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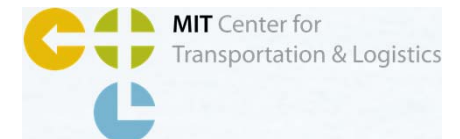
Low-Cost Covert Sensors for Remote Locations

Maritime Security Center
Stevens Institute of Technology, Hoboken, NJ
PI: Alexander Sutin
Stevens Institute of Technology

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Project Objectives –Targets

**The project aim is to extend USCG's coverage in its missions:
Drug Interdiction and Living Maritime Resources**

Targets of Interest: small boats (Lancha, Panga), Self Propelled Semi Submersibles (SPSS), and Go-fast boats)

Since October 2018 to October 2019 , Coast Guard assets have detected a total of 175 lanchas, intercepted 138 and interdicted 74.

Apr.7, 2020. Coast Guard crews consisting of air support, a small boat crew, and a cutter stopped three lanchas approximately 50 miles north of the Maritime Boundary



USCGC Mohawk and Tactical Law Enforcement Team South interdicted an SPSS on July 3, 2018.



Florida-Based Coast Guard Crew Intercepts Vessel Carrying Six Tons of Drugs



Current Detection Methods

Radar
& Cameras



Command
Center

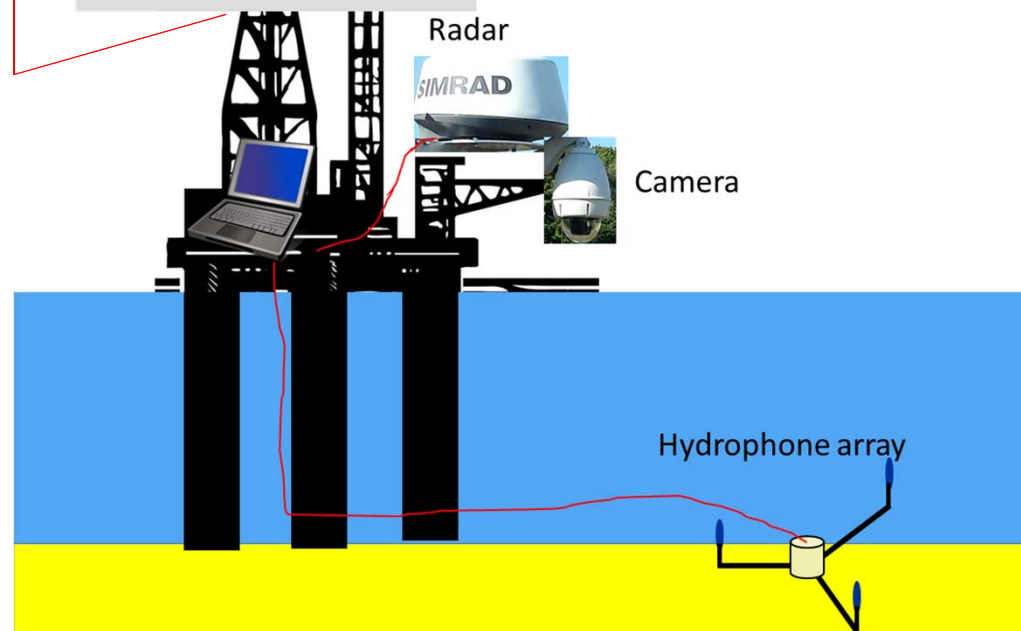


Target of
Interest

Suggested Sensor System on Oil Rig

Alert and Contact report to USCG

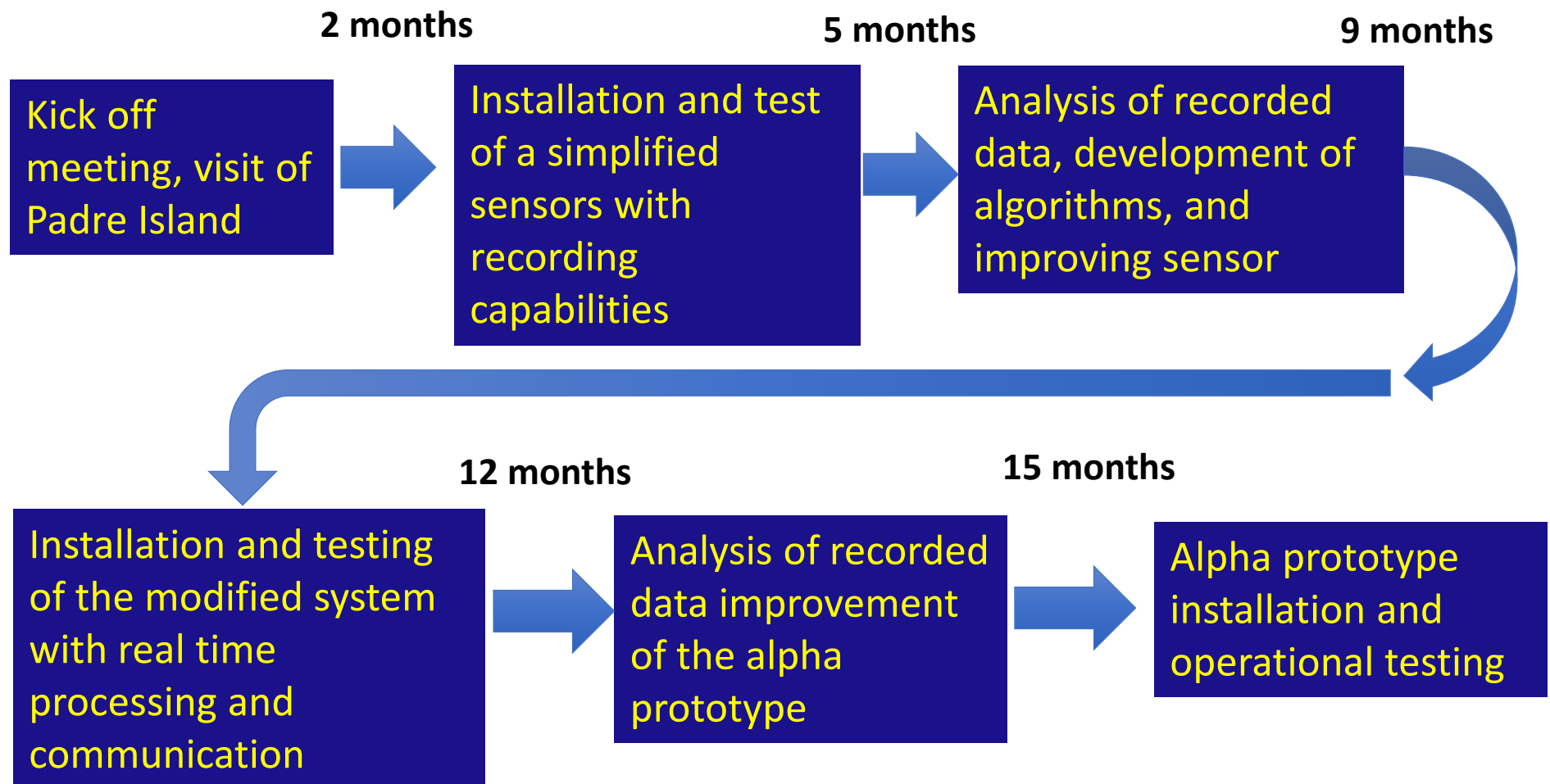
AIS, Signal processing,
Power, communication



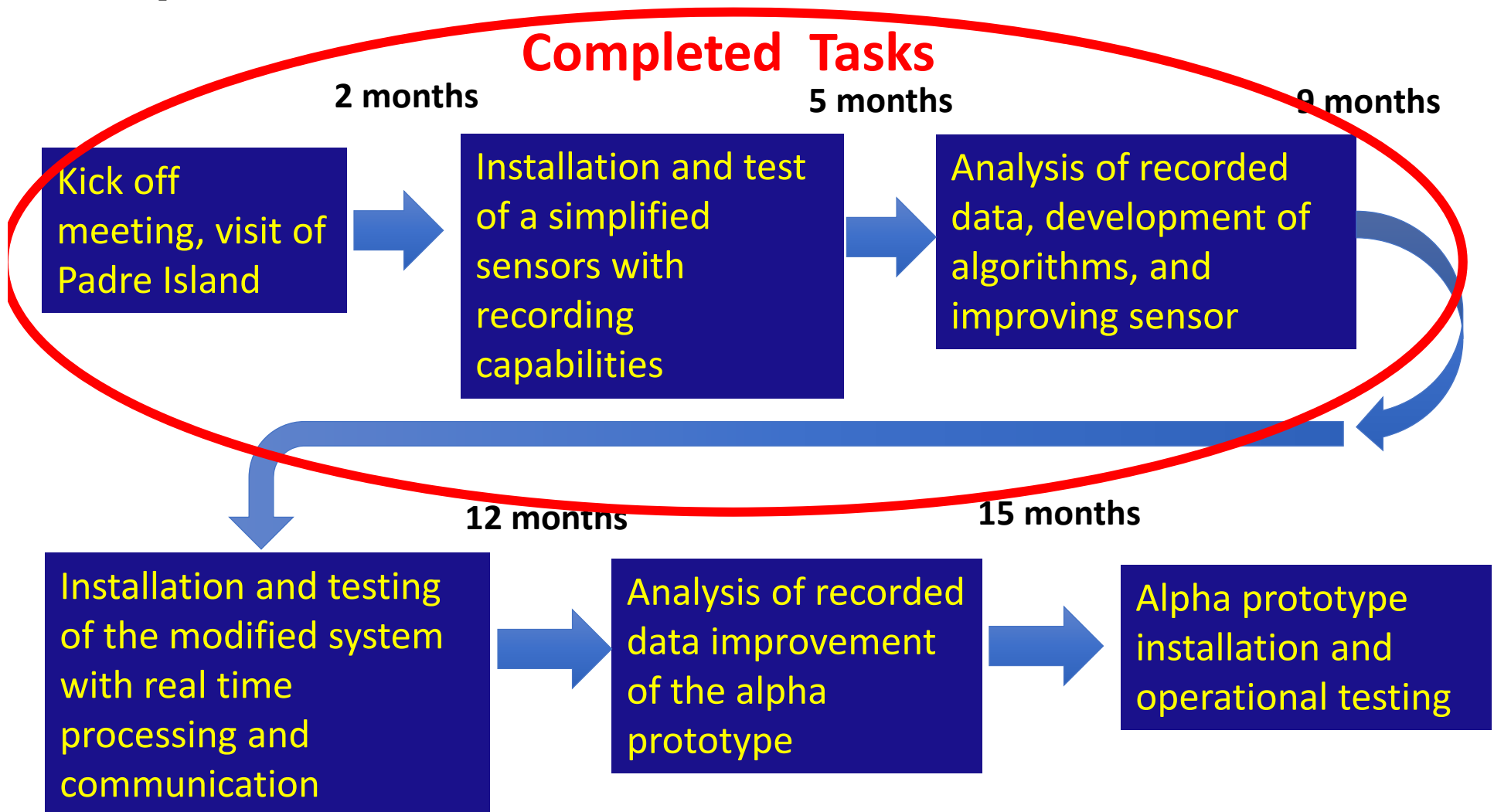
System advantages:

1. The main detection sensors are radar and acoustics. Camera is pointed to TOI by main sensors and used for classification and confirmation. AIS is used for separation of legitimate boats.
2. The system is autonomous. It does not require man in the loop. The system sends an alert and contact report with target images.
3. Acoustic sensors have longer coverage than radar and allow detection of SPSS. SPSS are loud and can be detected at long distances (up to 40 km)

Graphical Structure of the Planned Work

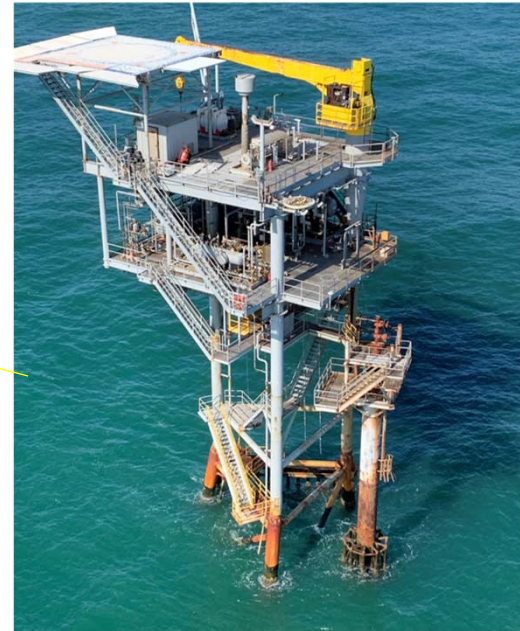
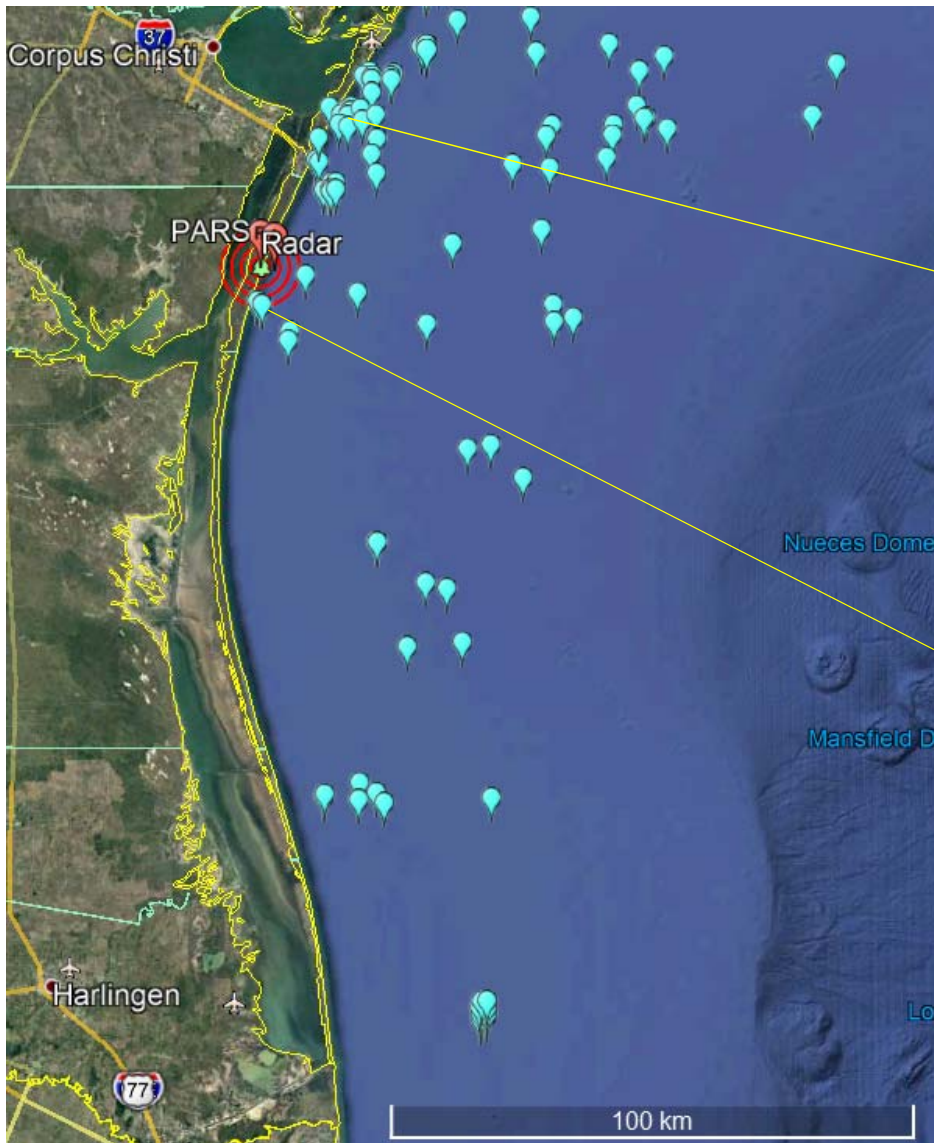


Graphical Structure of the Planned Work



Completed Task

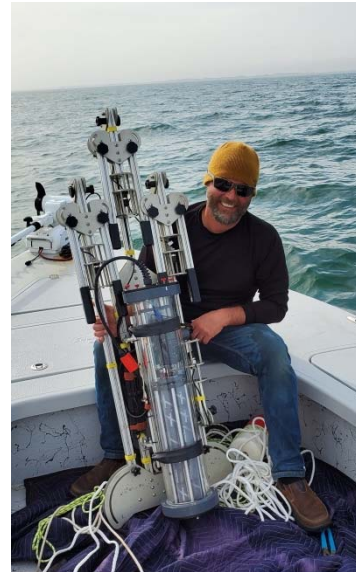
Oil Rig inspection and test side choosing



Completed Task

Padre Island Test Deployment

Acoustic recording system

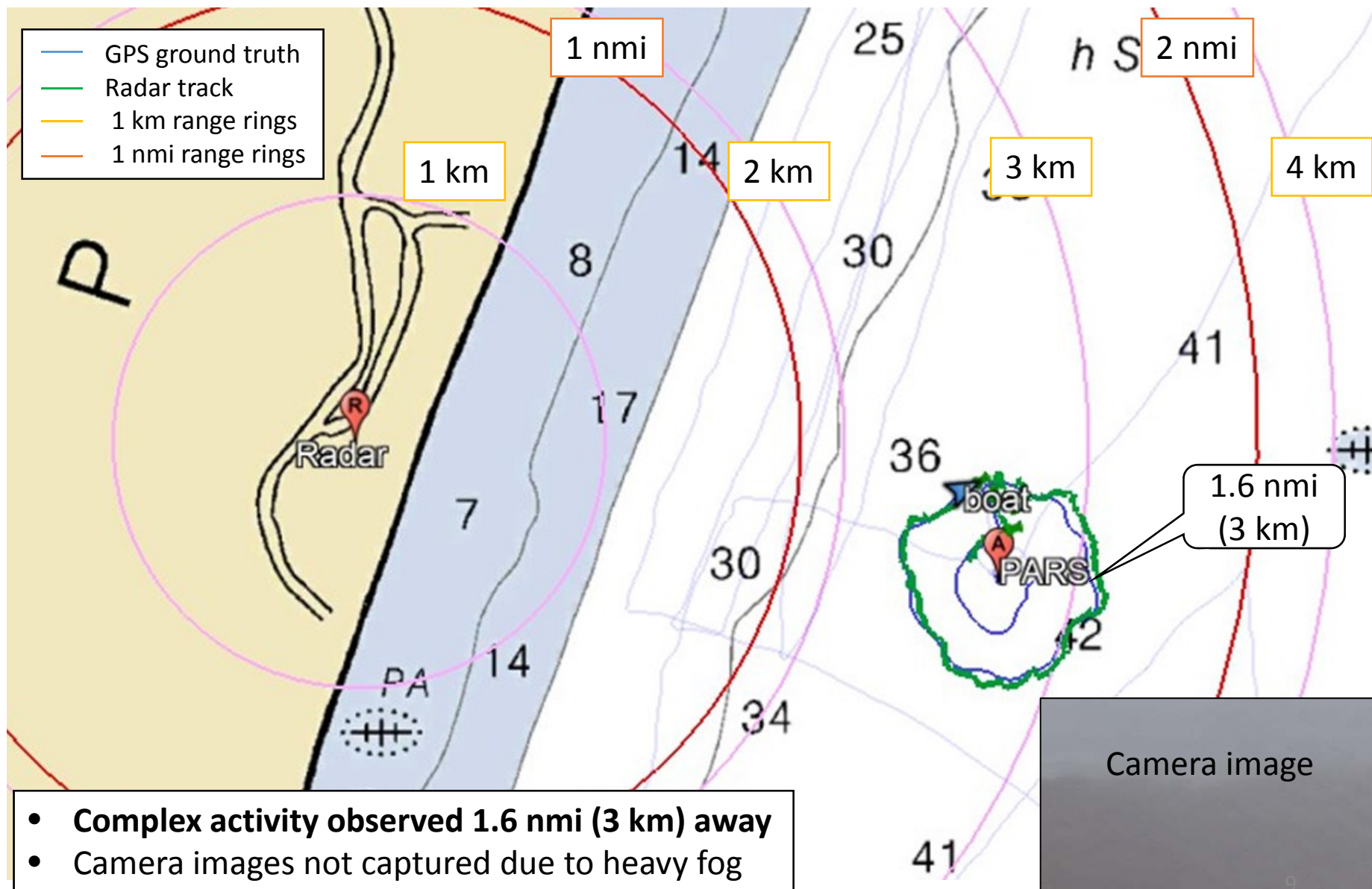


Boat for test and acoustic deployment



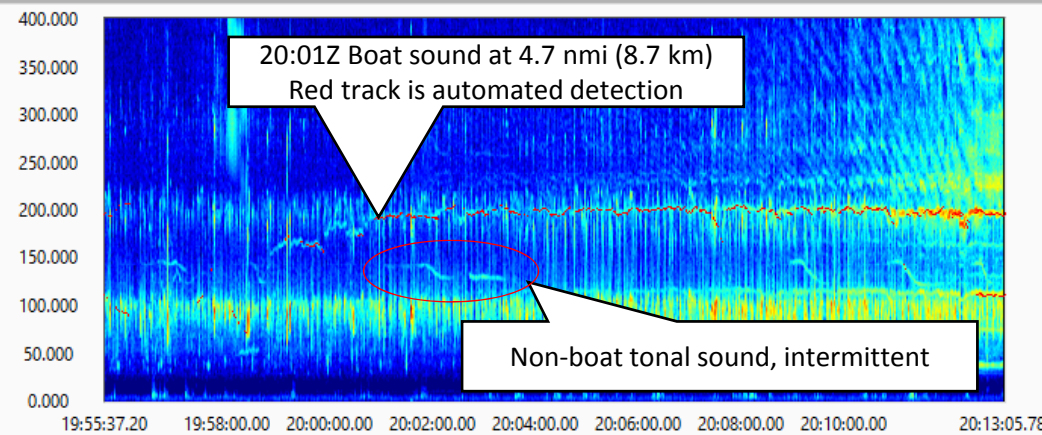
Completed Task

Example Track of Target Acquired by Radar

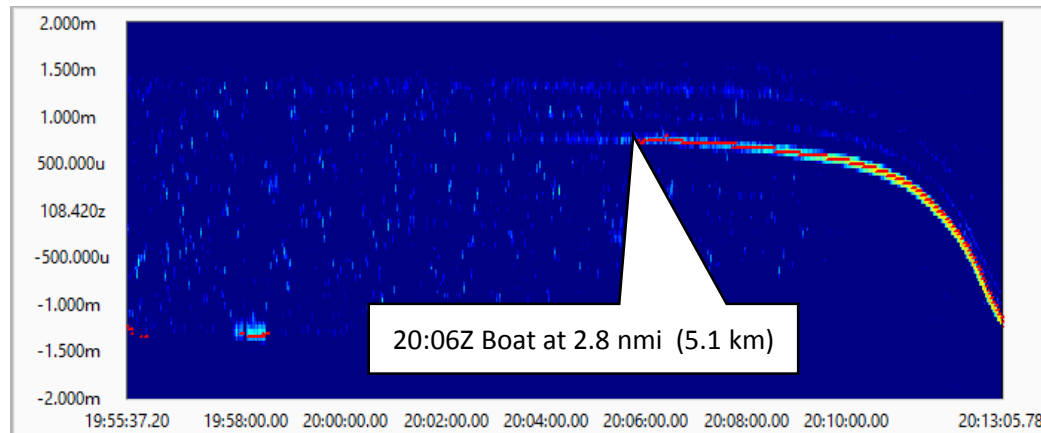


Acoustic and Optical Data

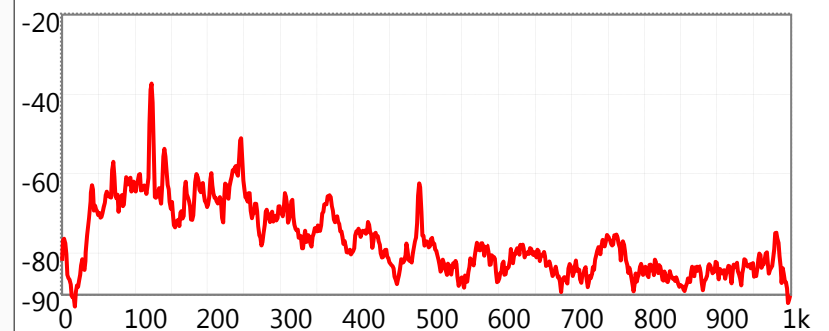
Spectrogram showing presence of boat sound



Cross-Correlation signal showing bearing to the target



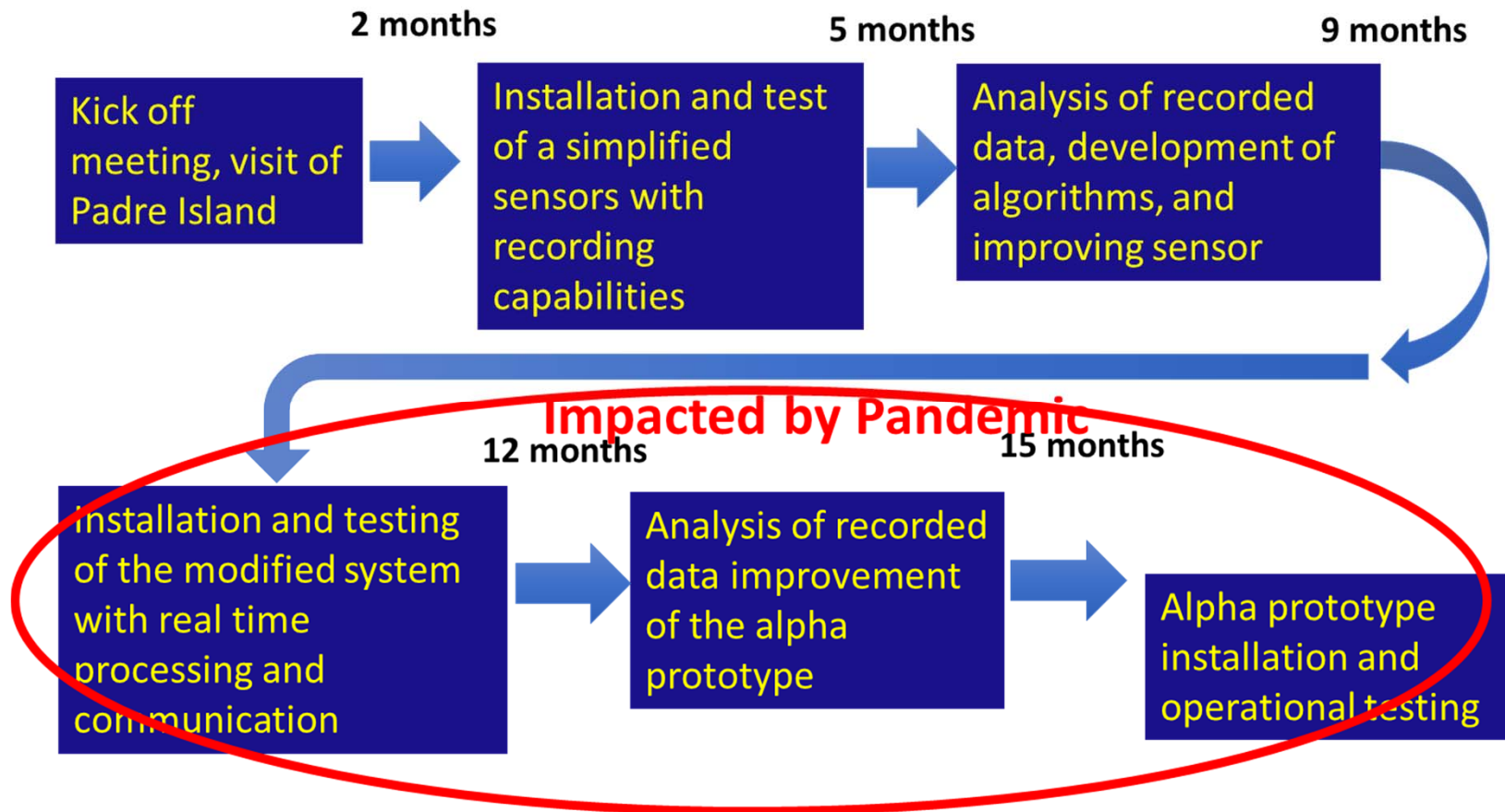
Acoustic signature of the boat,
Detection distance ~8.7 km



Optical image at 0.8 km in fog



Graphical Structure of the Planned Work



Two contingency plans:

1. Plan if the laboratory is opened on June 1. Back as planned with minimal modifications.
2. Flexible plan contingency depending on time of opening, travel restrictions, and site availability.

Contingency Plan – Milestones if the lab is opened on June 1

Original Date	Original Milestone	Status Modification	Contingency Plan #1 if the lab is opened on June 1
Kickoff 9/19/19	M1 Kickoff Meeting	Completed	
10/19/20 - 11/19/20	Task 1 - Site Visit: Padre Island (1-2 months)	Completed	
2/19/2020	Task 2 - Installation and Conduct Recordings	Completed	
3/19/20	Task 3 - Preliminary analysis of the data recorded during the test.	Completed	
05/19/20	Task 4: (Months 3 - 8) Develop prototype algorithms for data fusion, including alert to USCG. Build the new prototype of passive acoustic system (modify	Delayed.	The development of prototype algorithms will be delayed to 6/30/20. The modified acoustic system will be ready on 08/15/20
05/19/20	M2: (Month 8) The experimental sensor suite for detection and tracking of small boats.	Delayed.	M2: (Month 8) The experimental sensor suite will be ready for test on 09/01/20
6/19/20 - 9/19/20	Task 6: June -Sept (Months 9-12) Installation and long term prototype system test at Padre Island oil rig.	Modified	Installation of the prototype system at Padre Island oil rig or other place chosen by the USCG will be delayed to 09/15/20.

Contingency Plan – Milestones if the lab is opened on June 1 (continuation)

Original Date	Original Milestone	Status Modification	Contingency Plan #1 if the lab is opened on June 1
3/19/2021	Task 10 - At the end of the project, the developed alpha prototype may be left at the USCG location in Corpus Christi and may be used for the detection of illegal boats in this area.	Modified	With shored time for the system development the alpha prototype may not be ready to be left at the USCG location in Corpus Christi.
3/19/2021	Task 11- Prepare suggestions for future work		Task will be completed on time
3/19/2021	M4 - The sensor suite prototype will be capable of operating in an unattended mode		Task will be completed on time.
3/19/2021	Performance Metric 2: Acoustic, radar and optical signatures will be collected for at least 50 boats of various types .	Modified	Task will be completed on time but the collected data base will include less number of boats (15-20)
3/19/2021	Performance Metric 3: Prototype system evaluation according to System Usability Scale conducted by the USCG personnel.		Task will be completed on time.

Flexible Contingency Plan

COVID impact to work	Work modification and contingency plan
Possible delay or cancellation of the field tests in Padre Island.	Conduct field tests in the Hudson River. Test in the Padre Island taking into account quarantine restrictions.
Delay with the equipment development and manufacturing.	Conduct equipment development and manufacturing at homes of team members. Bring required tools from the lab.
Problem of implementation of the developed software to the sensor hardware and testing of the developed software with the hardware.	This work can be done using necessary precautions – two engineers in the laboratory wearing masks and gloves.

Contingency Plan – Working Home

Acoustic system frame
building



Sensors and electronic manufacturing



Current work – contingency plan

Tests at Hudson River

Current view



Water traffic before pandemic



Current work – contingency plan

Stevens/MSC Sensor Suite Looking at Hudson River and Data Collected

**Two radars, optical
and InfraRed Cameras**



Radar and video



Small boat at 2 km distance

IR



Optical



Example of Radar Track and Images Captured

Small police boat. Radar tacking up to 2.32 nmi (4.3 km)

2020_04_08_16_11_18.190_Az84.2_T-2.5_D911_HFOV20_ID0000889872.jpg



2020_04_08_16_12_38.753_Az146.6_T-1.7_D1319_HFOV20_ID0000889872.jpg



2020_04_08_16_16_07.653_Az181.0_T-0.5_D4290_HFOV13.5_ID0000889872.jpg



Map Length:	2.32	Nautical Miles
Ground Length:	2.32	
Heading:	181.34 degrees	

Concept of Contact Summary Report for Command Center



Information presented to the command center after Target of Interest (TOI) detection by **radar**:

Alert, TOI track, TOI images

Information presented to the command center after Target of Interest (TOI) detection by **acoustic system**:

Alert, TOI direction, TOI images

Contact summary: 2020-04-04 17:01- 17:07

Reference: 000073752 AIS ID: Unknown
Track range: 0.7 - 1.2 km

History of activity



Associated images



New contact: 2020-04-04 17:01

Reference: 000073752 AIS ID: Unknown
Track range: 1.2 km
Acoustic detection: yes



Engagement with End Users



- Work suggestions came for USCG Sector Corpus Christy. Stevens team visited Corpus Christy in February 2017 and in October 2019. CG CC provided information about Targets of Interest (Lanchas), conducted helicopter surveillance of oil rigs, provided assess to the land deployment side.
- Presented project milestones to Sector CC Commander
- Shared test plans, preliminary test results, and test report with USCG Champion and Sector CC



Transition of Project's Outcomes



- The low-cost sensor suite consisting of **Radar, Camera and AIS** with the developed software for automated boat detection and tracking is almost ready. The cost of the sensors and computer is about **\$6k** . Solar power and communication may be additional.
- The full system includes **an acoustic sensor** that provides longer coverage, detection of Semi Submersibles and classification of targets based on acoustic and optical signatures. The estimated cost of SPADES with a cable connection is \$20k. It requires sensors on the sea bottom and a land-based computer. Oil rig is the best place for the system deployment.
- The acoustic and optical systems can be installed on Navigation (ATON) or meteorological buoys (Radar may not)
- A prototype will be ready for transition at the end of the project. Currently evaluating best transition path (patent, licensing, etc.)

Anticipated Impact of the Project



The developed sensor suite will allow improving surveillance in the ocean and provide **persistent** detection of smuggling boats and SPSS in the proximity of oil rigs. An effective, low-cost solution will be available for Maritime Law Enforcement in areas that are typically not consistently covered.

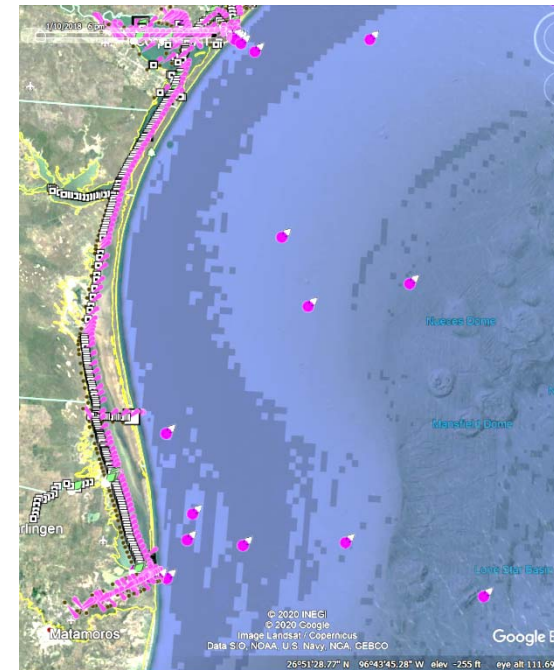
Acoustic sensors can be deployed on existing buoys and various Unmanned Surface Vehicles in the areas where surveillance is required.



Meteorological buoy



ATON buoys in Padre Island area



Plans for the Next Year



All milestones with modification will be completed in the next project period.

The project is expected to end **on March 19, 2021**. At the end of the project the alpha prototype of the system can be deployed and tested on oil rig or in the Hudson River.

Several options may be considered for future activities:

- Modification of sensor suite for installation on available buoys and USVs.
- Increasing the detection range of the land-based system with radar and camera, including the addition of an IR camera to the system, and preparation of documentation for system transition.
- Development of software for localization of TOI using triangulation from several acoustic sensors.

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