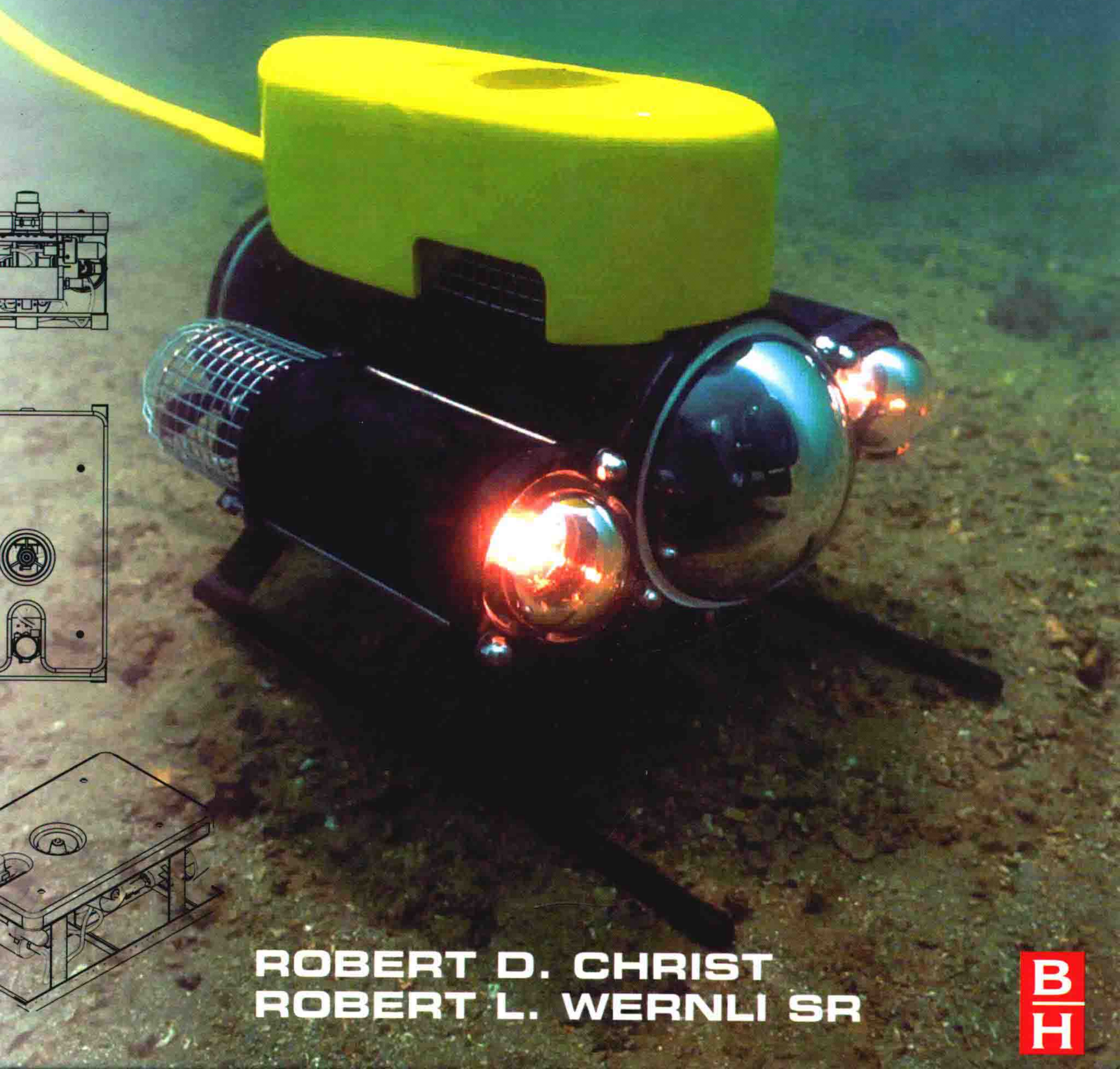
THE ROV MANUAL

A USER GUIDE FOR OBSERVATION CLASS REMOTELY OPERATED VEHICLES



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The ROV Manual: A User Guide for Observation-Class Remotely Operated Vehicles

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Foreword

When I returned to college to become a mechanical engineer in 1970, I had never heard the term ROV. The only remotely operated vehicles I knew of were essentially satellites that orbited the Earth. With the collapse of the space industry in the early 1970s, my attention was drawn toward the next frontier – the ocean. I was recruited by the Naval Undersea Center in 1973, primarily due to the allure of those interesting underwater robots being developed there like the *CURV III* (Cable-Controlled Underwater Recovery Vehicle). I was hooked!

My interest grew, the technology advanced and several ROV companies were born. This booming industry, especially around my home in San Diego, led to the creation of the first remotely operated vehicle conference, ROV '83, which I chaired. The theme of 'A Technology Whose Time Has Come' was timely and helped launch a conference series that continues today under the title of Underwater Intervention.

One of the first products of that conference series was the *Operational Guidelines for ROVs*, a ground-breaking publication by the ROV Committee of the Marine Technology Society (MTS). I had the pleasure of producing the book along with Frank Busby and a committee of experts who also helped launch the ROV conference series.

There were some other specialized publications that were produced to address ROV use and maintenance, but none that had the scope of the earlier Guidelines. The MTS ROV Committee asked me to update the Guidelines, and I, along with Jack Jaeger, who handled the production, took on the task. The result – *Operational Effectiveness of Unmanned Underwater Systems* – covered the entire scope of ROVs, from the history, through design and operation, and ending with a look into the future. The 700-plus page book, published as a CD-ROM in 1999, set another milestone in undersea vehicle documentation. My thanks to all those who contributed material for the book.

In 2005, I retired from my job at the Navy laboratory in San Diego and decided to begin my next career as a consultant on underwater systems and author of not only technical publications, but also fiction. My first novel – *Second Sunrise* – was an award winner and the sequel will be out in 2007. Hopefully, this will be the beginning of a series of undersea techno-thrillers that will not only entertain, but also educate my readers.

Now, to this publication – *The ROV Manual*. Once again, I was contacted to review and provide a critique of an original manuscript written by Robert Christ. I know the amount of effort that goes into preparing such a book and provided my thoughts on what looked like an excellent publication that addressed the specialized observation class of ROVs. To make a long story short, we agreed to work together on the manual and drive it to completion, which made our publisher more than happy.

For my part, I've added a few chapters and helped Bob edit and complete the manuscript. Bob has added his own real-life experiences throughout the book, which provide excellent anecdotes for the novice and expert alike. To the readers of this book, I hope it fulfills your needs and sparks a desire for an exciting career in underwater robotics.

Robert L. Wernli Sr

Preface

Principles of operating ROV equipment are similar throughout the size ranges of submersible systems. Although this manual covers a wide range of underwater technologies, the vehicle classification and size range covered within this manual is the free-swimming, tethered, surface-powered, observation-class ROV system with submersible sizes from the smallest of micro-ROV systems up to a submersible weight of 200 pounds (91 kilograms).

The purpose of this manual is to put forth a basic 'How To' for usage of observation-class ROV systems (along with some theory) in a variety of underwater tasks. With the addition of underwater duties to today's law enforcement profession's mission requirements, the requirement to view underwater items of interest is apparent. The use of ROVs and similar technologies provides the public safety, military, maritime security, archeological, and commercial diver with an array of options that offer reductions in risk (as opposed to using divers), potential time savings, and reduced cost.

This manual is a manufacturer non-specific document for ROV deployment that also contains standard operating procedures (SOPs), training materials, and qualification standards for qualifying personnel to operate ROVs. The material will augment manufacturer's equipment-specific instructions for use. All ROV systems share a similar set of operating parameters, environment, and methods of use. This manual also seeks to clarify the general techniques for optimizing ROV deployment to achieve operational requirements. Although there are many contributors to this manual, by industry experts as well as product manufacturers, this manual in no way endorses any specific product or manufacturer.

As with any new class of vehicle, the deployment of ROV systems involves specific tactics, techniques, and procedures to fully utilize the equipment's potential and provide satisfactory results for the customer. Although an ROV is a powerful tool, it is still a machine subject to operator experience, equipment capabilities, and environmental factors that affect its utility. ROVs are a compromise of size and power balanced against operational requirements. A large ROV system may accomplish more open-water tasks than a smaller system due to its ability to muscle to a location (through currents, distance offset, and around obstructions) with increased payload and additional sensors. But a larger vehicle with its support system may not fit aboard a vessel of opportunity (e.g. a 25-foot Rigid Hull Inflatable Boat or other small deployment platform), thus increasing the amount/type of resources needed to support the use of a larger ROV. A micro-ROV system may not possess adequate thrust to pull its own tether to the inspection site and is more likely to be affected by environmental conditions. However, these smaller systems are more mobile and can be operated in confined spaces with fewer resources. Regardless of the ROV size, visibility will vastly affect the amount of time and level of difficulty of the inspection task.

This manual focuses on the two lowest common denominators: (1) The technology and (2) The application. There is often misconception as to the utility and application of this technology. The goal of this manual is to introduce the basic technologies required, how they relate to specific requirements, and to help identify the equipment necessary for a cost-effective and successful operation.

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History and dedication

My father, C.J. Christ, learned in the late 1960s that a German U-boat (U-166) was sunk on 1, August 1942 by a US Coast Guard aircraft just south of our hometown of Houma, Louisiana. Thus began a 35+ year quest to find the wreck. Through that odyssey, a host of people cycled through our lives with similar interests in this project that was fueled by my father's infectious enthusiasm. Oceanographic pioneer Demitri Rebikoff stayed at our home for a month while staging for tests of his Rebikoff *Remora* early diver propulsion vehicle. The brilliant Dr Harold Edgerton from MIT brought down one of his new inventions by the name of 'side-looking sonar' (later termed 'side-scan sonar') that we spent interminable hours dragging behind small boats in the Ship Shoal area south of Last Island, Louisiana.

Instead of playing baseball each weekend, my Dad brought me offshore while he made dive after dive on the old WW2 wreck sites. Later, I began to make these dives myself to these rusted hunks of metal lying inert in the mud on the Outer Continental Shelf of the Mississippi river estuary.

As I grew older, those rusting hulks turned into living beings as my father had me accompany him on interview after interview with the survivors of those sinkings. This fueled an intense interest in history, taking me further into the technical aspects of underwater work. In the late 1990s, one of Dad's strongest long-term supporters of the U-166 project, Johnny Johnson of Oceaneering International, sent me offshore to work on large ROV systems in support of the Oil and Gas industry to 'learn how the real work is done'.

While performing a pipeline survey for British Petroleum during 2001 in 5000 feet of seawater 45 miles south of the Mississippi river delta (over 140 miles east of the recorded sinking location of the U-166), C&C Technologies from Lafayette, Louisiana found a blip on a sonar readout that resembled a German Type IXC U-Boat. The 60-year-old enigma of the U-166 had been solved – with my Dad known as the 'Grandfather of the U-166 Project'.

I dedicate this book to its inspiration, C.J. Christ – Pilot, Diver, Historian, Father, and Friend.

Robert D. Christ

C.J. Christ, Adm. Karl Donitz, and Capt. Peter 'Ali' Kramer in Germany, c. 1979 (from the C.J. Christ Archives).

Introduction

While working in the offshore Oil and Gas Industry in the 1990s for Oceaneering International, I noticed that the majority of the work being performed by large work-class ROV (WCROV) systems was simply taking pictures of work sites. The majority of human activity in the world's waters happens in the area known as the 'littoral' waters, generally described as from the surface to a depth of 600 feet. To deploy a WCROV system to the work site, heavy industrial machinery is required in order to simply launch the vehicle into the water. To support the crane and equipment needed for the submersible, a large 'platform of opportunity' is needed, such as a large supply or salvage boat. To staff this vessel, engineers, deckhands, vessel operators, galley hands, etc. are needed in addition to the ROV crew. All of this just to deploy a camera to a place where a meaningful picture can be taken. It seemed to be a waste of resources, in many of the operational situations, to use a multimillion dollar WCROV when a smaller system could have performed the same operation much more cost-effectively.

While on an unrelated trip to Russia in 1999, I was introduced to a Russian company tied to the Shirshov Institute, which was producing a micro-ROV system designed for structural penetration of wrecks and other light-duty tasks. Thus began my odyssey of observation-class ROV usage in underwater tasks.

ROV systems will not completely replace divers in the near future due to the lack of sensory feedback needed to do intricate tasks. But the ROV, in many cases, can replace putting a human in harm's way. This allows a safer and more cost-effective means of performing the mundane tasks of searching and monitoring. It takes less time, less effort, less risk, and (as a result) less money to drop a self-propelled camera into the water, go to the work site to look around and perform a task. By using an ROV system, the diver can be moved to a remote location that minimizes the risk to personnel (i.e. remote from the hazards of temperature, hyperbarics, moving machinery, and other underwater hazards).

The idea for this manual came about while I was trying to learn how to operate a Remotely Operated Vehicle (ROV). The larger operators of ROV equipment had operations manuals with standard operating procedures and standards, but the information on how to apply this knowledge was disparate and in many different locations. Most of the learning was provided as on-the-job training programs. Later, as I moved into smaller ROV systems, the problem became even more acute since there was no chain of command present with the necessary depth of knowledge of these skills (as with a larger ROV crew running working-class systems). In short, I had several failed projects due to my inexperience and lack of understanding of the operation and capability of ROV systems.

There is a body of knowledge with tricks and techniques that exist for operating ROV systems. Unfortunately, this knowledge set resides with the commercial ROV operators who do not normally share these tidbits of information, since their competitive advantage relies upon their knowledge and experience.

There are some excellent books written by an English gentleman by the name of Chris Bell published through an oil and gas publishing company. The focus of those manuals is on the basic science of ROV operations, since most of the entry-level folks purchasing that type of manual are destined for employment on large ROV systems. Entry-level oilfield ROV technicians learn all of the components of the equipment before operating the vehicle in the field. With the observation-class ROV system, however, there is usually no experienced supervisor or other trained crew members upon which to rely. Thus, the technician has to figure out the entire process on the spot. In this text, we focus on the 'How To' aspect of ROV operations, since we assume the operator, as the lead technician, is using a fully functional ROV system in a field location. Accordingly, a general knowledge of electricity/electronics, a basic understanding of physics, and a familiarity with the operation of general machinery is necessary.

At the end of my tenure in 2003 with the micro-ROV manufacturer VideoRay (a company which I co-founded in 1999), I made a series of recommendations to a large customer of mine (the United States Coast Guard) for the implementation of the ROV program into their fleet. Among the recommendations was a strong suggestion that they write a 'How To' manual including recommended standard operating procedures as well as a basic manufacturer non-specific training manual for ROVs. The recommendation turned into a contract – thus the genesis of this manual.

In 1979, the NOAA Office of Ocean Engineering produced a survey of ROVs (US Government Printing Office Stock #003-017-00465-1) to include the then-current technology. While reading through that manual, I noticed practically all of the same issues still exist today regarding the application of this type of technology. My operational experience with a range of systems (sizes, classifications, and applications) has shown that there is a commonality with the vehicles and environments. All vehicles share the same operating principles. Conveying them in one text is the focus of this manual.

For efficient use of this manual, read through the sections relevant to all systems then branch into more specific applications. However, read through all sections as time permits, since they contain information that could help solve operational problems in the field.

ROVs are a very useful tool to conduct a wide range of underwater tasks. Some of the projects encountered will be fascinating and satisfying. Others will be frustrating and embarrassing. In 2002, I spent an entire day attempting to recover an ROV system stuck in a doorway deep within the wreck of the *USS Arizona* in Pearl Harbor. The National Park Service project supervisor (Larry Murphy) kept threatening to use bolt cutters on the tether. Several high-profile officials were watching. That was frustrating! In 2003, I spent an incredible eight hours doing an internal wreck penetration/survey of a Swedish C-47 aircraft (shot down by a Russian MiG in 1952) at 425 feet of sea water. That was exhilarating!

Little of the Earth's oceans have been explored for the simple reason that the environment is so inhospitable to us humans. ROV technology is now maturing to the point where this exploration may now be conducted while we remain topside in a much safer and more comfortable environment. A whole new chapter in the exploration of the seas is unfolding each and every day with the advent of underwater robotic technology. The choice of delving into this technology places us on the wave of explorers 'going where no one has gone before'. We live in exciting times indeed.

Enjoy your work!

Robert D. Christ

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