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Enhanced Person in the Water Detection

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16. Abstract (MAXIMUM 200 WORDS)

A persistent challenge of the Search and Rescue mission is the difficulty of finding a person floating in the open ocean, waiting for rescue. The conspicuity of a floating person is a statement of how well that combination of person and floatation device is noticed by a human observer. This project focused on improving the detectability of a person in the water and used a subjective but quantifiable assessment of conspicuity to achieve a rank ordering process. That process was then applied in the down selection of prototypes solicited from the public in a prize challenge for improving detectability.

The primary activity of this project was the three-phase execution of a DHS S&T-sponsored prize competition; "U.S. Coast Guard Ready for Rescue Challenge." Phase I sought to cast a wide net for novel but practical concepts for improving detectability. If new options became available for reasonable cost, comfort, and usability, then rescue at sea could be a more manageable problem. The Phase II judging panel down selected the list from Phase I by identifying prototypes that could be developed further using available prize competition funding. Phase III included an evaluation in an open water field exercise.

This effort demonstrated the value of running prize competitions to foster innovative design solutions that can help reduce mariner risk with low-cost PFD enhancements. In addition, the conspicuity testing results related to patterns, colors, and intensities add to the existing body-of-knowledge and provide a framework that the Office of Design and Engineering Standards, Lifesaving and Fire Safety Division (CG-ENG-4) can use to monitor commercial product advancements that support Search and Rescue.

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The field event observers, reviewers, and subject matter experts;

The Aviation Training Center for the early contribution that initiated ideas and paths to success for developing enhancements to PFDs for observations from air assets;

The Coast Guard Auxiliary for contributing their expertise, time and vessels towards the success of the open water field event; and

Sector Long Island Sound, USCGC COHO crew and Air Station Cape Cod, HC-144 crew.

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EXECUTIVE SUMMARY

A persistent challenge of the Search and Rescue mission is the difficulty of finding a person floating in the open ocean, waiting for rescue. Wearing a life jacket or personal floatation device (PFD) may decrease the likelihood of drowning, but it does not imply an increase in probability of detection. In this project, the Coast Guard Research & Development Center (RDC) facilitated private sector development of lower-cost opportunities to enhance the detectability of search targets.

The project goal was to research technology enhancements that would increase the conspicuity of a person wearing a PFD and subsequently increase probability of detection. The research is related to previous studies on how to improve conspicuity with variations of patterns, colors and intensities. One project objective was to crowd source ideas for enhancements to the existing basic PFD with an affordable aftermarket purchase, with the intent that a PFD with such a device could also improve detection.

In January 2018, the Department of Homeland Security Undersecretary for Science and Technology (USST) approved the "U.S. Coast Guard Ready for Rescue Challenge" to be posted on the DHS S&T prize challenge website www.challenge.gov. Support for this project came from the project Sponsor; Office of Design and Engineering Standards, Lifesaving and Fire Safety Division (CG-ENG-4) and numerous USCG Headquarters stakeholders. There were three phases of the challenge competition offering $258,000 in cash awards. Phase I resulted in five awards of $5,000 each to the highest scoring entries. In addition, 16 honorable mentions were acknowledged. Of the finalists from Phase I, 13 accepted the invitation to participate in the Phase II "Piranha Pool" (March 2019) during which the entrants competed for additional prize money totaling $123,000 to support development of their prototypes. Four finalists competed in the Phase III open water field event for an additional $110,000 in prize funding to further develop their prototypes towards commercialization. The field event included a total of 19 observers, an 87' Patrol Boat, an HC-144 fixed wing aircraft, and four CG Auxiliary (AUX) vessels. The individual results are not provided in this report in order to protect Intellectual Property (IP) rights.

All four finalists made significant strides towards developing a commercial product within the price range (~$25) specified for general public accessibility. Each finalist gained valuable technical information throughout the prize competition with regard to improving their product. Finalists were provided the invaluable opportunity to field their prototypes with CG assets under realistic maritime conditions, and they have continued developing their prototypes towards improvement and commercialization.

In addition, the conspicuity testing results related to patterns, colors, and intensities add to the existing body-of-knowledge and provide a framework that CG-ENG-4 can use to monitor commercial product advancements that support Search and Rescue.

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TABLE OF CONTENTS

ACKNOWLEDGEMENTS ... v

EXECUTIVE SUMMARY ... vii

LIST OF FIGURES ... x

LIST OF TABLES ... x

LIST OF ACRONYMS AND ABBREVIATIONS ... xi

1 PROJECT BACKGROUND AND OVERVIEW ... 1

2 SELECTION OF FINALISTS FOR the FIELD EVENT ... 1

3 FIELD EVENT PLAN AND EXECUTION ... 2

3.1 Risk Mitigation ... 3
3.2 Field Event Configuration ... 3
3.2.1 Communication and Coordination ... 4
3.2.2 Scoring Method and Data Planning ... 5
3.3 Prototype Entries for Competition ... 7

4 RESULTS ... 9

5 CONCLUSIONS ... 13

6 REFERENCES ... 14

LIST OF FIGURES

Figure 1. Surface and air configuration. 6
Figure 2. SeeRescue system (left) as deployed (right). 7
Figure 3. Rescue Tracer (specific prototype photo not authorized by entrant). 8
Figure 4. Lumenus light system with phone application control (left) as deployed (right). 8
Figure 5. Visual Extender as deployed. 9
Figure 6. Niantic Bay on 24 Sept 2019 from CGC COHO. 10
Figure 7. Aircraft at 1000ft ~2.0 NM (87’ Cutter is in center field of view). 11

LIST OF TABLES

Table 1. Constraint Criteria Phase I. 3
Table 2. Scoring Criteria Phase III. 3
Table 3. Summary of latitude and longitude positions, call signs and communication channels. 4
Table 4. Coordination schedule of events. 5
Table 5. Weather data at start (1500 local). 10

LIST OF ACRONYMS AND ABBREVIATIONS

AIS	Automatic Identification System
AUX	U.S. Coast Guard Auxiliary
HC-144	Fixed wing aircraft
CG	Coast Guard
CGC	Coast Guard Cutter
CG-ENG-4	Coast Guard Office of Design and Engineering Standards, Lifesaving and Fire Safety Division
Ch (CH)	Channel for radio transmission, an assigned band of frequencies
DHS	Department of Homeland Security
ePIW	Enhanced Person in the Water
ft	Feet unit of measurement
GHz	GigaHertz, one billion cycles per second
HSIN	DHS Homeland Security Information Network
Hz	Hertz, a unit of frequency (#/sec)
IP	Intellectual Property
IR	Infrared
KDP	Key Decision Point
Kt	Knot
Lat	Latitude
lb	Pound, unit of weight
LOB	Line of Bearing
Lon	Longitude
MHz	MegaHertz, one million cycles per second
MMSI	Maritime Mobile Service Identity
NDA	Non-Disclosure Agreement
NE	Northeast direction
NM	Nautical mile
NW	Northwest direction
PFD	Personal Flotation Device
PIW	Person In the Water
Q&A	Questions and Answers
RADAR	RAdio Detection And Ranging
RDC	Research and Development Center
RF	Radio Frequency

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

S&T	Science and Technology
SAR	Search and Rescue
SE	Southeast direction
SW	Southwest direction
USCG	United States Coast Guard
USCGA	United States Coast Guard Academy
VHF	Very High Frequency
Yds	Yard, unit of length
µm	Micrometer, (one millionth of a meter)
USST	Undersecretary for Science and Technology

1 PROJECT BACKGROUND AND OVERVIEW

This project facilitated private sector development of lower-cost opportunities to enhance the detectability of search targets. The primary activity of this project was the three-phase execution of a DHS S&T-sponsored prize competition; "U.S. Coast Guard Ready for Rescue Challenge." Phase I sought to cast a wide net for novel but practical concepts for improving detectability. If new options became available for reasonable cost, comfort, and usability, then rescue at sea could be a more manageable problem. The Phase II judging panel down selected the list from Phase I by identifying prototypes that could be developed further using available prize competition funding. Phase III included an evaluation in an open water field exercise.

This report describes the Phase II & III execution and results. The Phase I Ready for Rescue Prize Competition Report (Connelly et al., 2018) described the prize challenge process and Phase I results. As each participant entered Phase II, they were required to sign a Non-Disclosure Agreement (NDA). The NDA was executed to protect the Intellectual Property (IP) of all the entrants. Throughout the entirety of the project from January 2017 to February 2020, DHS S&T and RDC Legal Counsel addressed questions as well as provided critical guidance on documentation and interactions. The project Sponsor from the Office of Design and Engineering Standards, Lifesaving and Fire Safety Division (CG-ENG-4) participated in the project as a panel judge as well as a field observer during the exercise.

Execution of the Phase III open water field exercise included the experimental design of the test objects as well as Coast Guard vessel and aviation assets needed to execute the evaluation. Judging criteria was also developed to ensure each entrant was fairly evaluated. Research also included reviewing conspicuity studies developed by RDC, the Marine Technology Society, Rochester Institute of Technology, and U.S. Naval Medical Research Laboratory. Conspicuity was a major project consideration for both the judging of prototypes, and for providing guidance to the finalists as they developed their prototypes. This project used the studies and materials from these organizations to formulate the approach to the scoring criteria. The Marine Technology Society Report, September 1996 "Enhancing the Conspicuity of Personal Watercraft," by Milligan and Tennant provided a basis for the field event scoring method. Halsey, R.M. et al., (1955) and Fuller et al., (2006), provided a benchmark for studies of color effectiveness. The Environmental Protection Agency Substance Registry Services Regulation also formed a basis for treatment of dye as a distress signal. The RDC reports, Lewandowski et al., (2019), (2017), and (2015) were referenced for wavelength, directed intensity measurements, and field testing configurations. With these details, the project developed a subjective but quantifiable assessment of conspicuity to achieve a rank ordered scoring process.

2 SELECTION OF FINALISTS FOR THE FIELD EVENT

RDC offered twenty-one finalists from Phase I opportunities to compete in Phase II for additional prize funding. This offer resulted in thirteen accepting the challenge of entering Phase II. In March 2019, the Phase II selection for the field exercise was held at RDC in New London, CT using DHS Homeland Security Information Network (HSIN) virtual connectivity. This network allowed setup of a communications platform to provide document sharing, chat, and video based communications. Competitors from Connecticut to Hawaii, were able to present their entries to a panel of 16 expert judges while based in their own location. The judging criteria for Phase II was driven by the requirement to have a prototype ready for a planned field event in September 2019.

The Phase II judging panel consisted of 16 members gathered into groups based on their knowledge areas. Each group was responsible for one criteria of the assessments. The selection process took place at RDC over a three day period.

Phase II scoring criteria are summarized as follows:

30%	Group 1 assessed whether the finalist understood a clear path to successfully building, manufacturing, and commercializing their idea.
25%	Group 2 assessed the finalists on their commitment to the process and their past experience that could be leveraged towards successful completion.
35%	Group 3 assessed how well the finalist understood their design and technology, and how well they considered potential improvements.
10%	Group 4 assessed the likelihood that the prototype's production could be scaled to effectively introduce it into the market for the general public.

The thirteen Phase II entrants were provided a dedicated presentation time and a Q&A period for a total of 35 minutes. A list of standard questions, plus questions customized to the competition team and prototype, were provided to all entrants in advance of the selection for the field event. Judges scored each entrant on a scale of 1- 10 (high). At the end of the three-day presentation period, the judges' results were tallied for each entrant. Subsequent meetings were held to discuss the findings, recommendations, advancement conditions, and asset support. Within two weeks the top competitors were invited to the field exercise event held in September 2019.

3 FIELD EVENT PLAN AND EXECUTION

Phase III of the prize challenge included an open water field exercise in which the finalists' prototypes selected during Phase II were evaluated. CG personnel experienced in Search and Rescue made direct observations of the prototypes in the water. Finalists prepared for the field exercise from March to September 2019, and were instructed to use the expert panel input to revise, improve, or enhance their prototype. Monthly status meetings between RDC and the entrants assisted the finalists with improvement of their designs. Reference material was provided to the finalists for prototype development as well as understanding the rationale of the judging criteria. The prototype development guidance included the constraint criteria from Phase I (Table 1) and scoring criteria for Phase III (Table 2). All finalists were provided the same information, references, and recommendations.

Table 1. Constraint Criteria Phase I.

• Visual 0.380 µm – 0.7 µm • Personal Locators signaling 406 MHz • AIS 1 161.975 MHz • AIS 2 162.025 MHz • Audio 20 Hz – 20 KHz	• Homing Beacon Frequency 121.5 MHz • Wave Infrared 3 µm – 5 µm • X Band RADAR (8 GHz – 12 GHz) • GPS 1575.42 MHz • Near Infrared .7 µm – 2 µm
Variations of dye markers, light patterns, brightness, varied form factors and colors were encouraged for prototype design	

Table 2. Scoring Criteria Phase III.

Suitability for marine use (30%)	How well does the prototype survive in the maritime environment? (i.e., how watertight is the device? Does it fall apart after an hour in the water? etc.)
Prototype maturity (15%)	How much can the prototype be improved?
Potential/commitment to publically commercialize (10%)	How likely will the team members move the prototype to market?
Conspicuity in the maritime environment for CG afloat, ashore and airborne assets (45%)	How well, how long, how easily and how distinctly can the observer assess the target? (Assessment was the basis of the field scoring.)

A Key Decision Point (KDP) Go/NoGo for prototype advancement to the field exercise was held at the beginning of September 2019. This KDP ensured that the prototypes were ready to be included in the field exercise plans, and resulted in four finalists being selected for the exercise.

3.1 Risk Mitigation

RDC planned the open water field exercise to be executed in a single 3-hour period for observation before and after sunset. The risk mitigation and safety plans included: 1) alternative vessels/aircraft if assets became unavailable; 2) alternate personnel if primary personnel became unavailable; and 3) rescheduling or cancellation if weather and/or sea conditions were unsafe.

The ePIW project team also considered the IP risk that competitors' designs, ideas, or constructions would be exposed to during the execution of the field exercise. In order to protect this information, competitors signed a NDA along with mutual agreement amongst themselves to not video or photograph, or otherwise make prototype designs available to people or entities that were not part of the field exercise.

3.2 Field Event Configuration

Technical references and previous studies of distress signals, spectral properties, and pattern analysis were used to guide the field configuration design as well as the prototype designs. Surface track spacing at ½ NM was chosen as a good range measurement for the effectiveness of distress signals given the type of prototypes that were being developed. Aircraft tracks were planned at typical search and rescue (SAR) altitudes for fixed wing assets (500' and 1000').

A minimum of four CG Auxiliary (AUX) vessels were required to monitor the four prototypes. The fifth AUX vessel would serve as a backup and if possible, encircle the target area to gain azimuthal observations of the targets. The AUX vessels served as the staging, deployment, and retrieval resource for the prototypes. The AUX crews supported the event with their knowledge of boat operations, sea conditions, and safety, as well as providing their own boats to assist.

3.2.1 Communication and Coordination

Coordination amongst the surface assets included a communications and a station keeping plan. A communications plan was established for in-situ status updates of the targets as well as coordination amongst the assets. To ensure continuous communication, all RDC personnel maintained contact via cell phone, though radio contact was the primary means of communication. Command and Control was conducted via the primary frequency (Ch. 81A) from the USCGC COHO once all assets were underway. Members were instructed to keep radio communications short and precise. If the primary frequency became congested with other mariner traffic then members would be instructed to change to the secondary frequency (Ch. 23A) as described in Table 3. Events were coordinated as shown in Table 4.

Table 3. Summary of latitude and longitude positions, call signs and communication channels.

Communications : Surface – Primary = VHF Ch. 81A | Secondary = VHF Ch. 23A | Tertiary = Cell Phone Air C144 – Primary = Cell Phone | Secondary = VHF Ch. 81A | Tertiary = VHF CH. 23A									
						Track Line North		**Track Line South**	
LOB	**Asset Name**	**Call Sign**	**MMSI**	**Lat**	**Long**	**Lat**	**Long**	**Lat**	**Long**
Center	CGC 87' COHO	Echo	366999660	41° 15.000'	72° 13.000'				
NE	Aux420	301	000000301			41° 16.383'	72° 12.000'	41° 15.700'	72° 11.000'
SE	Wauregan	398	000000398			41° 14.367'	72° 11.000'	41° 13.600'	72° 12.600'
SW	Sugar Magnolia	376	000000376			41° 14.367'	72° 14.850'	41° 13.600'	72° 13.917'
NW	SeaNile	989	000000989			41° 16.383'	72° 13.917'	41° 15.700'	72° 14.850'
NE	USCG Proto-1		000001791	41° 15.700'	72° 12.000'	Notes: These LAT/LON with +/- 100 yds (10% of ½ NM)			
SE	USCG Proto-2		000001792	41° 14.367'	72° 12.000'				
SW	USCG Proto-3		000001793	41° 14.367'	72° 13.917'				
NW	USCG Proto-4		000001794	41° 15.700'	72° 13.917'				
Circling	SeaDog	033	000000033			SeaDog to circumnavigate around entire demonstration area.			

Table 4. Coordination schedule of events.

Preparation for Field Event	
20 Sept	Go/NoGo Demonstration for Participants, Auxiliary, and Technical Teams
23 Sept	Morning All Hands at RDC for In-brief at 1000 (Safety and operations) Afternoon Q&A discussion with finalists for 25% of scoring criteria Equipment and Asset Check HC144 cleared to use Groton/New London Airport for 24 Sept Cutter COHO to dock at USCG Academy Buoy and anchor configuration completed for each prototype with spares
Field Event	
24 Sept	
1000	Equipment, gear & asset to Coast Guard Academy (CGA) and event staging area
1300	Personnel arrive at Cutter for in-brief with Cutter Crew
1400	Cutter underway to designated station for the field exercise
1500	Personnel (AUX/RDC) at staging area
1600	Boats depart to designated lat/lon to deploy prototypes
1630	Fixed Wing crew with observers at Groton/NL Airport in-brief
1715	Begin daylight observations. AUX, Cutter and HC144 begin scoring observations.
1844	Sunset – continue observations – this begins night time observations
2000	Secure from observations. AUX retrieve targets. AUX Transit back to staging area. Cutter transits back to USCGA. Fixed wing depart target area. Offload equipment and personnel. AUX debrief and release of volunteers.

3.2.2 Scoring Method and Data Planning

Field exercise observers recorded their best score for an individual observation interval of 15 minutes. Each observer was assigned five intervals. All observations and scoring occurred in a three-hour period. The AUX vessel observers recorded data for any target they were able to observe during the assigned period. Observations occurred around sunset (Sunset Time: 1844 local), transitioning from day time into night time to capture the environmental state known as thermal cross over. This time of day was chosen because both day time and night time light conditions would be present during the on-station timeframe. This timeframe was also a good representation of the cooling conditions that occur when an object is no longer reflecting (or absorbing sunlight) and begins to normalize to the temperature of the water.

The field exercise scoring criteria is described in Table 2. Each observer was asked to assess the prototypes with scores of 1-10 (high) for each of the five scoring times in the three-hour block. The guidance criteria for conspicuity was characterized by the following questions:

1) How easily can you determine that there is an object in the water?

2) How long can you maintain detection of the contact?

3) How well can you distinguish it from the background?

4) How quickly can you determine it is an object of interest?

The four finalist's scores were recorded then averaged into the weighted criteria (45% of total score) for conspicuity. The scheduled time for scoring occurred at approximately 1715, 1745, 1815, 1845 and 1915 local time. These five intervals provided two day time and two night time scores as well as one at 1815 (Sunset was 1844). The 1815 score time provided scoring opportunity for both light and dark conditions. The exercise plan had margin to extend scoring observation until 2000 local if needed. The configuration of assets described in the next section was used to maximize the likelihood under the best conditions that each target would be observed without interference.

The field exercise was designed to have observers in the air and on the surface using available Coast Guard search resources such as night vision, human eyes and ears, RADAR, electro-optics and infrared. Technical constraints imposed on prototypes included compatibility with sensors on existing CG assets as originally defined in Phase I selection criteria (Table 1). These criteria were posted in the crowd sourced challenge as well as discussed with competitors throughout the project evolution. Both the aircraft and vessel position and movement were designed to provide observation similar to the SAR mission. The observation vessels provided the platforms to observe the prototypes in close proximity or at distance. This allowed a range test observation for each prototype. The surface and air configuration is shown in Figure 1.

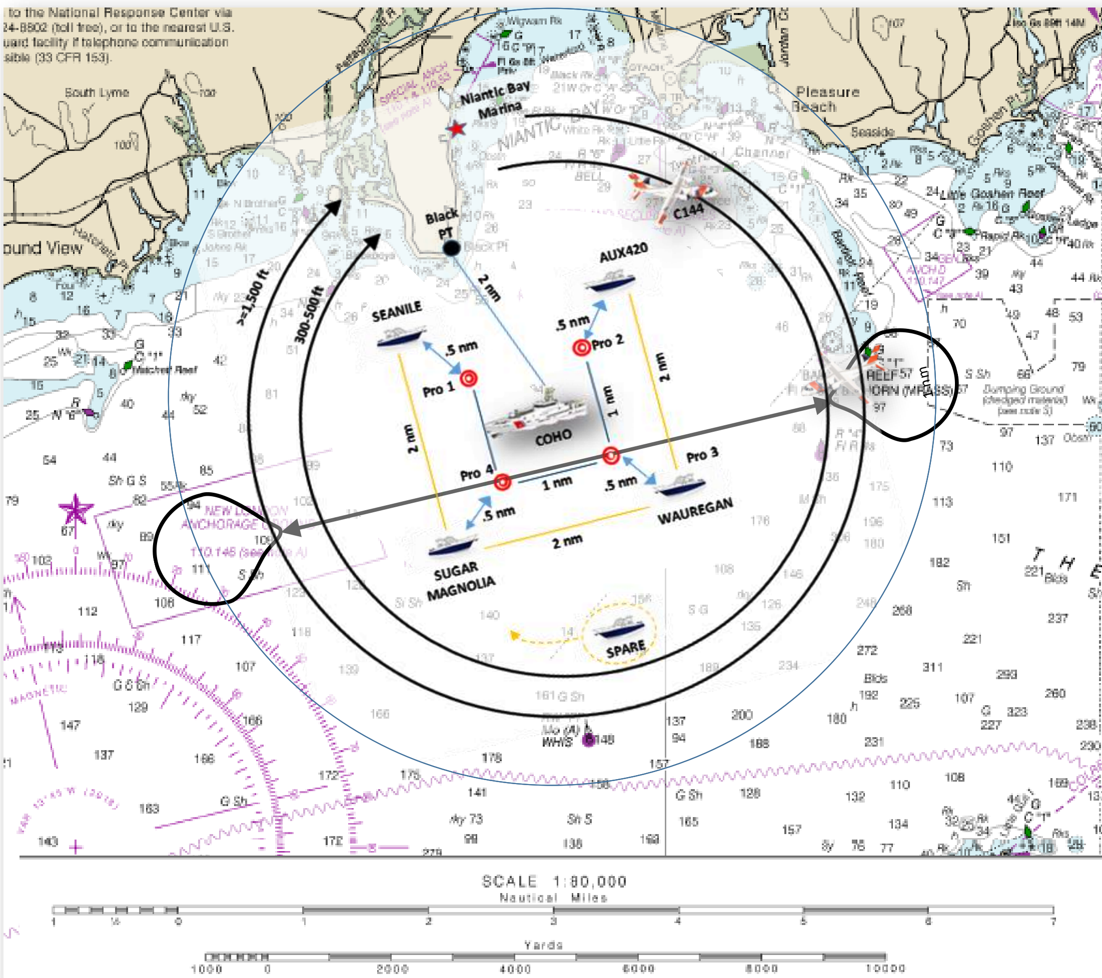

Figure 1. Surface and air configuration.

The asset position configuration afforded the observers with equal viewing opportunities of all four targets. The aircraft fixed track line provided measurement of range visibility to each target at 500’ and 1000’ at 120 knot ground speed. The aircraft teardrop pattern at 1000’ is a typical search altitude. Altitude at 500’ was designed to provide extended and azimuthal view while circling an individual target. The CGC COHO was positioned in the middle of a four-post configuration. Each corner of the square was positioned with a target and the associated AUX vessel. The AUX vessel positioning ensured the targets were functioning and providing maximum observation opportunity for the observer(s) onboard.

3.3 Prototype Entries for Competition

Four finalists were invited to compete in the September 2019 field event. The finalists were called:

SeeRescue

Rescue Tracer

Lumenus

Visual Extender

Each capability is shown in Figures 2 through 5.

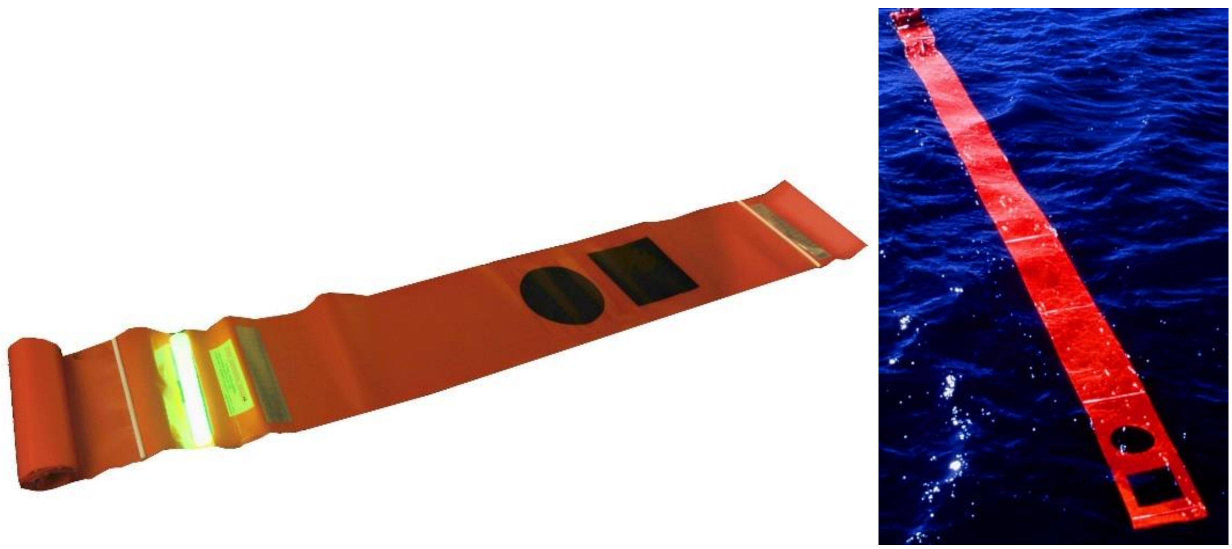

Figure 2. SeeRescue system (left) as deployed (right).

Figure 3. Rescue Tracer (specific prototype photo not authorized by entrant).

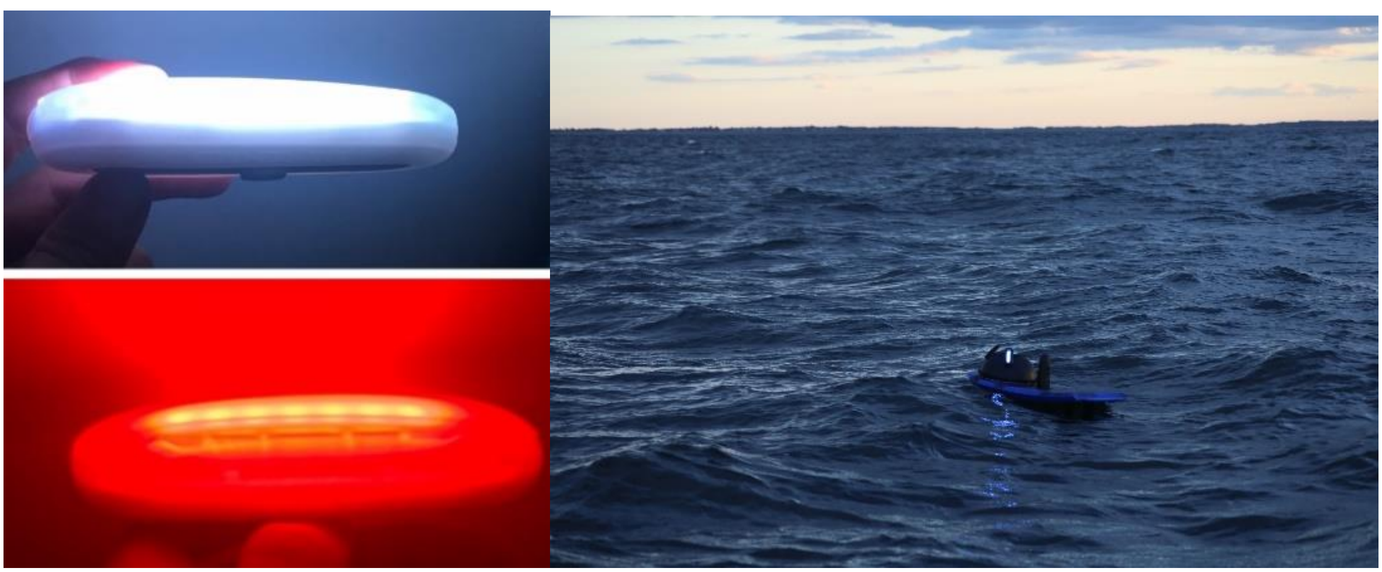

Figure 4. Lumenus light system with phone application control (left) as deployed (right).

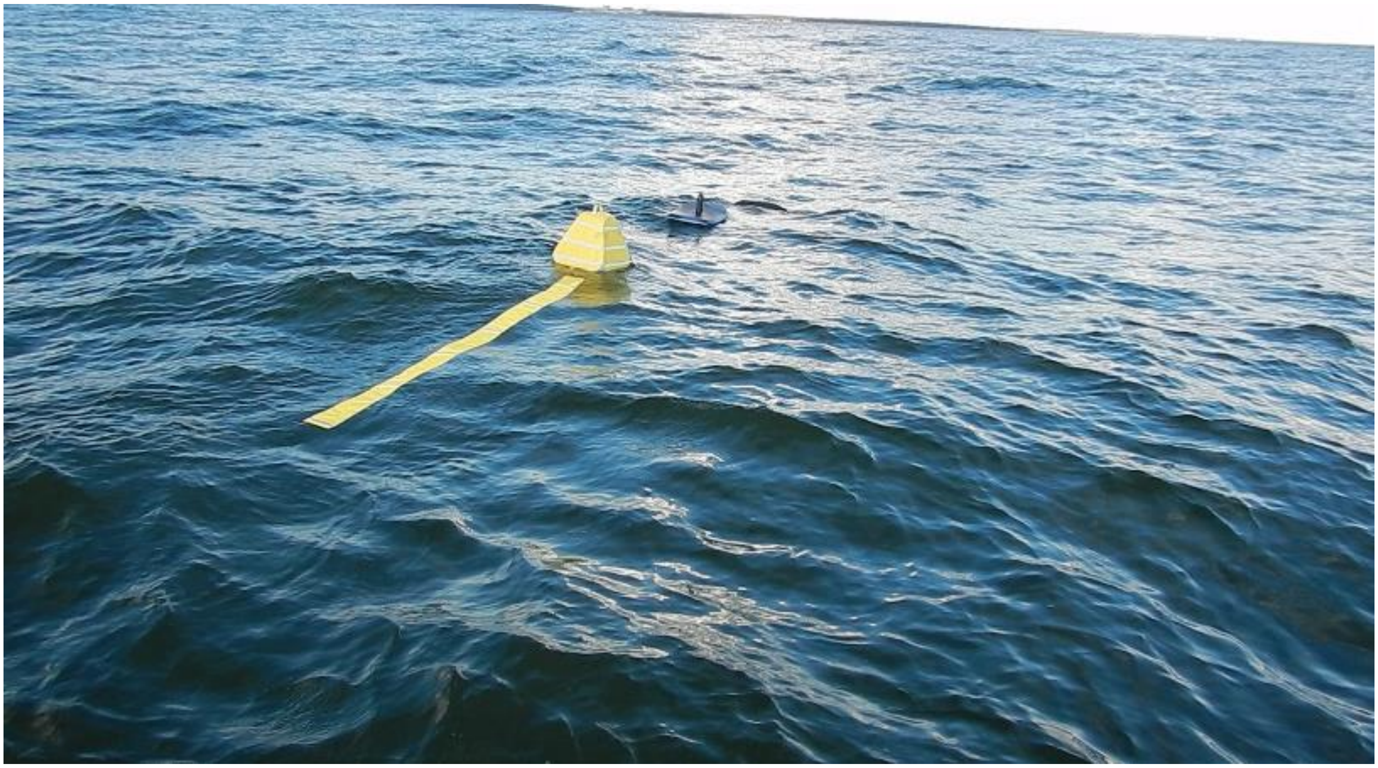

Figure 5. Visual Extender as deployed.

4 RESULTS

The field exercise was conducted on 24 Sept 2019 and was not recorded or photographed as per agreements with the entrants. All assets began observations at 1715 local. The targets in the field were visible from the air as expected for day and nighttime conditions. The aircraft pilots were not provided specific information about the targets such as form-factor or characteristics. They were asked to find something that appeared to be unusual in the field of regard. Once the pilots indicated a siting of an object, coordination with surface personnel determined which target they detected. In general, factors that enhanced detection during daylight included form-factor presence (i.e., its shape in the water), color difference from the background, and object height above water (particularly for RADAR returns). At night, distinctive factors included height of object above water (RADAR returns), flashing patterns of light, and thermal signatures (electro-optic and thermal imaging).

Figure 1 shows the relative position of the named surface assets. Two RDC observers were on the SeaNile, two on Wauregan, two on Sugar Magnolia, four in the aircraft, eight on CGC COHO, and one on AUX420. The weather parameters as determined from CGC COHO at the start of the evaluation period are summarized in Table 5. Weather monitoring began at 1500 local as the CGC COHO got underway from the pier at the Coast Guard Academy (see Table 5 and Figure 6).

Table 5. Weather data at start (1500 local).

Air Temperature	72° F
Sea Water Temperature	77° F
Visibility	Clear
Wind	17-27 kt
Wind Direction	247° +/- 15°
Current	3.2 kt SW
Barometer	29.64
Cloud Coverage	SC
Sunrise	0638 local
Sunset	1843 local
Sea Waves Direction	270°
Sea Waves Height	3’

Observers scored the observation experience on a scale of 1-10 (high). The day after the event, the team gathered and collected subjective assessments while confirming the written numerical scores provided. The data analysis was revised to consider the six sets (four questions each) recorded for each of the five observation times (1715, 1745, 1815, 1845 and 1915 local). The data analysis method considered each of the individual questions as contributing scores rather than an observer set as a single weighted score. All scores and subjective assessments were considered in the final scoring results.

Figure 6. Niantic Bay on 24 Sept 2019 from CGC COHO.

Figure 7 shows the good weather conditions from the air about 30 minutes before sunset. The picture helps to illustrate the real world challenge of finding a target the size of a person's head in the vast ocean by showing how small an 87 foot Cutter appears to an aircraft observer at typical search altitude.

Figure 7. Aircraft at 1000ft ~2.0 NM (87' Cutter is in center field of view).

During the field exercise, three foot seas added a substantial challenge to the observers on CGC COHO and AUX vessels to maintain contact with the prototypes, especially after sunset. The stronger than usual current (3.2 knots SW) and wind made it difficult to maintain position. In addition, the anchored prototypes drifted approximately ½ NM during the course of the test. AIS positioning was used to ensure the observers were looking in the correct general direction. The coordination between the air and surface assets using AIS positioning allowed for the recovery of targets.

The CGC COHO maintained courses that were generally congruent with the field exercise test plan. The Cutter maintained safe steerage in a westerly or easterly heading so the prototypes were off the starboard or port beam. When it was discovered that all four prototypes had drifted to the west, the CGC COHO moved to the center of the operational box approximately ¼ NM to the west. The VHF radios and cell phones were used to communicate and direct the assets to the targets.

The following were key observations based on previous RDC research and confirmed in this event:

- The most conspicuous dynamic visual signal, was a 4 Hertz (vs SOS) group alternating cyan and red-orange signal. This was observed as effective for approximately 5 min, and when "the color of light changed". Lime-yellow signals were not as noticeable.
- RF reflective material mounted at approximately 2 ft above sea level was detected by RADAR (8 GHz – 12 GHz) at approximately 5 NM slant range along the air track.
- Waterborne dye did not appear to be overtly conspicuous when observed from the surface or from the air.
- Material and light sources (strobe) in the near IR range of 0.7 μm to 5.0 μm were observed from both the surface (at range 0.3 NM – 0.4 NM) and the air (at range 4.5 NM).
- Distress signaling 121 MHz was effective in providing latitude and longitude.
- Daytime visual (0.3 μm – 0.7 μm) reflection (mirroring and/or reflective material) was conspicuous from the surface and air.
- SAR pilots were able to distinguish movement of an object versus movement of waves (i.e., a good indicator that something was unusual). This was likely due to the elevated sea state at the time of the evaluation. However in general, an object that moves differently than the wave movement stands out from the background. Additionally, signals using cyan, red, and orange patterns were noted by the pilots as easily distinguishable from the background.
- SAR pilots noted that even when an object appeared partially submerged, the movement of the light signal caught the eye. This movement, however, also made the object less persistent to see. In other words, the target caught the eye enough to divert from a planned track but was not persistent enough to be able to confirm location at all times.

The individual competitor performance results are not published in this report in order to maintain privacy of entrant IP.

5 CONCLUSIONS

The Ready for Rescue DHS S&T/USCG Prize Challenge met several objectives towards enhancing PFDs through aftermarket technology. Cash prizes totaling $258,000 were used by the participants to further their individual designs and some were able to develop an open water field testable prototype. The field exercise was a one-time event to assess prototypes in open water SAR conditions.

All four finalists made significant strides towards developing a commercial product within the price range (~$25) specified for general public accessibility. Each finalist gained valuable technical information throughout the prize competition with regard to improving their product. Finalists were provided the invaluable opportunity to field their prototypes with CG assets under realistic maritime conditions, and they have continued developing their prototypes towards improvement and commercialization.

There were over 700 registrants and over 100 competition entries submitted for this Ready for Rescue Prize Challenge. This competition raised public awareness and produced novel ideas with prototypes for potential advancement to commercialization at an affordable aftermarket cost. Several technologies were produced as field testable prototypes with a track towards commercialization. These technology enhancements could likely increase the conspicuity of a person wearing a PFD and subsequently increase probability of detection. In addition, the conspicuity testing results related to patterns, colors, and intensities add to the existing body-of-knowledge and provide a framework that the Office of Design and Engineering Standards, Lifesaving and Fire Safety Division can use to monitor commercial product advancements that support Search and Rescue.

The devices assessed in this study were not USCG approved and would not meet any USCG regulatory carriage requirement. However, there is no prohibition against carrying these devices as excess equipment.

Additional CG lifesaving information, including equipment approvals can be found at:

https://www.dco.uscg.mil/CG-ENG-4/

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