Remote Explorer (REx IV): An Autonomous Vessel for Data Acquisition and Dissemination

AUV Lab @ MIT Sea Grant
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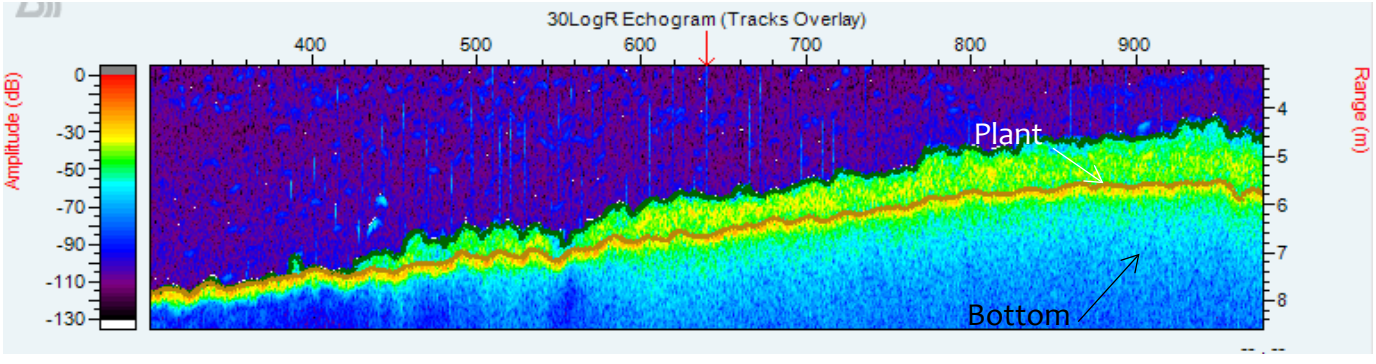
MOOS-DAWG 2015

MIT Sea Grant College Program: Mission

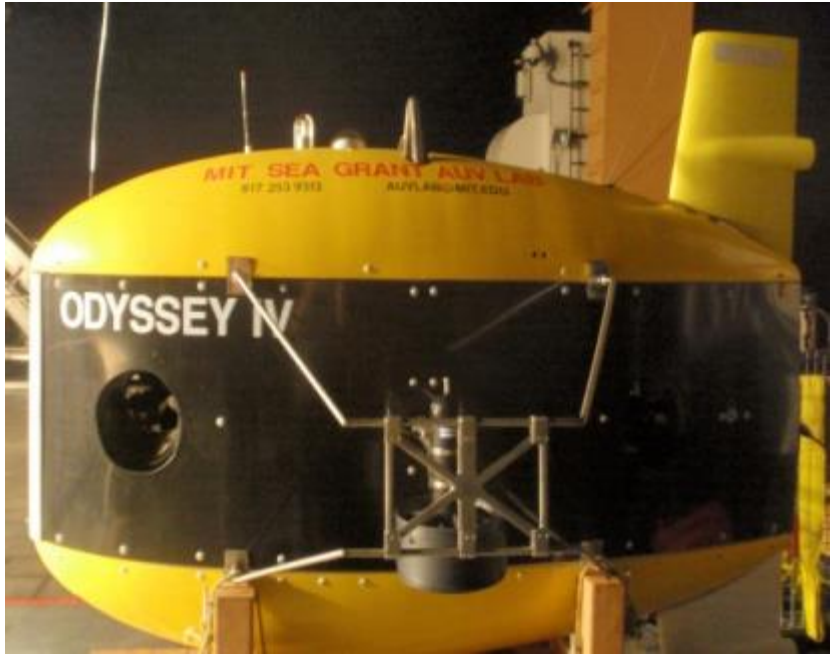
* National Sea Grant College Program
  * Founded in 1966
  * Network of 32 programs around the U.S



Eel-Grass Biometric Data, Pirates Cove, MA

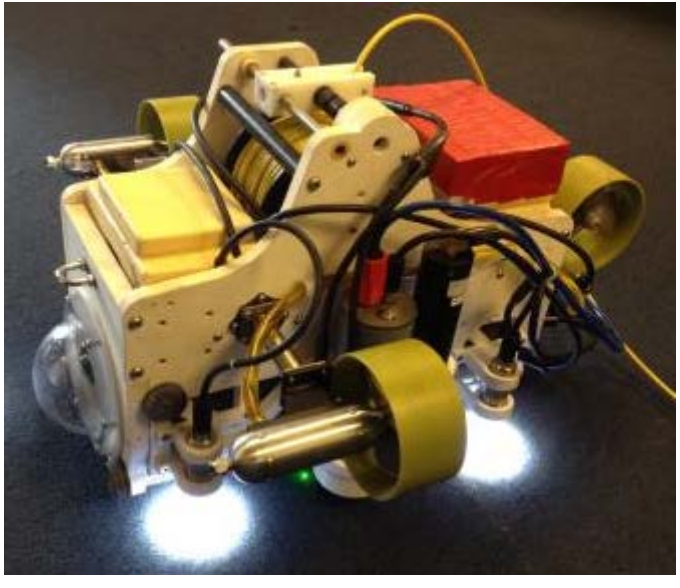
AUV Laboratory at MIT Sea Grant

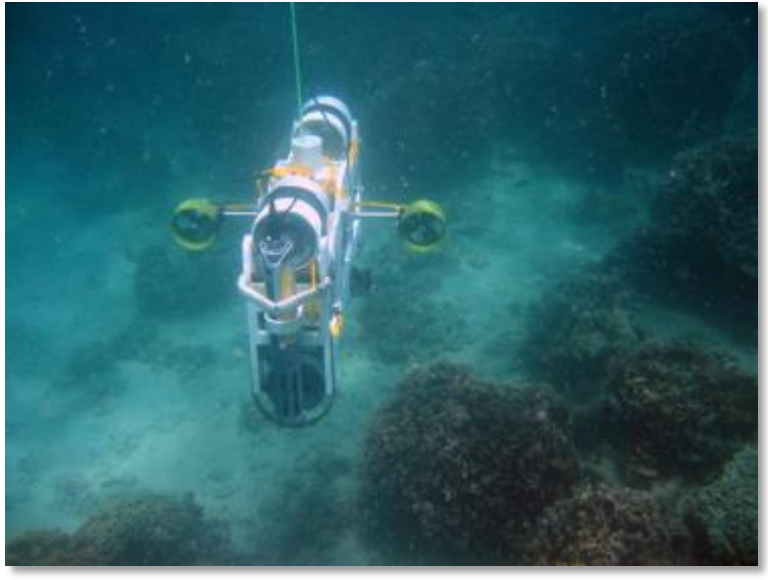
- Underwater robotic exploration for marine data collection and analysis within the MIT Sea Grant Advisory Group and the greater scientific community
- Invasive species detection and monitory
- Student mentoring
  - High school, Undergrad, Masters, Post-Doc
- Educational outreach
- Advancements in marine robotics and autonomy



Development of the REx Platform

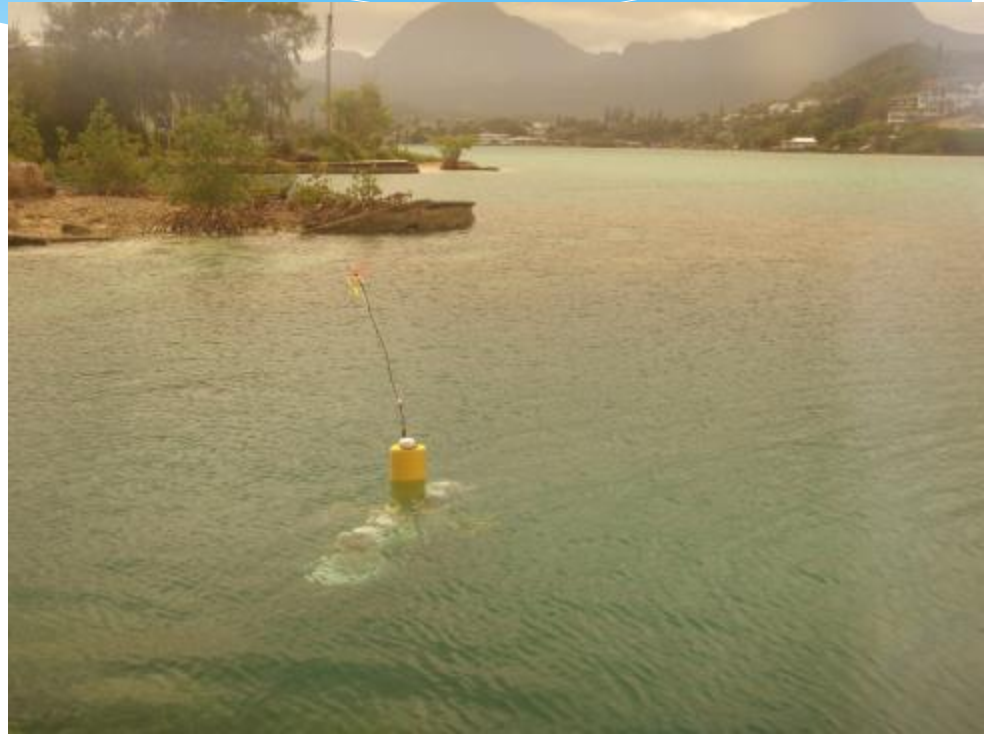
* Reef Explorer Program
* REx 1
* REx 2
* REx 3





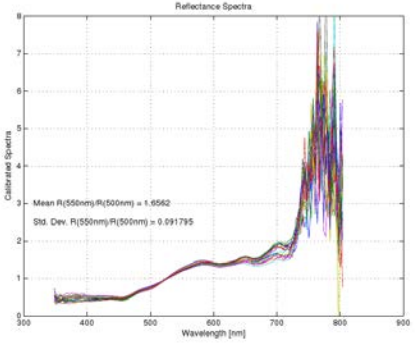
REx I

* Completed in 2008 @ MIT
* Operated in Hawaii from MIT's campus.
* Local high school students were enlisted to operate the vessel from the classroom.

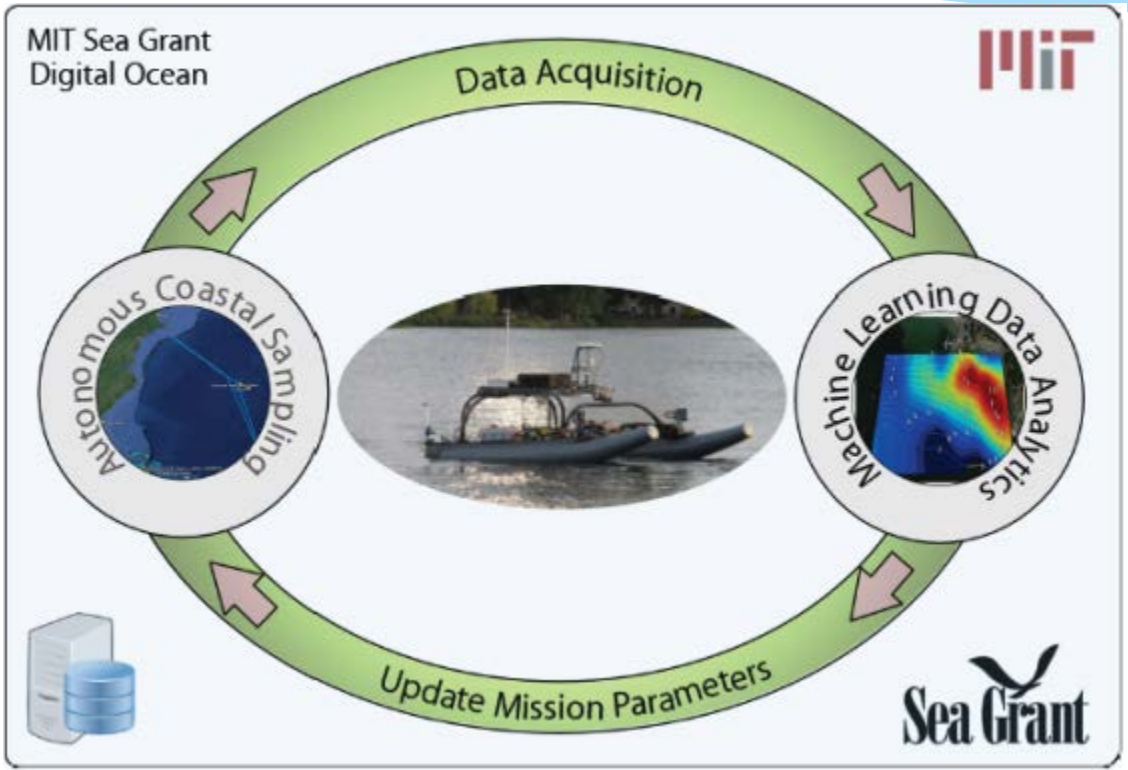


REx II/III

* REx II/III (2010)
  * Half the size and half the weight
    * Lighter more powerful batteries
    * Smaller profile
  * Sensor upgrades
    * LED lights
    * Altimeter
    * Radiometer



REx IV Overview



The Remote Explorer System

- **Hull:** Marine Advanced Research, Inc. 16' WAM-V platform
- **Software:** MOOS-IvP
- **Computing:** Based on Athena-Nike platform, MIT/Olin's winner in the 2014 Maritime RobotX Challenge
- **Capabilities:** Autonomous navigation, complex missions, long-range communications, subsea, surface, and atmospheric sensing, and data logging

REx IV Design Objectives
Vessel and Hull

Vehicle Characteristics

- Range: 10 NM range while operating in conditions up to sea state 3 w/hull extensions
- Payload weight: 34 kg (dry)
- Payload volume:
  - Limited on deck to enclosure approx. 356 mm x 309 mm x 178 mm (e.g. Fibox 8561015)
- Deployed by trailer

REx IV Design Objectives
Winch and Tether

Winch Payload Capability

- **Payload Weight:** up to 20 kg (dry)
- **Payload Size (including protective cage):**
  - Overall length: 813mm
  - Overall height, width: 203mm
- **Tether Depth:** 25 m, potential for 100 m.
- **Payload Data Interface:**
  - Ethernet, serial (RS232, RS422, RS485)
- **Payload Electrical interface:**
  - 12 VDC, up to 1A
  - REx provides a female SubConn Micro 8 pin

REx IV Design Objectives Communications

Onboard, wired Ethernet

- Wired Ethernet

Nearby Comms, 2.4GHz

- Intended for chase boat or nearby shore
- For vessel control and emergency stop
- 6 mbps @ 1km range

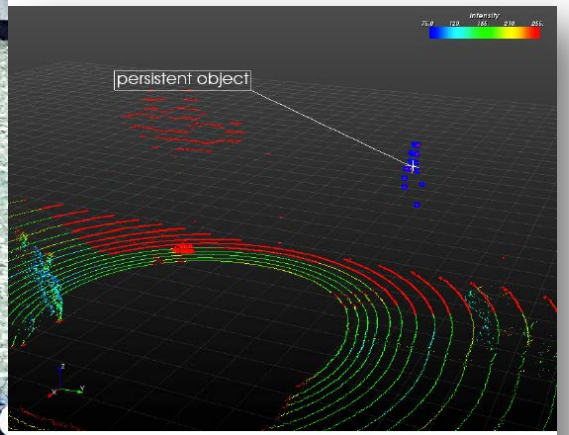
Remote Comms, 900MHz

- Intended for remote command-control shore station
- Limited to line-of-sight radio path
- Also for remote access to data/video feed
- 1 mbps @ 7km range

REx IV Design Objectives
Sensing

Existing Sensors

- Precision GPS
- High-accuracy heading and yaw
- Velodyne LiDAR HDL-32e
- Forward-facing camera
- Altimeter for water depth
- SeaBird CTD



REx IV Design Objectives
Sensing

Potential Sensors

Underwater, tethered:

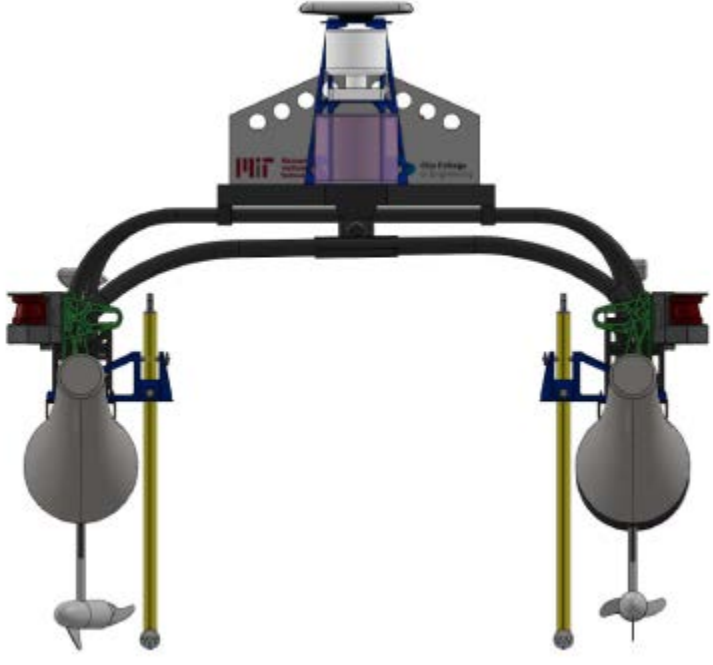
- CTD (e.g., SBE49)
- Sonde units (e.g., YSI EX02)
- Video
- ROV
- Other Ethernet/POE or serial devices

Underwater, hull-mounted:

- Hydrophones
- ADCP
- Sonar
- Other Ethernet/POE or serial devices

Atmospheric:

- Anemometer
- Other Ethernet/POE or serial devices



REx IV Navigation and Control Overview

Onboard

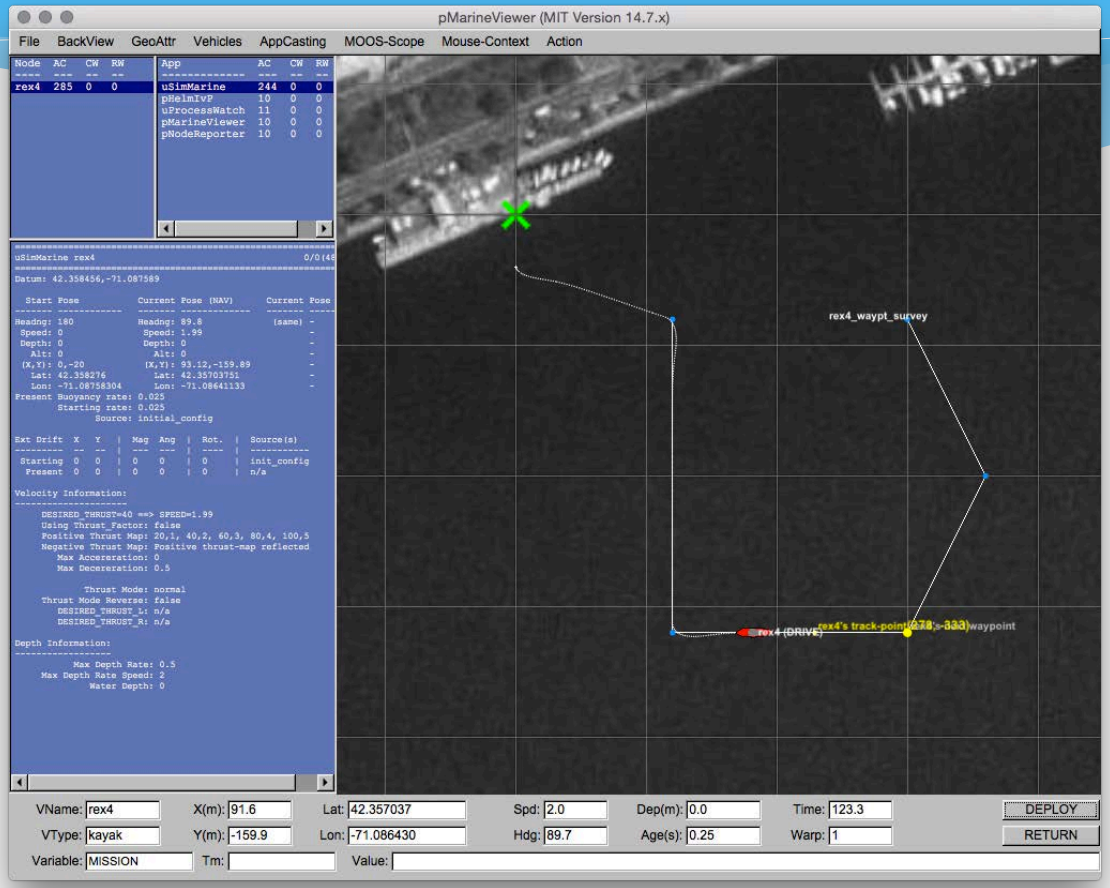
- Autonomous navigation
- Mission control

Nearby

- Emergency stop system
- Manual control unit

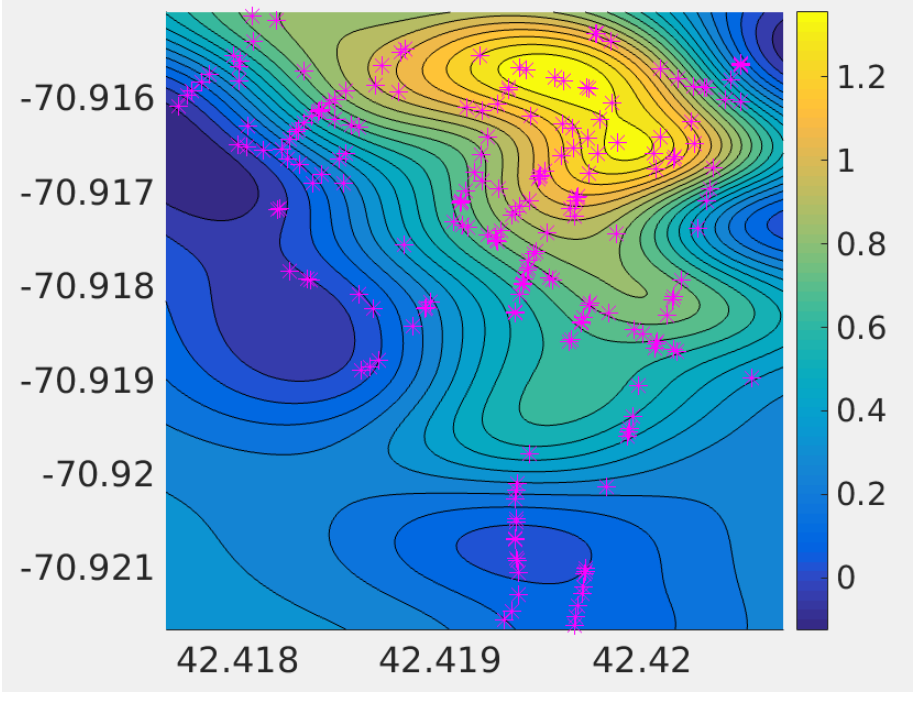
Remote

- Mission control
- Live mapping and data feed
- Simulation system

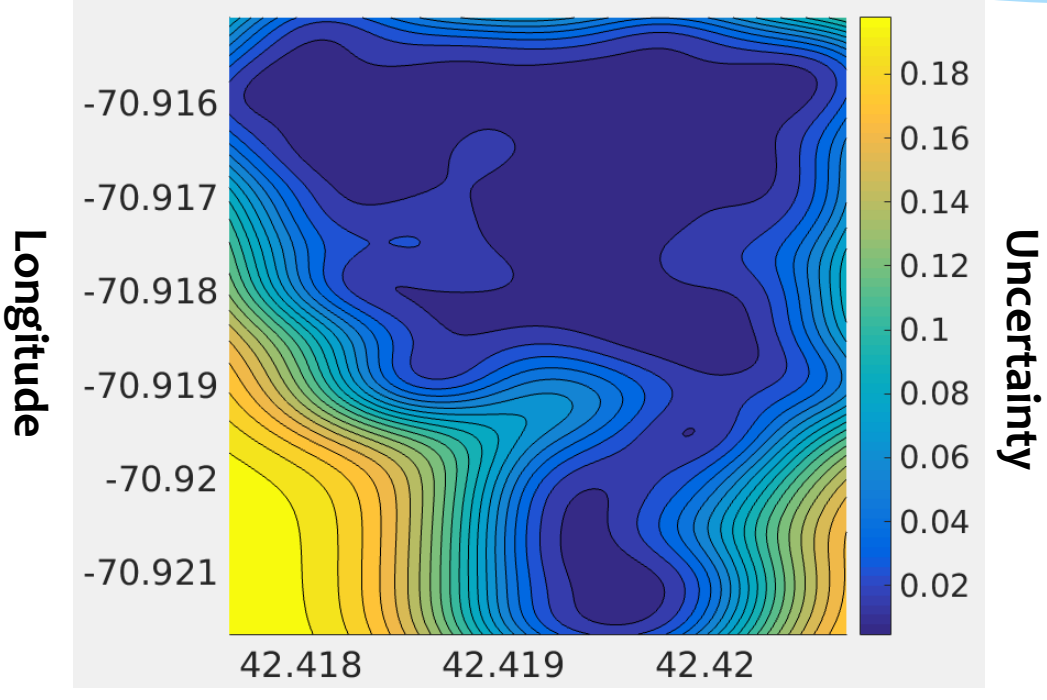


Real-Time Waypoint Updating

Eelgrass Dataset



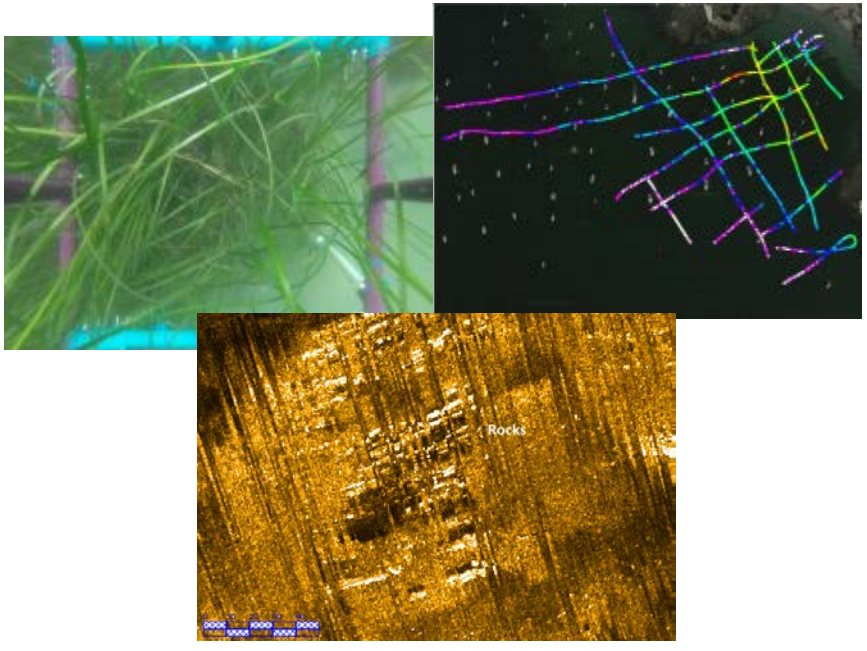
On the Fly Mission Re-planning



MIT Sea Grant
Data Management Objectives

Dissemination

- Archiving
  - Database
    - NetCDF, SQLite
- Processing
- Accessing
  - Digital Ocean
  - Google Earth
  - Exporting Data
  - Photos

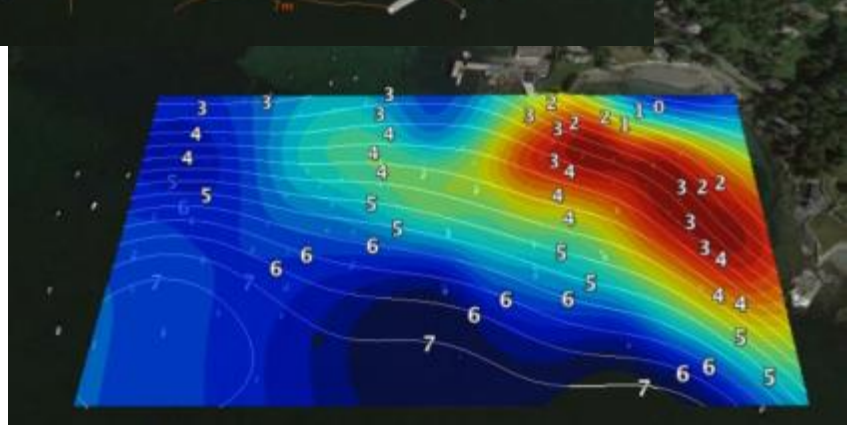


MIT Sea Grant
Data Management Objectives

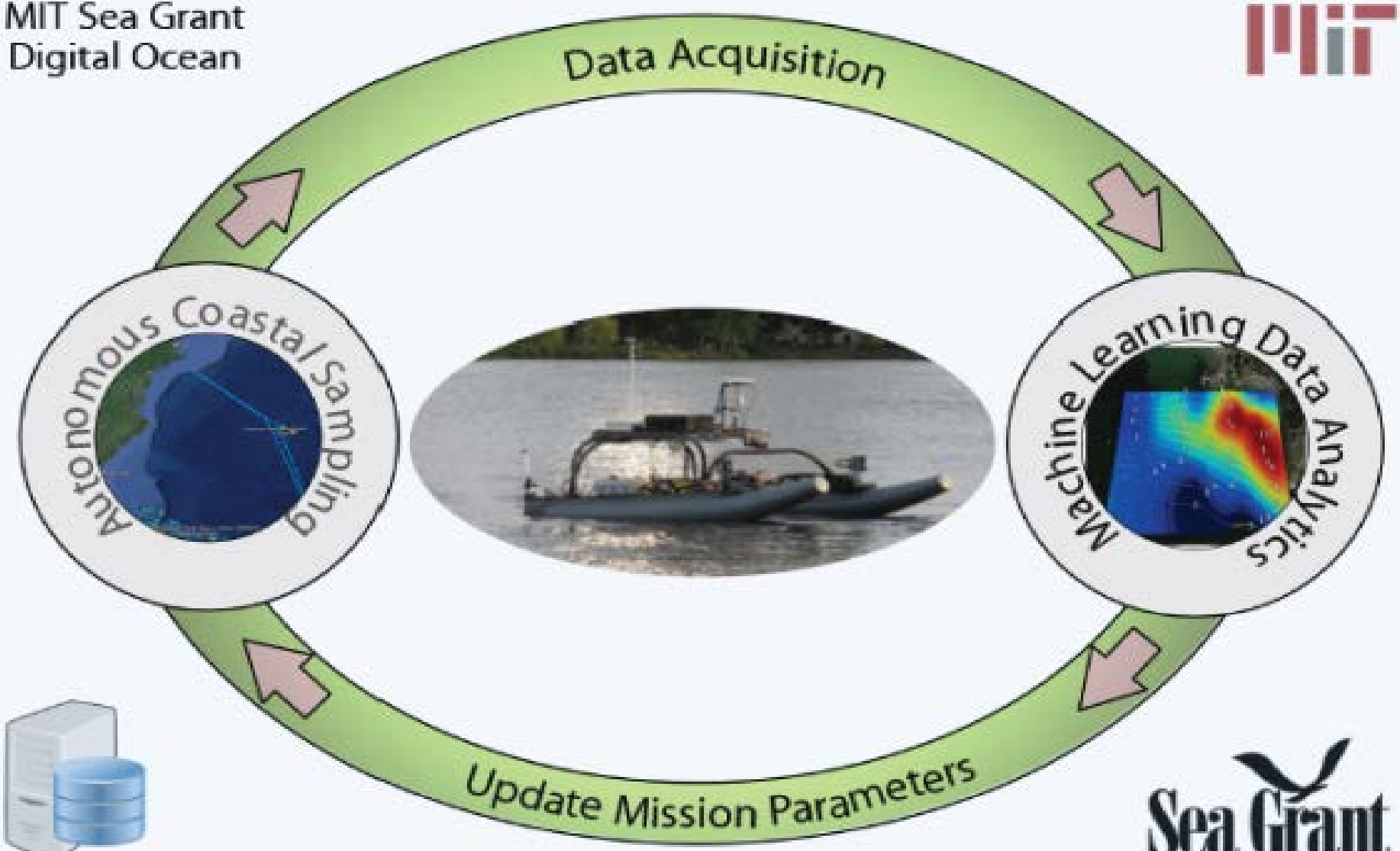
Digital Ocean

Statistical techniques

- Data assimilation
- Hydrofoil design
- Automated scene recognition



MIT Sea Grant
Digital Ocean



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