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U.S. NAVY
SHIP SALVAGE MANUAL
VOLUME 4
(DEEP OCEAN OPERATIONS)

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FOREWORD

This is the fourth volume in a series of six related publications that make up the *U.S. Navy Salvage Manual*. Each volume in the family addresses a particular aspect of salvage. The family collectively replaces the three volumes of the *U.S. Navy Salvage Manual* issued between 1968 and 1973.

The primary purpose of these volumes is to provide practical information of immediate use to Navy salvors in the field. They are not cookbooks; they are guidance. Salvors must use their imagination, intellect, and experience to expand the basic information and apply it to a particular situation. A secondary purpose is to provide an educational vehicle for learning the technical and practical aspects of our business before applying them in the hard venue of salvage.

Salvage of objects from the seafloor has been a major technical challenge for many years. The U.S. Navy has acquired extensive experience through cumulative research and development, both at naval and commercial laboratories. Long days at sea combining both new technology and seamanship have developed the world's best deep ocean search and recovery capability. This manual addresses principles and methods of deep ocean recovery. It is intended to serve as a guide for shipboard and deep ocean recovery personnel.

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STANDARD NAVY SYNTAX SUMMARY

Since this manual will form the technical basis of many subsequent instructions or directives, it utilizes the standard Navy syntax as pertains to permissive, advisory, and mandatory language. This is done to facilitate the use of the information provided herein as a reference for issuing Fleet Directives. The concept of word usage and intended meaning which has been adhered to in preparing this manual is as follows:

"Shall" has been used only when application of a procedure is mandatory.

"Should" has been used only when application of a procedure is recommended.

"May" and "need not" have been used only when application of a procedure is discretionary.

"Will" has been used only to indicate futurity; never to indicate any degree of requirement for application of a procedure.

The usage of other words has been checked against other standard nautical and naval terminology references.

SAFETY SUMMARY

This Safety Summary contains all specific WARNINGS and CAUTIONS appearing elsewhere in this manual. Should situations arise that are not covered by the general and specific safety precautions, the Commanding Officer or other authority will issues orders, as deemed necessary, to cover the situation.

GUIDELINES

Extensive guidelines for safety can be found in the OPNAV 5100 Series instruction manual, “Navy Safety Precautions.” Personnel required to perform salvage operations must be thoroughly trained and equipped not only to perform routine duties but also to react appropriately to unusual or non-routine situations.

The officers and crew of vessels likely to be involved in salvage operations should continuously conduct safety indoctrination lectures and exercises aimed at reducing hazards and at reacting appropriately to unusual circumstances with professional understanding of their duties and the proper use of safety equipment.

PRECAUTIONS

The **WARNINGS** and **CAUTIONS** contained in this manual and listed below are referenced by page number. In addition, the following general precautions are offered as part of this Safety Summary:

- All personnel responsible for salvage should read and comprehend this manual.
- Observe all warnings, cautions, and notes listed in this manual.
- Follow operational procedures. Observe operating parameters of all equipment.

Definitions of warnings and cautions are as follows:

WARNING

A statement used to call particular attention to an action or procedural step which, if not strictly followed, could result in the injury or death of personnel.

CAUTION

A statement used to provoke notice, awareness, and attention from personnel regarding an action or procedural step which, if not followed, could result in possible injury or equipment malfunction.

The following warning and caution statements appear in this manual and are repeated here for emphasis:

WARNING

High-energy transmissions are capable of causing significant injury to personnel and damage to electronic circuits in some search and recovery systems. HF radio transmissions must be coordinated with search and recovery system operators. (page 3-13)

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CHAPTER 1

INTRODUCTION

1-1 INTRODUCTION

Few environments are more hostile to man than the deep ocean. Until comparatively recent years, objects lost in the sea were recoverable only from shallow water and then with exceptional luck and perseverance. Increasing demand for deep ocean operations served to motivate the development of modern technologies, resulting in greater capability to locate, identify, observe and recover objects lost in the deep ocean.

The Navy conducts deep ocean operations to recover material which:

- May aid in an investigation to determine cause of a casualty.
- May be returned to service.
- May be hazardous.
- May prevent it from falling into hostile hands.
- Has intrinsic value.

Deep ocean operations may be divided into two broad categories:

- Search and recovery operations to locate, identify, observe and recover specific objects from the seafloor.
- Ocean engineering operations.

The first, which includes tasks such as aircraft salvage operations, occurs frequently enough that personnel and equipment remain in readiness for such an incident. Ocean engineering operations involve location, inspection, implantation and recovery of sensor arrays and other devices. These operations are conducted *ad hoc.*

The rapidly evolving technology and the specialized skills required for deep ocean operations often call for involvement of a broad segment of the Forces Afloat, the Shore Establishment and commercial industry. In some instances, special Navy units conduct an entire operation; in others, civilian contractors to the Supervisor of Salvage (SUPSALV) provide the search and recovery tools, equipment and specialized personnel. Laboratories and other Navy organizations may add to the technology and knowledge of both the special units and contractors. In most complex operations, Navy units and civilian contractors work together to complete the operation.

Deep ocean operations are slow and tedious, requiring much more patience and precision on the part of all participants than other types of salvage operations. Highly specialized and experienced people conduct these operations. These people have learned in a hard school what techniques work and that deep ocean operations cannot be rushed.

1-2 SCOPE

This volume of the *U.S. Navy Ship Salvage Manual* deals with deep ocean search and recovery operations. The technology of deep ocean operations has not reached the point where standardized equipment and systems are the tools of the trade, as in conventional ship salvage operations. Accordingly, this volume addresses neither the state-of-the-art at the time of writing nor the characteristics and capabilities of particular hardware. The purpose of the volume is to provide guidance to the people planning, conducting and supporting deep ocean operations; it describes the principles and methods which have evolved and proven effective at sea. Nothing in this volume should restrain the imagination of the salvor or his willingness to try new and unproven procedures. Only by stepping into the unknown and accepting the failures that inevitably occur is progress made.

1-3 HISTORICAL PERSPECTIVE

Salvage of objects from the sea has been of interest to the Navy for many years, however, technology limited the Navy’s ability to work in the deep ocean. It is only in the second half of the twentieth century that complex technology has been developed for locating small objects on the seafloor and allowing recovering objects far below depths at which divers can work. Prior to the development of advanced technologies (such as towed side-scan sonar), grapnels, divers and low-resolution sonars were the only tools for ocean search. Such searches were difficult, limited in depth and had a very low probability of success. Technological development has made it possible to locate and recover almost any object on any seafloor. The United States Navy has led in the development and application of deep ocean technology because of expanding strategic importance to locate and recover objects and due to the necessity of maintaining a position as the world’s most capable deep ocean operator.

Naval and civilian laboratories played a significant role in developing the applications into capabilities for deep manned submersible and remotely operated vehicle (ROV) technology. The marriage of the laboratory-based technology with the operationally oriented salvage community had its first test in the 1963 search for the submarine THRESHER (SSN 593). The marriage, coupled with the increased objectives, has been largely responsible for the evolution and success of Navy deep ocean operations.

1-4 TECHNOLOGICAL EVOLUTION

Progress into the sea is necessarily evolutionary rather than revolutionary. The rate of evolution is dependent upon accumulated knowledge, application of new ideas and the demand for services. As the cumulative knowledge base grows, the rate of technological development increases. Slow, steady progress has come from hundreds of Navy deep ocean operations. Early leaps in deep ocean technology came from the searches and investigations that followed the losses of the submarines THRESHER and SCORPION, as well as the search and recovery of an Air Force weapon off Palomares, Spain.

The technological evolution that has occurred over the intervening 20 years has included:

- Surface and underwater navigational systems that allow precise definition of target location and consistent return to the position.
- Search systems that permit fine-grained searches over large areas at greater depths.
- Imaging systems including laser- and computer-enhanced systems for identification and inspection of bottom objects and definition of debris fields.
- Seafloor mapping systems that precisely define bottom topography.
- Compact, high-efficiency camera and optic systems that can produce near-daylight conditions with far-reaching penetration in seawater.
- Manned submersibles that allow manned salvage operations beyond ambient pressure diving depths.
- ROVs for unmanned, long-duration salvage operations at virtually any depth.
- Lightweight, high-strength fiber optic umbilicals for command, control and data transmission.
- Acoustic communication links.
- High-strength, synthetic lift lines.
- Ship motion compensating systems.
- Stationkeeping systems for surface ships.
- Satellite communication systems.

1-5 PHILOSOPHY

Deep ocean operations and systems must be tailored to the specific conditions of the job. The job conditions are central to the choice of salvage systems:

- *Divers* can work and perform well in shallow water. The practicality of divers decreases drastically with depth and the accompanying decompression. Divers have the advantages of human vision, judgement and manipulative skills. However, depth limitations, dive duration, risk, support requirements and cost often offset these advantages.

- *Manned submersibles* and a*tmospheric diving systems* take man deeper than ambient pressure diving and incur no decompression debt. These systems have proven themselves in operations where it is advantageous to have an operator who can view the target in three dimensions and can reason on the bottom. Manned vehicles operate without tethers which can severely limit the maneuverability of tethered vehicles (ROVs), particularly in high-current areas.

- *Remotely Operated Vehicles (ROVs)* are the tools of choice for most deep ocean salvage operations. These vehicles are available in a broad range of capabilities, allowing the equipment to be fitted to the task. Unmanned ROVs eliminate the risk to human life inherent in manned systems. An ROV is capable of operating at depth until the task is complete or maintenance is required; operator fatigue does not limit mission duration. Long mission duration is particularly advantageous where the depth requires long ascent and descent times.

Rapidly changing sophisticated technology dominates deep ocean operations, but the human element remains. Technology alone cannot achieve the objective; seamen and salvors of experience must utilize the equipment with judgment, flexibility and innovation to ensure that the operational objectives are achieved.

1-6 THE ROLE OF THE SUPERVISOR OF SALVAGE

The U.S. Navy Supervisor of Salvage (SUPSALV), resident in the Naval Sea Systems Command (NAVSEA), is the primary Federal agent for underwater search and recovery. To supplement in-house Navy assets, SUPSALV maintains contracts with companies that specialize in deep ocean operations. These contracts enable SUPSALV to respond immediately to Fleet requirements. SUPSALV retains technical direction of the contractor and provides an experienced representative (SUPSALVREP) for each operation.

Except for tasks that originate within NAVSEA, tasking of SUPSALV for search and recovery assistance originates from the Chief of Naval Operations (CNO). The primary directive governing deep ocean operations is OPNAVINST 4740.2(series). Fleet Commanders-in-Chief may conduct deep ocean operations when they have suitable resources available. When such resources are unavailable, Fleet CINCs request services from CNO, who in turn tasks SUPSALV. The Shore Establishment, other Federal agencies, foreign governments and commercial interests make requests through CNO in the same manner.

While requests for services are not made directly to SUPSALV, operational alerts often are received prior to the formal request to CNO. SUPSALV responds to operational alerts by initiating the planning process or providing guidance.

CHAPTER 2

UNDERWATER SEARCH AND RECOVERY TECHNIQUES

2-1 INTRODUCTION

Underwater search and recovery operations to locate, identify, observe and recover specific objects from the seafloor are vital aspects of the Navy's ability to work in the deep ocean. These operations are similar, but never identical. The successful salvor must be able to select and integrate the most appropriate and compatible search and recovery systems, navigation systems, ships and specialized personnel to maximize the probability of locating the object of interest and effecting its recovery.

Typically, search and recovery operations are conducted as two distinct phases. Search operations encompass initial detection and classification of the object and, in some instances, direct identification or inspection. Inspection of the target can either be a prerequisite to the recovery or an end in itself. As some equipment and personnel may be common to both phases, it is useful to consider search and recovery together from the outset. As a rule, the operations are tailored to a particular set of expected conditions. The overall plan should be as detailed as possible, but still have built-in flexibility to allow modifications in response to changing conditions.

2-2 UNDERWATER SEARCH

Underwater search is a fundamental aspect of deep ocean operations, in that no object can be identified, inspected or recovered until it is first located and searchers can return to it at will. Because of the complexity and difficulty associated with the conduct of deep ocean search operations, precise planning and exacting attention to detail are essential to success. The keys to successful searches are:

- Thorough analysis of all available information.
- Application of lessons from similar searches.
- Detailed planning.
- Operational simplicity.
- Correct equipment selection.
- Expertise.

Throughout this manual are references to selecting the most appropriate equipment in response to the particular conditions of the search. The factors listed below are those that must be considered when selecting the various components that comprise a complete search system:

- The presence of acoustic pingers, transponders or other location aids.
- Datum quality.
- Target characteristics (size, material and breakup characteristics).
- Water depth and characteristics.
- Seafloor type and topography.
- Prevailing weather conditions.
- Geographical location.
- Equipment availability.

2-2.1 Search Classification. Search operations can be classified by a number of different parameters on an individual basis or in combination. The primary purpose of classifying an operation is to define the specific set of factors (primarily environmental and target related) that will characterize the search. The operations plan, a constantly evolving script that specifies the search systems, navigation systems, surface vessel, project organization and logistics support, will be tailored to the baseline classification during the earliest stages of pre-operational planning. Common ways of classifying a search include distance offshore, water depth and datum accuracy, as outlined below. For all three factors, moving towards the bottom of the list increases operational complexity on an exponential basis.

- Distance Offshore:
  - Short less than 30 nautical miles
  - Medium 30 to 70 nautical miles
  - Long 70 nautical miles or greater
- Water Depth:
  - Shallow less than 300 fsw
  - Medium 300 to 3,000 fsw
  - Deep 3,000 fsw and deeper
- Datum Accuracy (Search Area):
  - Excellent less than 1 square nautical mile
  - Good 1 to 10 square nautical miles
  - Fair 10 to 25 square nautical miles
  - Poor greater than 50 square nautical miles

2-2.2 Search Tools The range of tools available to the contemporary underwater search specialist vary from the simplest and cheapest of devices, such as a grappling hook, to complex leading-edge technologies, such as a laser-imaging system. In mastering their field, the search specialists' goals should not only be limited to achieving technical proficiency with each of these tools. Preferably, their goals should also include an understanding of each tool's relative advantages and disadvantages that will enable them to carefully select the most appropriate search equipment given the unique set of operational factors that have been presented. This manual does not attempt to offer that breadth of knowledge, for it is only with extensive first-hand experience that such mastery is achieved. Rather, the aim of the discussion that follows is to briefly outline the predominant tools used in deep ocean searches and how they are most commonly applied.

2-2.2.1 Echo-Sounders. Echo-sounders are a type of sonar that can serve several important functions during a deep ocean search operation. They consist of a power supply, a transducer (a ceramic device that converts acoustic energy into electrical energy and vice versa) and a graphic display and control unit. It is usual for echo-sounder systems to be permanently installed on a ship with the transducer arrays mounted through the hull. Selection of a suitable system, therefore, can be limited to the resident system onboard the chosen search vessel. Portable systems that make use of a towed or rigid-mounted, over-the-side transducer can be used when the ship has no deep water echo-sounder or when the installed system is insufficient.

The main value of an echo-sounder during a search is the continuous seafloor topography data it produces. This real-time information is critical in avoiding damage or loss of a towed search unit such as a side-scan sonar or a pinger-locator. Additionally, the topography data can reveal areas of extreme seafloor relief which could act as physical barriers to the incident travel of sound waves. Echo-sounders are infrequently used as the primary search sensor for deep water searches because their resolution is poor and the swath they cover in a single pass is relatively very narrow. The object of interest would have to be large, dense and have a well-known position to have even a reasonable probability of success; very large shipwrecks would be an appropriate candidate for an echo-sounder search while the debris field of an aircraft would not.

2-2.2.2 Side-Scan Sonar. Side-scan sonar is generally considered the single most effective tool for underwater search. A side-scan sonar uses acoustic transducers towed underwater to produce a plan view image of the seafloor that is analogous to an aerial photograph. The resulting acoustic image, often referred to as a side-scan sonar image or sonograph, reveals the topographic and compositional (rock/mud/sand) nature of the seafloor, as well as man-made objects lying on the seafloor (Figure 2-1). Because the swath of seafloor covered in a single pass by side-scan sonar is relatively wide (50 meters to more than 2,000 meters), large areas of seafloor can be systematically searched for objects with a level of efficiency (rate of area searched per time expended) and confidence that can not be matched by other search tools.

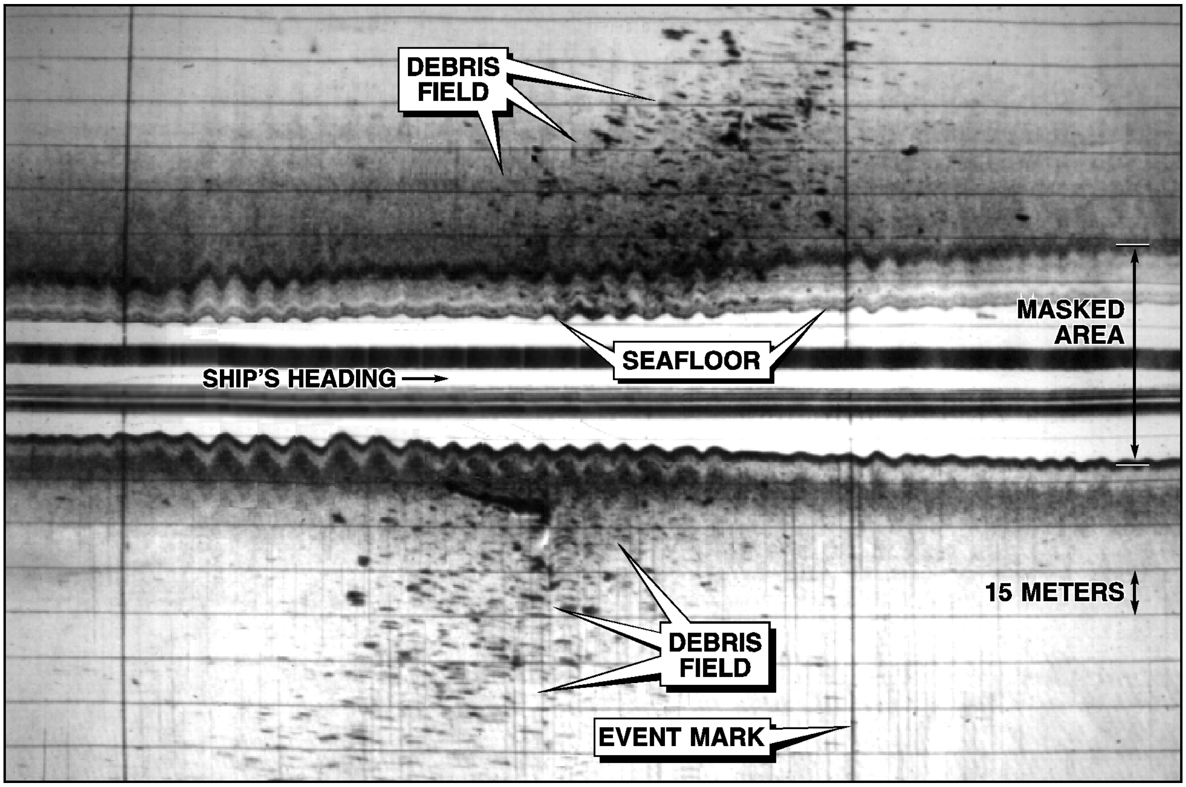

Figure 2-1. Typical Side-Scan Sonar Trace.

The effective resolution (the ability to resolve very small objects) of a side-scan sonar system depends largely upon the system's operating frequency; the higher the frequency, the greater the resolution. Unfortunately, swath width coverage is inversely related to frequency such that the higher the frequency, the smaller the area of seafloor covered in a single pass. These fundamental relationships weigh heavily in the planning of a search and the selection of the most suitable side-scan sonar system. Of the factors listed in Section 2-2, datum quality and target characteristics are the most critical with respect to this discussion on resolution and swath width coverage. For instance, a small object such as a 55-gallon steel drum will necessitate searching an extremely narrow swath (50 to 100 meters) with a high-frequency system (500 kHz). Larger objects (i.e., shipwrecks) lost under circumstances that result in poor datum quality have been located using low-frequency (30 kHz) systems that cover swaths up to 5 kilometers.

There are three basic components to any side-scan sonar system: (1) the towfish that houses the transducers and associated electronics, (2) the electromechanical towcable that connects the towfish to the shipboard control and display electronics and (3) the shipboard unit that controls the operation of the towfish and displays/records the sonar image for interpretation by the operator. Sonar images are displayed in real-time by either a graphic recorder in black and white or a computer monitor in color. Figure 2-1 shows a typical side-scan sonar image of an aircraft debris field produced by a graphic recorder. In addition to real-time display, many systems provide for logging the image data on a variety of storage media, such as magnetic tape, VHS video tape or computer-based optical disks. Once logged, the image data can be replayed at any time for further processing and analysis.

2-2.2.3 Pinger-locators. Pinger-locators are passive types of acoustic search systems that do not produce any sound - they only *listen*. Pinger-locators derive their usefulness from being able *to hear* the transmissions from acoustic beacons or pingers that are often attached to devices that have the potential of being lost at sea (cockpit voice recorders and flight data recorders used by nearly all military and commercial aircraft have secured to them a 37 kHz acoustic pinger to aid in their location in case of a crash at sea).

Pinger-locators that employ an omnidirectional hydrophone have a maximum detection range of approximately one nautical mile or 1,850 meters. Because the omnidirectional hydrophone can not give bearing information, several passes must be made over the pinger to pinpoint its position. A more advanced type of pinger-locator that employs a tuned array with a narrow directional hydrophone (±15°) has the added benefits of increased range (maximum detection to 2 nautical miles) and general bearing information. Towed pinger-locators (TPLS) are towed through the search area much like a side-scan sonar, but at a higher speed. Because of their long range, they are generally much more effective in locating the target in a shorter time period. Figure 2-2 illustrates the operation of a towed pinger-locator (TPL) system for search. Pinger-locators designed for hand-held operations from the surface or by divers, also exist for underwater search. However, their range is limited; thus they are only suitable when the pinger's location is known within narrow limits.

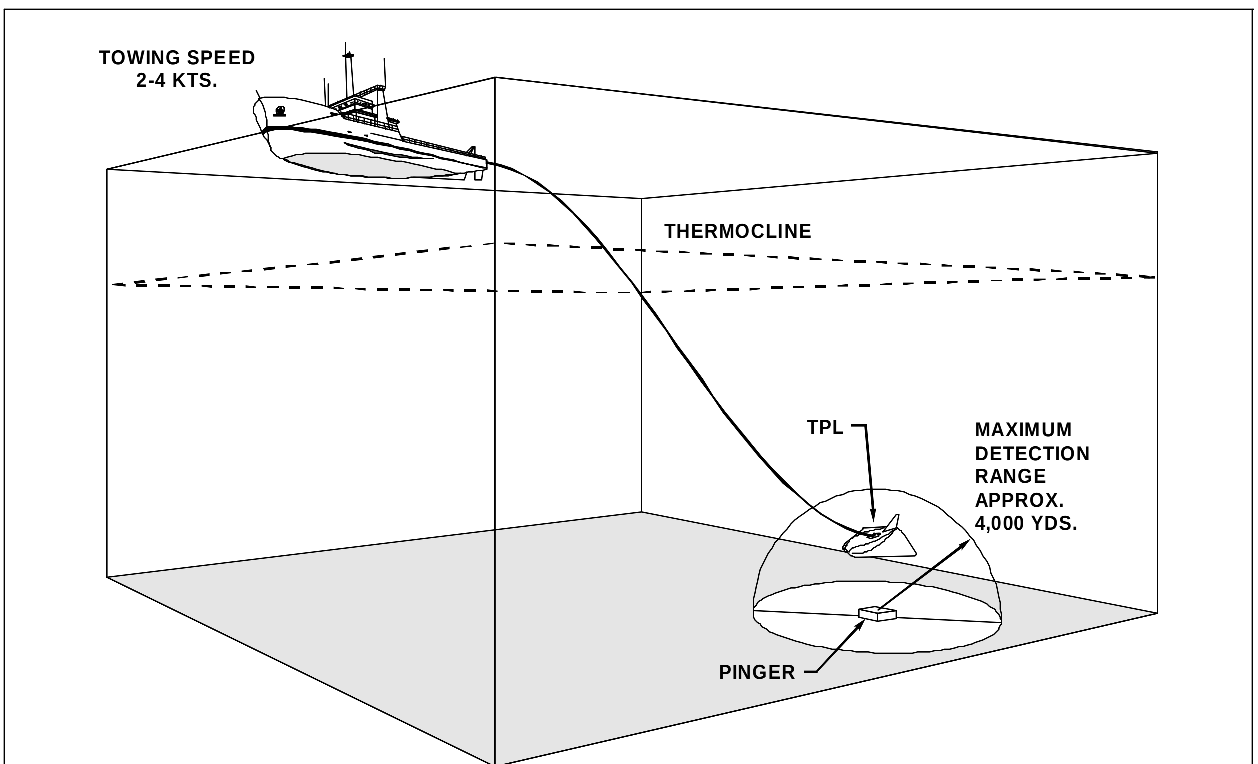

Figure 2-2. Towed Pinger-Locator (TPL) Operation.

2-2.2.4 Magnetometers. The use of a magnetometer for underwater search is strictly limited to metal objects that are magnetized - the object must contain iron or steel. Common objects that can be directly or indirectly located by a magnetometer search include pipelines, steel telephone cables, steel-hulled ships, engines, anchors, anchor chain, guns, mines, submarines, aircraft (indirectly via its engines) and ancient ships. Because of their relatively limited detection range (the magnetic response of an object decreases at roughly the rate of the cube of the distance between the sensor and the object), magnetometers are not often used as the primary sensor for deep ocean searches. However, they can be of value as a secondary sensor to a side-scan sonar search, particularly in instances where the object is lost within a target-rich environment, such as a field of rocks, and the sonar return from the object is not easily distinguished from those of the rocks. By correlating positive “hits” from both the side-scan sonar and magnetometer sensor that are towed in tandem, the probability of detection of the object is significantly improved. Moreover, a magnetometer is one of the only tools capable of locating an object that is buried deeply in bottom sediments.

2-2.2.5 Optical Imaging Systems. Optical imaging systems have been successfully used in deep ocean searches, either independently or in combination with a side-scan sonar. The obvious advantage of an optical imaging system is that the image produced should result in identification of the object without the need for time-consuming contact classification. On the other hand, the disadvantages of these systems are numerous, including:

- An extremely narrow swath width and range,
- Relatively low towfish altitudes and
- Low overall search speed and search rate.

The actual sensing devices used in optical imaging include:

- Still photographic cameras.
- Real-time video cameras.
- Electronic still cameras.
- Laser-imaging systems.

The first three devices all rely on conventional strobe or floodlights as their illumination source. Due to limitations imposed by attenuation of the light and backscattering, these sensors need to be within 10 to 20 meters of a target to identify it. A laser-imaging system utilizes a blue/green laser as the illumination source to minimize attenuation and backscattering problems and can image targets as far as 50 meters away.

2-2.2.6 Remotely Operated Vehicles (ROV). Unlike the search tools discussed above, an ROV is not inherently a sensor that has the ability to detect an object by sensing its physical characteristics. Rather, an ROV is simply a platform that can carry sensors into the deep ocean and maneuver them in proximity to the object. The value of an ROV as a search tool is measured on the basis of how effectively and efficiently it can cover a specific area as compared to towed systems. In essentially all instances, an ROV is limited to operating in relatively small areas because of the requirement of the support ship to hover directly over the ROV and the effect of the umbilical on the system's maneuverability. As a search tool, the ROV can be very effective at locating small isolated targets in a debris field previously surveyed with side-scan sonar or in locating large targets when the datum is known to be within approximately one square mile. To accomplish this, the ROV uses onboard search sensors (acoustic and optical) to locate the object, confirm its identification and perform any other mission-related tasks.

2-2.2.7 Navigation Systems. Accurate and repeatable navigation is an essential requirement for deep ocean search operations. Among the myriad of functions a navigation system provides to the search specialist, the most basic are:

- The ability to steer the vessel along predetermined search tracks.
- The ability to precisely track the position of the search vessel and sensor towfish at all times.
- The ability to return to any position at a later time.

Navigation systems commonly used in search operations range from shore-based and sophisticated satellite-based positioning systems to track the surface vessel, to acoustic positioning systems that track the subsurface position of the search sensor.

A review of the various navigation systems available is beyond the scope of this manual. Criteria used to select an appropriate system include:

- System accuracy,
- System repeatability,
- Range and
- Logistic support requirements.

Whichever system is chosen, it should include an easy-to-understand monitor to assist the helmsman in steering the vessel down track lines. Typically, these monitors display the search area box, track lines, current track being run, position of the vessel and search sensor along the track, off-line error, start-of-line and end-of-line points and various waypoint and event information. The monitor and a hard copy track plotter also allow the watch leader to monitor progress of the search. Finally, the system should have the capability to permanently log navigation data for subsequent review and analysis.

2-2.3 Loss Data Analysis. Loss data analysis is the process of defining the search area and most probable target location through the acquisition and analysis of all available information surrounding the loss of an object. This effort starts the overall planning process and will usually influence other planning activities, such as equipment selection and search pattern design. The first step is to compile absolutely every piece of information available from the actual scene of the loss. Oftentimes this involves a first-hand visit to the scene by the search specialist to interview eyewitnesses as soon as possible. Because it is well known that information degrades with time, speed is paramount. The search specialist attempts to gather the following information:

- Time of the loss and other related events.
- Eyewitness and survivor accounts describing the loss.
- Position of the loss or last contact with the object (LAT/LONG, visual range and bearing, radar fix, etc.).
- Position of floating debris.
- Position of survivor rescues.
- Weather conditions at the time of loss (wind speed and direction, visibility).
- Water conditions at the time of loss (tides, currents, wave/swell).

With as much of this information in hand, the search specialist will reconstruct the loss scenario with the focus of determining the most probable sinking position of the object In some cases, the sinking position will be known with high accuracy; in others, it will have to be deduced. All pieces of information, as well as their sources, will have to be analyzed for their accuracy. It is typical that some data will be contradictory and a judgement will have to be made favoring one datum over the other. The dispersion of a target by subsurface currents will have to be factored in to determine the most probable seafloor position of the object. The search area box around the most probable seafloor position must account for the cumulative error or the uncertainty inherent in the deduced position. The confidence level that the target lies within the search box should be very high before the actual search commences.

2-2.4 Search Probability Analysis. Search probability analysis takes the loss data analysis described above one step further in determining the most probable target location. In this higher level analysis, the search area box is partitioned into smaller areas called cells, each of which is assigned its own probability percentage indicating the likelihood the target rests within that cell. A computer-generated map of these cells will indicate to the search specialist where within the search box the initial searching should be concentrated. Theoretically, this analysis will result in a more efficient search and quicker location of the lost object if the search area is very large and can be searched in cells.

2-2.5 Search Patterns. Short of successfully locating the object of interest, the quality of a search is measured by how thoroughly and efficiently the search area is examined. Systematic examination of the search area is achieved by following a predetermined pattern that is tailored to the particular conditions of the search. A related advantage of search patterns are that they force the at-sea operations to be as routine and consistent as possible. This consistency allows all hands, particularly the ship's captain and crew, to become quickly accustomed to their duties and responsibilities.

The patterns presented below have proven to be both effective and practical for deep ocean searches. An important general rule for side-scan sonar searches, regardless of what search pattern is used, is to orient the long dimension of the search area so that it is parallel with the depth contours. Towing the side-scan sonar along constant depth contours minimizes the need to make periodic or rapid movements of the towfish altitude as the depth changes and results in better sonar performance. Signal loss on the down-slope side when running along contours may occur, but is preferable to poor returns from the towfish as it is hauled up and down.

2-2.5.1 Parallel Grid Search. The most commonly used search pattern for a towed sensor search (primarily side-scan sonar) is a rectangular grid with every straight-line search track parallel to the preceding one. Figure 2-3 illustrates this pattern. Adjacent search tracks are spaced close enough to allow the sonar coverage to overlap the previous lane. This overlap forgives ship track and sonar tow path variations, as well as compensates for the inherent loss in the sonar return and resolution at the outer ranges. Section 2-2.6 provides additional information on swath width, lane spacing and range overlap.

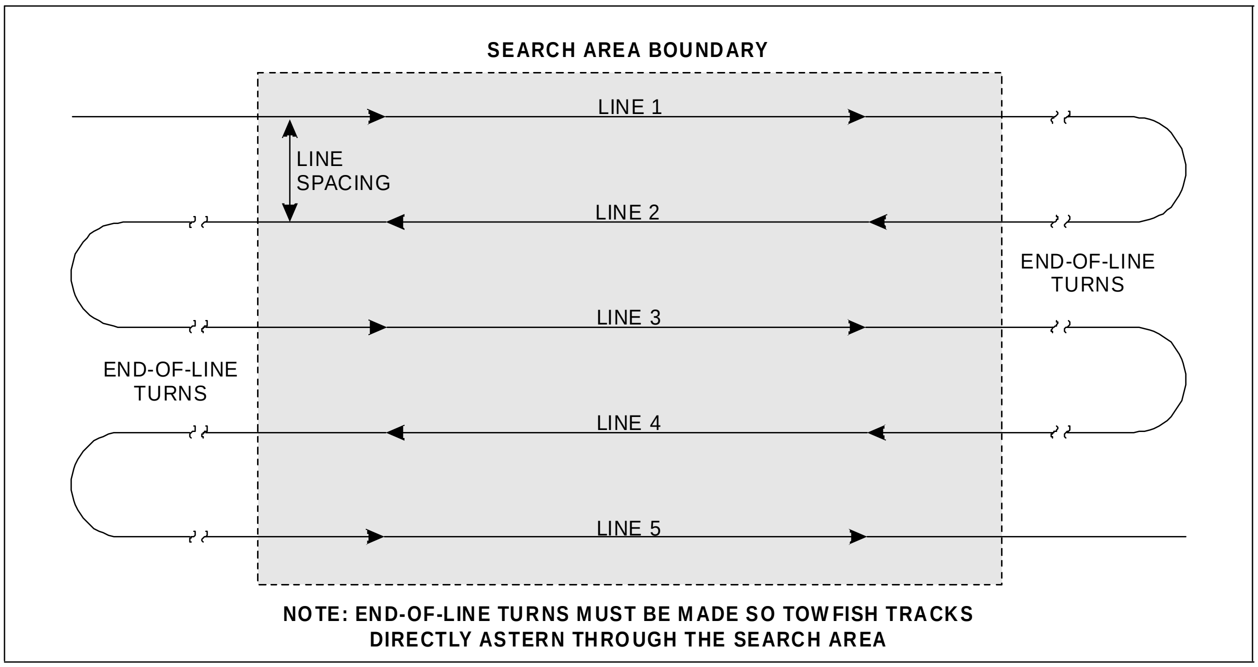

Figure 2-3. Parallel Grid Search

As illustrated in Figure 2-3, the ship must reverse course at the end of each line and steady on the course for the next search line with the towfish aligned behind her before entering the search area. Because a towfish will naturally tend to dive in a turn, turns must be made very carefully to avoid collision with the bottom. This is especially true in deep water as the towcable deployed is very long. In deep searches, a straight run of several miles is needed to stabilize the towfish laterally. As a result, the time required for end-of-line turns often exceeds that spent actually searching.

2-2.5.2 Constant Range Search. Constant range searches are used only out of necessity should the navigation system not have a resident capability for guiding the search vessel along straight lines. Maintaining a systematic pattern by this method relies on running search lines that are a constant distant from a fixed reference point. The reference point can be a navigation reference station established onshore, as shown in Figure 2-4 or even a landmass point that is kept in constant range by radar (the former method will clearly be more accurate). The other station(s) or radar range(s) can be used to mark the start-of-line, end-of-line and fix points for event recording. An important caveat to this type of pattern, when used for a side-scan sonar search, is that the range from the steering shore station must be great enough to yield a reasonably straight-line segment. Tracks that are not straight will degrade the side-scan sonar imagery and the job of interpretation much more difficult.

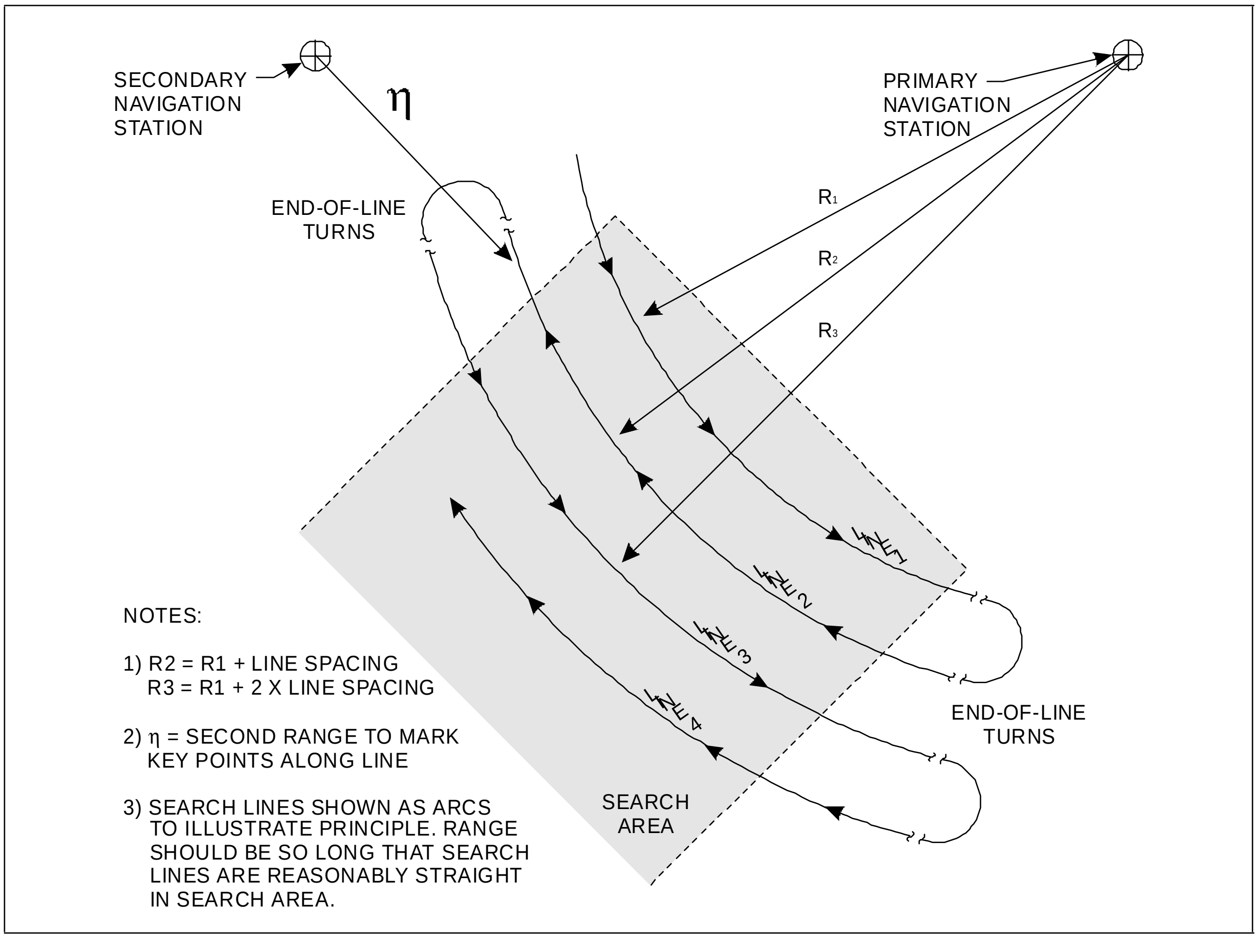

Figure 2-4. Constant Range Search.

2-2.5.3 "Z" Search. "Z" search patterns are used specifically for the location of an underseas pipeline or cable. "Z" searches can be very efficient in that they essentially cover the entire search area with slightly less detection probabilities than a parallel grid search, but without the need for 100-percent coverage and typical overlap. The "Z" search makes an advantage of the long and linear nature of pipelines and cables by ensuring that the towed sensor will cross the object several times at a reasonable aspect angle for detection. Should the object be detected with high confidence on the first few passes, the pattern can be modified such that the tracklines will be shortened to just span the object and eventually follow it continuously within sensor range. The primary disadvantages of a "Z" search are that the object's orientation must be known beforehand and that the actual moment of detection is short-lived and can be missed. For this reason, it is recommended that both a side-scan sonar and magnetometer be used in tandem when conducting a "Z" search for a cable or pipeline.

2-2.5.4 ROV Box Search. A box search is unique to ROV operations. The basic concept of a box search is that the ROV will individually and completely search a square area of seafloor and then move on to search an adjacent square area of the same dimensions. Through successive searching of adjacent boxes arranged in a grid, the ROV can systematically cover a search area with reasonable expectations of full coverage.

Box searches are typically designed around the effective range of the ROV's scanning sonar and the scope of free movement available to the ROV pilot by way of its buoyant tether. Once the grid of boxes is established, the search begins by deploying the ROV in the center of the box while the search ship continually keeps station over the box center. Guided by the sonar contacts it picks up, the ROV flies in radial lines from the center of the box to locate and visually inspect each contact.

2-2.6 Search Coverage. Search coverage is the area of seafloor described by the sensor swath width and the distance traveled by the search vessel on its track. It also pertains to the repeat searching of an area - one pass equals 100-percent coverage of an area and two passes over the same area equals 200 percent. As discussed earlier, the quality of a search depends in part on how thoroughly the search area is examined. Experience has shown, that while occasionally a cursory search may find an object, a thorough search should always be planned and the search area covered completely. The specific relationships between sensor swath width and lane spacing in determining search coverage is discussed in the sections that follow.

2-2.6.1 Swath Width. Swath width is the perpendicular-to-track or lateral coverage of the search sensor on the seafloor. In the case of side-scan sonar, the range is measured from the sonar at the center of the swath, thus the range is one half the swatch width. It is selected by determining the maximum detection range relative to the target characteristics and bottom terrain. Swath width is inversely related to resolution of the sensor, particularly for side-scan sonar - the greater the swath width the poorer the resolution. Assessing this fundamental trade-off in selection of the optimum swath width can only be made by experienced search personnel.

2-2.6.2 Lane Spacing. Lane spacing is the distance between two adjacent tracks in a parallel grid search. The lane spacing must be less than the swath width of the sensor to allow for range overlap and assure total coverage of the search area. The spacing between tracks along with the swath width determines the degree of coverage of the search area and ultimately the quality of the search. As lane spacing is decreased, the coverage and search quality increases because a greater percentage of seafloor is examined in two separate sensor passes. Closer lane spacing, while giving more thorough coverage, increases the search time because more passes are made through a given search area.

2-2.6.3 Range Overlap. Range overlap is the area of seafloor, lateral to the sensor tow track, that is examined twice on successive passes. Range overlap provides a margin of safety to mitigate ship track and sonar tow path variations, as well as compensate for the inherent loss in the sonar return and resolution at the outer ranges. The amount of range overlap required should be determined prior to commencing the search. One of the most common range overlaps used in a search by side-scan sonar is 50 percent. A range overlap of 50 percent is produced by establishing a lane spacing that is equal to 50 percent of the swath width. The entire area of seafloor inside the two outer tracks of the search box will be examined twice in this scenario or in other words, with 200-percent coverage.

2-2.7 Search Time. Search times are calculated during the initial planning to estimate the potential duration of a project. At best, only an idealized search time can be estimated because of the many unforeseen factors that can complicate a search operation. Actual operational times are often greater because they are affected by the realities of nonsearch occurrences such as weather down times, aborted search lines, equipment down times, etc. Additional time to investigate and classify contacts made during the search is also inevitable, but difficult to estimate. As experience increases in a particular search, time estimates can be refined based upon the existing search conditions.

The information needed to estimate search time includes (1) the dimensions of the area to be searched, (2) the lane spacing to be used during the search, (3) the estimated speed of the search vessel and (4) an estimate of the end-of-line turn time with respect to the water depth. The following exercises will lead to a determination of the time required for a search:

- Divide the short dimension of the search area by the lane spacing to determine how many search tracks are required to cover the area.
- Divide the long dimension of the search area by the search speed to determine how long it will take to complete each track.
- Multiply the time it will take to complete each track by the number of tracks required to determine the total time for actual searching within the search area.
- Multiply the estimated end-of-line turn time by the number of search tracks plus one (counting towfish deployment and recovery there will always be at least one more turn than search tracks run), to determine the total time for turning and alignment.
- Add the total time for searching to the total time for turning to determine the idealized search time.

2-2.8 Contact Classification. Echo-sounder, side-scan sonar and magnetometer searches will all generate contacts (anomalies in the case of a magnetometer) that will need to be classified. Classification is the process in which contacts are quantitatively and qualitatively analyzed by experienced search specialists. Essentially a process of interpretation, classification depends on the distinctive characteristics (size, shape, composition, etc.) of the object as the base of reference against which contacts are compared. In many instances, search specialists can easily identify a contact to be the lost object without the need for in-depth classification. In complex searches that involve numerous objects and numerous false contacts, the classification process can take days or weeks.

The quantitative analysis that can be performed on side-scan sonar contacts includes (1) measuring the intensity of sonar signal returned by the contact, (2) measuring the dimensions of the target and (3) measuring the height of the contact off the seafloor, as determined by its acoustic shadow. True quantitative measurements of this type are performed using an image processing computer and require that the sonar data be in digital form. Precise position data of the contacts as they lie next to each other on the seafloor can also be very instrumental in the overall interpretive process.

Qualitative analysis of a contact is the art of interpretation as practiced by the search specialist. Drawing on their background and experience, expert interpreters can provide more conclusive information about a contact than ever possible with quantitative analysis alone. The final product of all this analysis is a list of contacts that is ranked in priority for subsequent observation and identification. The ranking ultimately reflects the search specialist’s opinion, as supported by the quantitative and position data (if available), of which contacts are most likely to be the lost object.

2-3 TRANSITION BETWEEN SEARCH AND RECOVERY OPERATIONS

Search and recovery operations are closely related. Information regarding logistics, weather, bottom and water column conditions, navigation accuracy and many other locally important items developed as the search progresses contribute to successful salvage.

Keys to a successful salvage are:

- Consistency and information flow between the search and recovery phases.
- Complete information turnover, especially when the recovery team differs from the search team.

Recovery planning closely follows search planning. Any procedure, plan, equipment or navigation system that works during the search should continue to be used during recovery. Personnel, equipment and, sometimes, support platforms are suitable for both search and recovery, although the two operations are distinctly different. If possible, the same navigation and equipment team should position the recovery equipment.

It is especially important to a smooth transition for the search team to pass to the recovery team all data from the search that can assist the recovery operation. The Search Project Manager should brief the Recovery Project Manager and the SUPSALVREP and pass along all pertinent technical information. **Paragraph 4-3.1.4** contains a discussion of turnover files.

2-4 UNDERWATER RECOVERY

The development of deep ocean technology has extended the boundaries of ordinary marine salvage into the deep ocean. The major difference between deep ocean recovery and more conventional salvage lies in the tools. Deep ocean underwater recovery requires sophisticated, high-technology tools organized into a system for the particular job. The work also requires intelligent, imaginative and innovative people who are not discouraged by complex problems.

2-4.1 Recovery Systems. Deep ocean operations employ several recovery systems, among them divers, manned submersibles and atmospheric diving systems, remotely operated vehicles (ROVs) and surface-controlled grabbing devices. All systems have a place in the selection and application as recovery tools. The system selected for a particular operation depends upon the task to be accomplished, existing technology, availability, operational feasibility and economics. Every time an individual submerges, regardless of the depth, the degree of danger within the operation increases. For this reason and others developed below, ROVs have become the primary tool of choice for many deep ocean operations. Continuing improvements in robotics, sensors and control systems make it likely that they will continue in this role.

2-4.1.1 Divers. Divers bring human vision, judgement and manipulative skills to recovery operations. These qualities carry significant advantages in shallow water, but the advantages diminish rapidly as water depth increases. Increased water depth escalates the technical complexity of diving operations and the decompression debt incurred by divers. Current and visibility limit productive diving operations when target identification or complicated rigging is part of the task. Diving operations demand numerous personnel - both divers and topside support personnel - and a significant physical plant in the form of recompression chambers, compressors, gas banks and associated equipment.

As depth increases so does the size, cost and technical sophistication of the physical plant that supports the diving operation. There is also a decrease in the productivity of divers and in the proportion of productive time in each dive — at least until circumstances indicate saturation techniques. Saturation diving gives the deepest capability but introduces an order of magnitude increase in complexity of physical plant and cost, offset to some degree by increased diver efficiency. Even standard diving gives access only to shallow depths relative to those attainable by atmospheric diving systems, submersibles and ROVs. Divers are most effectively employed in shallow water when the hazards of the operation and the decompression debt are limited.

2-4.1.2 Manned Submersibles. Manned submersibles, including atmospheric diving systems, take man into the deep ocean for work while avoiding a decompression debt and going deeper than divers. Manned submersibles have proven themselves in operations at sea when it is helpful to have an operator view the target in three dimensions and analyze the situation on the seafloor. Effectively operated by well-qualified people, manned submersibles are safe craft that can be expected to produce excellent results. Untethered submersibles can be especially useful operating below surface currents where drag on an umbilical can limit the maneuverability of tethered vehicles such as ROVS.

Some disadvantages of manned submersibles are:

- Human operators are at risk.
- Manned submersibles must carry complex life support systems that demand power and have a limited duration.
- The submersible must have a man-rated handling system and, usually, a dedicated, specially configured support ship.
- The duration of on-board systems and operator fatigue limit the duration of any single dive.
- Submersible launch and recovery requires nearly ideal weather conditions with calm seas and good visibility.
- Extensive maintenance and certification requirements.
- The potential for conflict between operations and maintenance that must always be resolved in favor of maintenance.

2-4.1.3 Remotely Operated Vehicles (ROVs). In the latter half of the twentieth century, both military and commercial ocean exploration and technology evolved rapidly. It became obvious that an alternative to divers and manned submersibles was needed to accomplish certain tasks. The extremely high cost of conventional recoveries in time and money drove this need. Elements contributing to the high operational costs include:

- Dependence on life support systems with limited durations.
- Weather dependence.
- Requirements for substantial, specialized ships, large quantities of ancillary equipment and numerous team and support personnel.
- Mobilization and logistics complexity.

ROVs developed as a logical alternative. An ROV is an unmanned submersible usually equipped with thrusters, imaging devices and manipulators and controlled through an umbilical. ROVs can be any size and shape. They can be extremely low cost for simple shallow water applications or large and expensive when outfitted with specialized sensors and tool packages for complex deep ocean operations.

Equipped with video systems that provide real-time images of the targets on the seafloor, ROVs enable accident investigators on the surface to determine the specific targets to be recovered and to assign priorities for recovery while the targets are still undisturbed on the seafloor. Video and still photography allow photo documentation of the site before recovery begins.

- The advantages of ROVs are that they:
- Are relatively inexpensive to build and maintain.
- Require fewer operators and support personnel.
- Require smaller and less expensive support ships.
- Can work in rougher weather than submersibles or divers.
- Can remain submerged and engaged in operations for extremely long times.
- Eliminate the risk to personnel underwater.
- Do not require system certification.
- Are easily transportable by commercial and military air and are operable from ships of opportunity.
- Can provide real-time information to topside personnel.

The disadvantages of ROVs are:

- The umbilical limits mobility and control.
- Sensitivity to currents.
- They cannot perform manipulative tasks as dexterously as divers, especially in poor visibility.

2-4.2 Lifting. Every deep ocean recovery operation lifts targets from the seafloor. Lifts can be accomplished by any of three basic methods: vehicle lifts, buoyant lifts and synthetic line lifts. The size, weight and nature of the target as well as the assets available determine the method. Whatever the method chosen, the entire operation should be kept as simple as possible. Intricate maneuvers and complicated handling operations should be avoided. Both ROVs and manned submersibles have limited power and cannot be expected to move heavy weights or long lines.

Targets embedded in the seafloor normally require a force greater than the lifting force to break them out. Detailed discussion of breakout forces and the direction of their application are beyond the scope of this manual. In general, breakout forces are difficult to predict with any accuracy. These forces vary with the time during which they are applied. A large force applied over a short time may break a target out quickly; a smaller force over a longer time can have the same result. Excessive force may cause the target to break out unexpectedly and create destructive dynamic effects in the lift system.

2-4.2.1 Vehicle Lifts. Lifting items with the ROV can be the simplest and most reliable type of lift. ROVs may lift by gripping the target with its manipulator or through the application of a special recovery tool. Because of the potential for loss, it is far more routine to attach a gripping device to the target with the manipulator. The gripping device is in turn attached to the frame of the ROV. The primary limitation is the lift capacity of the vehicle. The ship must recover the vehicle with the target attached or the target must be re-rigged for recovery when the ROV nears the surface.

2-4.2.2 Buoyant Lifts. Buoyant material attached to a target can provide the lift force necessary to break it out and lift it to the surface. Theoretically, any type of buoyant device would work, but gas-generating buoyancy systems have proven most suitable for open ocean recoveries. These devices are most efficient in depths of less than 1,000 feet as the positive buoyancy generated decreases sharply below this depth. Buoyant lifts have the disadvantages of additional equipment rigged to the target and lack of both positive ascent and directional control during the lift.

2-4.2.3 Synthetic Line Lifting Systems. Synthetic line lifting systems, tailored to the specific job, have proven most satisfactory in deep ocean work. The primary components of such a system.

- The effective mass of the target must be considered, not solely its weight.

- Dynamic loading, particularly from surface ship motion, that is not encountered to the same degree while lifting in air significantly increases the maximum line loads.

The lifting system components must work together as an integrated system. For instance:

- The size and strength of the lift line must be capable of supporting the target load, breakout force, lift line weight and water depth.

- The winch type, size, drum diameter, drum width and level wind setting must be compatible with the lift line size.

- The motion compensator sheave diameter and groove size must be compatible with the lift line size.

- The motion compensator load capacity must be greater than or equal to the target load, lift line weight and/or breakout force.

As in other marine systems employing line-mooring, towing, pulling, etc., one of the most important properties of a lift line is its ability to respond to changes in load without parting. Lines respond to changing loads because they are elastic. Elastic line elongates as load increases and shortens when the load decreases. The elongation of a line is a function of its material, construction and volume (diameter and length). Long lines elongate more and can absorb changes in load better than short lines of the same material, construction and size.

Weight, as well as elasticity, influences selection of lift lines. Weight of the line, both as part of the mass to be lifted and as a consideration in air transportation and handling, effectively eliminates all but synthetic fiber lines for deep ocean lifting.

The total weight of the load and the weight of the lift line determine the static load on the lift line. In underwater lifting, the weight lifted is the combined underwater weight of the object and the deployed lift line. Underwater weight is simply the weight in air minus the weight of the water it displaces. If the same recovery system lifts the object through the water and in air, the air weight, including the weight of entrapped water, may determine the static load. In cases where the target is embedded in the seabed, breakout force may be the greatest load handled by the lift system.

In water, the load has three dynamic mass components: the in-water mass, entrapped water mass and entrained water mass. The entrapped water mass is the weight of the water trapped inside the object. This mass component is large for essentially hollow structures, such as submersibles, missiles, boats, torpedoes and aircraft. The entrained water is the mass of the water surrounding the load that moves with it. The entrained water mass changes with changes in shape orientation, acceleration and oscillation during the lift. For practical purposes, a single, conservative value of entrapped and entrained mass is calculated and applied to the lift system design. While calculation of entrapped and entrained mass are beyond the scope of this manual, consideration must be given to their impact for equipment selection for lifting operations.

Lifts are subject to the phenomenon of resonance. In a resonant system, small vertical movements of the ship cause large movements of the load and widely varying lift line loads. Resonance occurs when the natural frequency of the lift system matches the natural frequency of the ship's vertical motion. One of the factors upon which the natural frequency of the lifting system depends is the length of the lift line. As the length of the lift line changes during the lift, the natural frequency of the lift system changes. There is a resonant lift line length or depth for every system. When the load is deeper than the resonant depth, ship motion frequency is higher than the lift system frequency and the load moves less than the ship. When the load is shallower than resonant depth, ship motion frequency is lower than lift system frequency and the load moves with the ship. The danger to the system occurs as the system passes through resonance where very high loads develop. Motion compensation systems allow a system to pass through resonance safely

Ship motions move the upper end of the lift line relative to the load and stretch the lift line, causing dynamic loads. Snap loads are a type of dynamic load that occur when slack lines suddenly become taut. Snap loads relate directly to load mass and may reach ten times the load's static mass. These loads are difficult to predict and should be avoided. Careful ship maneuvering, proper line speed and handling the lift line through a motion compensation system is the best way to avoid excessive snap loads.

2-4.2.4 Motion Compensation Systems. The Emergency Ship Salvage Material System (ESSM) carries in its inventory motion compensated salvage lift systems designed to be transported by trucks and aircraft for installation on ships of opportunity. The systems — known as the Fly-Away Deep Ocean Salvage Systems (FADOSS) — prevent snap loading and reduce dynamic loading to 10 percent of the nominal static load when deploying or lifting loads.

FADOSS are available in three sizes: the smallest system is designed for a 15,000-pound nominal load, the medium system for a 30,000-pound load and the larger system for a 60,000-pound load. The systems consist of:

- A passive ram-tensioner that acts like a large spring to absorb transient loads.
- A high-pressure air compressor.
- A traction winch.
- A hydraulic power unit.
- A powered line storage reel.
- Fairlead blocks.
- An 8- by 8- by 20-foot storage, shop and office van that contains the ancillary kit with tools, rigging materials, etc.

The system layout can be configured to suit the operating platform.

The heart of the system is the motion compensator, a variation of the underway replenishment ram-tensioner system. The motion compensator, shown in Figure 2-5, regulates line tension to keep the line taut.

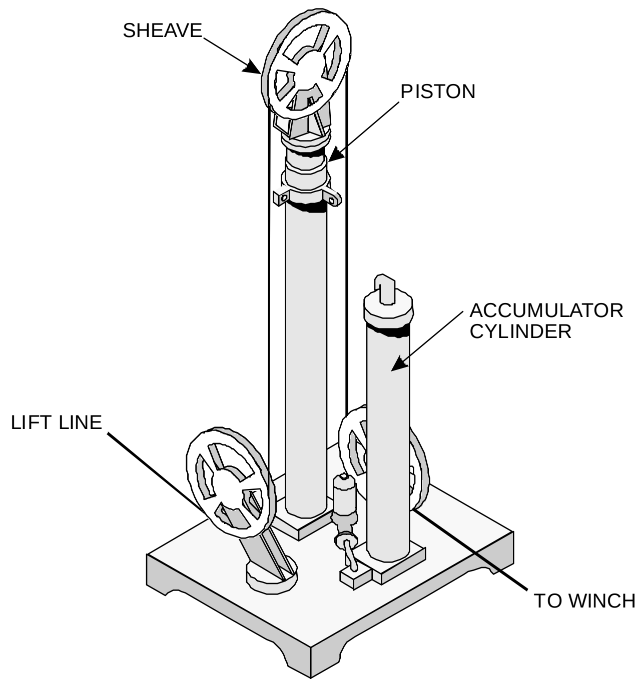

Figure 2-5. FADOSS Motion Compensator System

The motion compensator consists of a hydraulic ram and accumulator. In the accumulator, hydraulic fluid on the bottom and air on the top are pressure balanced. Lift line sheaves at the top and bottom of the ram support the lift line. Tension on the lift line compresses the hydraulic ram. Upon system activation, the ram is adjusted to a mid-stroke equilibrium point. Changes in lift line tension, caused by ship motions, move the ram away from its mid-stroke position causing changes in air pressure. The change in air pressure restores equilibrium between the compression of the hydraulic ram and the tension in the lift line. In this way, the tension in the lift line remains within ±10 percent of a constant value and snap loads are eliminated.

Fairlead blocks designed for synthetic line fairlead the lift line on deck between the FADOSS components-storage reel, traction winch and motion compensator. The blocks also may act as overboard sheaves to direct the lift line from the load to the motion compensator.

2-4.3 Underwater Recovery Operations with ROVS. The following paragraphs describe some considerations in underwater recovery operations with ROVS.

2-4.3.1 Launching. When the ROV system is ready for launch, the support ship is stabilized on a heading which minimizes roll and, with the concurrence of the commanding officer, the vehicle is launched. Although differences exist between various types of ROV systems, the procedure for launch is generally similar. ROVs are more vulnerable during launch, when operating in close proximity to the ship. At this initial point, the ROV has limited power and maneuverability. In fast current, moderate sea state or with the vehicle rigged for salvage, the risk of damage is greater because seas and current can push the positively buoyant ROV into the ship or, a maneuvering ship may overtake the vehicle on the surface

After the ROV is launched, the umbilical is paid out, allowing the vehicle to maneuver on the surface and away from the ship. The ROV holds position away from the ship while the operations team attaches floatation to the umbilical at pre-determined spacing. This *buoyant whip* allows the ROV to maneuver on the seabed without dragging its umbilical. The length of the floated whip will depend upon the depth and nature of the operation. After the floats are attached and the ROV positioned, the vehicle will submerge.

2-4.3.2 Surface Maneuvering. Operationally, one of the single most critical capabilities necessary for a safe and successful operation is the ability of the surface support vessel to maneuver and maintain position during operations with an ROV. Prior to commencement of diving operations, both the ROV project manager and the vessel commanding officer and crew should clearly understand the impact of weather and sea conditions on the maneuverability of the ship and the ROV system. Typically, the ROV project manager will coordinate the operation, directing the movements of the ROV and requesting adjustments to the ship's position. A clear understanding by both ship's crew and ROV operators of the operational requirements, the position or station-keeping tolerances and the ongoing effect of surface weather conditions is critical to success.

2-4.3.3 Underwater Navigation. During ROV operations, the position of the ROV must be known relative to both the ship and the target position to enable efficient maneuvering of the ROV to the designated target position. The most suitable systems are long-baseline (LBL) acoustic transponder systems similar to those discussed in **Paragraph 2-2.2.7**. An LBL system consists of a surface transducer, electronic processor, computer, several transponders and a ROV-mounted transducer. These systems are the most accurate for ROV navigation and are accurate enough to map a large debris field. In every operation, operators must determine seafloor topography, ship and ROV noise, water depth and any other factors affecting acoustic propagation to increase the equipment effectiveness.

An array of at least three transponders is deployed on the seabed around datum. The ship and ROV operating within the boundaries of the array alternately interrogate the transponders using acoustic commands. The transponders, in return, transmit replies that are received by a hydrophone device deployed from the ship. These signals are fed to the LBL computer. The computer calculates ship and ROV positions and displays them simultaneously. Typically, a video monitor will be installed on the bridge and display the positions of the ROV and ship. Figure 2-6 illustrates the basic principles of positioning with a LBL system.

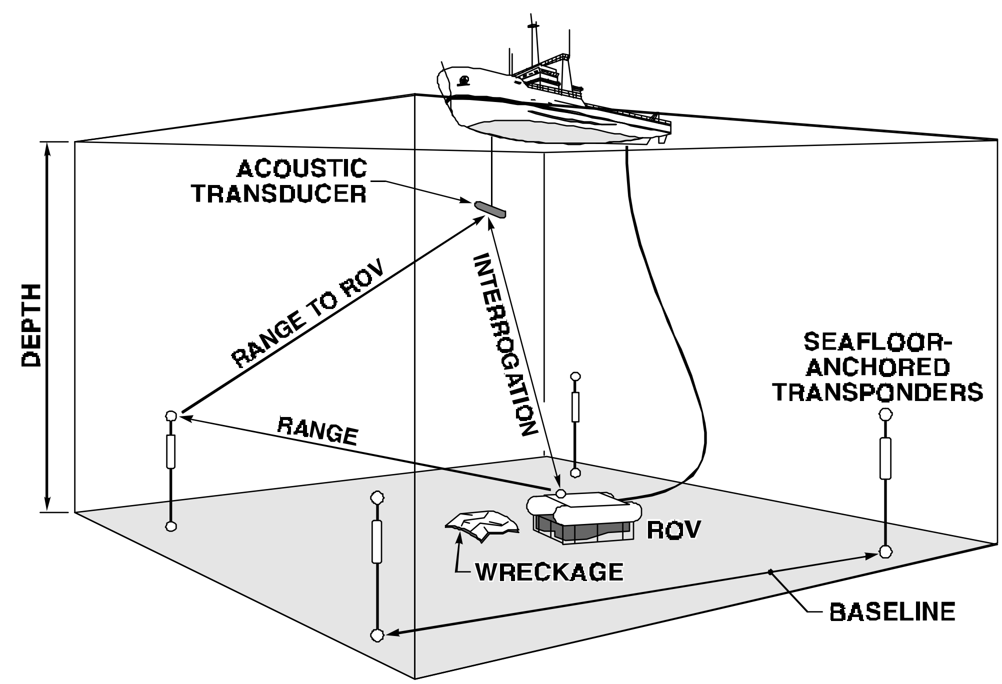

Figure 2-6. Positioning ROV by Long-Baseline System.

When the operation is completed or terminated, the weights anchoring the transponders in position on the seabed can be released via coded acoustic commands from the surface, allowing the buoyant transponders to float to the surface for recovery.

2-4.3.4 ROV Recoveries. ROV Systems are typically deployed with a dedicated handling system operated by the ROV personnel for both launching and recovering the ROV. Recovery with salvaged targets, recovery with a spooler or emergency recovery with no electrical power or with the umbilical damaged may, however, require coordination with the ship's crane.

- *Routine Recovery.* Routinely, the ROV is brought to the surface well clear of the ship with umbilical leading outboard. As the vehicle is maneuvered on the surface, the umbilical is hauled in and ROV personnel remove the umbilical flotation. The ROV is maneuvered to maintain a safe distance from the ship, but will be constantly closing the ship during recovery. Changes in the ship's position are typically limited to fore and aft adjustments while maintaining a steady heading. As the last float is removed from the umbilical, the handling system is oriented outboard to the recovery position and the vehicle hauled in and placed on the deck.

- *Salvage Recovery.* Efforts are made to operate an ROV in a slightly buoyant configuration. Retrieval of an ROV with material or salvage equipment attached often precludes this and the handling system is used to augment vehicle thrust to haul the vehicle to the surface. ROV movement is limited to small position adjustments to avoid having the umbilical contact the ship's hull. If possible, the ship will maneuver to maintain the umbilical as near vertical as possible, while simultaneously reducing roll. When the vehicle reaches the surface, the load is transferred to the ship's crane and the ROV is recovered.

- *Emergency Recoveries.* An emergency recovery is any condition in which the vehicle is not under full control. These conditions usually result from an electrical or hydraulic failure on the ROV or damage to the umbilical.

  In a *loss of power recovery*, the ship maneuvers to maintain a slight outboard lead on the umbilical and maneuvers to maintain the ROV outboard of the handling system as the vehicle surfaces.

  In a *severed umbilical recovery*, the positively buoyant vehicle floats to the surface while its position in the water column is tracked. The ship maneuvers to keep clear of the ROV. When the vehicle is on the surface, an auxiliary recovery line will be attached to the ROV for recovery. If a small boat cannot be launched, the ship must maneuver alongside the ROV to enable a snap hook to be attached to a lift point using a boat hook. The ROV can be recovered by an auxiliary recovery line attached to the snap hook.

CHAPTER 3

UNDERWATER SEARCH AND RECOVERY OPERATIONS

3-1 INTRODUCTION

Underwater search and recovery operations are categorized into four distinct phases: planning, mobilization, at-sea operations and demobilization. While attention focuses on the at-sea operations as the phase that produces the results and accomplishes the mission, all phases are important. The four phases must coalesce into an integrated whole for the operation to be successful and effective. This chapter describes considerations in the four phases of underwater search and recovery operations.

The first step in planning any operation is to determine its goal. Search may be the first operational phase generally followed by salvage. However, in some instances, the task specifications may require concurrent search and recovery. Concurrent search and recovery operations require carefully coordinated planning. These operations are planned when:

- The salvage is urgent and time-critical and both search and recovery teams can mobilize simultaneously.

- There is a large amount of debris to recover. Location and documentation of debris positions can occur simultaneously with recovery.

- The geographic remoteness of the area and data analysis may dictate that a combined mobilization is time- and cost-effective.

Operational procedures for concurrent search and recovery must address mutual interference among different systems. The consequences of fouling ROV and sonar cables when operating in the same general area must be at the forefront during the planning phase. Fouling becomes even more significant when manned vehicles operate with ROVs and towed sonars.

3-2 PLANNING

The complexity of deep ocean operations requires careful planning and preparation. Planners must understand the mission thoroughly in order to identify the proper equipment for both the known mission and contingencies. Selection of the right equipment is vital to a successful, efficient operation. Search and recovery systems must be compatible with the ship, capable of working in the environment and expected water depth and capable of completing the task. Likewise, the ship must suit the mission and provide all the facilities needed. If the equipment is not on hand due to omission or is unsuited for the task, costly delays and possibly mission failure may result.

Planning proceeds in a logical sequence from the general to the specific. This section delineates elements of planning that are necessary in any deep ocean operation.

Flexibility in the face of changing conditions is an absolute necessity in deep ocean operations. In changing conditions, planners and operators must neither adhere rigidly to a plan nor change plans without thorough consideration and sufficient cause.

3-2.1 Pre-Task Planning. This phase of an operation is perhaps the most important of all and could dictate the success or failure of the entire mission. For example, a little extra time spent in planning and data analysis will frequently save many days of searching in the wrong area. On a critical search mission, the task will most likely proceed until the object is located, but on many occasions, only a limited amount of funding is available. In such cases, unless the object is located rapidly, the mission may be shut down before location is achieved.

The pre-task planning phase entails gathering all known or anticipated work parameters to effectively:

- Assemble the proper hardware and support equipment.
- Identify logistics requirements and potential customs problems.
- Formulate contingency plans.
- Assign personnel.

From this information, a detailed operation plan and schedule can be formulated which will serve to familiarize the crew with the overall effort, as well as identify the role each member will play. Teamwork is an essential ingredient in any offshore operation and it begins on the beach.

3-2.2 Loss Analysis. For a search mission, all data surrounding the loss must be collected and carefully reviewed so a loss scenario and search datum position can be established. Potential sources of information will include radar data, TACAN or Inertial Navigation System (INS) data, the position of a wing man, eyewitness reports and the positions of recovered floating debris or survivors. The accuracy and reliability of the information gathered allows an assessment to be made of the accuracy of the calculated datum position and the probability of the lost object being within a given area. Probability of detection is calculated based on bottom topography and object size. The overall size of the search area is then selected to encompass the highest probability areas.

3-2.3 Environmental Data. Work site identification for a search operation will depend on the quality of the information gathered during the above analysis. Once the operations area has been established, additional data must be collected to assist in the development of the actual search plan. Collection of site information is a significant element of this planning process. Data to be gathered includes:

- Water depth.
- Bottom topography.
- Current and tidal information.
- Prevailing weather and sea conditions.
- Obstructions or hazards to operations, such as shipping lanes, fish trawling areas, submarine operating areas, offshore structures, subsea cables, subsea wellheads, known shipwrecks, sea mounts, etc.
- Distance from nearest shore points for possible navigation shore station setup and availability of geodetic positioning system coverage at the suspected site.
- On-site logistics.

3-2.4 Equipment Selection. Equipment identification and selection is made on the basis of task objective and an analysis of information relating to anticipated on-site conditions. The use of SUPSALV assets should be examined. For a search mission, the ORION search system may be used depending on the location and water depth. When its use cannot be justified due to shallow water or transportation economics, the need for either the SUPSALV deep or intermediate winches will be determined. For a recovery mission, the SUPSALV-owned ROVs Deep Drone, CURV or Mini-Rovers can be used.

Once the search or recovery system is selected, the next step is to gather all of the necessary spares, test equipment, tools, manuals and other materials for on-scene troubleshooting and system repair. One hundred percent redundancy in key equipment and spare parts is essential to efficient operations. Complete replacements for critical equipment allow the operation to continue while equipment is maintained or repaired. Checklists are always used during loadout to ensure that nothing required for the job is left behind in the flurry of activity which normally accompanies the fast response mobilization.

3-2.5 Precision Navigation System. A precise navigation system will be selected based on the distance offshore and the existence of LORAN-C coverage in the operations area. If LORAN-C coverage is good in the area, it can normally be used rather than setting up a precise navigation system. If there is no LORAN-C coverage, the use of alternative systems must be investigated. These alternative systems include:

- Microwave range-range line-of-sight systems (Del Norte Trisponder, Motorola Mini-Ranger, etc.). These systems have a maximum range of 50 to 80 nautical miles and require a minimum of two shore stations for position triangulation. Typical accuracies range from three to five meters.

- UHF over-the-horizon systems (Syledis or UHF Trisponder). These systems have a nominal range of two to three times line of sight, out to a range of 100 to 130 miles, depending on the height of the master and remote stations. These systems also require a minimum of two shore stations and achieve accuracies ranging from three to five meters.

- Differential Global Positioning System (DGPS). The GPS satellite constellation now offers 24-hour-per-day coverage worldwide, with an accuracy of approximately +/- 100 meters. When coupled with a reference station placed ashore at a known position, accuracies of less than ten meters can be expected at ranges of up to 300 miles. The differential corrections can also be sent via satellite, increasing the distance between the operating area and the reference station to over 2,000 miles.

With the exception of LORAN-C or Non-Differential GPS, all of the above systems require shore stations. The proximity of a suitable shore station location often dictates which system can be used. In all cases, at least one technician will be left on shore to maintain the shore station equipment. This technician can also be useful for logistics support and communications at remote sites.

Another system that can be of significant use in either remote locations or for deep water towfish tracking is the long-baseline (LBL) acoustic navigation system. This system is sometimes uneconomical due to the number of transponders that may be required for coverage of a large area, but it does provide the exact towfish location and greatly simplifies contact location calculations. Since an LBL system gives the towfish location, it also allows a more accurate search to be conducted and minimizes the overlap required to assure complete coverage of the search area.

3-2.6 Support Equipment. Support equipment will also be identified and selected on the basis of task objective and other related operational considerations. The marine support platform, for example, could be a large or small vessel depending on the task (search or search/salvage), distance offshore, anticipated weather and sea states, free deck space required, craneage required for the task, vessel availability, transit time to reach the port of loadout, stationkeeping ability (bow thruster, slow speeds, twin screws, controllable pitch, etc.), operational endurance and berthing availability. Navy or commercial assets can be utilized depending oN the outcome of the analysis of these factors.

3-2.7 Base Port Selection. The port of mobilization is selected based on a variety of parameters including proximity to operations site; adequacy of port facilities such as craneage, shipyard support services and welding for vessel modification and equipment installation; communications; proximity of suitable marine support platforms; availability of other supplies and services, such as fuel, food, consumables and spares; proximity to airports with suitable aircraft and cargo handling capabilities; and adequacy of roads (permit restrictions, low bridges, sufficient load capacity, narrow roadways, etc.).

3-2.8 Operations Plan. From the information collected and analyzed during this phase, a detailed operational plan is developed. Search line spacing, search line axis, range scale and overlap are all selected based on target and environmental data collected. As in any operational planning, a contingency plan is formulated for all eventualities. This may entail alternative operational scenarios, the sourcing of backup equipment in case of catastrophic failure of the onscene equipment, weather evasion plans and secure communications plans.

3-3 MOBILIZATION

Mobilization begins with the operational alert. The elements of mobilization are:

- Advance party dispatch.
- Operational Planning.
- Equipment shipment.
- Team movement.
- Shipboard installation.

3-3.1 Advance Party. An advance party plays a role in mobilization, as well as in planning. On-scene preparations by knowledgeable search and recovery team members must follow up the preliminary work planning accomplished. Few individuals in either the Navy or the maritime industry are familiar with the requirements involved in a search or recovery operation. Close liaison between the search or recovery team with the other involved parties is essential to both planning and execution of the operation.

For mobilization, an advance visit will:

- Familiarize the personnel with the area.
- Permit inspection of the support vessel, port facilities and other logistic support assets.
- Allow arrangements for establishing shore-based navigation sites.
- Provide a direct point of contact for queries and feedback.
- Establish local communications, transportation and security.
- Allow the contracting of local support services such as a shipping agent or chandler to support the operation.

The advance party meets with and briefs the sponsor. This meeting serves as the starting point for verifying pre-task assignments, analysis findings and reveals additional information which may alter the pre-task analysis.

The advance party verifies truck and material handling equipment capacity and availability, makes loading arrangements and coordinates pickup and delivery times.

3-3.2 Equipment Shipment. Transportation of search equipment or recovery equipment is accomplished by truck, air transport, sea freight or a combination of the three. Most search and recovery equipment is maintained ready for immediate ground or air transportation. In some cases, where the response factor is not urgent and the point of mobilization is international, equipment may be transported via containerized sea freight. In this case, some additional preparation is required to configure system equipment for packing and shipment.

Selection of the transportation mode is based upon the urgency or level of response required, the size and weight of equipment to be moved and the geographic location of the final destination. Direct routing with the fewest possible transfers or layovers gets the equipment to the mobilization point most promptly and in the best condition. Whichever mode of transportation is selected, delays directly affect the operating schedule and costs. In a time- or cost-critical operation, delays can cause the withdrawal of a programmed ship, the loss of critical targets or increase the operational cost.

A logistics coordinator is designated at the outset. This individual must be familiar with all transportation restrictions at both the point of departure and arrival, aircraft loading and packaging requirements for military and civil aircraft, sea freight requirements and customs requirements in destination countries. Properly completed customs documentation, state highway permits, USAF aircraft loading documents and other documentation will help minimize mobilization delays. A standard loadout checklist, specific to the system, guides the logistics coordinator in assuring all necessary equipment and documentation is included. Figure 3-1 shows the loading of a deep ocean recovery system into an Air Force aircraft.

Figure 3-1. Loading an ROV System Aboard an Aircraft.

Salvage equipment transportation can be a single- or three-phase evolution, depending on the location of the operation. Within the continental United States, equipment can move by truck directly to the operational staging areas. Experience has proven that direct transportation by truck can be more effective and efficient than air transport. However, highway transportation requirements, such as wide-load movement, overweight or over-height restrictions and restricted movement time periods, may impact truck transportation and delivery schedules.

Packaging pallets and tie-downs are an integral part of each system. Normally, individual pallet loads are measured and weighed for each deployment. This data helps the trucking company or aircraft loadmaster distribute the load properly.

For overseas operations, a three-phased transportation evolution is typical:

- Surface movement from warehouses to a designated airport or marine terminal.
- Air or sea transport.
- Surface movement between the destination point of entry and support ship.

When transporting equipment to a remote location with limited transportation and support assets, search and recovery equipment may be shipped together. Consolidated transportation is often more efficient and eliminates duplication of effort when moving equipment to the ultimate point of shipboard mobilization.

Commercial aircraft can be utilized for transporting equipment for shallow work. Deep ocean operations usually require large, heavy and bulky equipment which is better handled by large USAF cargo aircraft.

Special Assignment Airlift Mission (SAAM) aircraft are appropriate for extremely urgent operations or transport of a single system directly overseas. A SAAM message in the prescribed format is sent to the Navy Military Transportation Office (NAVMTO), Norfolk, to request a SAAM mission. Both scheduled and SAAM Air Force aircraft may carry team members as passengers or couriers, as well as transport equipment.

Materials handling equipment (MHE) is particularly important for intermodal transfers. Cranes, forklifts and special loaders must be of the correct type and capacity and must be readily available. Large recovery equipment may require special loading equipment for loading onboard military aircraft. Such special requirements are stated in the transportation request. Transportation planners must ensure that the proper material handling equipment is specified and is available at the destination airfield.

Loading equipment and any required operating personnel must sometimes fly in advance of or with search or recovery equipment when deploying to remote locations with limited ground support facilities.

If possible, at least one team member escorts the equipment from warehouse to final destination. The escort ensures that the load remains secure and intact and receives proper handling. A qualified team member is available to answer questions about the equipment and its transportation requirements. Upon arrival at the destination, the escort supervises offloading, handling, customs clearance and storage.

3-3.3 Shipboard Installation. The search or recovery system is installed onboard the support ship at a military or commercial installation. The project manager coordinates the installation of equipment with the operating crew, the SUPSALVREP and the command or support activity.

When mobilization is to be performed at a military installation, clearance requests are submitted in advance of equipment and personnel arrival. All contractor personnel carry documents identifying them as government personnel or contractors. Outside commercial support services - cranes, welders, etc., - are arranged by the project manager or through the base services. Local contractors providing support services at military installations normally arrange for their own personnel and equipment facility clearance and access.

Arrangements for ship berthing at the installation facility vary with the type of facility and vessel. Arrangements for commercial facilities are handled by the project manager or agents for the ship's owners. The berth provided for ship mobilization must be accessible by flatbed trucks transporting the equipment, as well as support equipment such as cranes and forklifts. In addition to the space considerations, piers or berthing areas must be capable of handling the additional weight of the equipment.

The operational team refines the preliminary installation plan and surveys the ship to ensure all details are covered. Placement of equipment onboard must be closely coordinated between the search or recovery team project manager and the support vessel's commanding officer, master or his designated liaison.

The project manager should make a clear presentation of the planned installation, equipment placement, crew support requirements and basic plan of operation to the key members of the ship's crew. Questions, restrictions, reservations, recommendations or any changes necessary due to shipboard requirements should be cleared and resolved during such an interface. Proposed placement of all components should be marked by chalk and the operation walked through if the ship has not supported this type of operation previously.

Routing for electrical cables, rigging and hoses must also be marked to ensure routes are clear with no interference. Securing points should be located and the proof rating substantiated. Installation material, including rigging and securing material, are transported with the system or procured on site. Any material that is not common in general marine usage should be provided with the system. If the system is loaded in a remote or comparatively undeveloped port, all material necessary for shipboard installation must be supplied with the system.

In most instances, navigation and communications equipment with associated displays for coordinating stationkeeping and ship movement are installed on the bridge, which will serve as the central control area for the operation. This supplementary equipment is positioned to facilitate observation and utilization by personnel involved in directing the operation and by those involved in handling the ship stationkeeping responsibilities.

3-3.4 System Testing. When assembly is complete, power is systematically applied to test and exercise the system. A full system test is completed as soon as possible following installation to determine system status, readiness and additional preparations required.

In-water testing while alongside follows successful on-deck system testing. Depending on the configuration of the handling system, it may be necessary to have the ship turn around to facilitate launching of the vehicle. The wet testing assures the system is fully operational before transiting to the operations site — typically remote from shore support.

3-3.5 Preparation for Sea. The operations team secures the equipment for sea with the use of chain or other acceptable rigging. Some ships have permanently installed tie-down points in predetermined patterns on deck and when possible, such points are used. If these are not available, tie-down points are welded to the deck. The system must be secured before departure for sea.

3-4 AT-SEA OPERATIONS

Once the ship sails for the operational site, things start to fall together. The difficult mobilization procedure is finished and the operation is about to commence. This is when the advance planning becomes most important. The ship's crew must learn to work closely with the specialists operating the search or salvage systems and vice versa. In complex operations, dress rehearsals are conducted to familiarize all participants with not only their roles, but those of all other participants. Successful operations always involve a harmonious team effort.

3-4.1 Operational Organization. The command and control structure depends upon the complexity of the operation. Simple search and recovery may require only an afloat organization. More complex operations require:

- Task force organization with ashore and afloat commands.
- Joint or combined military organizations with U.S. and foreign representatives.
- Logistic support, technical advisory and public relations groups.

3-4.2 On-scene Personnel Interface. Search and recovery operations require close coordination between parties from several organizations. The roles and relationships of participating organizations must be established before the operation. Flexibility on everyone's part and a willingness to give highest priority to the success of the mission is important to a smooth running, successful operation. The roles of major participants are:

- *Naval Commanders and their staffs in foreign countries* — Naval commanders and their staffs in foreign countries can assist with liaison with the host foreign government, obtaining approval for operations in foreign territory, gaining entry into the country for personnel and equipment, mobilization in foreign ports, obtaining approval for establishment of shore-based navigation sites and other logistics support requirements.

- *Ship's Commanding Officer or Master* — Throughout the operation, the commanding officer remains responsible for the operation and safety of his ship and crew. The commanding officer will be the central point for consolidating schedules, plans or courses of action. Numerous assets of the support ship will be required and assigned directly by the commanding officer or through an assigned member of his staff or crew.

- *SUPSALV Representative* — The Supervisor of Salvage representative (SUPSALVREP) reports directly to the on-scene commander, acts as a liaison between contractor, sponsor and ship and represents the sponsor's interests.

- *Project Manager* — The contractor's project manager is responsible for the performance of the operational team and the equipment. He is responsible to and consults with the SUPSALVREP on the operational plan and techniques to be employed. The project manager must make applicable support requirements known to the ship's commanding officer and works directly with the commanding officer and SUPSALVREP to achieve the requirements of the task's objectives.

- *Technical Advisors/Incident Investigators* — Technical advisors or investigators will frequently deploy with a recovery operation to assist salvors with technical details or data regarding physical aspects of a target. Such information may include data regarding hazardous material handling, structural information, object or component identification, preservation techniques, etc. Accident investigators may require specific documentation of targets as discovered or may recommend target recovery priorities. In either case, information necessary to the success of the operation may be available and such representatives should be involved in operational planning.

- *Shore Establishment* — Especially in foreign or remote areas, the local shore establishment plays an important role in the operation. Liaison with the host government, approval for operations in foreign territory, customs clearance for personnel and equipment and logistics assistance are all vital to successful operations.

3-4.3 Interface with the Ship. Whether the ship is a U.S. Naval vessel, foreign naval vessel or commercial charter, the SUPSALVREP and the project manager must establish a professional working relationship with the commanding officer or vessel's master. The commanding officer should receive a complete and through briefing of the overall task, search and recovery techniques, watchstanding procedures and requirements for ship's support.

All parties must understand special ship handling techniques such as end-of-line turns, steering, speed changes, precise stationkeeping, coordination of ship movements and safety requirements during equipment launch, operation and recovery. They also must understand the interplay between the operations team and the ship's force necessary to a coordinated effort. Methods of passing helm and engine orders and the action required must be understood thoroughly. If not clear, misunderstandings can occur and result in equipment damage, loss, delays and possibly jeopardize the success of the mission.

The commanding officer should advise the project manager of pertinent ship's regulations and safety precautions including those normally required of the ship's force, such as participation in applicable emergency drills and the teams' emergency muster stations. The commanding officer may appoint specific ship's personnel to work with and assist the search or recovery team during operations.

Clear communications, cooperation and coordination are the keys to successful operations and team effectiveness in deep ocean operations. The commanding officer is in charge of the ship, its operational movements and its overall safety. The project manager is in charge of the operational team, the equipment and their operations and operational safety, including when and how to launch and recover. A mutual understanding of these responsibilities plus the ability to work together as a cohesive team is of primary importance.

3-4.4 Operating Schedule. An overall operating schedule should be developed and issued to all key parties, including personnel ashore. This schedule should contain such information as:

- Scheduled underway date and time.
- Dates of planned returns to port and the services expected to be required.
- Communications schedule.
- Provisions for standby emergency services.
- A code for reporting key operational events when a secure communications network is needed but unavailable.
- Final return date regardless of success.
- Any other information specific to the operation.

3-4.5 Work Routine. During around-the-clock operations, two twelve-hour watches are typical for the search or recovery teams. Operations conducted on a twelve-hour-a-day basis are typically run during daylight hours; however, there are situations which involve unfavorable currents or tides, security or transiting between target positions which may require an operation to deviate from a daylight hours operation plan.

The operations team for search or recovery will normally cause minimal impact on the ship's normal at-sea routine of meals, mess sittings and daily scheduled ship's work. Minor adjustments at 1200 and 0000 messing may be necessary to accommodate the additional personnel coming on or going off watch. These problems will be addressed during the liaison with the commanding officer.

3-4.6 Communications. At-sea operational elements rely on good communications with shore-based support installations and operational and administrative commanders for routine reports, general and administrative traffic and logistic arrangements.

Naval vessels have relatively large communications departments capable of handling both routine and secure message traffic. If operations are conducted from a chartered commercial vessel, especially a foreign-flag vessel, it may be necessary to provide communications equipment and personnel to support the operation. Alternatively, a code to describe completion of key events can be devised for the operation.

A portable satellite communications system is an excellent deep ocean operations asset. These systems provide clear, instant voice and facsimile communications almost anywhere in the world. However, care must be exercised when using such equipment as it is **not** a secure voice or data transmission system and its use is restricted in a number of ocean operating areas and environments.

WARNING

High-energy transmissions are capable of causing significant injury to personnel and damage to electronic circuits in some search and recovery systems. HF radio transmissions must be coordinated with search and recovery system operators.

3-4.7 Weather Reports and Forecasts. The ability to prepare for deteriorating weather and associated heavy seas is of great importance in any operation at sea. Planners should arrange periodic weather reporting, long- and short-range forecasting and emergency reports specific to the operating area.

Naval vessels receive operating area and vicinity weather forecasts on a routine basis. U.S. Navy and other U.S. Government weather facilities may provide special or supplemental forecasts for specific operations. Commercial weather services that serve the maritime and offshore industries also can provide specialized local forecasts.

3-4.8 Safe Haven and Emergency Procedures. As part of the operational planning, a careful review to determine the closest acceptable ports offering shelter or suitable anchorage which could provide a protection in adverse weather should be made. When conducting operations far offshore, the only option for heavy weather may be to recover and secure all equipment and ride out the weather or, if time permits and forecast conditions pose a serious threat to equipment on deck or the support vessel, steam away from the area of the storm. In this regard, it is imperative that all representatives fully understand and appreciate the weather operating limitations affecting the ship, the equipment and personnel required on deck during in-water operations.

Provisions must be made for emergencies, particularly medical evacuations. The nearest medical facilities should be identified and logistic arrangements for a medical evacuation should be established before departure. Naval operational commanders may be able to obtain evacuation and medical assistance from other Naval vessels operating nearby. In the United States and some other countries, the Coast Guard or similar organizations may provide emergency services. In remote areas, such services may be available through commercial assets; however, such services should be thoroughly investigated prior to commencement of an operation.

3-4.9 Salvage Techniques. ROVs use a variety of relatively simple tools to accomplish deep ocean salvage operations. Most common are nooses, safety hooks, shackles, clamps and grippers. Figure 3-2 illustrates typical grippers. When necessary, cutters and other more complex tools are adapted for the operation. Lift lines are either very short to simply connect the attachment tool from the target to the ROV frame or long enough to reach from the seafloor to the ship for a direct lift. Long lift lines are generally deployed to the seafloor on a spooler to prevent fouling between the line and the ROV umbilical. Figure 3-3 illustrates a lift line spooler.

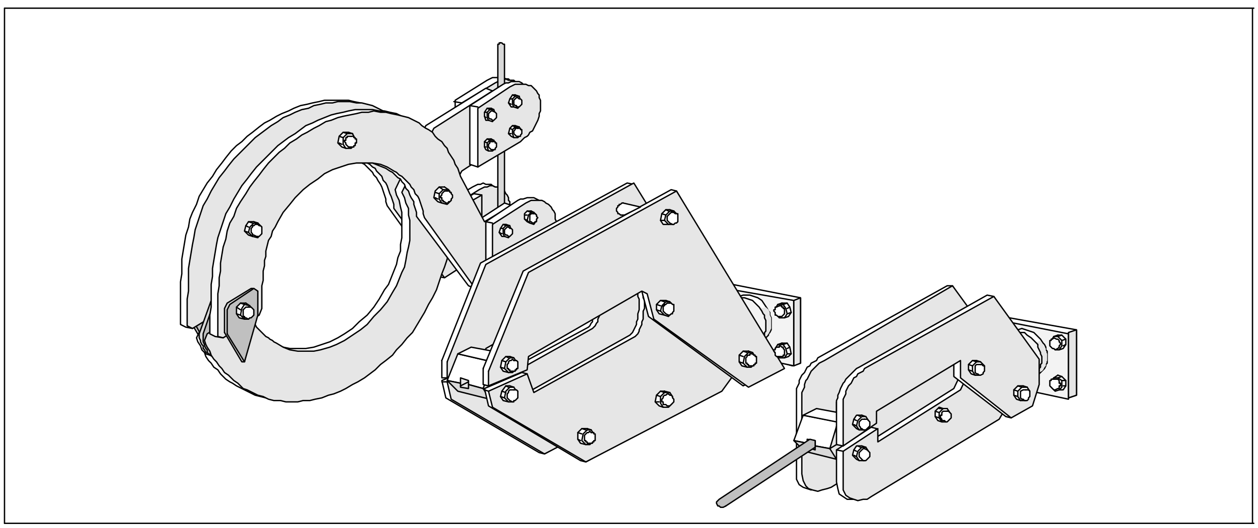

Figure 3-2. Typical ROV Grippers.

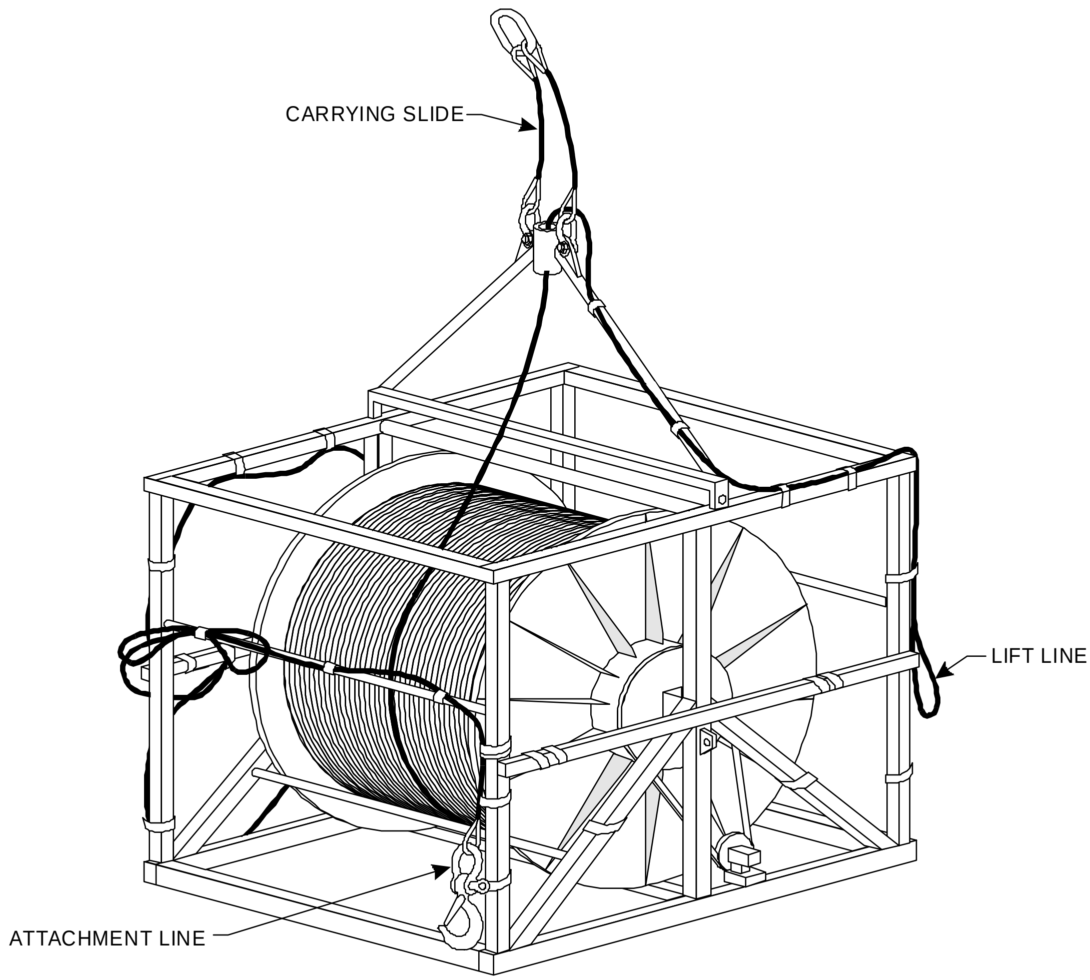

Figure 3-3. Typical Lift Line Spooler

To salvage small objects, the tool is held in the ROV manipulator and attached to the vehicle frame by a short lift line. To effect the lift, the ROV attaches the tool to the target, releases it from the manipulator and proceeds to “fly” the object to the surface.

When the ROV reaches the surface, a separate lift line is often attached to the object to transfer the load from the ROV to the ship’s crane. This is done either by the deck personnel or divers, depending upon the circumstances.

Large or heavy lifts are much more complicated and require multiple dives to accomplish. The execution requires detailed planning and a coordinated effort by all hands. Generally, the ROV locates and inspects the target for attachment points. A lift bridle is then assembled using wire, chain or synthetic line, with some sort of attachment device on each end. In the center will be a D-ring or shackle where the lift line will ultimately be connected. The ROV will then return to the target and attach the bridle. Depending on the established plan, the line spooler will be lowered to the site by the ship or "flown" to the site by the ROV. In either case, the spooler is placed near the target, the ROV attaches a line between the spooler and the previously installed bridle and then "flies" the end of the lift line to the surface. This allows the FADOSS to contend with the heavy spooler and target on the bottom, rather than straining the ROV umbilical. Figure 3-4 depicts a typical spooler lift sequence.

3-5 DEMOBILIZATION

Demobilization encompasses all the requirements necessary to return the support vessel, the operating equipment and the operating personnel back to their respective home bases. Demobilization normally commences as soon as operations are terminated on site.

3-5.1 Mission Conclusion. Demobilization is typically accomplished in a shorter time frame than mobilization if the same high level of planning is utilized. Preliminary demobilization plans are made during operations planning. Tentative plans are discussed in detail with the local support and logistic command and shore-based logistic support personnel assigned to search or recovery contractors. Every effort is made to incorporate the site-specific lessons learned from mobilization into the demobilization plans. This includes such points as transportation mode, packaging, documentation, berthing requirements and availability of support equipment. Additionally, the nature of the recovered target or debris must be considered and details for its offloading and disposition should be considered as a priority in any demobilization plan.

Collectively, the commanding officer, SUPSALVREP and the system project manager can forecast the likely completion of an assigned task. An early alert to the responsible office or coordinator ashore allows timely arrangements to proceed for support such as berthing, offloading equipment, security and transportation arrangements. Special attention in preparing for demobilization and transportation arrangements should include consideration for security, holidays, weekends, customs clearance, debriefing, etc.

3-5.2 Transit. The physical demobilization process may commence while in transit from the operations site to the designated demobilization port. Transit time provides an excellent opportunity to prepare the system for rapid offloading and to schedule work which must be completed on the vessel and system upon reaching port. Additionally, it provides the opportunity for completion of administrative tasks and to ensure the data required for the final reporting and debriefing are complete and in order.

Typically, an operations crew dismantles and disconnects the system as completely as is practical while underway. Lifting with a ship's crane or boom is not normally performed while underway - nor is it recommended - due to the unpredictability of the ship's motion. All equipment will remain secured on deck until the vessel arrives alongside.

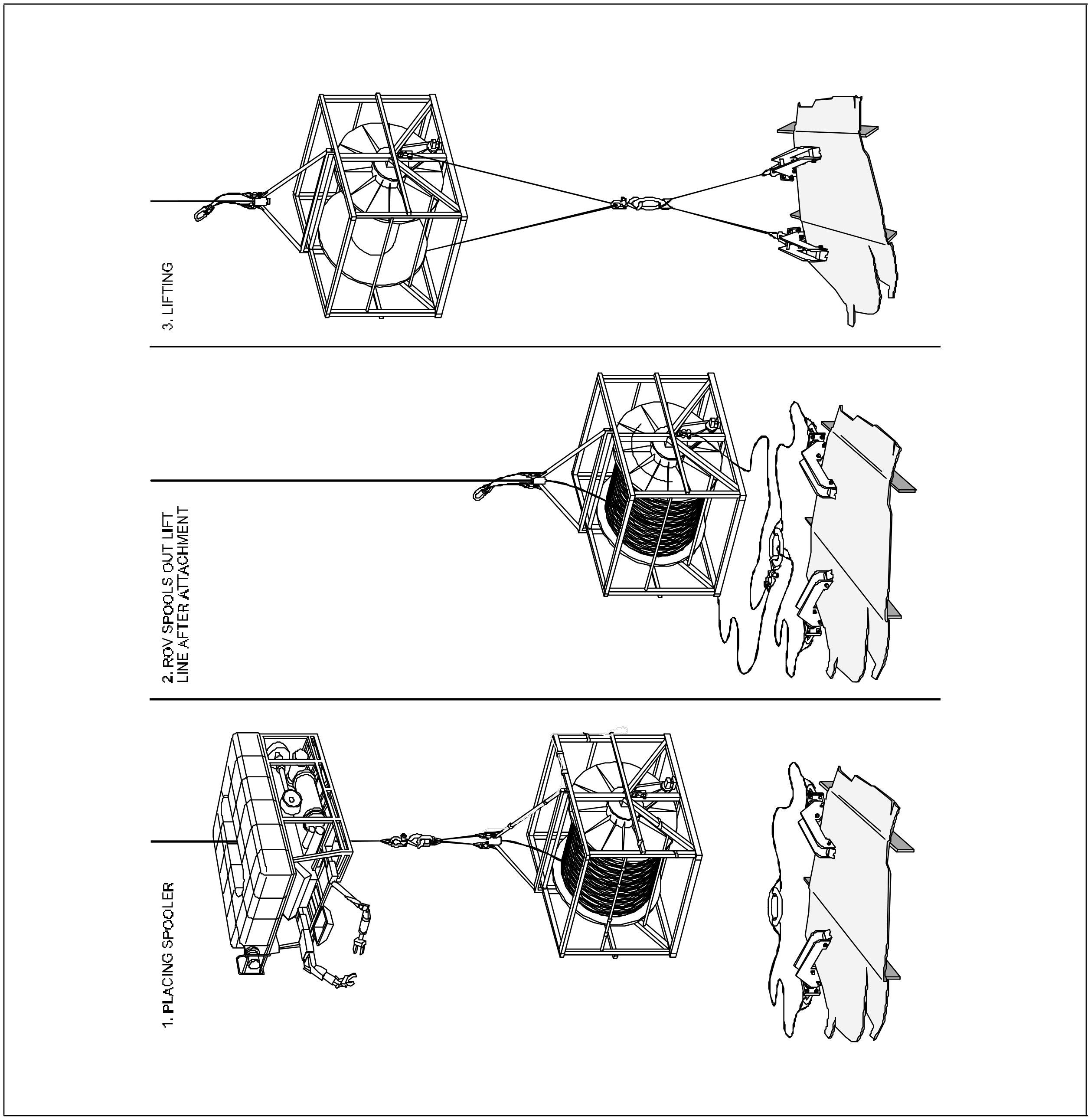

Figure 3-4. ROV Spooler Operations.

3-5.3 System Offload. Material handling equipment for system disassembly, offload and transportation is scheduled by the shore-based logistic support personnel or arranged through other coordinators. A crane is employed to disassemble heavy equipment and to lift equipment from the ship onto the pier or directly onto waiting transportation.

The system or equipment offload is followed by reconditioning of the support vessel as required; this includes replacement of any structure removed or modified, removal of weldments, cable runs, etc. The commanding officer and project manager should complete a thorough check, ensuring all items are completed and satisfactory.

3-5.4 Return Shipping and Travel. Transportation mode to return search and recovery equipment to its primary staging area or home base will depend on several factors. Included in these are:

- Priority or scheduling of additional follow-on tasking.
- Cost verses urgency.
- Availability of required transportation equipment or aircraft.
- Distance.
- Practicality.
- Equipment involved.

Within the continental United States, transportation will typically be provided by truck. Transportation internationally will be completed by military airlift or sea freight. Equipment will be documented, manifested, packed and staged for transport regardless of the mode. As with mobilization, personnel will remain with the equipment until loaded for transport or until otherwise directed by SUPSALV.

2-4.4 Explosives, Hazardous Material and Pollutants. The target may contain any of a number of hazardous materials that require special handling. In naval deep ocean salvage operations, the most common materials encountered are fuels of various kinds (including jet fuel and solid rocket fuel) ordnance and pyrotechnics. Anytime explosive ordnance, hazardous substances or pollutants are present in the target, advance plans must be made to deal with them prior to beginning the salvage operation. Salvors are not expected to be expert in handling all hazardous materials they may encounter. Specialists - EOD technicians, fuels specialists, HAZMAT specialist etc.-with expert knowledge of the materials or devices being recovered - must supplement or advise the operations team.

2-4.5 Post-recovery Procedures. Ideally, proper preservation techniques are practiced following the salvage of recovered objects. This is not always possible due to environmental exposure or because of the size or quantity of individual objects. The following general guidelines apply to handling of recovered objects:

- *Paper, cloth, leather and wood* - seal in a plastic bag while still wet and store in a larger container for shipping and handling.
- *Small objects* - rinse with fresh water and brush off mud and marine growth. Immerse in fresh water for 24 hours. Seal in a plastic bag preferably while immersed, otherwise while wet. Box for shipping.
- *Large objects* - rinse with fresh water and brush off mud and marine growth. Remove small equipment and handle as for small objects. Scrub the object with detergent and fresh water to remove as much mud, marine growth and corrosion as practicable. Rinse with fresh water and keep wet for several hours. Allow to dry. Protect from salt spray.
- *Black Box* - on-site preservation is limited to storing the device in a sealed container filled with deionized water. The recorder should be transported to a preservation facility immediately to limit damage resulting from oxidation.

CHAPTER 4

LOGISTICS AND REPORTING

4-1 INTRODUCTION

Comprehensive logistics planning and support keep operations running efficiently, increase operational effectiveness and keep costs down. Conversely, poor logistics result in delays, reduce effectiveness and may contribute to higher operational costs.

Complete documentation and accurate reporting not only facilitate post-operational analysis and cost accounting, but assist in analyzing progress and redirecting efforts when necessary.

4-2 LOGISTICS

A military maxim summarizes the importance of logistics. *Amateurs study tactics while professionals study logistics*. Complete, effective logistic support contributes as much to the success of an operation as do the equipment and skill of the operators. Poor logistics can impact the operation, causing lengthy delays or even halting the operation or reducing on-scene time through excessive costs. Logistics so permeate operations that many subjects addressed in the planning and mobilization sections of the preceding chapter are directly tied to logistics considerations.

Logistics must focus on the mission objective. No two operations have identical requirements, but preparation, thoroughness and simplicity are common to successful logistics for all deep ocean operations. Good logisticians must be part magician — able to produce needed material immediately — and part clairvoyant — able to anticipate problems and to solve them before they occur. In addition, they must be meticulous in attention to detail and cost-effectiveness.

4-2.1 Logistics Coordinator. For larger, more complex operations, a logistics coordinator may be appointed at the beginning of the operation by the project manager. For smaller operations, the position is usually carried out as part of the project manager’s function. The logistics coordinator functions throughout the operation and has a major role in every phase. To function properly, the logistics coordinator must be expert in rapid response and long-distance, remote-area logistics, as well as be knowledgeable of deep ocean operations. It is particularly important that the logistics coordinator balance operational urgency with cost-effectiveness and make the appropriate choices. A representative of the logistics coordinator should be part of the advance party to contact the logistics agent and to pass logistics requirements between the site and home base.

4-2.2 Logistics Agent. The logistics agent is an individual identified from the local command supporting the operation, an individual assigned by the search or recovery contractor, or a local civilian shipping agent hired for the operation. Logistics agents cannot be expected to be knowledgeable in deep ocean operations. Their operational function is in making the requested arrangements required to support the operation. Shipping agents and chandlers are familiar with the facilities of a specified port and are familiar with its system of operation. In international ports, agents may have ties with local governments that can expedite bureaucratic requirements. When language barriers exist between the ship, loadout facility and operations team, the agent can supply interpreters. The logistics coordinator and logistics agent work as a team. The logistics coordinator knows what is needed; the logistics agent knows how to supply it. The logistics agent should be identified as early as possible to facilitate the assembly of information necessary in planning an operation. A logistics agent may not be necessary for small tasking or tasks in localities which are familiar to operators.

4-2.3 Logistics Planning. Logistics planning commences simultaneously with operations planning. The logistics coordinator provides input on logistical support available in the operations area to assist the project manager in selecting the base port. This information includes naval support activities, port facilities, transportation access, commercial or military air facility location and size, industrial facilities, customs requirements and similar information. Published port guides furnish basic information; the logistics agent supplements this.

4-2.4 Mobilization Logistics. Mobilization — the movement of personnel and equipment from the base to the mobilization port, installation on the ship and movement to the operations site — is all logistics. Mobilization logistics include:

- Packaging equipment, spare parts and support equipment.
- Assuring backup spares and repair parts beyond expected needs are available,
- Preparing or providing correctly formatted input for all bills of lading, transportation permits, aircraft loading plans, customs forms and other transportation documents for the equipment.
- Arranging transportation of the equipment.
- Assuring handling equipment such as cranes and forklifts are available.
- Arranging short-term, secure storage at the destination.
- Arranging support vessel berthing, provisioning, fueling and other port services.
- Making travel, accommodation and local transportation arrangements for operational personnel.
- Arranging support for personnel and equipment at shore navigation sites.

- Assuring vendors are available for supplying consumables, spare parts, repair parts and other materials to the operation.

- Setting up a transportation system between the base and the operations site.

- Setting up the shore command center and its communications.

- Organizing special and emergency services, such as medical evacuation.

4-2.5 At-Sea Operations Logistics. Once the operation commences, the logistics support changes significantly. Problems that arise must be resolved quickly or the entire operation might stall. The logistics organization is key to ensuring that required spare parts are delivered to the ship, arrangements for emergency repairs are made, supply requirements are met and emergencies are resolved. Generally, these requirements are emergent rather than planned.

4-2.6 Demobilization Logistics. Demobilization logistics move personnel and equipment from the point of demobilization to the home base. Many of the steps are the same as those taken in mobilization. For the logistician, demobilization begins as soon as the deployed operations crew advises that the task is nearing completion. An early start on demobilization arrangements and preparations assures an orderly process and prevents delays. Demobilization may not carry the operational urgency of mobilization; nevertheless, demobilization must be planned efficiently to facilitate return of the equipment to its base to place it in a ready-for-deployment or -issue status.

Demobilization at a remote location requires special care to assure the equipment inventory is complete and equipment properly packed for transport. Inventory levels must account for all equipment shipped to the site during both mobilization and the operation. The support vessel must be restored to its pre-operation condition. Operational personnel should be repatriated as soon as practical. The home base should be informed of equipment transportation schedules and condition so receipt, maintenance and refurbishment can be scheduled.

4-2.7 Communications and Logistics. Good communications is as important to logistics as it is to operations. Logisticians must communicate with:

- The support base.

- The operations site.

- Suppliers and vendors.

When the operations base is a naval facility, naval messages are a good means of communicating with supporting naval activities. For urgent voice communications, logisticians should have access to single-side-band radios and satellite telecommunications. Regular communications schedules between the operations base and the at-sea operation and the operations base and home base should be established for routine logistics communications.

4-3 REPORTS, DOCUMENTATION AND RECORDS

Data collection and operational reports and their management are an integral part of every deep ocean operation. Technical and operational records, along with photodocumentation of the operation, provide data for:

- Documentation of the operation.
- Analysis of system performance.
- Review of techniques and procedures performed.
- Accident investigation.
- Determination of system maintenance requirements.
- Development of system modifications.
- Historical purposes to review problems encountered and lessons learned.

Documentation requirements for routine tasking may be fulfilled with as little as a written report and accompanying photodocumentation; larger scale, more complex projects may require additional post-operational computation and fully integrated data collection and storage techniques. Task directives should, and normally do, define the specific documentation requirements as an inclusive task assignment.

4-3.1 Operational Records. The following paragraphs discuss operational records for all deep ocean operations.

4-3.1.1 Chronological Log and Task Narrative. The project manager maintains a chronological log of all key events, activities performed, problems encountered, accomplishments, weather, equipment status, area coverage, milestones, etc., to assist in preparation of daily reports and operational reports. The log results in an operational narrative for a historical record and for the compilation of the final report The log commences with tasking of the operation and concludes with the return of personnel and equipment to the home base. As a minimum, the log will contain:

- Personnel deployed - project manager, SUPSALVREP, technical advisors, etc.
- A brief description of the daily events.
- Weather.
- Direction received with the source and background information.
- System performance.
- Dive data.
- Ship movements.
- General observations and analytical comments.

Charts and plots and other raw site data may supplement the log.

4-3.1.2 Navigation Records. Precise, accurate navigation records for all types of operations must be maintained and must contain at least:

- Day, date (including time zone) and system in use.
- Sequential numbering for each timed fix or event.

Navigation records for search or recovery operations also contain:

- Search line number, direction and speed of advance.
- Detailed data such as remarks, sonar scale, track-line course steered to maintain line and distance off-track, holiday notations, bottom changes and any other information that may affect the search.

When the navigational data is computer-generated, supporting remarks can be hand-logged. The remarks serve as memory aids for reporting and are of great assistance to recoveries and investigations.

4-3.1.3 Sonar Records. Notes on sonar records link them directly to the navigation plot. Coordination of all recorded data permits each run to stand independently for analysis and retention.

Notations of sonar conditions, equipment tuning, contact information, winch operation and other remarks can be made directly on the sonar record. Upon completion of each search run, all data is collected and stored for review by the watch supervisor and project manager. As each set of records is reviewed, the watch supervisor and project manager initial the records.

4-3.1.4 Turnover Files. When one crew searches and another crew does the recovery, all information that can help the relieving group must be passed in an orderly manner. Before the search team demobilizes, the search manager makes up turnover files. These files may include:

- Navigational information about the object’s location.
- Navigational plots showing the target and debris field(s).
- Sonar traces of the target and its disposition and attitude.
- A full description of the surrounding terrain, accompanied by amplifying sonar traces.
- Information about currents and their direction and velocity.

4-3.1.5 Operations Log. The operations log is the primary record of the search and recovery operation. The log, maintained by systems operators throughout the mission, contains detailed forms for search, dive, target and video recording data; the photographic record; an events narrative; and maintenance records. Specifically, the log contains:

- *Dive page* - conditions on site and on the seafloor; weather; dive objective, depth and time; operator names and comments; and navigation records for the dive. The electronic log of the integrated navigation computer may replace the manual log, particularly when the mission includes extensive debris field mapping and identification.
- *Target information* - identification, description and the designation of each sonar target investigated with its location in the debris field.
- *Video and photographic records* - the number of photographic exposures or a video tape count and a description of the target photographed or videoed.
- *Events narrative* - a detailed chronology of the dives, including dates, times, vehicle heading and depths, current information and events.
- *Maintenance records* - identification of component or subsystem failures or modifications during the operation. This portion of the log is removed and held separately following the operation as the source for the post-operation work and component failure data.

4-3.1.6 Classified Records. Classified operations require separate classified records. Operations personnel are briefed on what information is classified, the classification level and what data will be considered classified. The on-scene security officer reviews all data generated during the course of the task to ensure that the security of classified data is maintained. All electronic media from the navigation computer is given to the security officer, then purged from the system.

4-3.1.7 Records Retention. All records - target data, navigational data, sonar traces with the contact, daily logs, narratives and the final report - is retained for future operational planning, training, reference and historical files.

4-3.2 Reporting. Operational reporting includes both daily reports and a final operations report prepared after the operation is complete.

4-3.2.1 Daily Reports. The senior Navy representative makes a daily report to naval authorities. Addressees for the daily report vary with the operational organization, but always include CNO, SUPSALV, the sponsor and operational commanders. The report details the status of the operation, objectives completed, problems and intentions. Daily reports may include requests for support. These reports are suspended or purged of classified information during classified operations if no secure mode of communication is available. Alternatively, during classified operations, key events may be reported in the clear with a prearranged code.

4-3.2.2 Final Report. Any significant deep ocean operation requires a formal final report. In SUPSALV-controlled operations with commercial contractors, a Delivery Order specifies the final report requirements. NAVSEAINST 4740.8 (series) delineates Fleet reporting requirements.

APPENDIX A

DOCUMENTATION MATRIX

A-1 PURPOSE

The purpose of this matrix is to provide the user of this manual with a listing of additional reference documentation. This is given by reference manual and topic area.

A-2 REFERENCE DOCUMENTS

The following manuals/publications are referenced on the matrix (**Table A-1**):

- SAFETY MANUAL – *U.S. Navy Ship Salvage Safety Manual* (S0400-AA-SAF-010), 1989

- SALVAGE MANUAL – *U.S. Navy Ship Salvage Manual*

  Volume 1 ***Strandings*** (S0300-A6-MAN-010)
  Volume 2 ***Harbor Clearance*** (S0300-A6-MAN-020)
  Volume 3 ***Firefighting and Damage Control*** (S0300-A6-MAN-030)
  Volume 4 ***Deep Ocean*** (S0300-A6-MAN-040)
  Volume 5 ***POL Offloading*** (S0300-A6-MAN-050)
  Volume 6 ***POL Spill Response*** (S0300-A6-MAN-060)

- SALVOR'S HANDBOOK – *U.S. Navy Salvor's Handbook* (S0300-A7-HBK-010), 1990

- UNDERWATER CUT & WELD – *U.S. Navy Underwater Cutting and Welding Manual* (S0300-BB-MAN-010), 1989

- ENGINEER'S HANDBOOK – *U.S. Navy Salvage Engineer's Handbook*

  Volume 1 (S0300-A8-HBK-010), 1992
  Volume 2 (S0300-A8-HBK-020), 1992

- TOWING MANUAL – *U.S. Navy Towing Manual* (SL740-AA-MAN-010)

- ESSM MANUAL – *Emergency Ship Salvage Material Catalog* (NAVSEA 0994-LP-017-3010)

- EXPLOSIVES MANUAL – *Technical Manual for Use of Explosives in Underwater Salvage* (NAVSEA SW061-AA-MMA-010), 1987

		SALVAGE MANUAL								ENGINEER'S HANDBOOK				
TOPIC AREA	SAFETY MANUAL	VOLUME 1	VOLUME 2	VOLUME 3	VOLUME 4	VOLUME 5	VOLUME 6	SALVOR'S HANDBOOK	UNDERWATER CUT & WELD	VOLUME 1	VOLUME 2	TOWING MANUAL	ESSM MANUAL	EXPLOSIVES MANUAL
DAMAGE CONTROL				●				●		●				
STABILITY		●				●		●		●	●			
SHIP STRENGTH		●				●		●		●	●			
RIGGING	●	●	●		●	●	●	●		●		●		
ANCHORS	●	●					●	●		●			●	
STRANDING		●				●		●		●	●			
PULLING SYSTEMS	●	●						●		●			●	
SAFETY	●	●	●	●	●	●	●	●	●	●		●		●
MACHINERY	●							●		●		●	●	
EXPLOSIVES			●					●		●	●			●
HAZMAT	●					●	●	●		●			●	
POL	●					●	●	●		●				
OFFSHIP FIREFIGHTING	●			●		●		●					●	
TOWING: POINT-TO-POINT						●						●		
RESCUE				●				●				●		
PATCHING		●	●					●		●				
COFFERDAMS								●		●				
LIFTING SYSTEMS	●		●		●			●		●			●	
POLLUTION CONTROL	●					●	●	●		●			●	
PONTOONS			●		●			●		●			●	
SALVAGE PLANNING	●	●	●		●	●	●	●		●				●
PROPERTIES OF MATERIALS		●				●		●		●		●		●
CONVERSION FACTORS		●						●	●	●				
COMPUTER PROGRAMMING											●	●		
DEEP WATER RECOVERY					●			●					●	
CUTTING	●		●						●					●
WELDING	●								●					
CARGO OFFLOAD	●	●				●	●	●		●				

Table A-1. Salvage Documentation Matrix.

APPENDIX B

DEEP OCEAN OPERATIONS PLANNING GUIDE

The following is a generic planning guide and check-off for deep ocean search and recovery operations. Operators of ships and systems and managers of operators should expand, contract, modify, or amend the guide to fit their particular circumstances. No single guide is always pertinent. The information presented herein reflects the experience of many operations but is not all-inclusive and does not take the place of careful study, analysis, and original thought about the deep ocean operation at hand.

1. TARGET INFORMATION

a. What is the target?

b. What is the purpose of the operation?

c. What is the target's height? Depth? Length? Shape? Weight in air? Weight in water?

d. What are the flight characteristics of the target in air? In water?

e. Does the target carry pingers or other electronic location devices? If so, what are their characteristics?

f. Have similar targets been lost under similar circumstances? Are search and recovery reports available? In hand? Are personnel from these operations available? Are they on site?

g. Is an identical object available for inspection? Where?

h. Are technical manuals describing the target available? In hand?

i. Are technical personnel familiar with the target available? On site? If not on site, how may they be reached?

j. Are plans of the target available? In hand?

k. Are photographs of the target available? In hand?

l. What is the probable condition of the target? What is the probable heading? Depth of embedment? Attitude?

m. Are there any projections or parts that might restrict vehicle maneuvers?

n. Have lift points on the target been identified? What are they?

o. What are the standard lifting arrangements?

p. Have any special handling requirements been identified? What are they?

q. What is the maximum lift required?

r. What is the maximum breakout force expected? What is the optimum direction of pull?

s. How may connections for lifting be made?

t. Are there oil or other pollutants in the target? What type? What quantity? What hazard(s) do they present? What special materials are required for their containment, removal, disposal, or cleanup? Are they likely to have been dispersed in the loss?

u. Are technical personnel familiar with the specific pollution hazard and its control available? Are they on site? How are they reached? How long do they require to be on site?

v. Are hazardous substances on board the target? What are they? What quantity? What hazard(s) do they present? What special materials are required for their containment, removal, disposal, or cleanup? Are they likely to have been dispersed in the loss?

w. Are technical personnel familiar with the specific hazardous material and its control available? Are they on site? How are they reached? How long do they require to be on site?

x. Are explosives or pyrotechnics aboard the target? What are they? What quantity? What hazard(s) do they present? What special materials are required for their containment, removal, disposal, or cleanup? Are they likely to have been dispersed in the loss?

y. Are explosive ordnance disposal personnel familiar with the specific devices available? Are they on site? How are they reached? How long do they require to be on site?

2. TARGET INFORMATION

a. What is the geographic position of the target?

b. How was the position established? Has the accuracy of the primary means of positioning been verified?

c. Were secondary means of establishing the position used? Have the accuracies of secondary means of positioning been verified?

d. Are eyewitnesses available?

e. Have all eyewitnesses been interviewed? Are the interview reports in hand? Have they been analyzed and correlated?

f. Are there photographs of the loss? Video tape? Acoustic or optical data? Are they in hand?

g. Has floating debris or other material been recovered and its position plotted?

h. Is GPS available at the datum? What other navigational systems are available? What are their accuracies?

i. How far offshore is the datum? Where are the nearest sheltered waters?

j. What is the water depth?

k. What is the prevailing weather (wind, sea and swell, temperature, precipitation) in the operations area?

1. What is the orientation of the search area?

m. What weather forecasts are available?

n. What conditions (thermoclines, currents, visibility, temperature gradients, salinity, etc.) prevail through the water column?

o. What is the seafloor composition? What are the seafloor topography and conditions? Are there seafloor terrain features that will interfere with search and recovery equipment operation?

p. Is the target and datum information clear enough to permit definition of a single search area or must secondary and tertiary areas be designated?

q. What is the nearest port that can support mobilization? How far is it from the operations area?

r. What is the nearest port that can support at-sea operations? How far is it from the operations area?

3. SEARCH AND RECOVERY SYSTEMS SELECTION?

a. What search system is most suitable for the operation? Why?

b. Is the system available? If not, when can it be available? Do the availability dates match the operational requirements?

c. What is the second choice of search system?

d. What surface navigation system will be used during the search?

e. Are there suitable sites for shore-based navigation systems?

f. What recovery systems are available?

g. Which of the available systems is most technically suitable? Why? Most cost-effective? Why?

h. Is the system available? If not, when can it be available? Do the availability dates match the operational requirements?

i. What is the second choice of recovery system?

j. Are suitable recovery tools and equipment available? If not, what must be done to acquire them?

k. Is a ship motion compensation system required? Is a system available? If not, when can it be available? Do the availability dates match the operational requirements?

1. Are materials for cleaning, handling, packaging, and storing salvaged objects available?

4. PERSONNEL

a. What will be the organization for the operation?

b. Have the advance party been designated and briefed? What is the composition of the advance party? What is their schedule?

c. What personnel skills are required for the search operation?

d. What personnel skills are required for the recovery operation?

e. What shore support skills are required?

f. What special technical personnel are required?

(1) Have suitable personnel been identified? Are they available?

(2) Have alternates been identified? Are they available?

(3) Are the search and recovery teams the minimum size needed to do the work effectively?

5. BASE PORT(S)

a. What port is to be used for mobilization?

b. Is this a U.S. Navy, foreign navy, or commercial port?

c. Who is the principal liaison or agent?

d. What airfield serves the port?

e. What type of aircraft can the airfield handle? What aircraft unloading equipment is available?

f. Are there scheduled air cargo and passenger flights for bringing in small items and personnel, and handling emerging logistics requirements?

g. What transportation is available to move equipment from the airfield to the port? Is intermodal MHE available on both ends?

h. Will local regulations restrict transportation or other operations at or near the port?

i. Is ground transportation available for operations team members entering the area?

j. Are accommodations available for operations team members entering the area?

k. Is there a suitable shoreside operations base available?

1. What facilities are available for berthing the ship? For making necessary modifications? For loading out? For conducting systems tests?

m. What facilities are available for resupplying the ship?

n. Is the same port to be used for mobilization and to support at-sea operations? If not, what port will support at-sea operations?

o. Is this a U.S. Navy, foreign navy, or commercial port?

p. Who is the principal liaison or agent?

q. Are there scheduled air cargo and passenger flights for bringing in small items and personnel, and handling other emerging logistics requirements?

r. Will local regulations restrict transportation or other operations at or near the port?

s. Is there a suitable shoreside operations base available?

t. What facilities are available for resupplying the ship?

6. SHIP

If the salvage operation warrants more than one ship to conduct the search and recovery phases, the following questions apply to each primary and support vessel:

a. What ships are candidates for the search phase?

b. Does the candidate search ship have enough deck space to stow and operate the search system?

c. Can the candidate search ship maneuver at slow speed? What is the slowest practical towing speed?

d. How long can the candidate search ship spend on station?

e. Can the candidate search ship keep the sea in all weather in which the system can operate effectively?

f. What is the availability of the candidate search ship? Can the schedule of the candidate search ship accommodate delays in the search operation? What delay will be encountered in moving the ship to the mobilization port?

g. Does the candidate search ship have accommodation for the search crew? If not, is there space for portable berthing to be installed on board?

h. What modifications will be required to fit the candidate search ship for the operation?

i. What are the daily operating and standby costs for the candidate search ship?

j. What ships are candidates for the recovery phase?

k. Does the candidate recovery ship have ability to support the recovery system? Is there:

(1) Enough deck space to stow and operate the recovery system?

(2) Adequate protected stowage?

(3) Space to accommodate the salvaged target?

(4) A suitable handling system?

(5) Enough power of the correct type? If not, can the candidate recovery ship provide fuel for the system's generators?

1. Does the candidate recovery ship have the ability to keep station with the accuracy required for the salvage operation?

m. Can the candidate recovery ship keep the sea in all weather in which the recovery system can operate?

n. How long can the candidate recovery ship spend on station?

o. What is the availability of the candidate recovery ship? Can the schedule of the candidate recovery ship accommodate delays in the salvage operation? What delay will be encountered in moving the ship to the mobilization port?

p. Does the candidate recovery ship have accommodation for the recovery crew? If not, is there space for portable berthing to be installed on board?

q. What modifications will be required to fit the candidate recovery ship for the operation?

r. What are the daily operating and standby costs for the candidate recovery ship?

7. SHORE NAVIGATION SITES

a. Will shore sites for navigation systems be required?

b. What are the candidate shore navigation sites?

c. What is the access to the candidate shore navigation site?

d. What intersect angles in the area of operations are possible from the candidate shore navigation sites?

e. Is there an unobstructed line of sight to the entire operations area?

f. Is enough power of the correct type available at the candidate shore navigation site?

g. If battery power is to be used, what are the arrangements for battery replacement and charging? Is an adequate number of batteries for uninterrupted operation available?

h. Is the candidate shore navigation site inherently physically secure? What arrangements are necessary to provide security?

8. LOGISTICS

a. Who is the logistics coordinator?

b. Who is the logistics agent?

c. Are equipment and spares for both the search and recovery phases packaged, checked out, and ready for immediate deployment? If not, how much time will be required to prepare them?

d. Are any equipment modifications required before deployment? If so, how much time is required?

e. What mode(s) of transportation will be used for the search equipment? For the salvage equipment? Have all transportation arrangements been made?

f. Will search and recovery equipment be shipped concurrently?

g. Has all transportation documentation (bills of lading, permits, loading plans, customs forms, etc.) been prepared?

h. Have sources for purchase, lease, or manufacture of special equipment been identified? Have arrangements been made with suppliers?

i. Have sources and available stocks of backup spares and replacement equipment been identified? Have arrangements been made with suppliers?

j. Have arrangements been made for intermodal handling and ground transportation at the mobilization port?

k. Have arrangements been made for short-term secure storage at the mobilization port?

1. Have arrangements been made for berthing and servicing the ship(s) at the mobilization port?

m. Have arrangements been made for industrial services to modify the ship and install the system(s)?

n. Have all personnel been checked to ensure they have valid travel documents?

o. Have arrangements been made for personnel travel, accommodation, local transportation, and facility access?

p. Are systems in place for transporting material and personnel between the operations site and the operations base?

q. Has storage for material that will not be taken to sea been identified and arranged for?

r. Has the shore command center been identified and established?

s. Have special and emergency services been identified and arranged?

t. Are arrangements in place for handling relief crews, personnel repatriation, VIP visits, and personnel emergencies?

u. What system(s) will be used to communicate between the operations site and the shore base? Between the operations site and the home base? Between the shore base and the home base?

v. What regular communications schedules will be maintained?

w. What arrangements are there for emergency or unscheduled communications?

x. What other communications requirements are there? How will they be handled?

y. Are arrangements in place for packing and shipping recovered material?

9. DOCUMENTATION AND REPORTING

a. Have the documentation requirements been identified? What are they?

b. Are systems available for acquiring, cataloging and managing data and documentation? What are they? How will they be used?

c. Have reports to be made during the operation been identified? What are they? What is their frequency? Who are the action and information addressees? What means will be made to make them? Who will prepare them? Who will approve them?

d. Have normal and supplementary reports to be made following the operation been identified? What are they? Who are the addressees? Who will prepare them? Who will approve them?

10. SECURITY

a. Is any part of the operation or of the target classified?

b. What is its classification?

c. Who is responsible for security of classified material?

d. What security arrangements are necessary? Are they in place?

11. TIME AND COST ESTIMATES

a. What are the estimates of time and cost for:

(1) System preparation?

(2) Special equipment purchase, lease, or manufacture?

(3) Transportation of equipment and personnel?

(4) Personnel?

(5) Ship charter and port fees?

(6) Documentation and reporting?

b. How long is the operation expected to take?

c. What are potential causes of delays and interruption and what are their potential costs?

WHAT DID YOU FORGET?