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.

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

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

Radar & Cameras

Command Center

Target of Interest
**Alert** and Contact report to USCG

**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

- **2 months**
  - Kick off meeting, visit of Padre Island
  - Installation and test of a simplified sensors with recording capabilities

- **5 months**
  - Analysis of recorded data, development of algorithms, and improving sensor

- **9 months**
  - Installation and testing of the modified system with real time processing and communication

- **12 months**
  - Analysis of recorded data improvement of the alpha prototype

- **15 months**
  - Alpha prototype installation and operational testing
Graphical Structure of the Planned Work

Completed Tasks

- Kick off meeting, visit of Padre Island
- Installation and test of a simplified sensors with recording capabilities
- Analysis of recorded data, development of algorithms, and improving sensor
- Installation and testing of the modified system with real time processing and communication
- Analysis of recorded data improvement of the alpha prototype
- Alpha prototype installation and operational testing
Completed Task

Oil Rig inspection and test side choosing
Padre Island Test Deployment

Completed Task

Camera

Radar

Acoustic recording system

Boat for test and acoustic deployment
Completed Task

Example Track of Target Acquired by Radar

- Complex activity observed 1.6 nmi (3 km) away
- Camera images not captured due to heavy fog
Acoustic and Optical Data

**Spectrogram showing presence of boat sound**
- 20:01Z Boat sound at 4.7 nmi (8.7 km)
- Red track is automated detection
- Non-boat tonal sound, intermittent

**Cross-Correlation signal showing bearing to the target**
- 20:06Z Boat at 2.8 nmi (5.1 km)

**Acoustic signature of the boat, Detection distance ~8.7 km**

**Optical image at 0.8 km in fog**
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

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

<table>
<thead>
<tr>
<th>Original Date</th>
<th>Original Milestone</th>
<th>Status Modification</th>
<th>Contingency Plan #1 if the lab is opened on June 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/19/2021</td>
<td>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.</td>
<td>Modified</td>
<td>With shortened time for the system development the alpha prototype may not be ready to be left at the USCG location in Corpus Christi.</td>
</tr>
<tr>
<td>3/19/2021</td>
<td>Task 11 - Prepare suggestions for future work</td>
<td></td>
<td>Task will be completed on time.</td>
</tr>
<tr>
<td>3/19/2021</td>
<td>M4 - The sensor suite prototype will be capable of operating in an unattended mode</td>
<td></td>
<td>Task will be completed on time.</td>
</tr>
<tr>
<td>3/19/2021</td>
<td>Performance Metric 2: Acoustic, radar and optical signatures will be collected for at least 50 boats of various types.</td>
<td>Modified</td>
<td>Task will be completed on time but the collected database will include less number of boats (15-20)</td>
</tr>
<tr>
<td>3/19/2021</td>
<td>Performance Metric 3: Prototype system evaluation according to System Usability Scale conducted by the USCG personnel.</td>
<td></td>
<td>Task will be completed on time.</td>
</tr>
</tbody>
</table>
## Flexible Contingency Plan

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

<table>
<thead>
<tr>
<th>Contact summary: 2020-04-04 17:01-17:07</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference: 000073752  AIS ID: Unknown</td>
</tr>
<tr>
<td>Track range: 0.7 - 1.2 km</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>History of activity</th>
<th>Associated images</th>
</tr>
</thead>
</table>

Information presented to the command center after Target of Interest (TOI) detection by acoustic system:
- *Alert*, *TOI direction*, *TOI images*

<table>
<thead>
<tr>
<th>New contact: 2020-04-04 17:01</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference: 000073752  AIS ID: Unknown</td>
</tr>
<tr>
<td>Track range: 1.2 km</td>
</tr>
<tr>
<td>Acoustic detection: yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>New contact images</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Image 1]</td>
</tr>
<tr>
<td>![Image 2]</td>
</tr>
</tbody>
</table>
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.
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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