

MicroROV Technology Helps in *USS Arizona* Preservation

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Abstract

ROVs are forging ahead in fragile and hazardous – even sacred – environments that divers dare not tread. The 8-pound VideoRay ROV took a leading role delivering instruments and video cameras into the *USS Arizona* with the National Geographic Society and the National Park Service in September, 2000 and June, 2001.

Brief history of *USS Arizona*

The *U.S.S. Arizona* sank in less than nine minutes in Pearl Harbor on December 7, 1941. Taking 1,177 lives, the *U.S.S. Arizona* symbolizes the start of World War II for America. [1] The *USS Arizona* along with the *USS Utah* remain the only ships left in-place from the attack on December 7th. These wrecks are located in Pearl Harbor in less than 50 fsw and remain as part of America's historical cultural heritage.

Debate on Preservation vs. Leave the Wreck to the Elements

Controversy still rages today as to whether to preserve the wreck as a national heritage or to leave it to the elements as a war grave. Initially, of the 1,177 sailors that died that day 105 bodies were removed from the wreck by 1942. But because the ship was never raised, the remainder could not be recovered. The US Navy considers the sea as a proper final resting place for sailors died at sea hence the status as tomb for the lost sailors. Survivors of the December 7th attack continue to be buried with their shipmates to this day inside Barbette #4.

An assessment had to be made in order to determine the degree of intervention needed before a decision could be made to intervene to preserve the structure.

Need for NPS to gather data

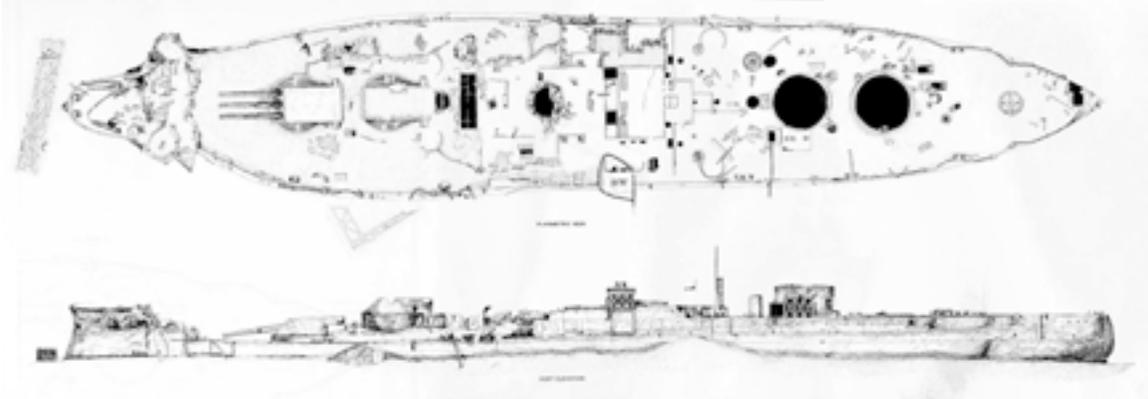
Since 1943, no diver has entered the *U.S.S. Arizona*. President Eisenhower dedicated the site as a memorial monument in 1962, and four archeological surveys were conducted on the *Arizona* during the 1980s. A National Treasure, the *Arizona* must be surveyed periodically by the National Park Service, without disturbing her delicate structure which corrodes slowly over time. The goals of these missions were to perform a complete corrosion status survey of the internal structure of the *Arizona*. The team also wanted to pinpoint the sources of the oil that still seeps daily from the wreck as it has been since 1941.

Enter VideoRay

Due to its size and enclosed structure capabilities, VideoRay was identified by the team as the only piece of equipment that would be small enough to not disturb the archeological integrity of the wreck and small enough to fit into even the most confined places. Sized just slightly larger than a shoebox, VideoRay penetrated through portholes, air ducts, manholes, and openings created by bomb blasts. In 2 missions in September, 2000 and June, 2001, VideoRay was able to deliver a variety of instruments into the depths of the *Arizona* to determine the degree of deterioration of the structural members of the wreck. Because of its low thrust generation (due to its light-weight and hydrodynamic efficiency), the sub was able to gather clear video without stirring silt which would bring visibility to zero in the case of diver penetration.

Layout of the wreck

Recent detailed maritime archeological assessments and documentation reveals the *Arizona* to be substantially intact, lying at a five to ten degree list to port. The *coup de grace* was delivered by a 1,760-pound bomb which slammed through her deck, igniting her forward ammunition magazine. The explosion of ammunition and fuel demolished the forward section of the vessel, which collapsed inside the hull.



Artist's rendering of the wreck as it lays today

1st mission in September, 2000 with NGS for video survey

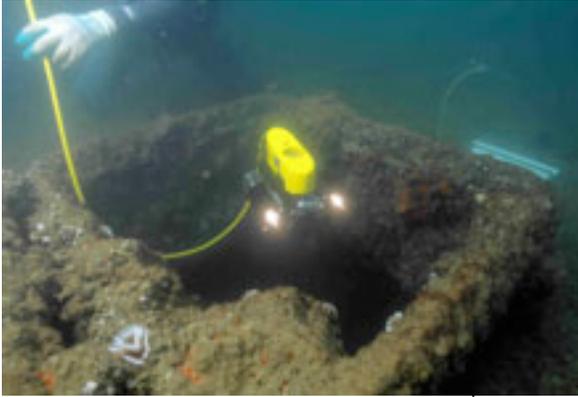
The National Geographic Society along with the National Park Service sponsored the first Post WW2 internal survey of the *USS Arizona* in conjunction with the 60th anniversary of the attack at Pearl Harbor. The core of the survey involved probing the wreck for access points to the living quarters on the 2nd deck for filming of the documentary *Pearl Harbor: Legacy of Attack*. [2] During this survey, visual evidence of the condition of structural support members was captured on film for later dissemination. Further sorties were made to the 3rd deck to examine a bulkhead for corrosion status. 2nd deck was found to be substantially corroded in areas with close proximity to open spaces such as portholes, hatches and bomb holes. In areas with closed portholes and no Oxygen circulation, paint was still intact and desks were found with papers still legible from 1941.



VideoRay entering air shaft at stern just forward of peak of stern (Photo by Brett Seymour, NPS)



VideoRay entering porthole on port side beam 2nd deck (Photo by Brett Seymour, NPS)



VideoRay entering hatch penetrating into 3rd deck for oil analysis and metal corrosion analysis (Photo by Brett Seymour, NPS)

2nd mission in June, 2001 with NPS to gather data

On the 2nd expedition to the *USS Arizona* in June, 2001, a more thorough and systematic analysis of all accessible areas within the wreck was planned and executed. During review of the tapes from the first expedition, an open hatch to the 3rd deck from the second deck was discovered. Penetration into the 3rd deck living quarters was made with progress all the way to the stern water-tight bulkhead. A systematic survey of all living quarters and common spaces was made on the 2nd and 3rd decks. A penetration was made through the #3 barbette down to the first platform to survey the oil bunkers for structural status.



Larry Murphy of the NPS preparing to tend tether for VideoRay inside of Barbette #3 (Photo by Bob Christ)

A dissolved oxygen probe was attached to VideoRay and flown through several points within the hull.



VideoRay with Dissolved Oxygen probe attached on the bottom of the starboard-side hull (Photo by Bob Christ)

A CP probe, Cygnus IV Multi-Echo Ultrasonic Thickness Gauge and solid/liquid sampling trays were attached to the sub for data gathering.



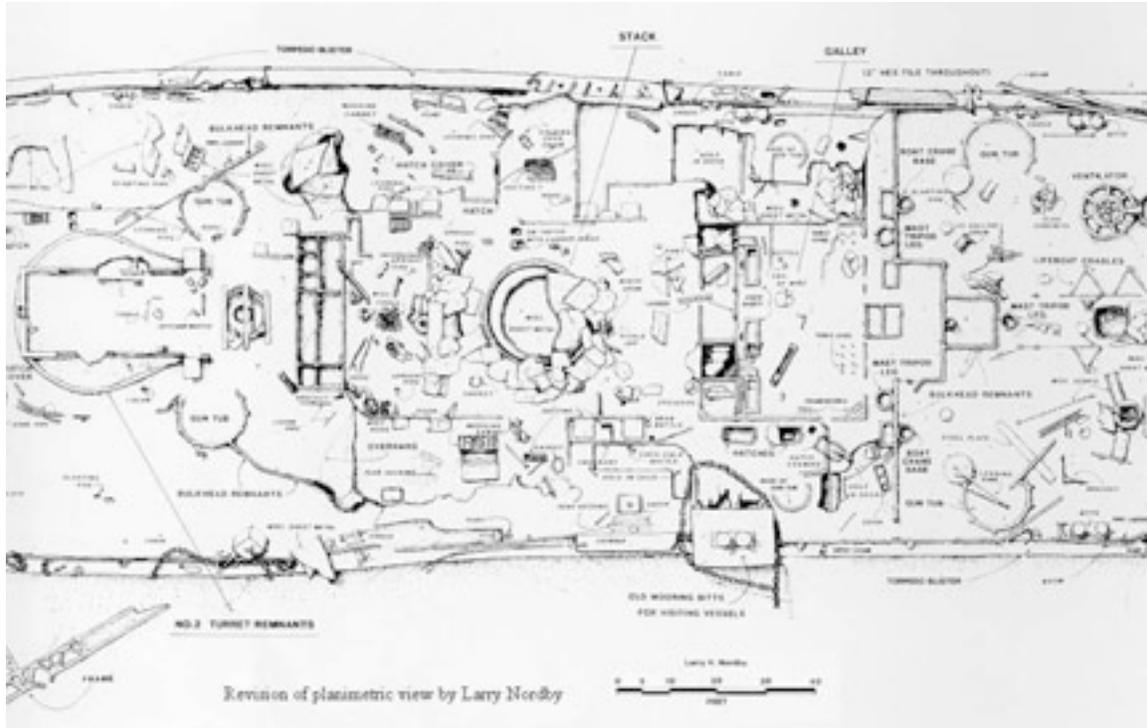
VideoRay with overhead sampling tray as well as Cygnus IV Multi-Echo Ultrasonic Thickness Gauge attached. (Photo by Bob Christ)

Setup at the memorial topside and into wreck

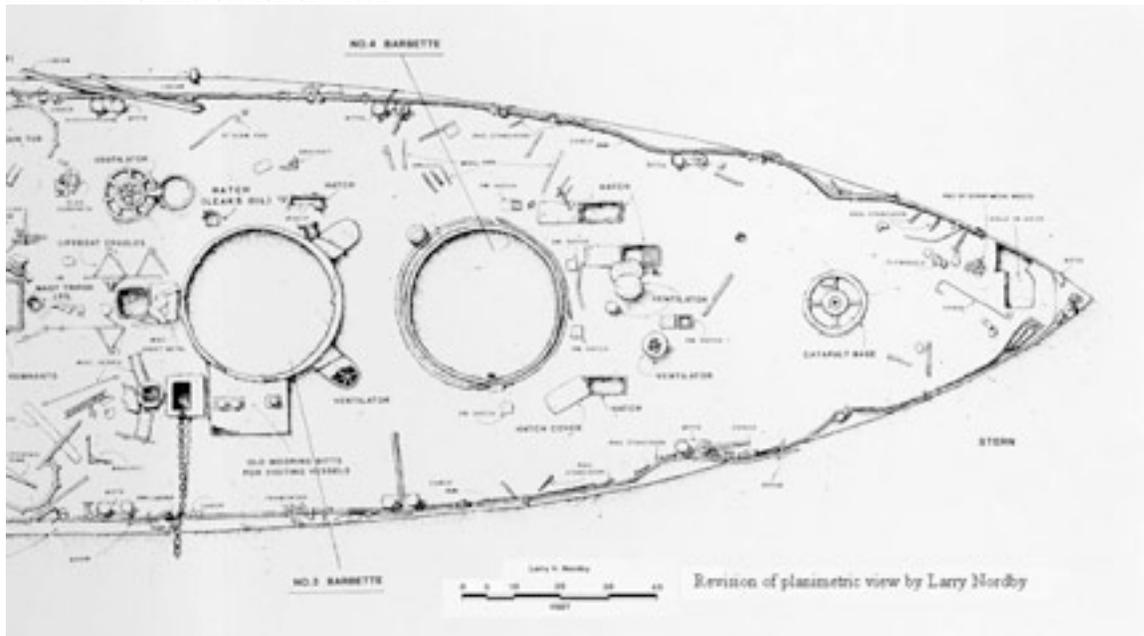
Topside operations were conducted aboard the memorial in a broom closet just inside the entranceway. Underwater acoustic diver comms were rigged to the dock just outside the memorial. The memorial maintained a full schedule of visitors throughout the conduct of this expedition with VideoRay operations causing minimal disruption. Tether was routed through the entrance breezeway into the water. The sub was met in the water by the diver. The diver then led the sub to the penetration point.

Penetration points

All penetration points were aft of the forward gun turret due to damage to the bow from the forward ammunition magazine burst. The main penetration points were hatches and barbette for access to lower decks, portholes for access to individual cabins, air ducts for access to inaccessible areas of the ship and bomb holes for survey of bomb damage.



Planimetric of mid-section of wreck



Planimetric of aft section of wreck

Diver tending tether

Techniques were worked out between NPS divers tending tether and VideoRay surface operations aboard the memorial. Specifically, divers would meet the sub and lead it to the penetration area then slack and pull tether to allow for easier penetration. Divers could assist in un-fouling tether snags, help pull tether around corners and monitor the progress of the dive.

Instruments used – D.O., Cygnus, sampling, C.P.

VideoRay functioned as the delivery vehicle for a variety of instruments for taking measurements as well as gathering both solid and liquid samples. The most innovative of the modifications was the addition of a universal joint mounted to the skid of VideoRay to accommodate the Cygnus IV Multi-Echo Ultrasonic Thickness Gauge. Since the transducer had to be flat against the metal surface in order to gain an accurate measurement, the universal joint allowed for VideoRay to pivot with the thrusters operating to gain a solid fit while allowing the transducer head to fit flat against the surface.



VideoRay with universal joint for mounting of Cygnus IV gauge (Photo by Bob Christ)

Tricks used to make deep penetrations

We found quickly that the best method to penetrate deep into the wreck was first to pull tether down a hallway or breezeway then survey back towards the penetration point. VideoRay made best progress with no more than 2 turns before reaching the extent of the penetration. The best method was to pass the area of interest (cabin, work area or room) until the necessary tether was pulled then come back to survey the area. There were several tether snags which were eventually cleared. These included a snag on the air duct in the ceiling due to a [buoyancy] light tether, a catch on a table due to a heavy tether and a difficult tether snag due to attachment of the dissolved oxygen probe cable attached to VideoRay's tether. The fix for the tether buoyancy problem with the heavy cable attachment was tapered floats.



Tapered float on junction of instrument cable attachment to VideoRay tether (Photo by Bob Christ)

Findings and results

VideoRay functioned as the delivery vehicle for video cameras as well as a variety of instruments to gather data and video for the determination of corrosion status of the *USS Arizona*. Due to its small size, it was able to complete functions impossible to accomplish by divers. VideoRay was able to penetrate areas not seen since the attack on December 7, 1941 in a safe and controlled fashion.

The wreck was found to be in an advanced state of deterioration at certain sections yet surviving with paint intact in other sections of the wreck. VideoRay was able to provide to the National Park Service valuable previously inaccessible data to allow for an objective and scientific determination of the status of the wreck.

Summary and conclusion

Micro ROV technology has come of age due to recent innovations in miniaturization of components as well as new operational techniques allowing delivery of subs to inaccessible enclosed structures. New more sensitive control interfaces coupled with light weight, portability and one-man deployment has made the Micro ROV a powerful new tool taking its place in the best tool chest of the commercial diver.

Acknowledgments

Big thanks are due to Dan Lenihan, Larry Murphy and Kathy Billings of the National Park Service, Emory Kristof and Keith Moorehead of the National Geographic Society and Chris Roper of Roper Resources for their help in making this operation such a huge success.

References

[1] Daniel J. Lenihan, Editor. Submerged Cultural Resources Study. Southwest Cultural Resources Center Professional Papers No. 23. Santa Fe. New Mexico (Third Printing 2001)

[2] National Geographic Society release in May, 2001 of the documentary *Pearl Harbor: Legacy of Attack* narrated by Tom Brokaw.