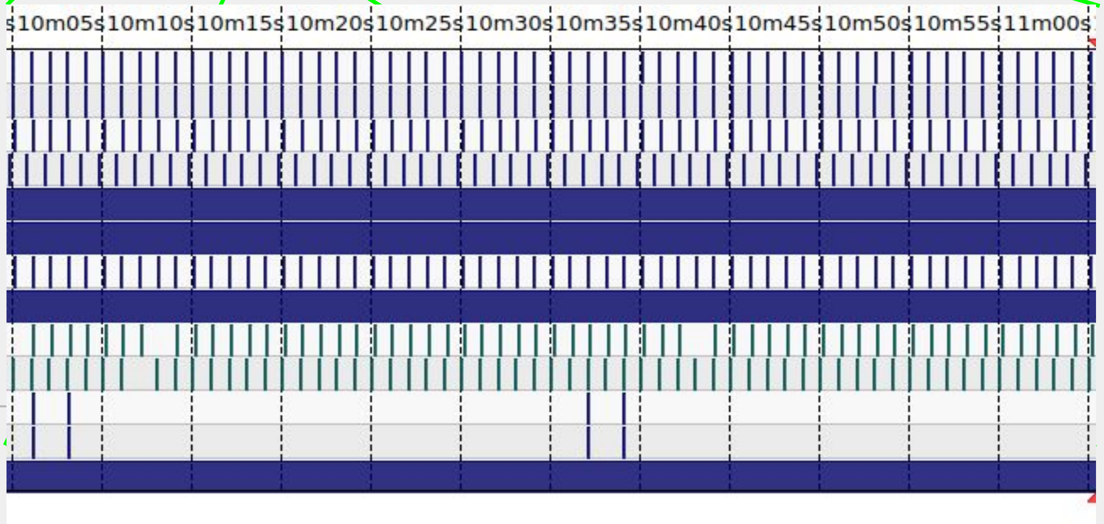


20minutes of recording -> 60GB of raw data
1 FPS x 2 camera

redundant frames
initial/final landing imagery
area of interest -> 1 minute

Optimise the data acquisition/storage strategy to reduce the amount of redundant images:

- start recording when the UAV is on RoI
- altitude threshold



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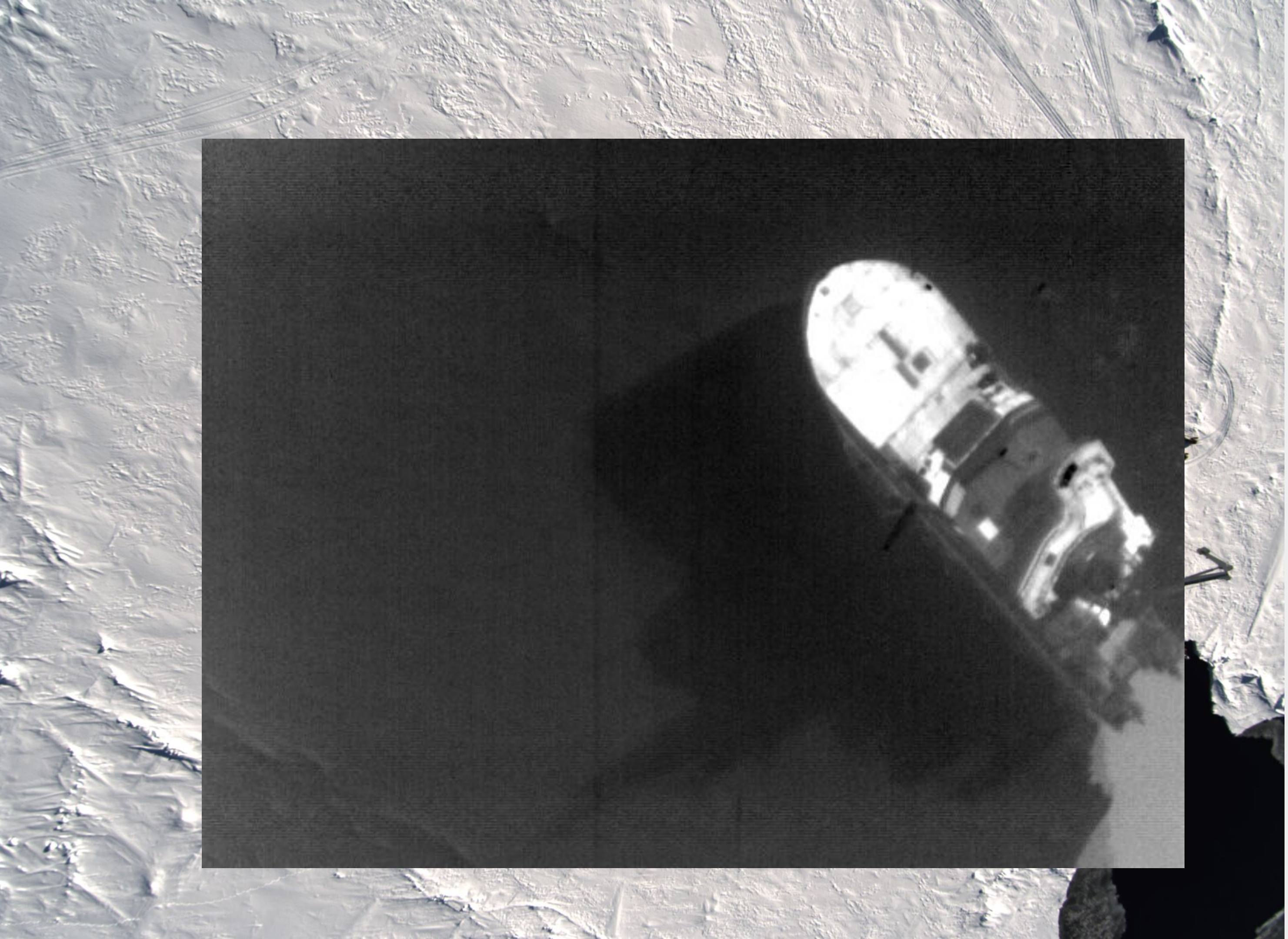

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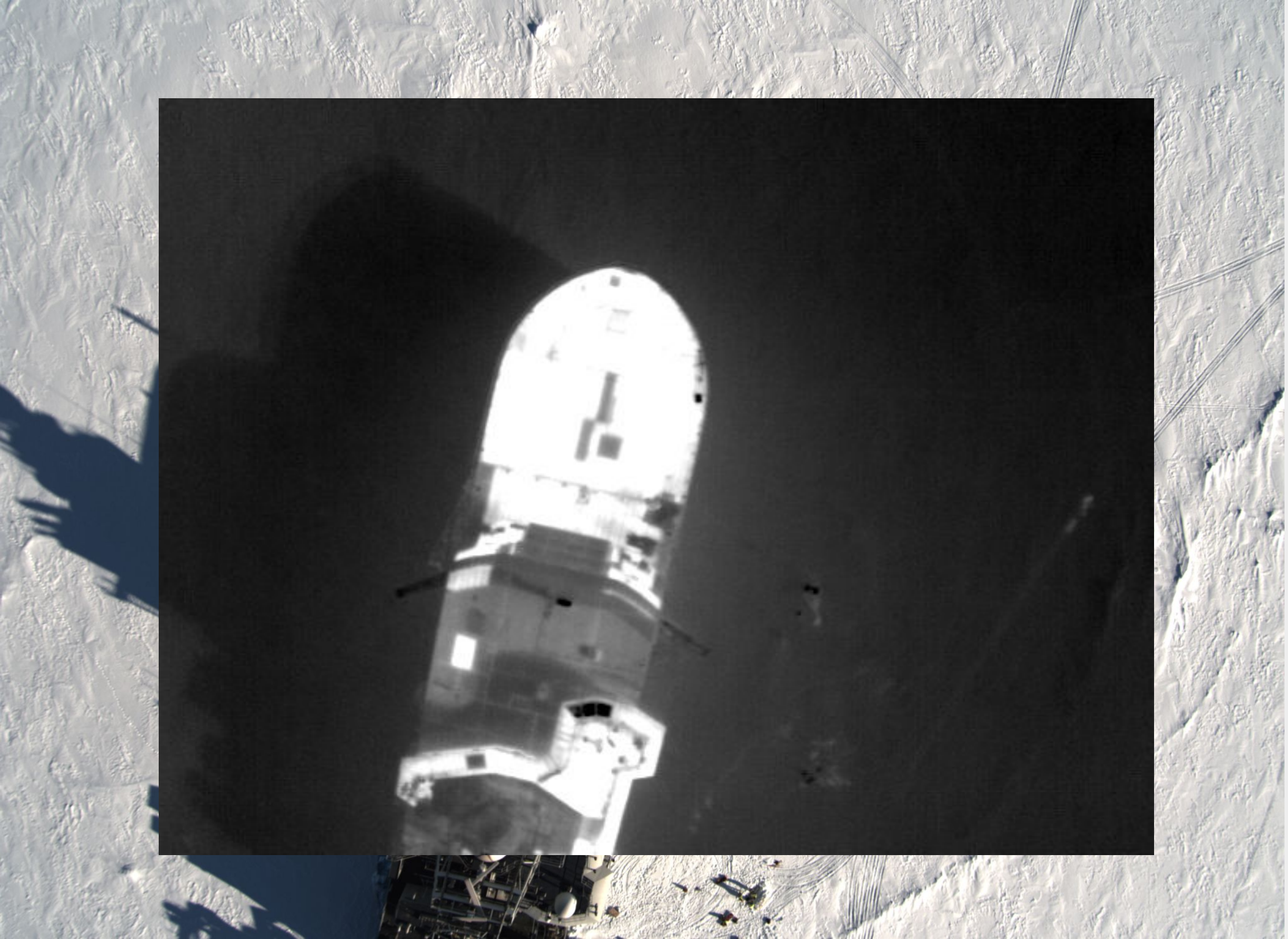

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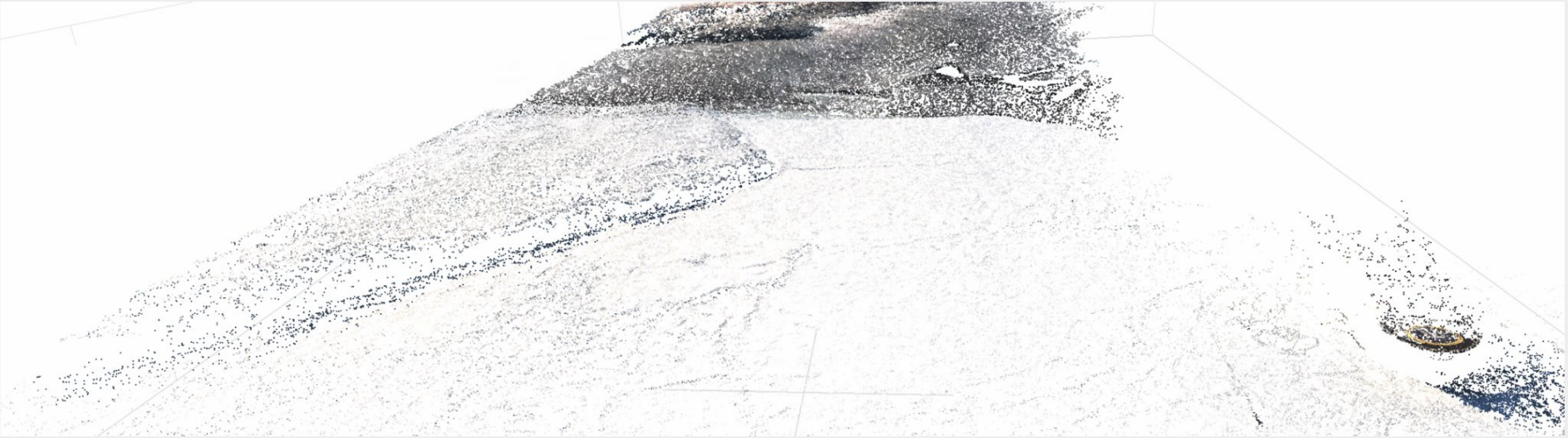
High Resolution Orthomosaic

Workflow for creating High Resolution Orthomosaics

- loading images
  - inspecting images (removing unnecessary images)
- aligning cameras
- building dense point cloud



Workflow for creating High Resolution Orthomosaics

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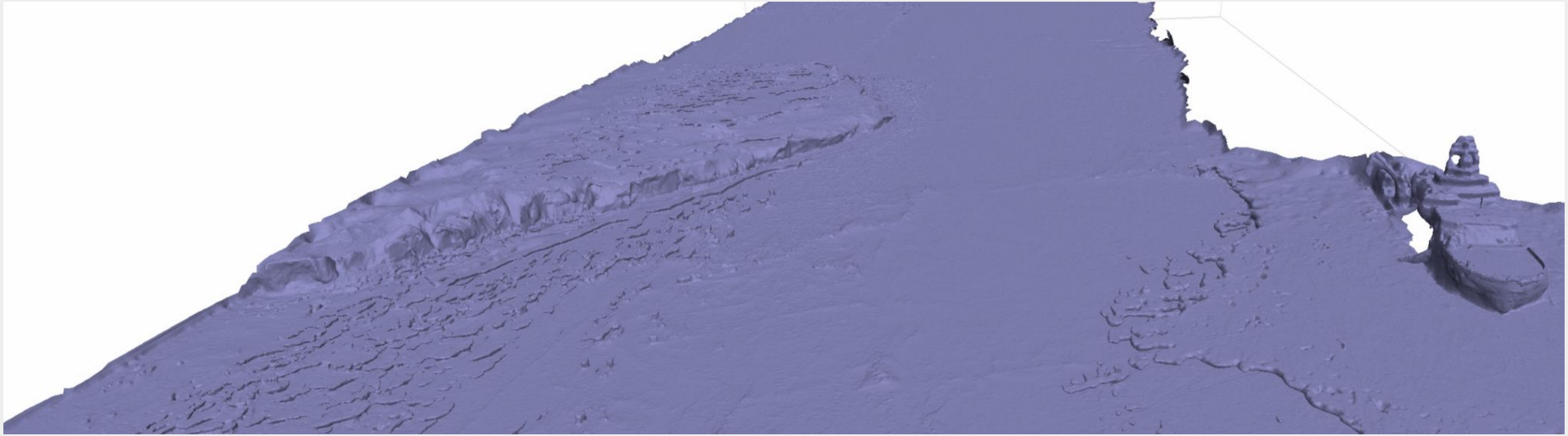
- building mesh (3D polygonal model)



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Workflow for creating High Resolution Orthomosaics

- loading images
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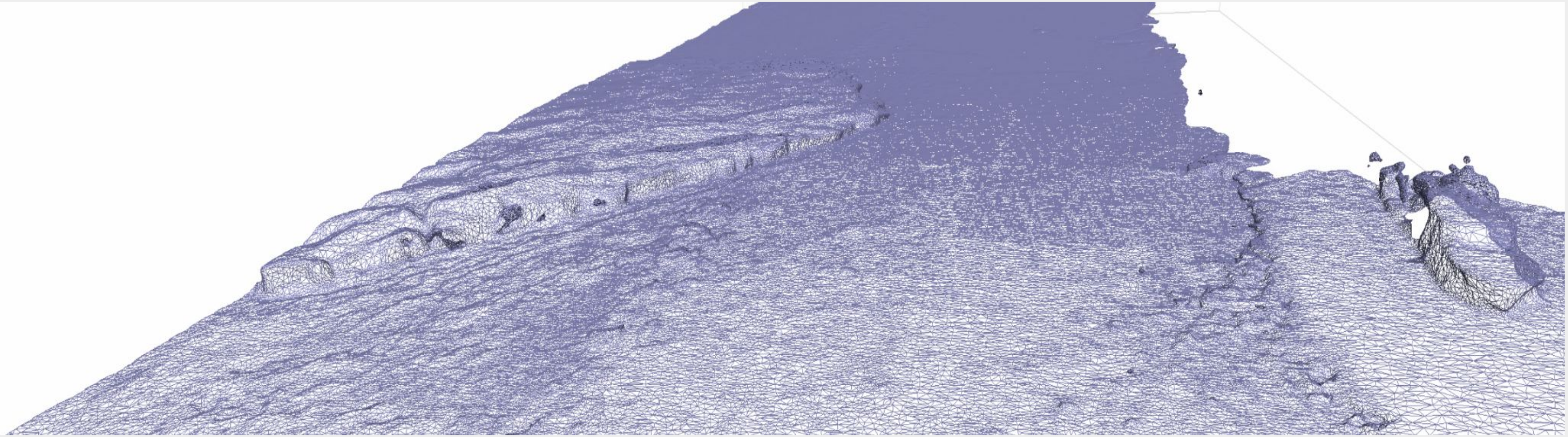
- aligning cameras
- building dense point cloud
- building mesh (3D polygonal model)
- building tiled model



Workflow for creating High Resolution Orthomosaics

- loading images
  - inspecting images (removing unnecessary images)
- aligning cameras
- building dense point cloud
- building mesh (3D polygonal model)
- building tiled model
- generating texture

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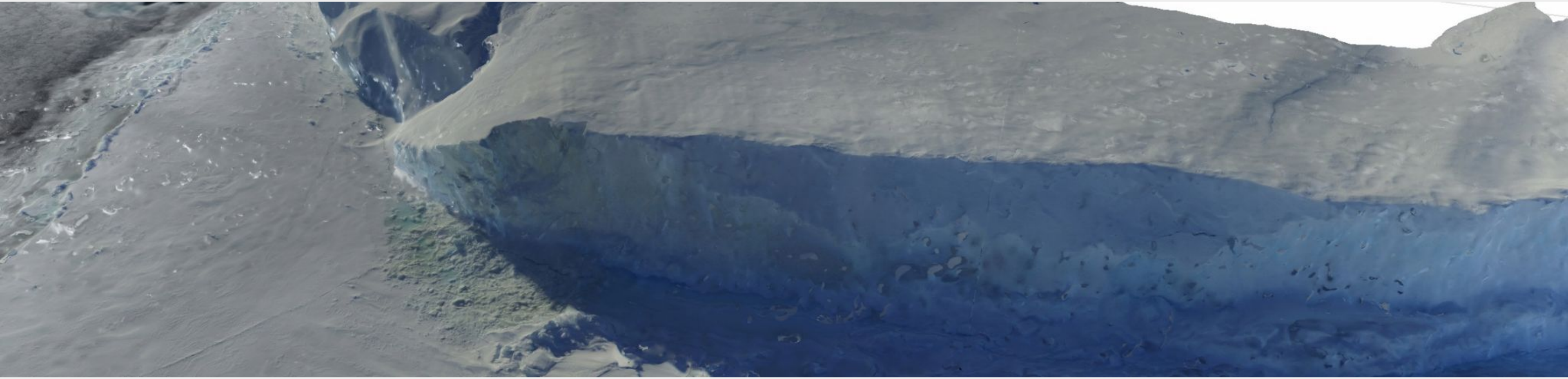


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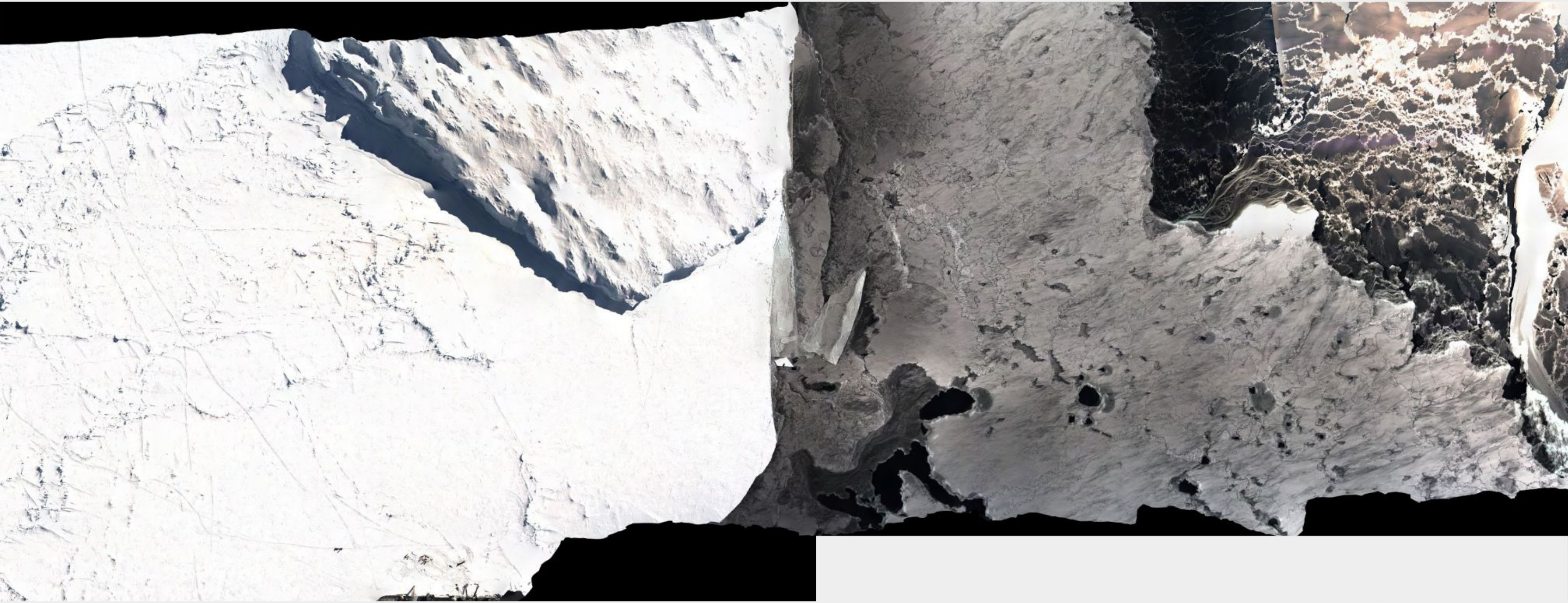
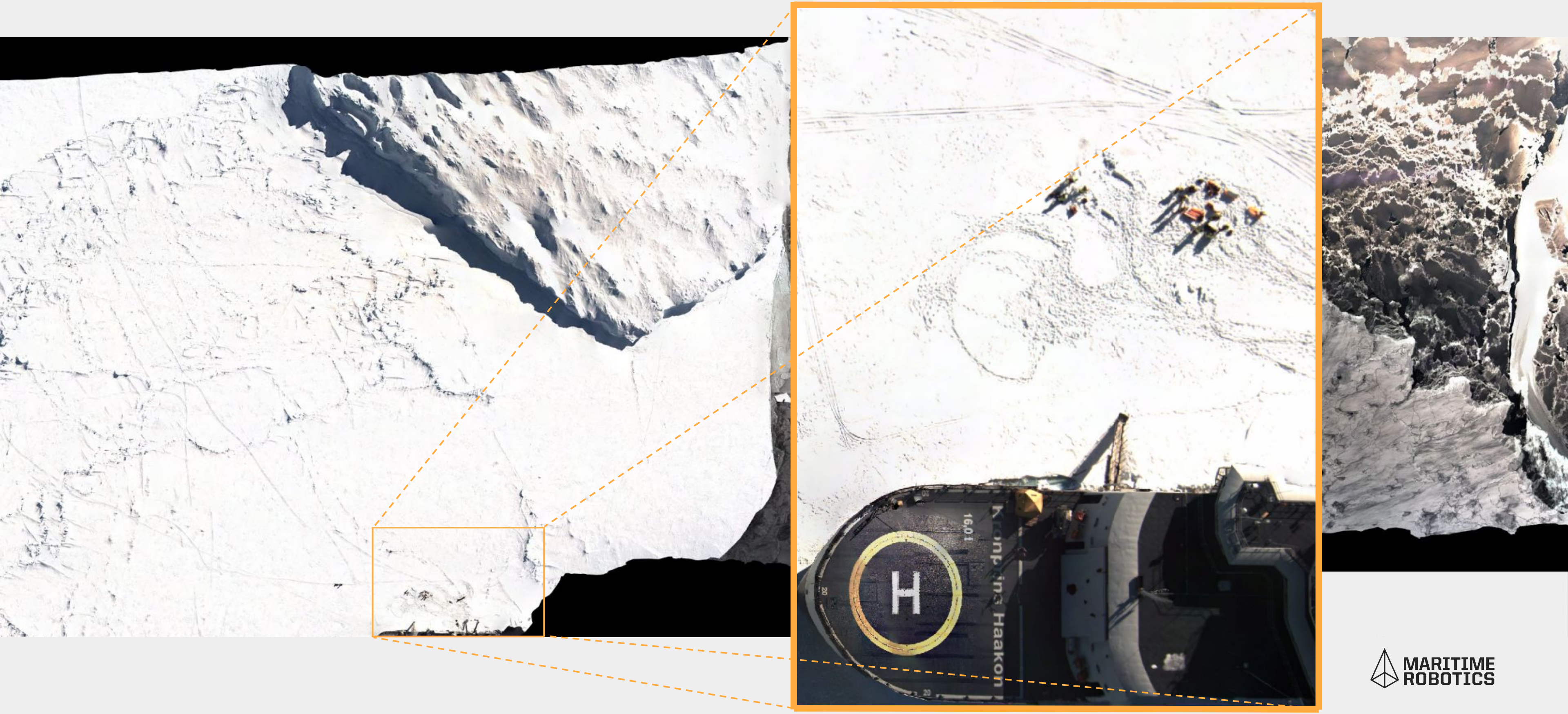
High Resolution Orthomosaics



High Resolution Orthomosaic - details



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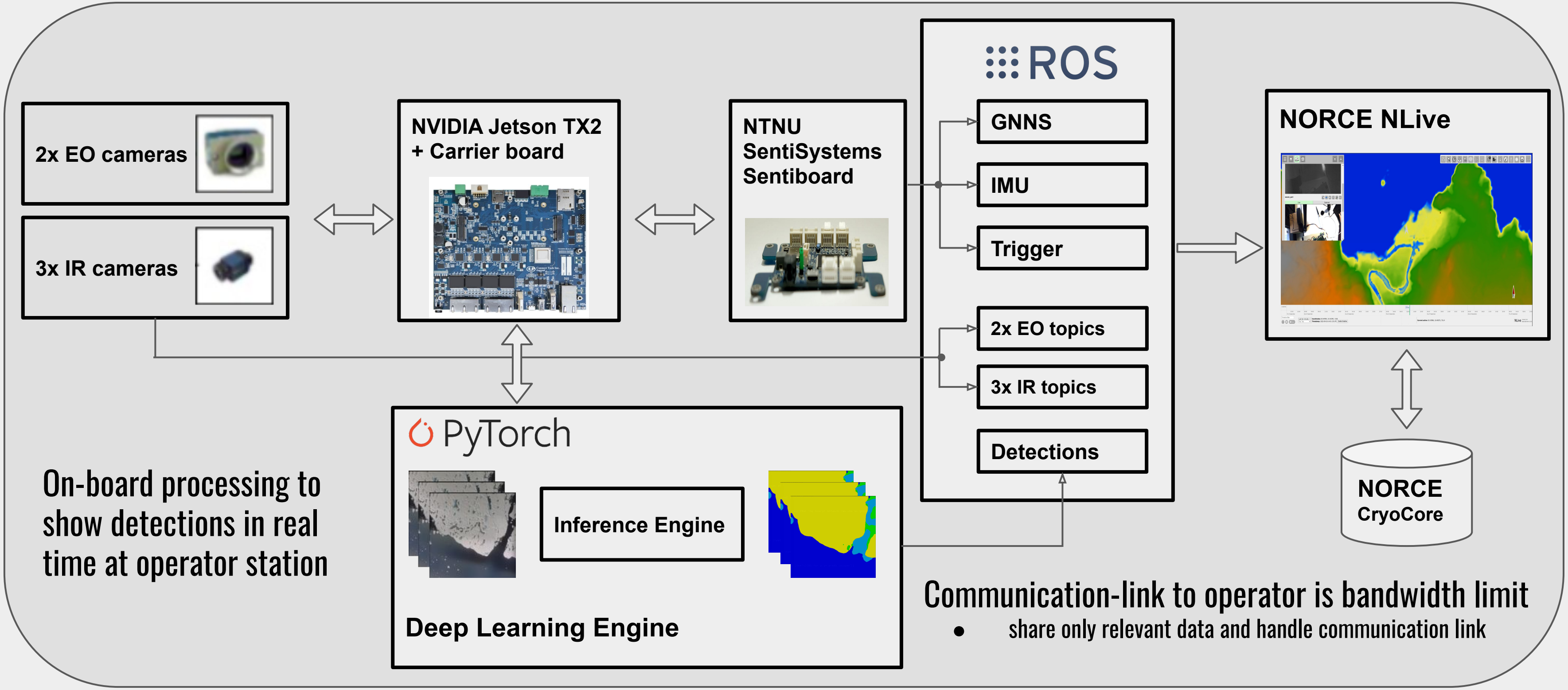
MR Situational Awareness architecture



On-board processing to show detections in real time at operator station

Communication-link to operator is bandwidth limit

- share only relevant data and handle communication link

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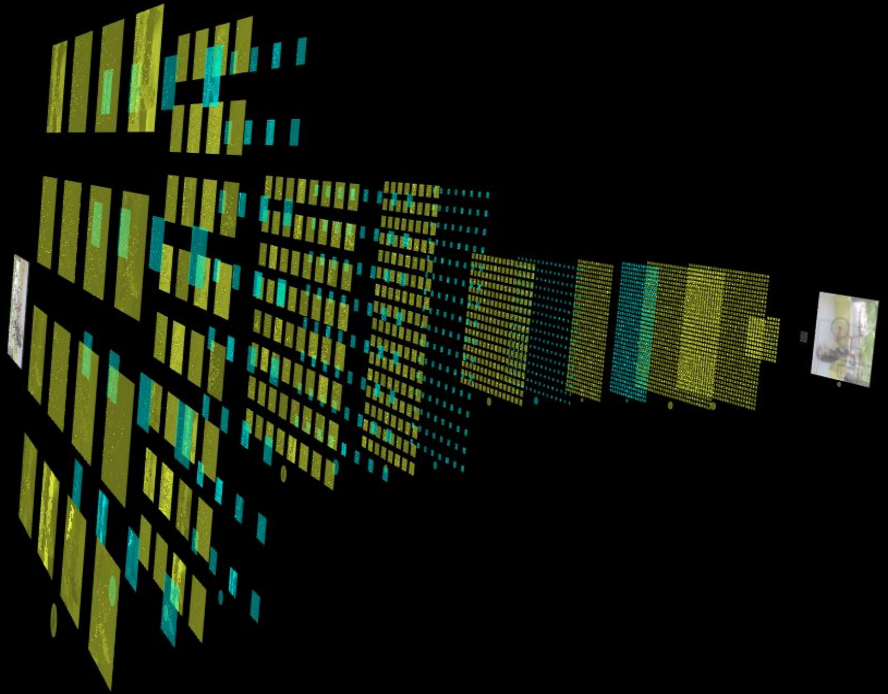
Deep Learning

a type of machine learning based on artificial neural networks:

- multiple layers of processing are used to extract progressively higher level features from data.



3D CNN architecture image generated with Tensorspace (https://github.com/tensorspace-team/tensorspace)

DAS: Sea Ice classification

data_dir
—**Train**
—--Image
——---*Image1*
-
——---*ImageN*
—--Mask
——---*Mask1*
-
——---*MaskN*
—**Test**
—--Image
——---*Image1*
-
——---*ImageN*
—--Mask
——---*Mask1*
-
——---*MaskN*

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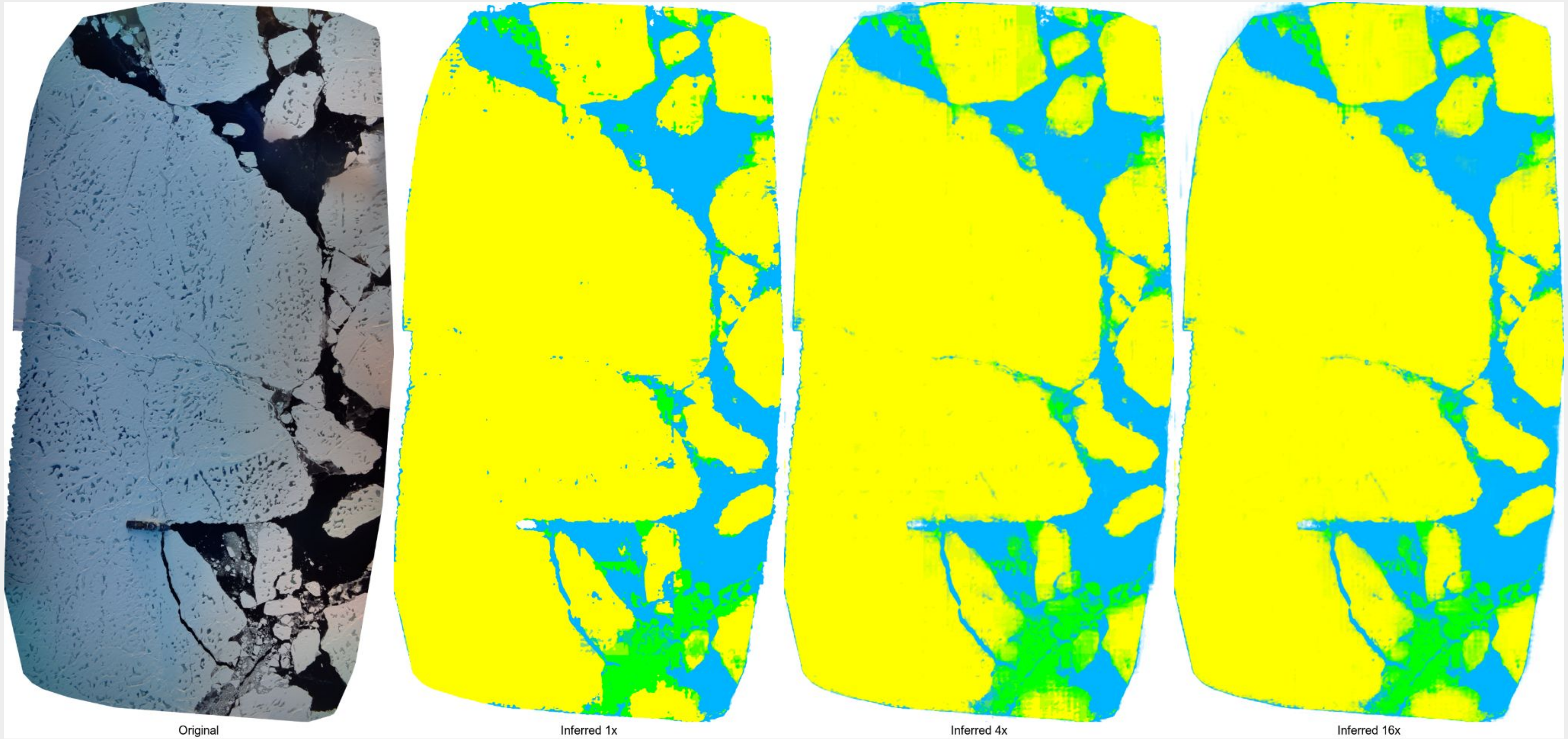
DAS: Sea Ice classification



Inference results of Bergen Robotics DL model (y=solid ice g=crushed ice b=open waters)

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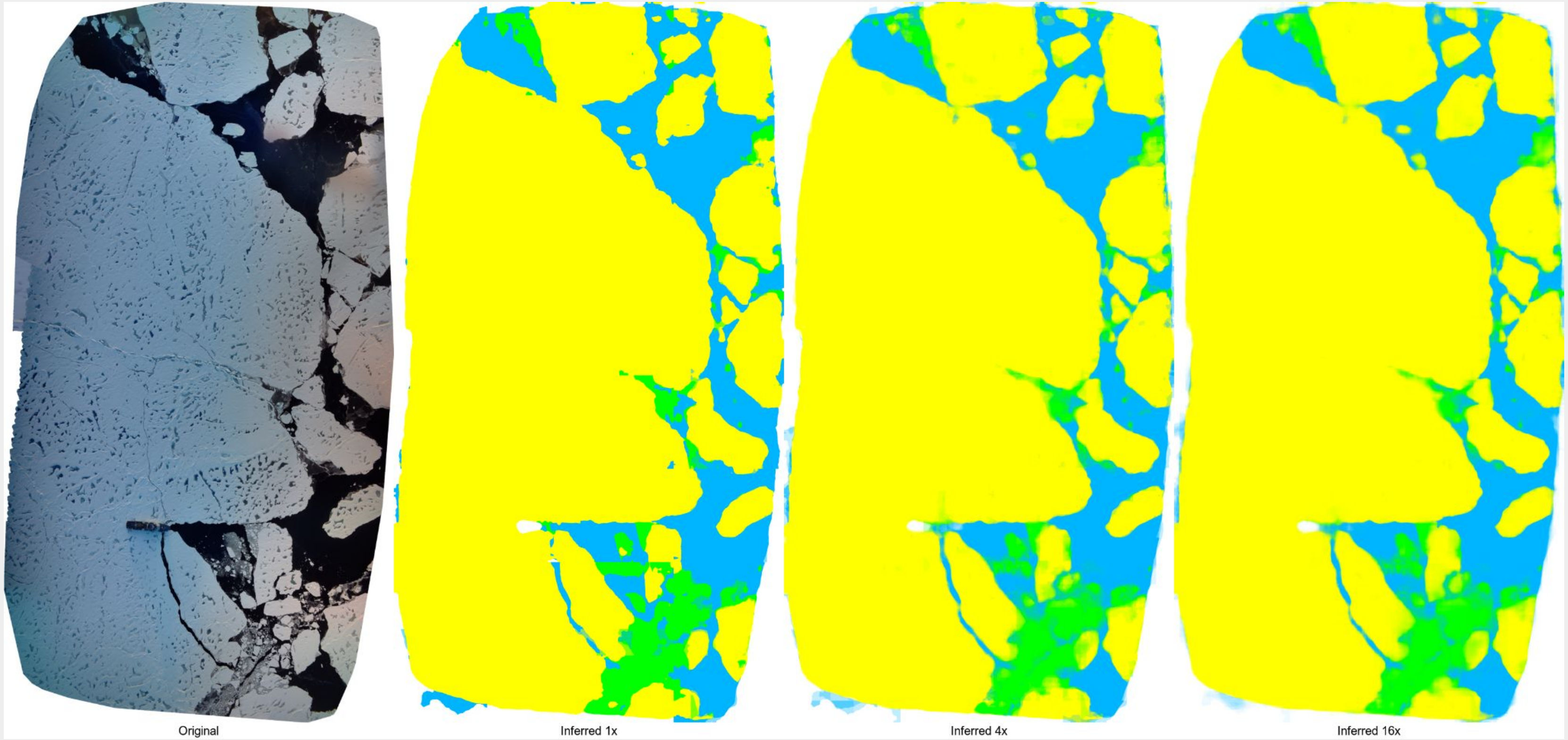
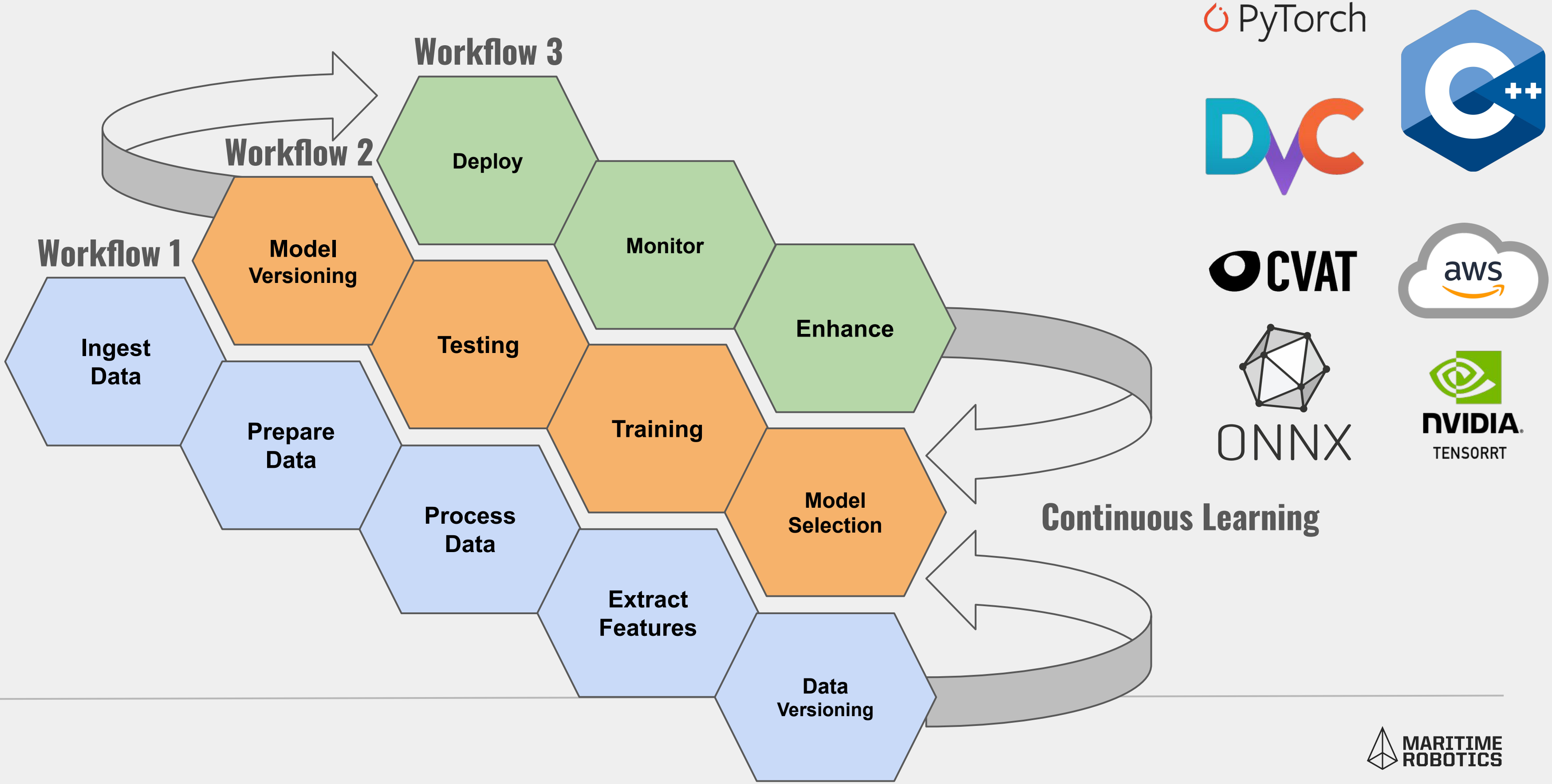
DAS: Sea Ice classification



Inference results of Bergen Robotics DL model (y=solid ice g=crushed ice b=open waters)

Deep Learning Infrastructure



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Key challenges working with UAVs

- Design
  - Electronic parts housing;
  - High-performance materials.
- Operational:
  - Flight planning
  - Trajectory planning for cost minimization
  - Avoiding data redundancy, occlusions etc
- Data acquisition:
  - On-board data storage
  - On-board real-time data processing
- Post processing
  - Automated workflow to clean data, create and share datasets.

Continuing and future work

- D-Ice system:
  - Test the system at different speeds (range of 25 - 35m/s) vessels in any weather and light conditions
    - to measure its performance and establish good data for model creation and simulation fusion & tracking
- Situational Awareness
  - Visual support to operators, e.g prevent risks, increase safety/efficiency of operations
- Machine Learning Infrastructure optimisation and improvement
  - Deep learning model's ensemble, e.g detect and classify object of interest
    - **model robustness across different scenarios**
  - Manage large amounts of data needed to train Deep Learning models
  - Dataset creation (labelling data is time consuming!)

Thank you for your attention!

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