A RECOMMENDED APPLICATION OF REMOTE VEHICLE TECHNOLOGY TO THE NAUTICAL CHARTING PROGRAM

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THIS REPORT RECOMMENDS A SYSTEM CONCEPT ADDRESSED TO THE CLEAR CHANNEL MISSION, AS A POTENTIAL APPLICATION OF REMOTELY OPERATED VEHICLE TECHNOLOGY. IT EXAMINES THE MISSION, THE SYSTEM ELEMENTS, AND THEIR FUNCTIONAL ROLES; AND DEMONSTRATES THE SYSTEM OPERATION IN THE CONTEXT OF A HYPOTHETICAL MISSION SCENARIO.

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A REPORT

ON

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1.0 INTRODUCTION/BACKGROUND

On May 16, 1985, David Price made a presentation with pictorial slides and video sequences on the subject of remotely operated vehicles (ROV's). This was done as an initial look at ROV's from a perspective of potential applicability to National Oceanic and Atmospheric Administration (NOAA) and particularly to the National Ocean Service (NOS) and hydrographic operations.

ROV technology has developed largely in response to the offshore oil industry's need for an underwater inspection and work capability. In this, the ROV developed as a replacement for or as an extension of the diver. Diving contractors, who initially performed their service with divers, expanded that service to include the capabilities made possible by these vehicles. The application of ROV and related technologies to mine countermeasure problems has provided a more recent impetus to developments.

Until recently, the vehicles have been relatively large and expensive, requiring significant logistic support so that applications to routine NOS operations were precluded by the cost and sheer logistics. In only the last year, the introduction of small, low-cost vehicles has made it reasonable to consider possible applications to NOAA needs.

In the May 16, 1985, presentation, the recommendation was made to examine further, the potential applications of ROV's to NOS' operations. This was in view of the developments in small, lost-cost vehicles. The consensus of the attendees was in support of this, and Admiral Bossler directed that the initial investigation be adjusted in scope in order to reach the next level of definition in a 2-month time frame.

2.0 OBJECTIVE

The objective of the most recent effort has been to select a promising application of ROV's to an NOS program area and to develop sufficiently an operational scenario and a system concept on which to base a decision on further steps.

3.0 APPROACH TO THE SELECTION

In the initial look at ROV's from a NOAA perspective and following the presentation of May 16, numerous potential applications were identified. It was found particularly helpful to interact with the NOAA Diving Office and to use the NOAA Diving Activity reports and data base to guide considerations. This was certainly not surprising in view of the historical relationship of ROV's and divers; i.e., the candidate areas for ROV application would be found where divers have been applied or would be applied except for specific constraints. It was not the intent of this effort to develop a selection methodology nor to document numerous potential applications. The view taken is that a promising application is one judged to have the potential for demonstrable improvements in quality or productivity of results, preferably both. It is more important to get on with a promising application, than to expend effort to establish that it is indeed the most promising application. Additionally, the initial selection should be such as to facilitate entry into additional areas of application.

4.0 APPLICATION(S) SELECTED

A suggested application, which emerged early, was to utilize an ROV in lieu of a diver in the "wire drag mission." However, "wire drag", is not a mission but a technique for a mission which may be referred to as a Clear Channel Mission (CCM); i.e., to assure that a channel or area may be certified clear of obstructions. It is the CCM which has been selected, and the technique used is not based on wire drag.

A mission closely related to the CCM is the Obstruction Evaluation Mission (OEM); i.e., to determine the character of an obstruction, its location (and extent if applicable), and minimum depth over the obstruction. It is these two missions, the CCM and the OEM, which are proposed for the initial application of ROV technology.

In the execution of a CCM, it would be likely necessary to perform an obstacle evaluation. It is also common to have obstructions evaluated as singular items and not in the context of a CCM. Whether we call this one or two different missions is not important. What is important, is that since the CCM must be structured to include obstacle evaluation, the equipment suite and procedures for an OEM will be covered by discussion of the CCM.

The following factors favored the selection of the CCM application:

- --It is a significant concern in the Nautical Charting area.
- --It has a potential to yield significant program benefits.
- --It is a manageable problem to define.
- --It is a manageable problem to conceptualize a solution to.
- --The necessary technology appears to be realizable within the state of the art.
- --The equipment and techniques learned would have a high generic utility as would be basic to additional missions.

5.0 A SYSTEM FOR THE CCM

The concept of a system for the CCM is presented in the following steps:

--A characterization of the mission phases.

--Identification of the major system elements and a definition of their salient functional features.

--Presentation of a scenario representative of a CCM operation in which the role of the functional features can be seen in context.

5.1 The CCM Phases

The CCM Mission may be viewed as comprised of the following phases:

--The general search phase

--The specific search phase

--The obstructions evaluation phase

5.1.1 The General Search Phase

The area, having been bathymetrically surveyed previously to standard charting practice, is examined by acoustic detection methods for indications of features or obstructions which would potentially constitute exceptions to the clear depth certification. Coverage required of the general search, set by policy for the particular circumstance, would never be less than 100 percent and possibly as great as 200 percent.

5.1.2 The Specific Search Phase

The location of each potential obstruction detected in the general search phase is revisited and the position localized further to enable approach for visual contact. An OEM would typically begin with this phase on the basis of a previously reported approximate position. If the reported obstruction could not be located, a search employing 400 percent coverage would be required to disprove the existence of the obstruction.

5.1.3 The Obstruction Evaluation Phase

The obstruction having been brought within visual contact, its nature is characterized through visual inspection; e.g., type of wreck or bottom feature. It would be further characterized dimensionally as necessary for documentation and charting purposes; e.g., location, horizontal extent, minimum depth.

5.2 Major System Elements

Requirements and specifications for specific functional features of the major system elements will actually stem from a detailed analysis of the operational scenarios. Rather than invoke the inference process here, the major system elements will be identified and their salient functional features stated. The short scenario to follow will place in context some of these features. The nature of possible constraints and general design considerations will be given where appropriate.

The mission is accomplished with a system comprised of the following major system elements:

-- Surface vessel
-- Navigation references
-- ROV
-- Sensor equipment and special tools
-- Navigation integration and data management system

5.2.1 Surface Vessel

The surface vessel serves as support for the equipment in the following discussion. Size requirements will likely be dictated by the desired operational and survival seagoing characteristics, and will not, at least initially, be significantly different from vessels currently used for similar functional applications. Optimal speed during mission operations will be derived from sonar performance considerations.

Considerations in the development of the equipment suite should be to minimize the impact on vessel requirements so that the system design and possibly even the equipment could be applicable to various classes of vessels.

5.2.2 Navigation References

Navigation references will be required to fix the position of the surface vessel and an ROV within the geodetic reference grid. For this, the surface vessel would use conventional position fixing as for hydrographic applications; e.g., land based electronic ranging systems or ultimately the Global Positioning System (GPS). The ROV position fixing in three dimensions relative to the surface vessel would be achieved by an ultra short base line acoustic positioning system, or USBL.

Such a USBL system consists of a single shipboard transducer assembly (with multiple sensors) and a single subsea transducer on the ROV. The ability to use additional subsea pingers or transducers could present a useful enhancement under special circumstances.

5.2.3 ROV

The ROV is conceived of as capable of either being towed by the surface vessel when the surface vessel is underway, or being maneuvered by its own propulsors under commands transmitted through the tether. While not all ROV's are designed to be towed, some are towable. It is expected that this flexibility will contribute to the efficiency of the operation. It is recognized that there are possible considerations which would favor two separate vehicles. The ROV would expectably be larger than the smaller towed bodies presently used for side looking sonar applications but not significantly larger than required for operation as a controlled ROV. The ROV is expected to be of a size and configuration to be managed over the side by two persons. Some, relatively light handling machinery would be cost effective in extending operability in light seas.

5.2.4 Sensor Equipment and Special Tools

Major acoustic sensor equipment requirements derive from the search function. Here the techniques utilized would likely be a combination of side looking sonar and obstacle avoidance sonar techniques. This function could be realized with the presently available technology. Advances in this area could have considerable impact on system effectiveness, and the system would be designed to accept improved equipments. The principal capability desired of the acoustic search function is detection. Final localization of the targets would be performed at the slow speed of the ROV mode. Identification and evaluation would be performed visually using video. Thus, the acoustic sensor should be optimized toward detection.

If detection capability could be sufficiently improved, it might be considered to trade some of this capability, under certain circumstances, to allow increased surface vessel speed during general search. Consider that the rate of fuel consumption on the RUDE or HECK, for example, is not significantly different at nine knots than at five knots. As long as acceptable detection performance can be realized, an increase of speed could be used to yield a proportional increase in productivity.

In the category of special tools, a simple manipulator arm could prove useful.

5.2.5 Navigation Integration and Data Management

A navigation integration and data management system, micropressor based and referred to as NIM, is used to relieve the operator workload and make possible the integration of the varied system elements in real time. Without such a system, the operation would be excessively drawn out in time and require substantially more manpower. The system combines three primary functions:

--It integrates the navigation information from a number of sources.

--It manages collected data for visual display and permanent storage.

--It integrates information in real time to provide on-line guidance for decisions by the operations officer.

5.3 A CCM Scenario

5.3.1 Introduction

The scenario is presented as a device for examining some of the system features in a somewhat specific, albeit hypothetical, context. Any scenario can only encompass a limited situation. Thus, it is not intended to prescribe strategies or guidelines. While computer aiding is indicated in a number of applications, prudent practice would require the operator to monitor the reasonableness of all activity and to be prepared with contingency measures.

5.3.2 Situation

The situation posed is that of an approach to a new tanker port. The approach is composed of several segments, and the specific segment to be investigated is ten miles long and two miles wide.

The general water depth as established by previous bathymetric surveys is in the range of 85 to 100 feet, and it is desired to certify the clear channel to a depth of 70 feet. Several reported obstructions with approximate positions are noted on the chart. The NOAA Ship PROVE, outfitted with the latest CCM system, is assigned the task.

5.3.3 Preplanning

The coordinates of the survey area, the survey policy regarding search overlap, bathymetry, tide and current information are entered into NIM which generates the planned track lines to follow, vessel speed, towed body depth, and plotter and sonar range settings. A check-off list is generated to monitor mission readiness.

5.3.4 Approach

Prior to the start of the general search phase, all systems are checked out against the computer prompted list. The ROV is streamed and operation verified. A run is made against a standard sonar target (deployed to be retrieved later) to further verify equipment operation.

The NIM tracks the vessel position and provides guidance to acquire the initial trackline. The initial trackline (extended) is acquired, the initial course to steer set, and all elements stabilized to operating conditions for the half mile prior to entering the area to be searched.

5.3.5 General Search Phase

During the approach and all operations, NIM estimates set and drift as a factor by which the course to steer is adjusted to make good the desired track. NIM also adjusts the course to steer to correct for minor track deviations during track following and provides guidance for maneuvering to acquire a new track as required at the end of a traverse. The searched area is continuously tracked and monitored on a video display and/or a plotter. The computation takes into account the position of the vessel, the position of the ROV (the sonar platform) relative to the vessel, and the direction and range of the search beam. The track computations and guidance are directed at tracking the search sensor. When a suspected target is detected, by operator observation of the sonar presentation (usually not instantaneously), the time or times associated are entered into NIM together with the range, bearing, and other parameters obtainable from the sonar display. NIM computes the position of the contact within the geodetic reference frame, identifies the contact by number, stores the data, and displays a contact symbol and identifier on a video display and/or plotter. At the end of a traverse, a maneuver is executed under manual control, either at the direction of the operator, or under guidance from NIM, to acquire the next track. NIM applies its latest estimate of set and drift to arrive at the proper initial course to steer for the new track and continues to compute the course to steer to keep the sensor on the track line. In the track following mode, the course to steer is automatically followed by the steering control.

5.3.6 Evaluation of General Search Results

The general search would likely be completed before specific search was undertaken. The searched area plot is monitored during general search operations, and holidays are corrected when best accommodated. It is possible that more than one target may be detected in the same vicinity. It is necessary then to consider whether there is strong enough evidence to conclude that it is the same target or to expand the specific search in that vicinity after the initial target is localized. A plan is made for examining each contact which cannot for good reason be disregarded.

Where contacts have not been made which correspond reasonably to previously reported obstructions, plans would include the accepted procedure for disproving the report.

5.3.7 Specific Search Phase

Contact with the target would be reestablished by guiding the ROV to the most likely coordinates of that contact as determined by NIM. The ROV would possibly have made contact before assuming the ROV mode of operation (as opposed to the towed mode). In any event, in the ROV mode, it would now be able to adjust its heading and depth to search, and widen its search if necessary, to make the contact. Meanwhile, the location and horizontal plane excursions of the ROV are being plotted by NIM in relation to the expected position of the target. The ROV operator also has a vertical plane situation display to assist in maneuvering the ROV. When sonar contact is made, the target position is reset to the improved information as the ROV drives toward the target. Even before the target is within visible range, the lights and video cameras are turned on to gain a preliminary assessment of the area surrounding the target.

With visual contact established, evaluation proceeds.

5.3.8 Obstruction Evaluation Phase

The detail required here will be a function of the nature of the obstruction. Assume that it is a capsized barge. It is therefore of interest to map the extent of the barge, mainly to ensure that we have examined all the points which would present the potential for minimum depth. The barge can be mapped by visiting the extremities and points of the periphery with the ROV, while recording and plotting the ROV position by NIM. The recordings of the video camera (possibly stereographic) are keyed to the plotted outline of the barge. It is not likely that the entire barge would be visible from a single vantage point, but NIM makes it possible to integrate the data. It would be possible to enhance the USBL operation by deploying an additional acoustic transponder to remain in a static position during this phase. The transponder could be recovered with the arm of the ROV. The measurements of most significance are at the points of minimum depth and their location.

Minimum depth would be obtained from the precision pressure depth gage on the ROV when it is at the high points of the barge and checked by the depth of the ROV as determined in the position fix using the USBL system.

With this much complete, the ROV would move out to check the immediate vicinity, possibly there are other hazards posed by some long beams which had been part of the cargo of the barge.

If an item corresponds in location with a previously reported obstruction and also corresponds with what is known of its nature, it could be concluded that the existence of the previously reported obstruction, its location and minimum depth has now been established. If there is no such correspondence, then it will be necessary to disprove the existence of any other obstruction within a radius as prescribed by policy in this regard.

5.3.9 Mission Review

The extensive records and documentation acquired holds significant learning potential. This statement can correctly be made with regard to much of our work at sea. The difference here could be in that the data is now more accessible and more easily managed. Indeed, if we know what we seek to learn from our experiences, we should be able to structure the data management to help us. One facet of the learning is to be able to interpret better the imperfect images of our sonar sensors and another is how to develop our hardware systems, software, displays, and operations methods to do an even better job.