Utilizing NASA's MiDAR Fluid Lensing and NeMO-Net for Automated Airborne Detection, Localization, and Characterization of Underwater Military Munitions

MR24-4534

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In-Progress Review Meeting

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Project Team

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ACES Team

SERDP

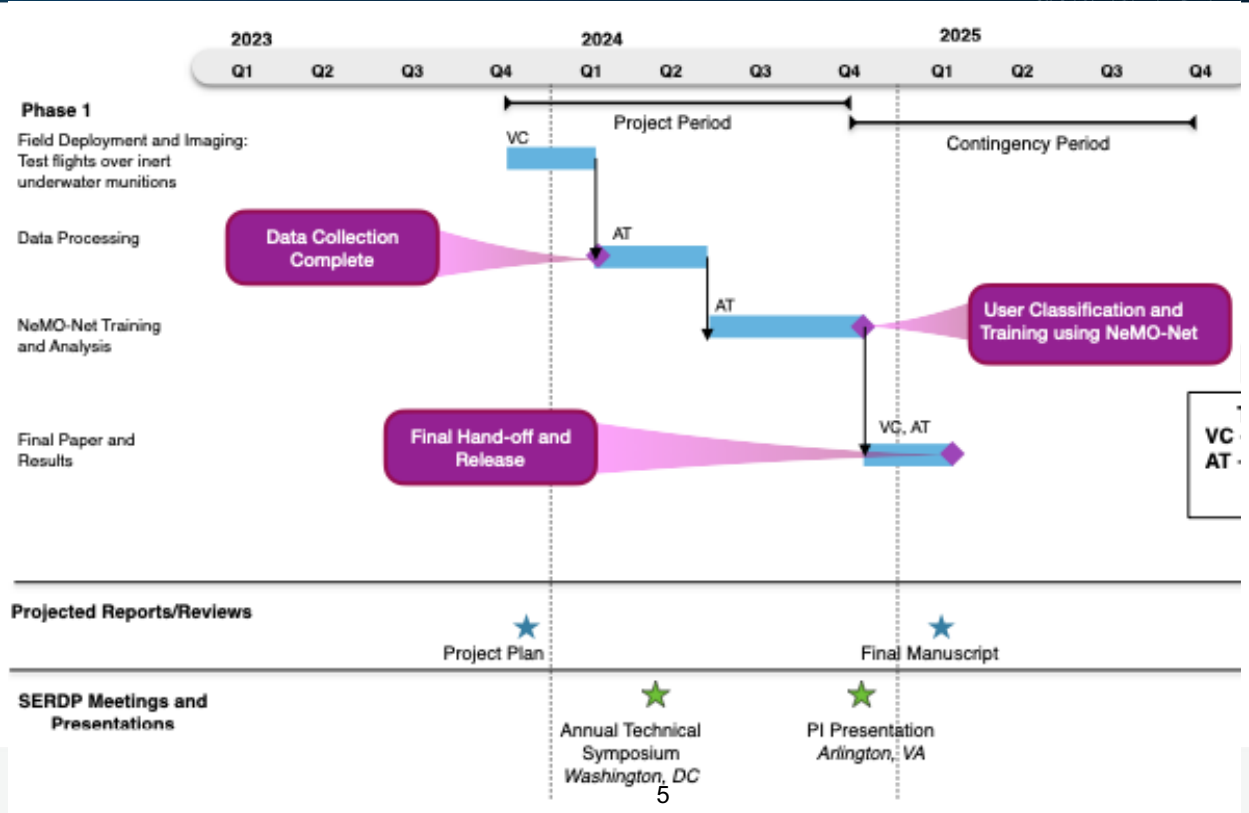
Bottom Line Up Front

- Fluid Lensing and MiDAR are novel NASA patented technologies invented by PI for imaging underwater through ocean waves. NASA NeMO-Net, an opensource CNN-based AI is used to analyze data from these novel instruments for habitat mapping globally. Here, we are using it to find underwater munitions.
- Delays in project award and contracting meant project started much later than initially proposed, but we are catching up quickly and already performed lab imaging of the munitions and calibrations. The next phase is field deployment for which vessel, drones, and site are already setup.

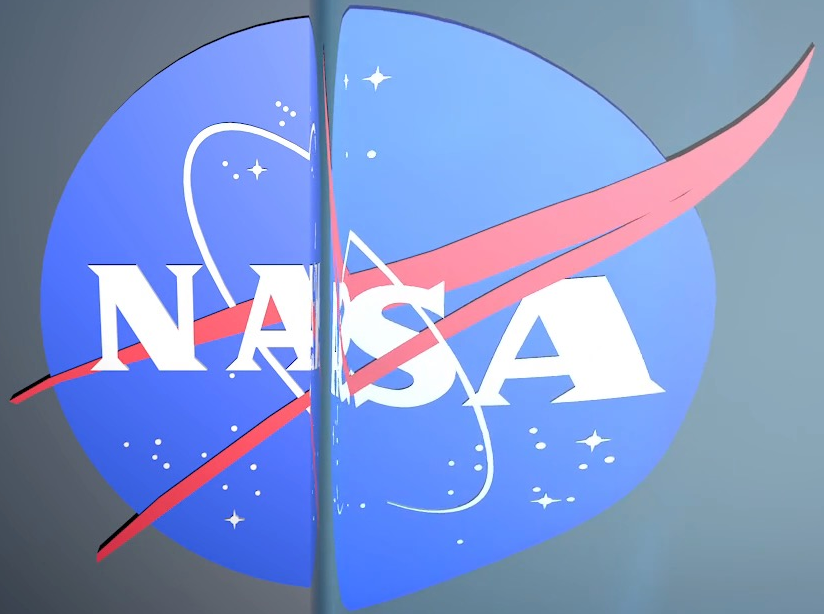
Technical Objective

- We proposed utilizing NASA's airborne fluid lensing and MiDAR technologies, invented by PI Chirayath for NASA's Earth & Planetary Science applications, along with NASA's NeMO-Net convolutional neural network, for the automated detection, localization, and characterization of underwater military munitions.

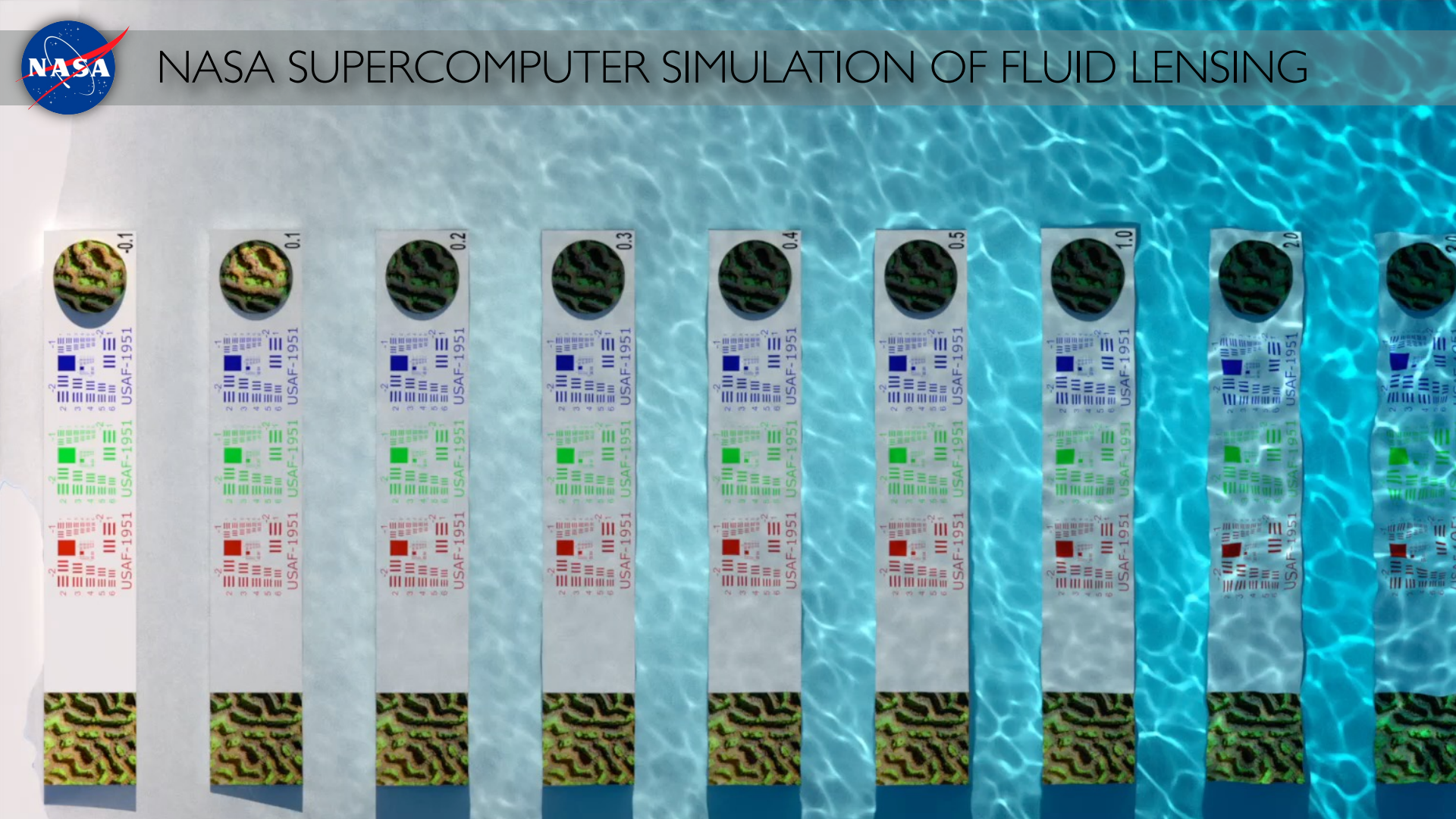
Technical Approach

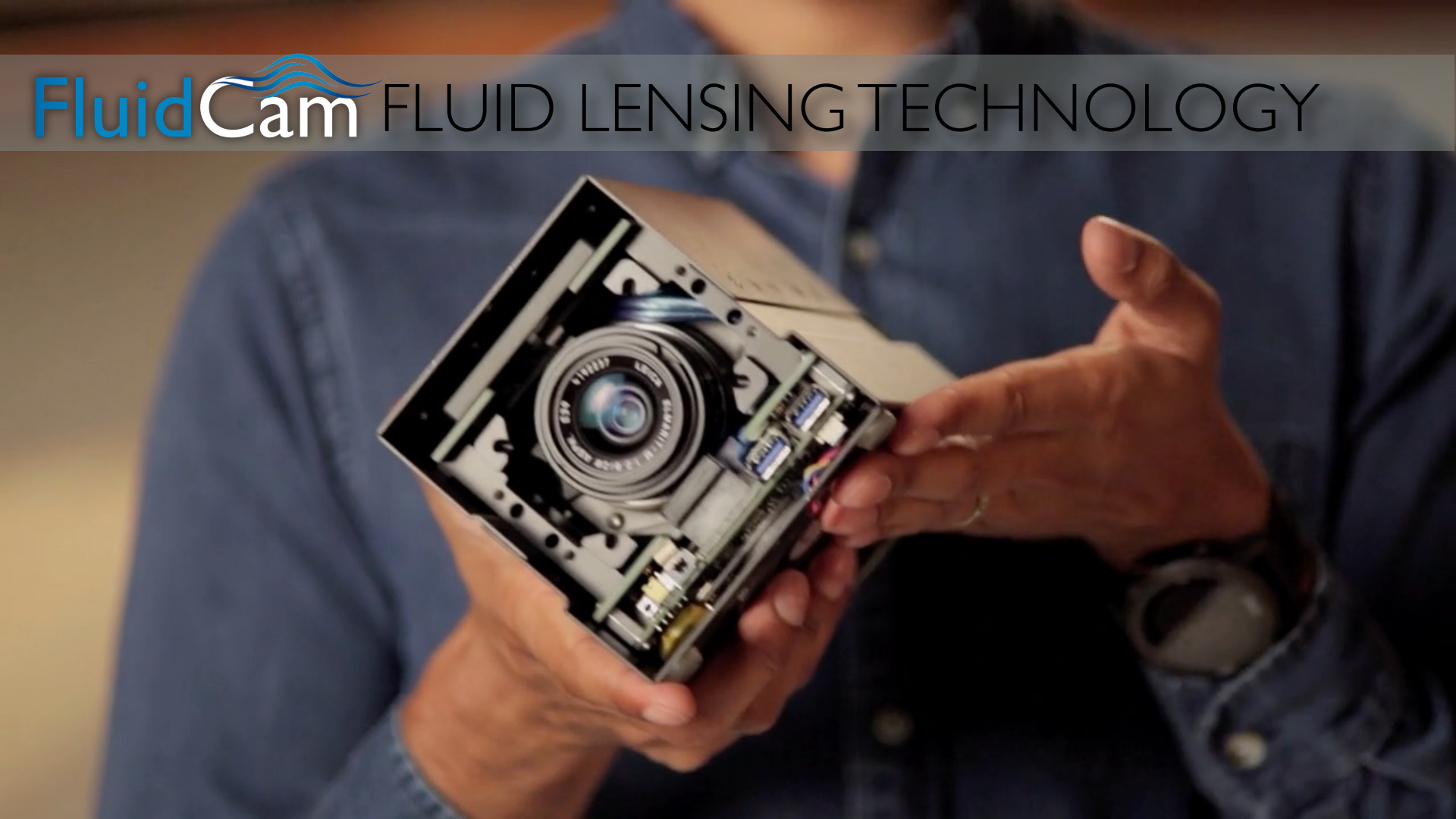


HOW TO SEE UNDERWATER?



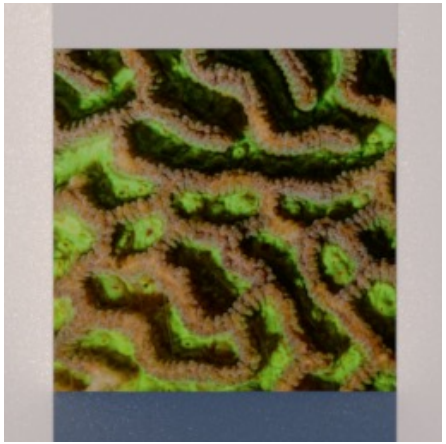
NASA SUPERCOMPUTER SIMULATION OF FLUID LENSING



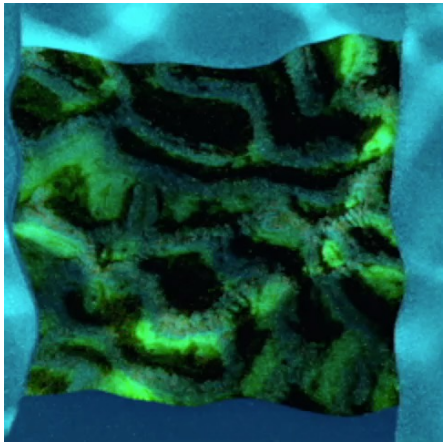

FluidCam
FLUID LENSING TECHNOLOGY

2D Fluid Lensing,Depth = 4.5m, MSL

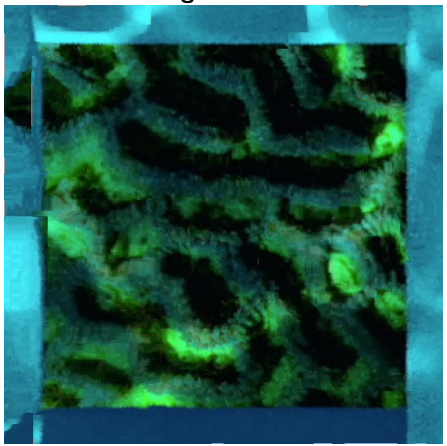
No Fluid



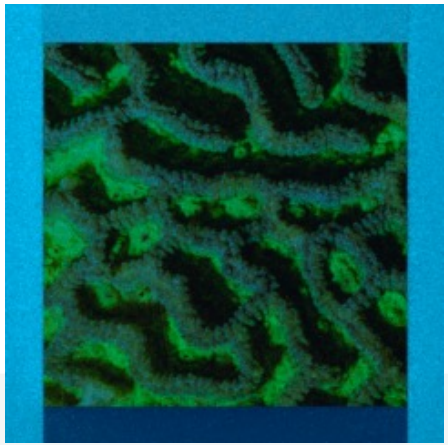
Raw Distorted Frames



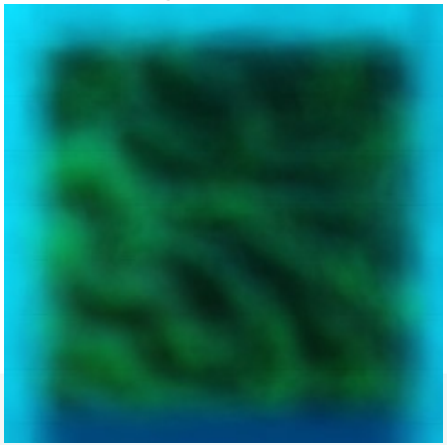
2D Fluid Lensing Results



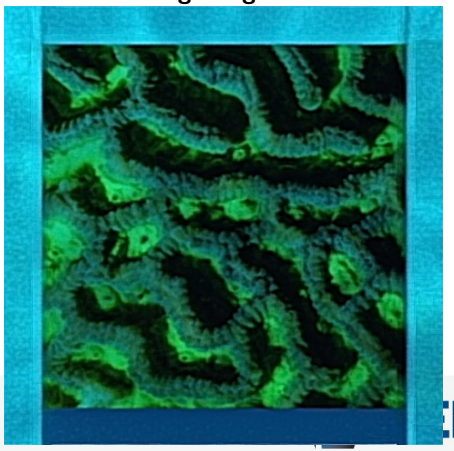
Flat Fluid



Mean Image



2D Fluid Lensing Integration

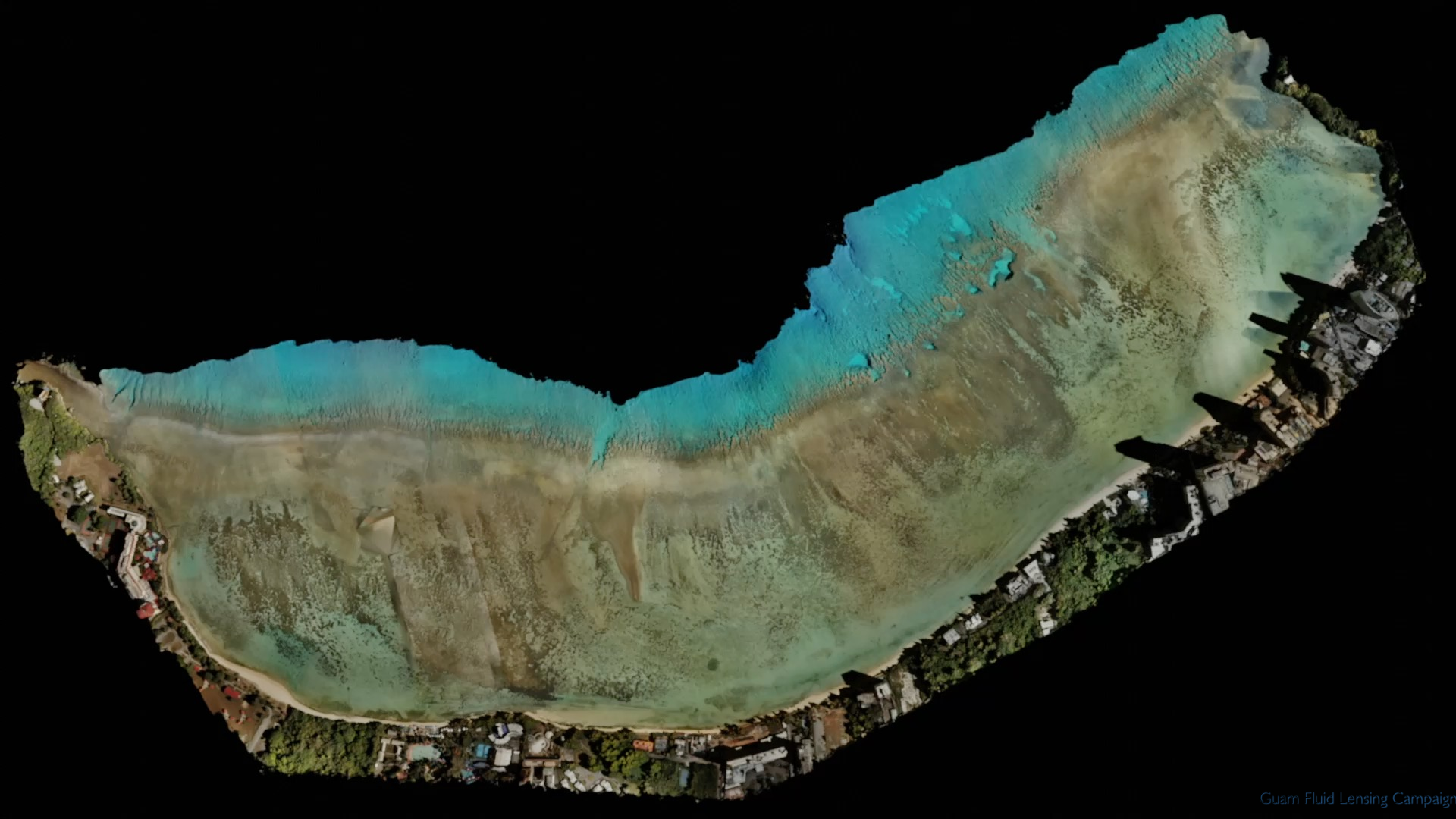


FluidCam FLUID LENSING

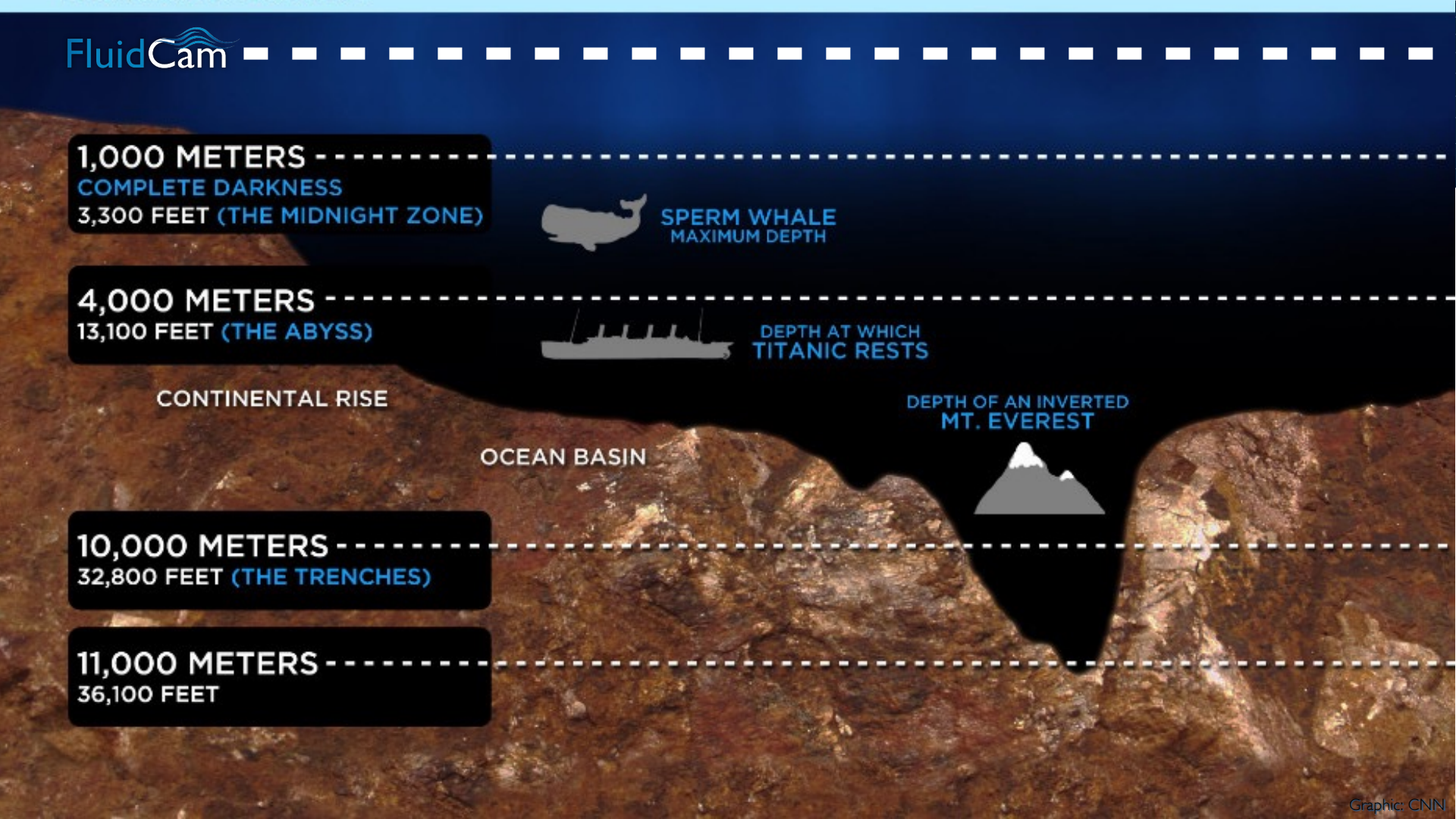
FLUID LENSING - GUAM


Maxar

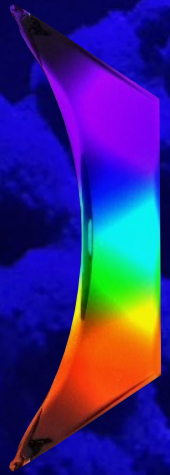

Guam Fluid Lensing Campaign


Guam Fluid Lensing Campaign

FluidCam



Graphic: CNN



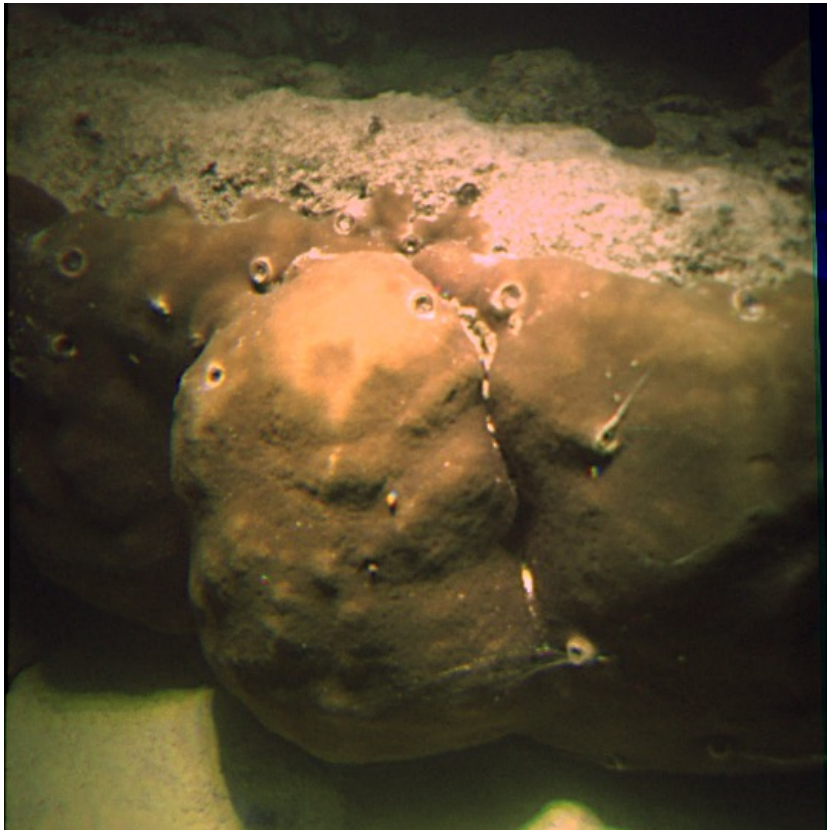
MiDAR

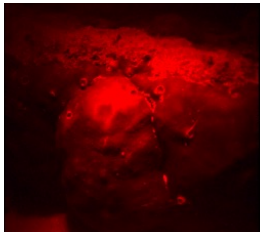
MULTISPECTRAL IMAGING, DETECTION AND ACTIVE REFLECTANCE INSTRUMENT
NASA 2019 INVENTION OF THE YEAR

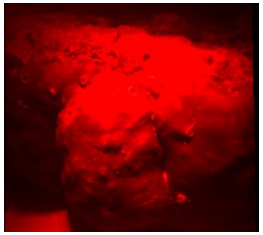

MiDAR

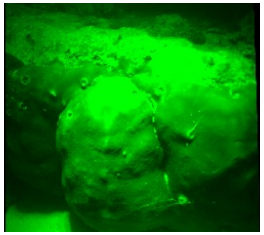

2023 MIDAR Guam Field Campaign

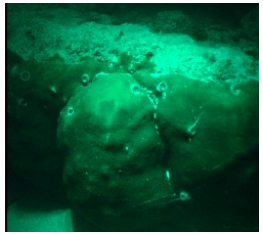
MiDAR-7 RESULTS

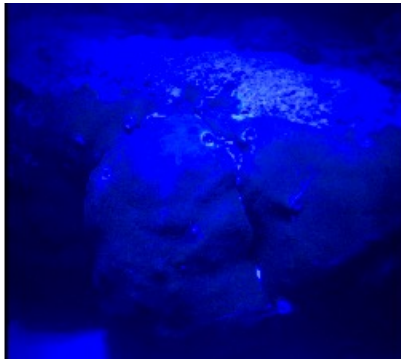


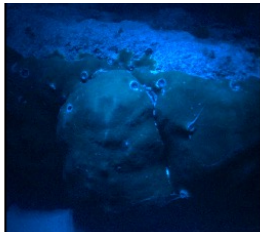


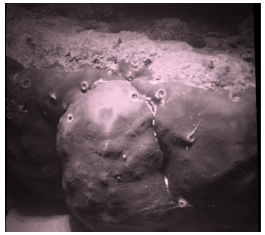












NASA NEMO-NET - GLOBAL MARINE MAPPING

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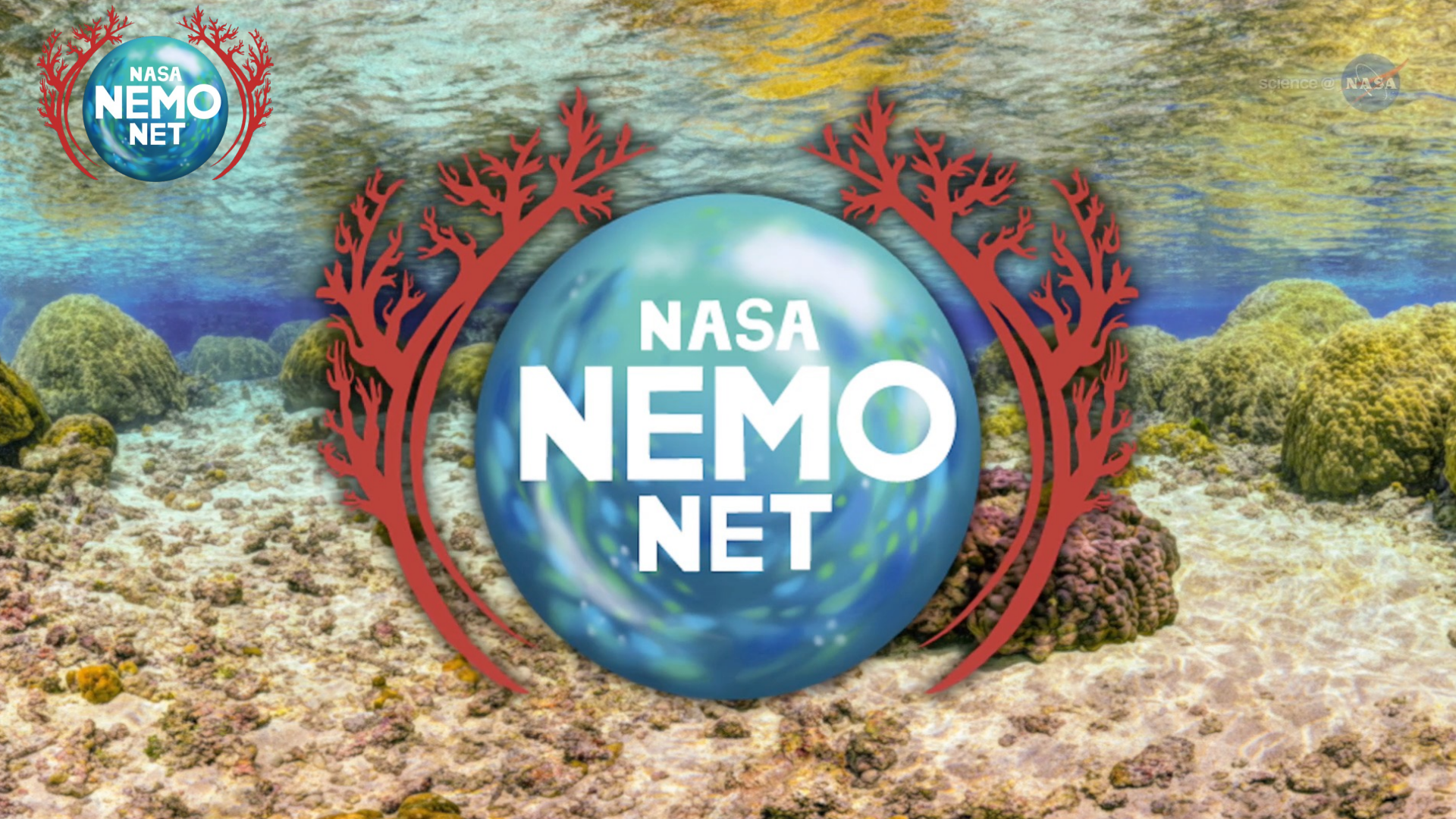
NASA
NEMO
NET
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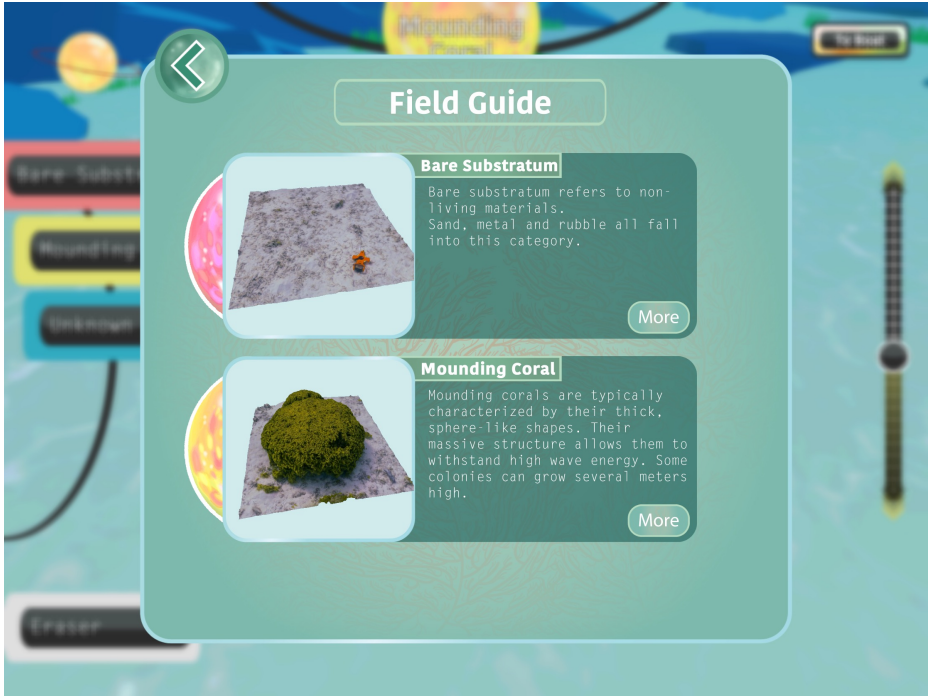
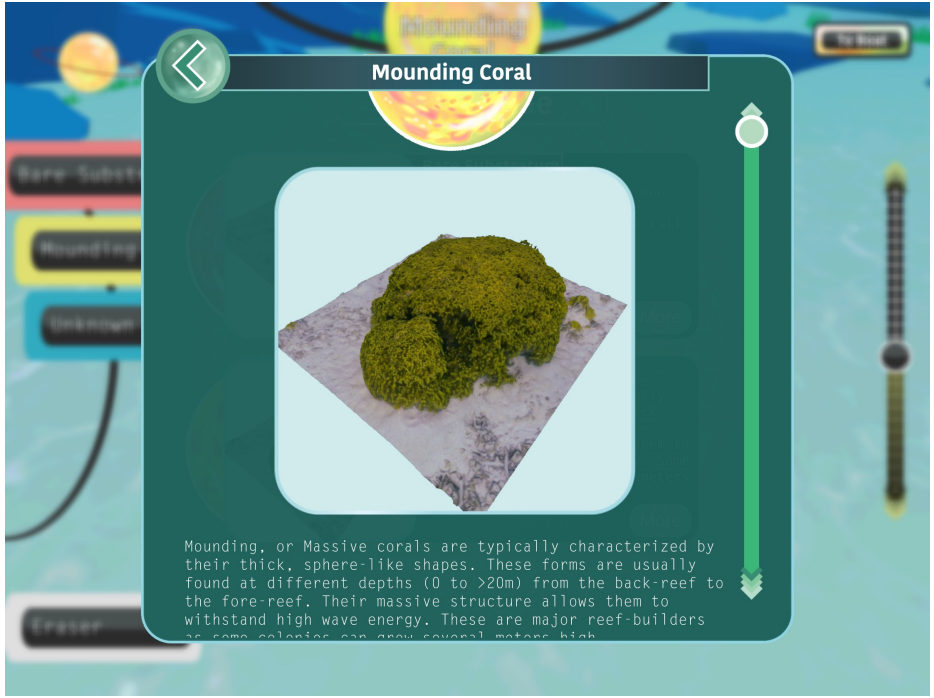
science @ NASA

NEMO-NET TRAINING & LEVELS





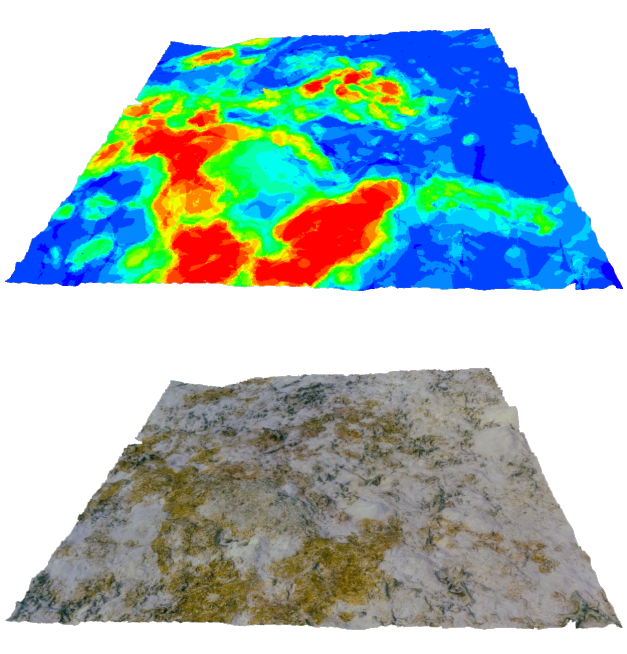
NEMO-NET GAME

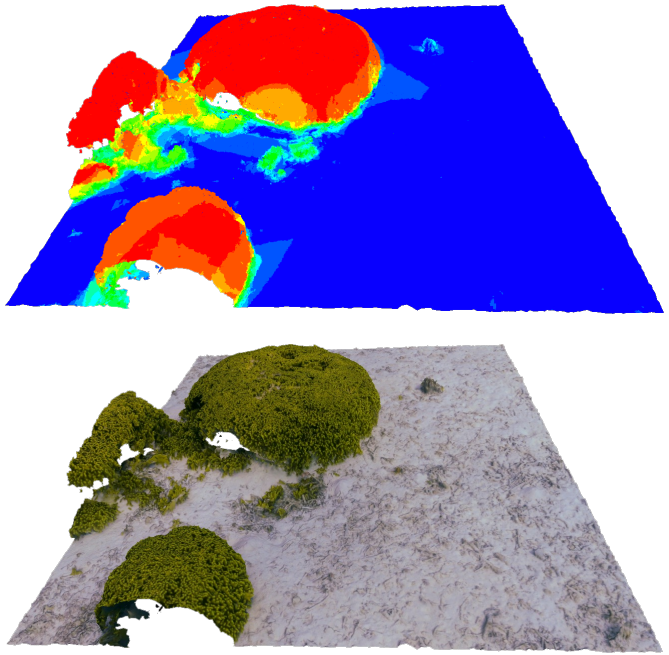
Players are required to classify coral at a minimum accuracy before sending data to the neural network

CLASSIFICATION CONVERGENCE

Heat Map of Algae

Heat Map of Coral

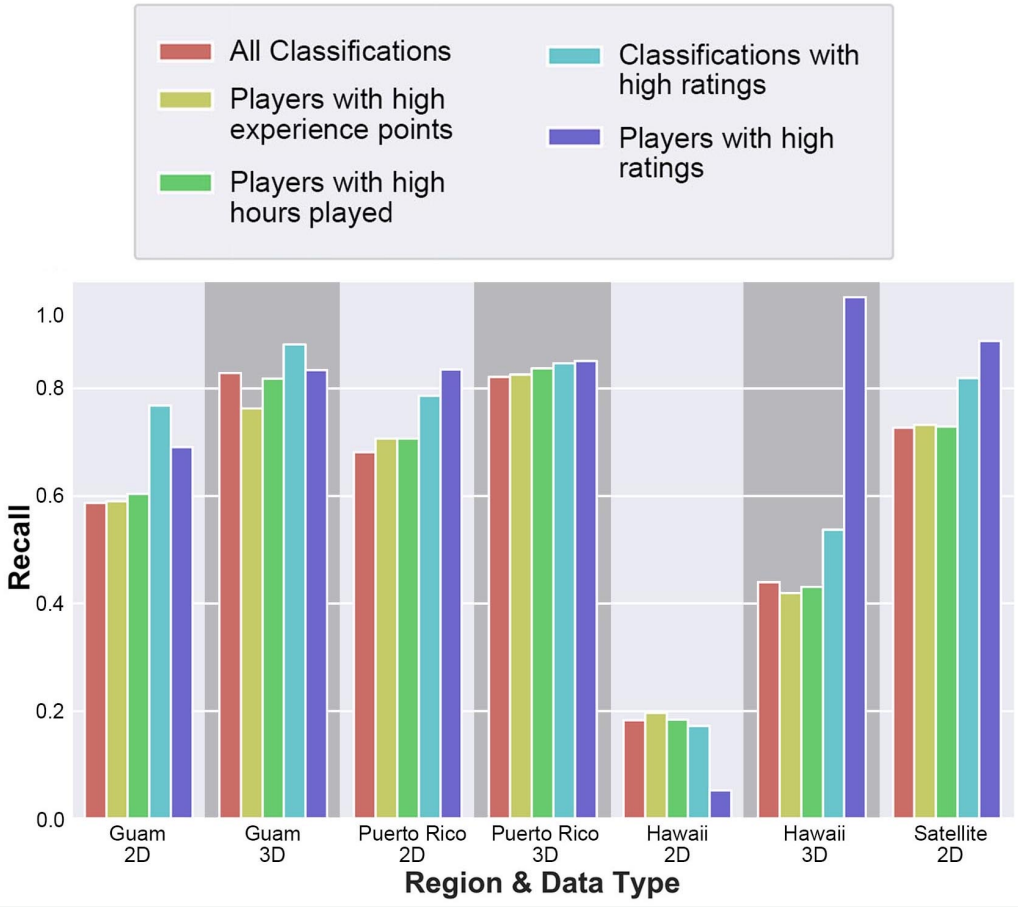




0% of Users Classified as Algae / Coral

100% of Users Classified as Algae / Coral

CLASSIFICATION ANALYSIS



Classification ratings are an effective filter!

Each of NeMO-Net's regions has a higher 3D recall than 2D recall.

- Guam (all classifications) has a 41.14% increase

- Puerto Rico (all classifications) has a 20.26% increase

- Hawai'i (all classifications) has a 140.45% increase

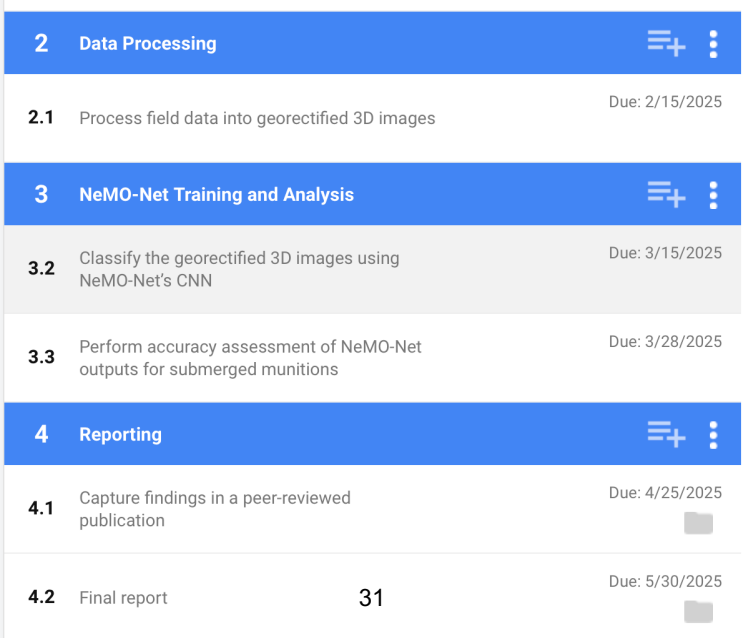
- High rated Hawai'i players have a 1739.9% increase

Results to Date

- We coordinated with the munitions facility and successfully received an assortment of inert munitions in the ACES lab.
- These munitions were setup on an optical bench and imaged using a 10-band passive optical instrument, mounted on our stationary drone. These calibration data will be used to compare to the munitions when deployed in the field underwater and through a process of natural biofouling.
- Next are images of the munitions setup in the laboratory and the 10-band imagery that was captured from the drone on the optical bench in air. The test contains a calibrated reflectance panel as well as a multichannel LED array for calibration to MiDAR. The images in the table below show the different bands and panchromatic channel with an assortment of munitions.

Next Steps

- Deploy munitions in field and image over time period for fouling (delayed by permitting agency)
- Timeline:



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Technology Transfer

- The core technologies are already patented and owned by the US government through NASA and are actively being applied for licensing through NASA's technology transfer program.

Issues

- Significant delays in award contracting, funds transfer and start.
- Permitting delays from local agencies to deploy munitions for field test.
- Schedule and logistics complexities with delays that incurred impacts to our other fieldwork and Antarctic expedition.

BACKUP MATERIAL

MR24-4534 – Fluid lensing UXO

Performers:

Ved Chirayath, Drew Christensen

Technology Focus

- *Utilize NASA fluid lensing and NeMO-Net to detect UXO*

Research Objectives

- *Use fluid lensing and MiDAR to image munitions and novel NeMO-Net CNN to automate detection of them in data*

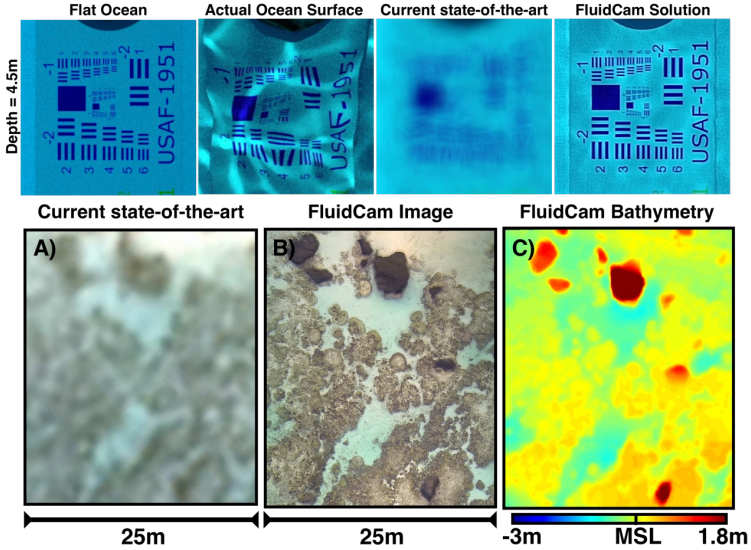
Project Progress and Results

- *Munitions imaged in lab and aircraft and research vessel ready to deploy in field and image through biofouling*

Technology Transition

- *Technologies are patented by US Government through NASA and already have licensing applications for use commercially.*

NOTE: This slide may used by the Program Office in future presentations to provide a brief overview of the project.



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Plain Language Summary

- We are trying to use new NASA airborne technologies to see underwater and discover hazardous objects like unexploded and lost bombs.
- We are using novel sensing technology and AI to image and locate lost underwater objects over large areas
- We expect to advance the ability to find ordnance and develop datasets that be used to train AI to find them at scale.

Impact to DoD Mission

The Program Office wants to convey the significance of your research to DoD leadership, Congress, and the broader community.

- What's the most impactful thing that's happened since the last time you presented your work to us?
  - Advances in our drone technology and imaging technology
- Why is this important?
  - It ensures US preeminence in underwater detection from aircraft.
- How is your project advancing DoD capabilities?
  - We have capabilities unique in the world for underwater mapping

Literature Cited

- Chirayath, Ved. 2021. “System and Method for Imaging Underwater Environments Using Fluid Lensing.” United States Patent and Trade Office. Patent No. 62/634,803. https://patents.google.com/patent/US20190266712A1/en
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