NAVFAC and NCF Support Acoustic Test Range Construction In International Effort:

PROJECT AFAR

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In an effort to improve undersea acoustic communication, an eight nation task organization agreed to construct an acoustic test range in the Azores Archipelago. The participants included Canada, France, Germany, Italy, The Netherlands, Portugal, United Kingdom and the United States.

The initial concept of the range was to mount one transmitting array and two receiving arrays atop individual seamounts off the west coast of Santa Maria Island. This site was chosen because of the area's unique bottom topography and winter storm conditions which would offer a desirable set of circumstances well-suited for acoustic experimentation and not available in continental shelf testing.

Additional facilities were to include a subsurface oceanographic buoy for continuous measurement of sea parameters, and a shore station consisting of a laboratory and power plant to monitor range experiments.

The United States Navy was vested with the overall management responsibility of Project AFAR (Azores Fixed Acoustic Range). This responsibility included the identification and coordination of the material, service, and financial support of each of the participating nations. As part of the total U.S. contribution, the Naval Facilities Engineering Command and the Naval Construction Force were charged in 1970 to provide the engineering support and construction services necessary to install and immobilize four inshore cables through the surf zone of an isolated bay of Santa Maria and up the adjacent 500-foot slope, which terminated in a cliff.

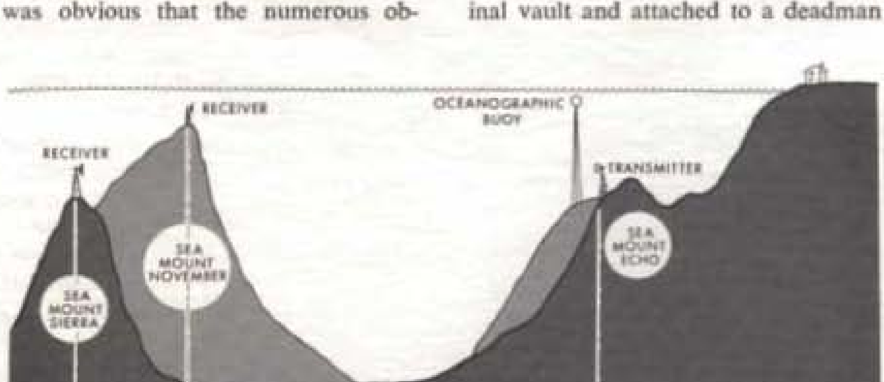
As developed, this inshore cable task consisted of preparing a suitable route through the surf zone and up the slope to a terminal vault installed atop the cliff; laying the four double-armored coaxial cables from the cable tanks of the Italian cable ship *Salerum* and the British cable ship *Bullfinch;* encasing each cable with split pipe armor protectors to a depth of 60 feet, and pinning the encased cables to the rock bottom at specified points along the cable route. The work was to be accomplished within the weather window of 1 June through 30 August; otherwise weather and sea conditions were not likely to be compatible with the planned surf zone operations.

A predeployment diver's survey revealed a seafloor of basalt marked by rugged rock outcroppings and wide, vertical-walled ravines running transverse to the proposed cable path. It was obvious that the numerous obstacles and steep slopes would have to be removed to prevent undesirable long cable suspensions. Utilizing hand-held and track-driven crawler pneumatic drills, Seabee divers drilled and packed the necessary dynamite holes with charges and placed additional plastic explosives where required.

Following the initial detonations and while additional Seabees prepared the cable track on shore, underwater demolition hose charges were strung over the length of cable route to clear blasted rubble from the prepared trench.

The first two cables were laid from the *Salernum* which held position 3000 feet offshore using a combination of anchoring, ship's power and tug assistance. Each cable was hauled ashore by two crawler tractors traversing the top of the cliff with grapnel lines connected to the cable's shore end. To prevent cable contact with the seafloor during the inhaul operations, ship's personnel attached flotation balloons to the cable as it left the *Salernum's* bow.

Once the cable had been hauled to a prescribed position beyond the terminal vault and attached to a deadman



Cross sectional view of Fixed Acoustic Range anchor on the beach, divers swam the cable from the shore seaward, cutting loose the floats and, thereby, depositing the cable on the seafloor along the prepared path.

In and near the surf zone, cables are likely to experience their greatest hydrodynamic force loadings and must be protected and stabilized to reduce possible damage from chaffing and pounding surf. In locations where the seafloor consists essentially of hard rock, preventing cables from being buried beneath protective sediments, a common practice is to encase the cables within modular sections of cast iron split pipe. Such was the case at Santa Maria.

Applying an analytic method developed by Lt. Robert T. Hudspeth of NAVFAC, it was determined that each cable would require 1500 feet (to a depth of 60 feet) of these split pipe protectors to minimize the damaging effects of a maximum 40-foot winter surf.

The commercial technique of split pipe application was to stage the heavy three foot sections underwater along the cable track and later to bolt them in place section by section. However, this method was determined to be too lengthy a process to complete the four cable application before the close of the weather window and an innovated technique was substituted.

Split pipe was applied to the cable in 30 foot lengths on shore and towed by a motorized causeway pontoon along the entrenched cable to where it could be diver-connected to the

Tug assisted in-haul of cables from the cable tanks in the ships to the beach. Crawler tractors atop cliff on shore pulled cable to antenna sites.

Divers used hand-held and tracked crawler pneumatic drills to drill dynamite holes for blasting out obstacles and leveling steep slopes along cable path. They also drilled holes in the rocky floor for placing U-bolt anchors to prevent cable motion and possible fatigue failure.

previously applied sections. This process was repeated until the required 1500 feet of cable had been encased.

Although two weeks were required for encasing each of the first two cables, this method saved nearly one month over the time estimated for commercial application. Adequate clearance did not exist between the remaining two larger diameter cables and split pipe, however, and this improved encasement technique could not be utilized.

A second innovation was prepared in time for the arrival of the *Bullfinch*. A standard amphibious causeway pontoon was placed in a four point moor about 600 feet offshore, just beyond the point of appreciable surf action. The cable was pulled by the two crawler tractors on shore across the causeway's deck in 75 feet increments. Each time, a 75 foot length of cable was encased, adequate floats were applied, and the encased cable was floated progressively ashore until it reached the shoreline.

There, the cable was secured to the deadman anchor and divers began cutting away the flotation balloons lowering the cable to the seabed. The following day, as the causeway pontoon underran the cable seaward, Seabees onboard applied the remaining 900-feet of split pipe. Both of the latter cables were laid and encased in just four days representing a significant time saving over both previous encasement techniques.

As an additional safeguard against cable motion and possible fatigue failure, it was decided to cement U-bolts into the rock bottom about each encased cable at ten foot intervals. The U-bolts were fabricated from large diameter reinforcing bars, each four feet long and bent to fit around the

split pipe. Divers, heavily weighted down in order to apply sufficient force to the hand-held pneumatic drills to penetrate the bottom, spaced and drilled the required holes on both sides of each cable. Mixing a fast drying hydraulic cement while under water, the divers placed and cemented nearly one hundred U-bolts about the four encased cables. Where the encased cables spanned small ridges and crevasses, they were secured in place by wire rope anchor lines running to rock bolts embedded in the bottom.

While the underwater workers were completing the surf zone cable immobilization, additional teams of Seabees were busy installing technical equipment and related systems at the laboratory and power plant, and laying four lead-jacketed shore cables. These latter cables were onshore extensions of the inshore cables and ran between the terminal vault and power plant. By mid-September, all personnel and equipment were readied for transport back to the United States, having successfully completed a demanding inshore cable task.

Neither Santa Maria nor the Seabees were to see the last of each other. During the winter of 1971, thermistor chain was needed to replace the original inoperative thermistor string on the range, the American NCF team was again requested to install the shore and inshore cables. A second cable was deemed advantageous to serve as a shoreward link to an underwater acoustic system for range navigation. The only significant difference between the 1970 and anticipated 1972 operations was that the French cable ship *Amphere* would not be available on site until October of the latter year — well beyond the weather window for safe diving operations.

Following a study by Underwater Construction Team-One (where many of the 1970 AFAR personnel had since been assigned), in conjunction with NAVFAC's Ocean Engineering and Construction Project Office, it was decided that UCT-One could install the shore and inshore cables during the summer of 1972. The plan was to lay the inshore cables from the well deck of an LCM-8 using the reeled pipe laying technique of the Navy's Amphibious Construction Battalions. The French cable ship had meanwhile agreed to deliver the necessary cable lengths to the Azores Archipelago prior to the American team's arrival.

Following an intense period of planning and preparation with an eye to the September weather window deadline, five personnel of UCT-One arrived at Lajes AFB, Azores, with the necessary equipment and materials to install two drum winches and their power source in the well deck of one of two borrowed LCM-8s. Making best use of the "Can Do" Seabee attitude and some well devised jury rigging, the UCT detail succeeded in winding each 1.25 mi. length of cable on the two winch drums. Augmenting one enlisted coxswain and six Portugese enginemen/riggers from the Army unit at Lajes, the NCF personnel sailed their LCM-8s to Santa Maria. There they joined forces with the remainder of UCT-One already underway with base camp construction.

On 1 July 1971, the two LCM-8s, lashed side by side, bow to stern, were secured in a four point moor which had been installed 1500 feet from shore by divers two days earlier. Similar to the 1970 operations, the first cable was gradually floated ashore utilizing flotation balloons and the hauling force of a 5-ton cargo truck. Once the shoreward cable end was secured by means of shackle and Kellam's grip to the existing deadman anchor, the cable was guided into place above the existing offshore track and lowered to the bottom by divers detaching the buoyancy floats.

By early afternoon, the LCM-8s were ready for breaking moor and taking to sea. While personnel aboard the winch-contained LCM-8 controlled cable payout and tension by applying the necessary winch braking force, the Army coxswain aboard the second LCM-8 controlled both vessels' speed and heading. As prescribed in the operations plan, the cable was laid out along a track two depth distance from the existing cables out to, and along, the 100 meter contour so as not to subject the cable to excessive water depth. This last segment of cable track was navigated with the aid of two transit stations set up on shore and a fathometer. Information from both the stations and fathometer was used in conjunction with a prepared bathymetric chart developed from soundings taken by UCT-One.

Two days later the second cable was similarly laid without incident. This set the stage for a July 4th celebration which included a Portugese prepared fresh fish and lagosta (lobster) dinner — complete with movies and fireworks for the benefit of a tired team and local inhabitants alike.

The following day, while a four-man team was engaged in laying the shore cables, two diving crews began staging the split pipe protectors along the cable route. Utilizing air-impact wrenches and pneumatic drills and drawing on experience gained from similar cable installation and repair projects, UCT-One completed the protection and stabilization tasks on both cables in fourteen working days.

Nearly one month after arriving on Santa Maria, UCT-One had successfully completed two cable landings and stabilizations and were packed and ready for direct embarkation to a North Atlantic site and yet another underwater task in the growing list of accomplishments of the NCF underwater construction team.

Since the successful installation of the transmitting antenna array during the summer of 1971, the Navy Underwater Systems Center, tasked with the responsibility of range operations, has been conducting on-going transmission-measurements of the effects imposed by stormy weather and rough bottom topography upon propogating sound signals. While the results of these studies are disseminated to each of the participating NATO nations, Italy, France, and Germany, to name just a few, have used the range for independent oceanographic - acoustic studies from their own surface and subsurface vessels.

The successful accomplishment of ocean projects such as the cable landings and stabilizations of Project AFAR has demonstrated the ability of the NCF with the support of NAVFAC to perform successfully in the marine envnronment. Even more important, these accomplishments have provided a source of knowledge and experience upon which to advance the navy's capabilities in ocean engineering.

Flotation balloons suspend cable in water while it is being hauled ashore to prevent chafing on the rocky sea floor.

Conventional method of applying split-pipe cable protectors requires divers to install them underwater while cable is still suspended by flotation balloons.

Innovated technique for applying protectors to 30 foot lengths of cable on the beach, after which the length is towed into the water to be submerged and joined with the previously installed sections.

Installing cable protectors in the dry saved nearly one month for the operation as compared with conventional underwater method of installation.