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ADVANCED UNMANNED SEARCH SYSTEM

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ABSTRACT

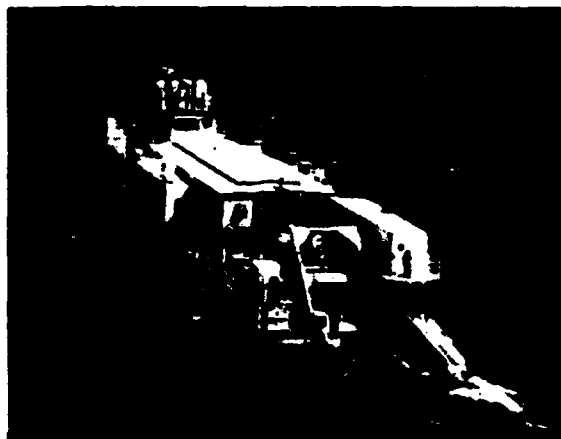
The Advanced Unmanned Search System (AUSS) uses new technologies and completely new methods to locate, identify, and inspect objects on the ocean bottom at depths from 2,000 feet to 20,000 feet. AUSS achieves an order-of-magnitude improvement in the overall search rate of conventional towed, tethered, and manned systems, and it provides the capability to perform immediate and detailed optical inspection of objects found.

CONCEPT OF OPERATION

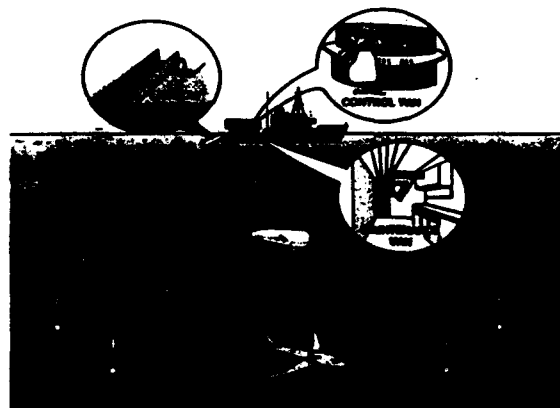
A small, untethered vehicle provides sonar and optical images of the ocean bottom to operators on a ship thousands of feet above. The operators analyze the images, make tactical decisions, and supervise the vehicle's operation. An acoustic link transmits compressed search data to the surface and sends high-level commands to the vehicle. The operators acoustically command the vehicle where to go and what to do, not how to do it. The vehicle performs each task until it is completed or until the operators interrupt with a new command.

The vehicle's computers use a Doppler sonar and gyrocompass to perform onboard navigation. In effect, the vehicle always knows where it is in Doppler coordinates. The vehicle can be commanded to go to a specific location and hover there, or to execute large search patterns without assistance.

Side-looking sonar (SLS) is used for rapid search of large areas. A scanning forward-looking sonar (FLS) is used for closing in on sonar targets. A charge-coupled-device (CCD)



AUSS installed onboard the offshore supply boat MARSEA FIFTEEN along with the 20,000-foot depth Advanced Tethered Vehicle (ATV). The control van is seen stacked upon the maintenance van. The vehicle is in the water just aft of the launch and recovery ramp. The external acoustic relay system (EARS), which is a communications towfish, is located on the port stern. The rest of the deck equipment is ATV gear.



The AUSS concept: Sonar and optical images of the ocean bottom are transmitted acoustically to the vehicle supervisor on the surface. (The transponder network shown is optional.)

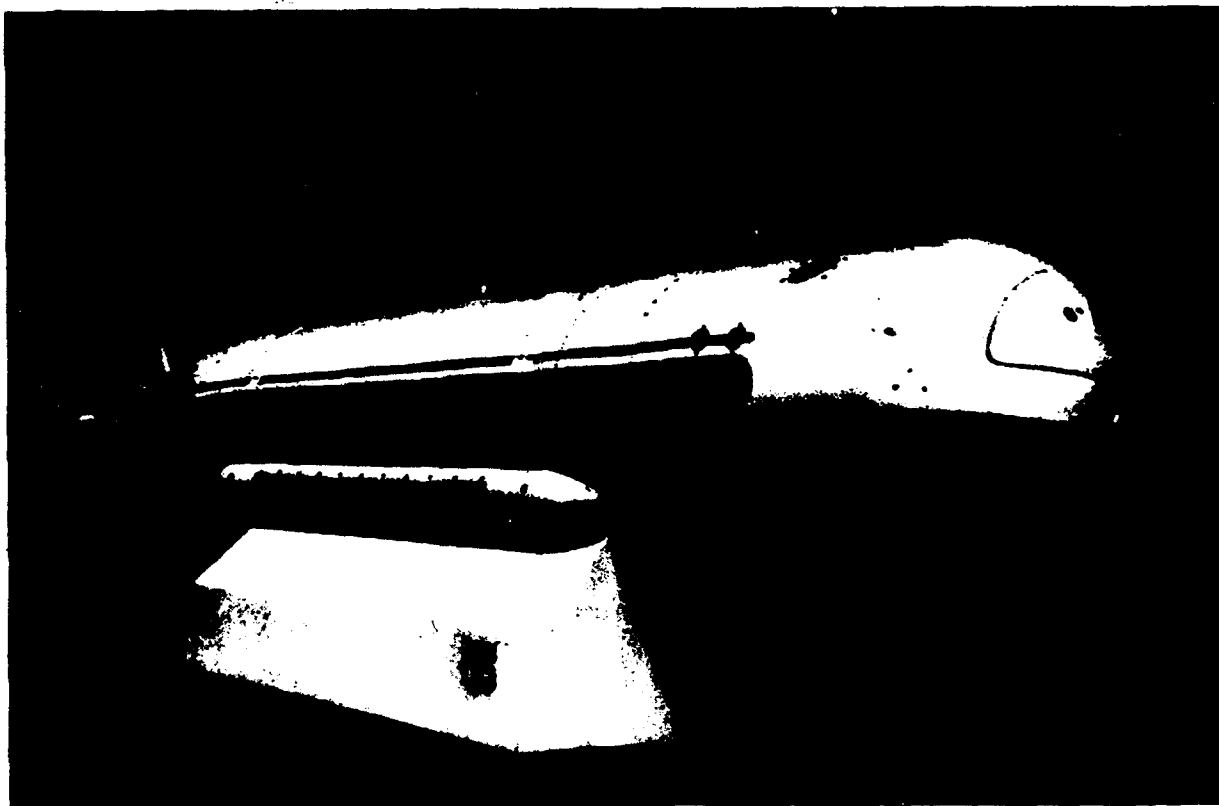
CONCEPT OF OPERATION (contd)

electronic still camera is used to identify false targets and to perform detailed inspections of targets of interest. A 35-mm photographic camera is used for documentation.

Data from the electronic search sensors are formatted into discrete images. Images are compressed and acoustically transmitted to the surface. Vehicle navigation data within the images permit an operator to obtain the Doppler coordinates of objects by placing a cursor over the image and marking by a simple keystroke.

The two highest level commands are the SLS search command and the optical photomosaic. In both, the operator defines a rectangular area of the bottom to be covered. The vehicle proceeds autonomously in a square-wave pattern, while continuously transmitting images. The photomosaic command can be used for optical search, or as a technique for optical inspection and documentation of an area.

SLS is the primary sensor for search. When a likely contact is seen on the SLS display, search may be suspended, and the object immediately investigated. Alternatively, the target may be marked for later investigation. If the target is not that which is sought, a single command causes search to be resumed where suspended. If the target is the object sought, various techniques are available for performing detailed optical inspection.



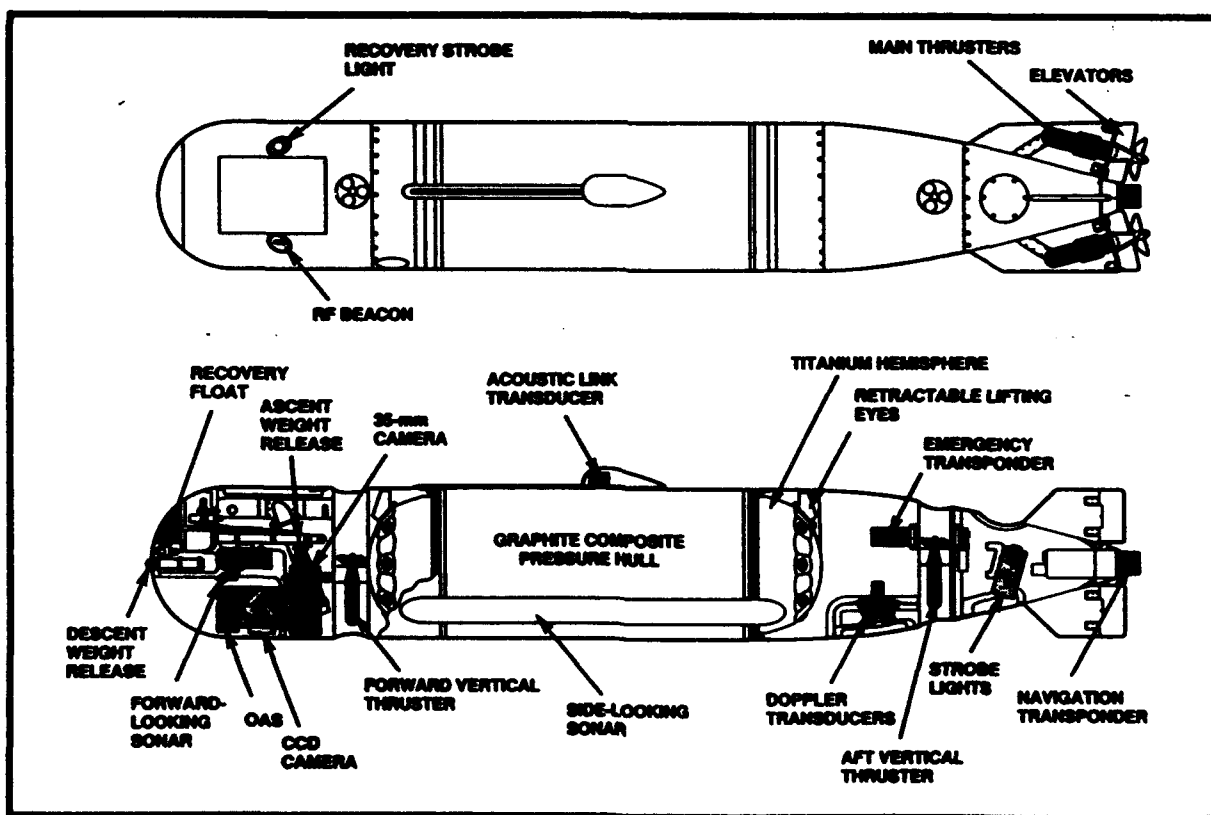
SYSTEM DESCRIPTION

The AUSS system consists of the vehicle, a control van, a maintenance van, a launch and recovery ramp, and a shallow towfish for acoustic communications. The system easily fits on an offshore supply boat.

The AUSS vehicle is 17 feet long, 31 inches in diameter and weighs 2800 pounds. The center section is a cylindrical graphite epoxy pressure hull with titanium hemispherical endbells. The hull provides the central structure of the vehicle and all the buoyancy needed. External pressure housings are of titanium. The freely flooded forward and aft end fairings and structure are of a nearly buoyant composite.

The two main thrusters provide forward and aft propulsion and steering. Two vertical thrusters, one forward and one aft, provide vertical propulsion and affect pitch trim at low speeds. Elevators provide vertical control at high speeds. The silver-zinc battery endurance is 10 hours at the maximum velocity of 5 knots.

The vehicle handling system uses an overboarding launch ramp with one end floating and the other gimbaled to the deck. The vehicle is rolled from the maintenance van into the ramp. The ramp is then extended overboard, and the bottom end is lowered to float on the ocean's surface. The vehicle is released to slide down the ramp and is pulled to the bottom of the ocean on a weighted line. At the end of the mission, the vehicle drops ascent weights, floats to the surface, and is recovered up the ramp. In 10,000 feet, ascent and descent each require about one half hour.



AUSS vehicle.

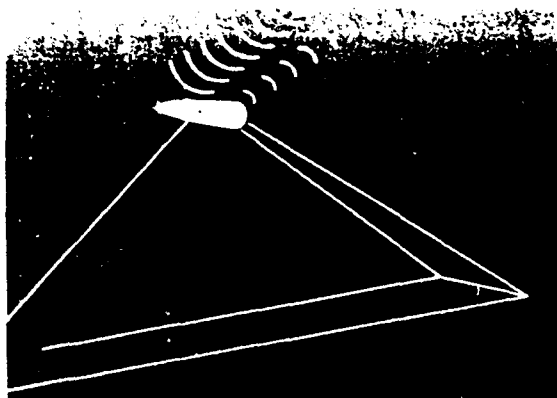
A major strength of AUSS is the capability to quickly identify sonar contacts. The following scenario illustrates how this is accomplished.

- command the vehicle to interrupt the search and come to a stop;
- mark the target to determine the approximate Doppler coordinates of the contact from the SLS image;
- command the vehicle to go to a distance of 75 feet from the contact;
- order an FLS scan;
- mark the target to obtain revised Doppler coordinates from the FLS image;
- command the vehicle to go to the new coordinates;
- request a CCD image;
- evaluate the CCD image;
- command the search be resumed.

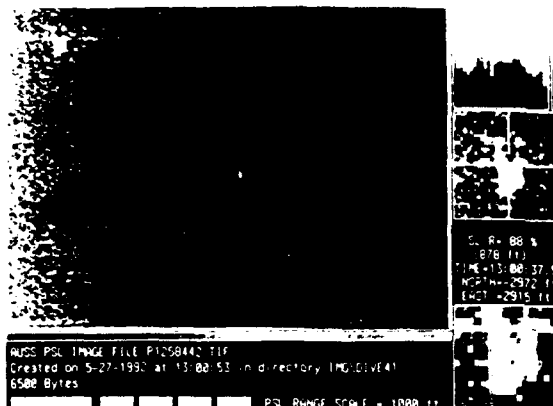
OPTICAL INSPECTION

- retransmit one or more previous CCD images at higher resolution;
- mark a different portion of an image and move over that location;
- hover at a higher or lower altitude;
- take another CCD image;
- turn the 35-mm camera on or off;
- take a series of pictures while moving in any direction;
- perform an optical photomosaic area coverage;
- back away and take another FLS scan at higher resolution or at longer range.

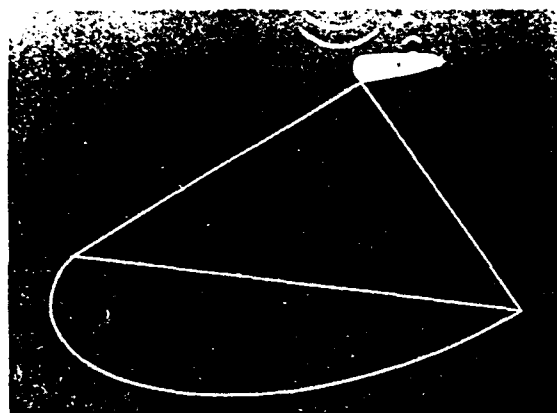




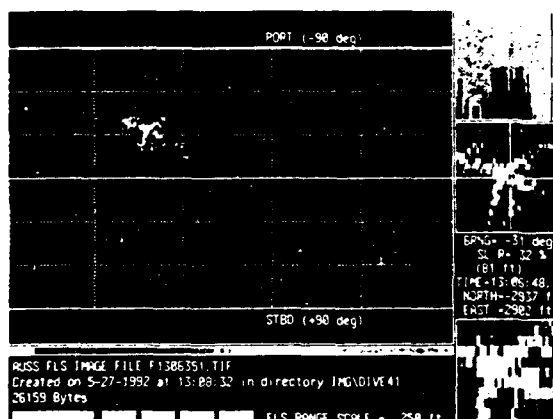
1. SONAR SCAN OF SUBMERGED OBJECT



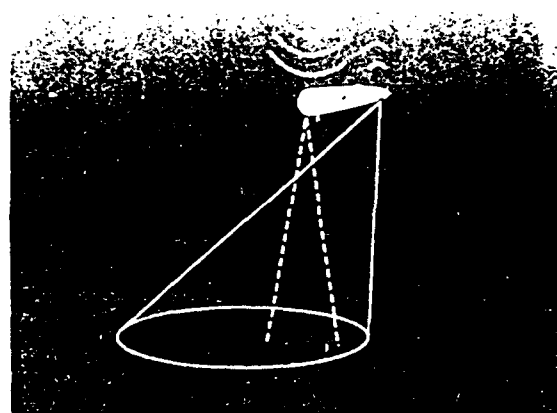
2. SONAR SCAN OF SUBMERGED OBJECT



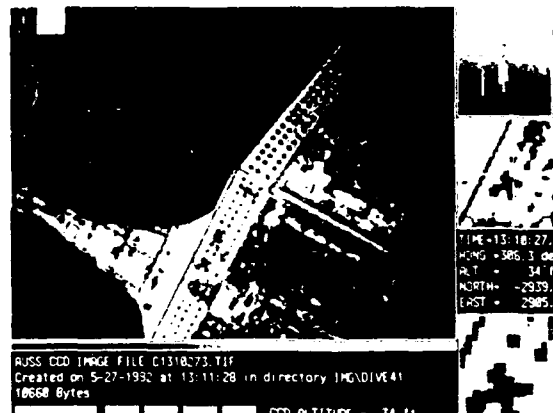
3. SONAR SCAN OF SUBMERGED OBJECT



4. SONAR SCAN OF SUBMERGED OBJECT



5. SONAR SCAN OF SUBMERGED OBJECT



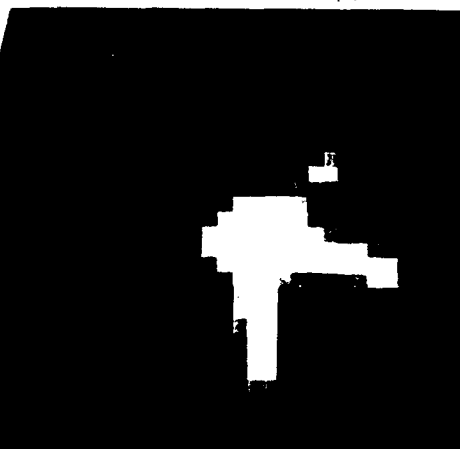
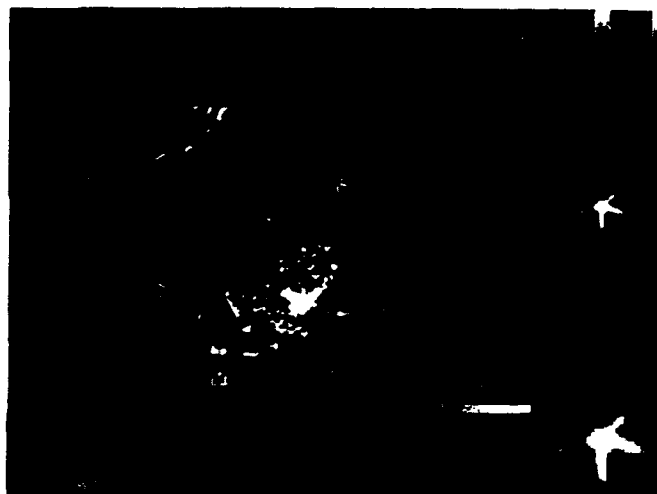
6. SONAR SCAN OF SUBMERGED OBJECT



The product of AUSS is images. The system is capable of collecting, storing and post-dive processing sonar and CCD images. The illustrations on this page are a variety of CCD images that were recently obtained.



← 25 cm →



Two-dimensional marking yields mensuration within a single image or between different images within the same Doppler reference system.

ACCOMPLISHMENTS

AUSS has exceeded its original program goals as a search system. With operational experience, completely new techniques and capabilities have evolved.

AUSS accomplishments include:

- 89 dives to a depth of 2500 feet with a prototype system;
- 45 dives at depths of 2500 to 12,000 feet with the final system;
- SLS search approaching 3 sq-nmi/hr;
- immediate contact evaluations;
- detailed operator-directed inspections;
- optical photomosaics using film and/or CCD;
- successful searches and inspections with and without acoustic tracking transponder fields;
- sustained area search rates in excess of 1 sq-nmi/hr, including contact evaluations.

THE FUTURE

The sonar images and electronic camera images shown in this paper indicate the thoroughness with which search and inspection can be conducted. The technology advanced by AUSS is directly applicable to exploring for commercial resources, environmental monitoring, subbottom profiling, and the sciences of oceanography, biology, archeology, and geology.

Unmanned, untethered underwater vehicles have become the next generation of deep ocean sensor platforms to deliver the "eyes and ears" of the inquisitive to all depths of the ocean.



This is a composite of CCD images from a photomosaic run at 12,000 feet taken by AUSS as the vehicle's path was aligned with a drag track of a target.

