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**DEMONSTRATION OF A REMOTELY OPERATED VEHICLE SYSTEM
FOR MARINE SECURITY**

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ABSTRACT

Remotely operated vehicles (ROVs) can play a variety of roles in the protection of marine assets against waterborne threats. The Underwater Security Vehicle program, sponsored by the Defense Nuclear Agency, was developed as an assessment tool to complement other security systems. The demonstration system, a Benthos Super SeaROVER vehicle equipped with a Smiths Hi-Scan 600 sonar, has been successfully used to acquire, track, and intercept designated diver targets. Current efforts include expanding the detection capacity of the vehicle and the addition of non-damaging response techniques.

1.0 INTRODUCTION

1.1 Need

An underwater security system is required to protect against underwater threats to critical waterside or waterborne assets such as weapon depots, loading areas, power plants, ships, and submarines. Threats may take the form of swimmers, scuba divers, and swimmer delivery vehicles. Current systems may lack the ability to deal fully

with underwater threats; and in many critical areas, there are no provisions for underwater security at all. Use of a ROV can serve to meet these needs, without exposing humans to hazardous conditions or routine, repetitive tasks.

1.2 Objective

The objective of the Underwater Security Vehicle (USV) program was to evaluate the feasibility of using an underwater remotely operated vehicle (ROV) system as an aid to underwater security. The USV system will be used to assess diver-like contacts in a near shore environment, augmenting existing security systems such as the Waterside Security System (WSS).

1.3 Approach

By direction of the program sponsor at the Defense Nuclear Agency, the USV was developed as an assessment adjunct to the Waterside Security System. Existing systems were evaluated, and a demonstration system was procured based on a commercially available vehicle and sensors. The system was tested and evaluated under a range of pierside security conditions.

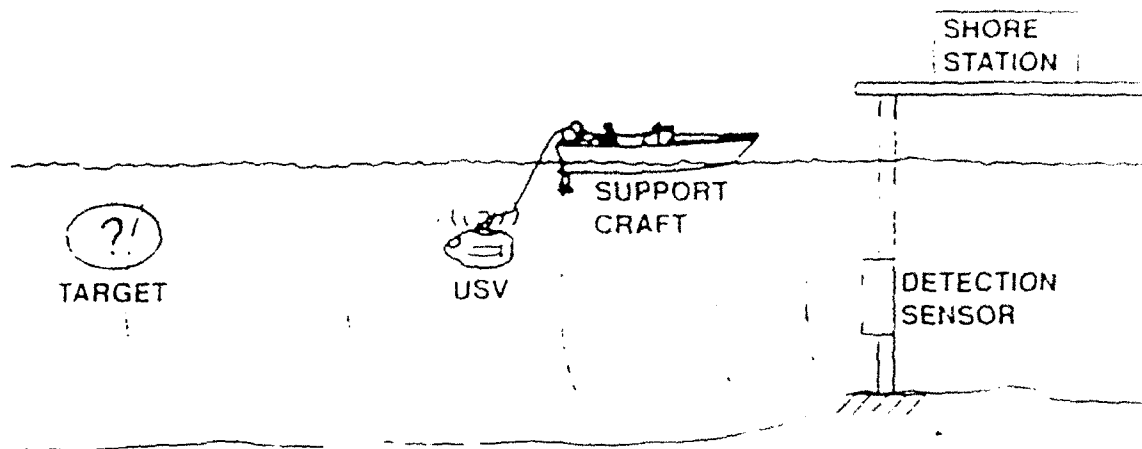


Figure 1: USV System Concept

1.4 Mission Description

The USV system concept (figure 1), shows how the vehicle would be used to respond to a target detected by another system. Once a contact is made by the detection sensors, the USV will be taken out and deployed at the contact location. The operator will reacquire the target on the vehicle sonar, and use the information to vector the vehicle into visual contact range of the target. Video and sonar information from the USV will be used by the operator to assess the target and to determine an appropriate course of action.

2.0 USV SYSTEM DESIGN

2.1 Evaluation of Commercial ROVs

A series of demonstration tests were held in San Diego in January-February 1990 to evaluate the capabilities of a range of commercially available ROVs [Nobunaga 1990]. Five companies participated: RSI Research with SEAMOR, Sachse Engineering Associates with Sea Search MK II, Perry

Technologies with SPRINT 101, Benthos with SUPER SeaROVER, and Deep Ocean Engineering with PHANTOM SS4. Each system was evaluated on four major areas: physical characteristics, human factors, vehicle performance, and sensor performance. Operational sequences were performed demonstrating target acquisition, interception, and assessment of actual diver targets. Based on these tests, the SUPER SeaROVER and the PHANTOM SS4 were deemed most suitable to fulfill the USV mission.

2.2 USV System Description

A specification was developed for the USV Proof of Concept System based on the mission requirements and available systems. The system procured was the Benthos Super SeaROVER vehicle with the Smiths Hi-Scan 600 sonar as shown in figure 2. Of the sonars evaluated, the Smiths sonar was considered the best choice for the USV system due to its high scan rate (8/second), clear display, high resolution, and ease of use under the required dynamic operating conditions.

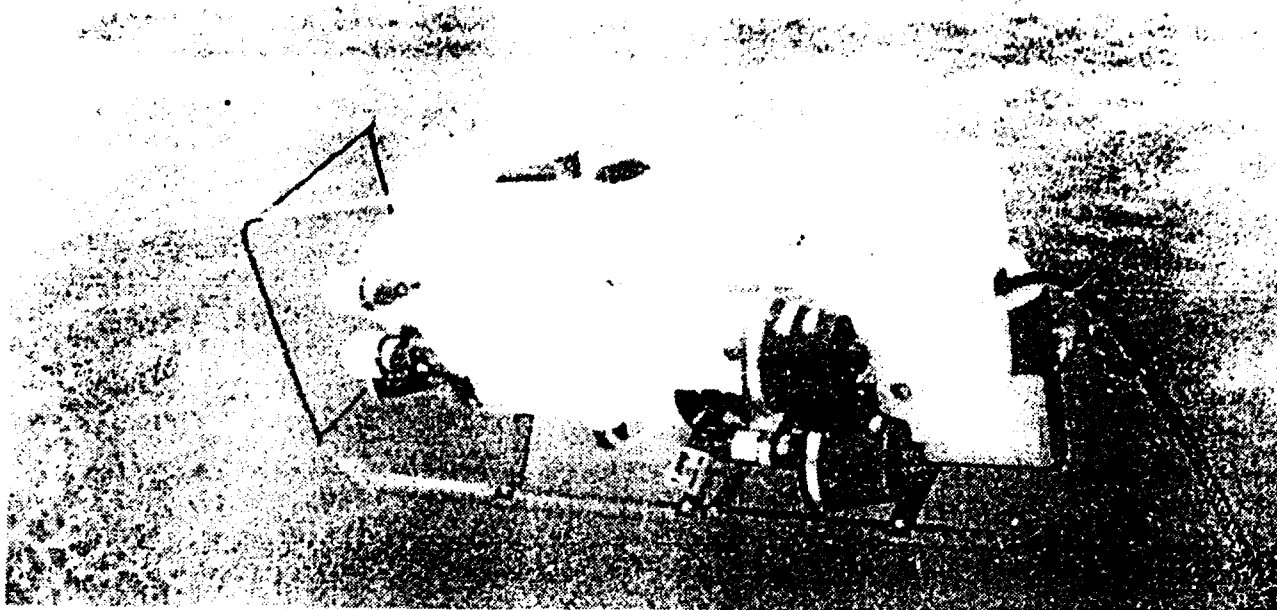


Figure 2: The USV Vehicle

3.0 USV TEST AND EVALUATION

3.1 System Performance Tests

To evaluate the feasibility of using an ROV for underwater target assessment, tests were run to determine the ability to use the vehicle system to reacquire, track, and intercept a diver-like target. The first tests were run to determine the characteristics of the USV system in terms of acquiring the target. Specific factors measured were target depth, type, and orientation. The best methods of operating the system were determined in order to optimize the target acquisition range.

Under actual operational conditions, the position of the target in the water column will not be known. Therefore, the first test was to determine the optimal operating depth of the vehicle for the full range of target depths. The maximum range achieved was 42 m. for a

midwater target detected by a midwater vehicle. Near range (<2 meters) detection was limited due to the target falling outside of the cone of the sonar beam. Based on these results, it was determined that the best operating position for the USV was in the midwater position to achieve the maximum detection range for the full range of targets. In deep water, this recommendation should be modified so that the vehicle is operating in the midrange of where the target is expected (ie surface to 100').

The second series of tests were to determine the ability to track different target behaviors such as speed and path. The target divers were given a variety of paths to swim, including straight compass courses, dog legs, varying depths, near bottom, erratic patterns, and full-on evasive maneuvers. At any given time, the target course was unknown to the vehicle

operator. During formal testing 15 different runs were made, with visual target contact accomplished 11 times, a 73% success rate overall.

Overall, the system performed well, aptly demonstrating the capabilities to acquire, track, and intercept diver targets (figure 3). It should be noted that these tests were all performed with vehicle and sonar operators with less than 10 hours of operational time, indicating the usefulness of the system even in relatively untrained hands.

3.2 Proof of Concept

In addition to the tests described above, the capabilities of the USV system were demonstrated during a Coast Guard harbor defense exercise on 10-11 August 1991. The system was deployed and in the water at approximately 2345 on 10 August. In-water visibility was poor (approximately 1 foot), but excellent sonar images were received from targets and the surrounding structures. The vehicle was placed in an outward looking position, roughly 50 feet from the deployment platform at the designated 0001 starting time.

Once in position, the operator demonstrated the vehicle's capability to yaw and scan a wider area than the 30 degree sonar beam. At approximately 0025 hours on 11 August, a sonar contact was made at a range of 25 meters. The vehicle was driven to intercept the target, using the sonar to maintain contact with the target. At a range of



Figure 3: Vehicle Operation Showing Intercepted Target

approximately 3 meters, sonar contact was lost. The vehicle lights were then turned on to illuminate the target from below. At this point, the target reappeared on the sonar and was again tracked to within 2-3 meters. Vehicle lights were again turned on, enabling surface personnel to locate the target. While no visual contact was made with the vehicle camera, it was clear by the action of the sonar contacts that the targets were of interest, providing a useful level of assessment.

3.3 Operational Observations

In the low-visibility harbor environment, it was found that video was of little use until the target was closely approached, generally within 1 meter. No improvement of video cameras can produce a picture at a range beyond that of the water visibility. This points up the absolute necessity of having a sonar suited to the desired application.

The high update rate of the Smiths Hi Scan 600 sonar proved to be invaluable for tracking moving targets while based on a moving platform. The high resolution allowed for the acquisition of diver-like targets and their subsequent tracking and interception. Two major difficulties were found: one, the narrow sonar beam (30 degrees horizontal and 10 degrees vertical) made following erratic path changes difficult, particularly at close range; and two, it was very easy to overshoot a target, particularly if it was above the vehicle operating depth. As the sonar does not give target depth information, once the vehicle is close, a target may be directly above or below the vehicle, thus out of the sonar cone. If a target was below the vehicle, often the bubbles would be detected, indicating the location and nature of the target. However, if the vehicle was below the target, it was easy to pass, losing the track.

4.0 CURRENT EFFORTS

4.1 System Enhancements

The USV system fills but

one portion of the need for the detection, assessment, and response to underwater threats. During the USV testing, it became apparent that the vehicle could provide additional capabilities beyond the interception and assessment of underwater targets. An additional lower-frequency sonar with a wider field of view could supplement the tracking capability of the Smiths sonar with a limited target detection capability. The target could be detected initially by the additional sonar, giving the operator the proper bearing to direct the vehicle. Once the vehicle is pointed in the correct direction, the Smiths sonar would be used to track and intercept. Similarly, if the target is overshoot, the additional sonar can be used to determine the proper bearing for a return. This dual function would equip the USV to operate as a both a detection and assessment device appropriate for use in a confined area or around a small platform.

Due to budgetary constraints, no vehicle navigation system was installed on the initial USV system. An ORE Trackpoint II system was used with the vehicle during the initial operator training, vividly illustrating the need for knowing where the vehicle is relative to the host platform. The addition of a tracking system would greatly extend the USV utility and ease of use.

4.2 Response Techniques

The third function of a security system is response to

a perceived threat. As the USV will be at the site of the threat for assessment, this capability is a logical step for development. A wide variety of responses are currently being investigated, falling into five main categories: warning, disorientation/irritation, position marking, target marking, and target capture. Many of these make use of standard vehicle equipment such as lights and manipulators, while some require more specialized outfitting with hydrophones and tools. Response techniques currently planned for test and evaluation are summarized in table (1).

RESPONSE EFFECT	TECHNIQUE
Warning	Hydrophone Strobe
Disorientation/ Irritation	Strobe Siren
Position Marking	Flood lights Buoy drop
Target Marking	Buoy Tag
Target Capture	Grabber Snare

Table 1: Response Techniques

4.3 Future Considerations

In order to perform in an actual security scenario, it is essential that operation of the vehicle be simplified. It would be highly desirable for a single operator to be able to operate the USV system independently, controlling both the vehicle and the sonar. In order to do this efficiently, the video and sonar information should be available on a single monitor screen and the controls on a single panel. The vehicle

must also be rapidly deployed and recovered, requiring attention to the intended operational platforms. Integration of the system with other security systems will also have to be addressed for effective operation.

5.0 CONCLUSION

The USV system has effectively demonstrated the concept of using a vehicle for the assessment of underwater targets. Current work includes the incorporation of an additional sonar, navigation system, and response devices. In an operational environment, it would also be necessary to consider the issues of launch and recovery, operator display, and integration with other security systems. With these additions, the USV can become an effective security asset.

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