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The internal electron quickly removable for fast access. Comanche can be supplied with a survey pod which allows easy intefac survey pod includes multiple electrical The. Actual equipment may be different as a result of product improvement or other reasons. Specific interface and performance information should be reconfirmed at time of order placement. SubAtlantic Ltd. Woodburn Road, Blackburn Business Park, Blackburn,Aberdeen. AB2I OPS. UK SubAtlantic Inc. 10642 West LittleYork, Suite 100, Houston, TX 770414014USA Prices are indicative only and may vary by country, with changes to the cost of raw materials and exchange rates. As the city was struggling to recover from Hurricane\n \n Katrina, Hurricane Rita delivered the final blow to both the people on the coast of the Northern\n \n Gulf of Mexico as well as to the oilfield infrastructure. In the aftermath, close to 200 oil and gas\n \n production structures lay on the sea floor. The remaining structures fortunate enough to still stand\n \n incurred heavy damage.\n \n In the midst of this crisis, we were busily trying to complete the first edition of this manual to\n \n meet an April 2006 publishing deadline. Then a platform damage inspection was needed... dive support for decom\nmissioning... structural repairs due to wind and wave stresses from hurricane force winds and\nseas... the publication deadline passed and yet Bob was still in the field. Bob Wernli was juggling\nhis consulting, atsea test support and a publication deadline for his second novel. Time was run\n \n ning out for both of us so we quickly buttoned up the first edition, although it was not as complete\n \n as we had originally envisioned.\n \n In this second edition, we have come closer to our goal of producing a broad overview of ROV\n \n technology. Through the help of leaders and companies from throughout the industry, we have pro\n \n duced a solid survey of the current state of this capability.http://www.splubatowa.pl/userfiles/capresso-coffee-maker-453-manual.xml

Our sincere gratitude and thanks go out\n \n to those who contributed to our quest. These contributors are recognized in the Acknowledgements\n \n section. What we envisioned from the beginning for this manual is a basic How To for ROV tech\nnology. We hope that we have achieved this goal through this edition\n \n of The ROV Manual.\n \n This manual is a living breathing entity. Every book is a piece of history upon the publication\n \n date; therefore, we welcome comments on this edition. Each subject within this manual could fill an entire book in and of itself.\n \n We struggled with editing this manual with a nominal word and text cap to include all subjects in\n \n as short and succinct a manner as possible while still getting the point across. The subsea oilfield is firmly embracing the landbased model of network interconnectivity\n \n bringing man remotely back into the harsh environment of the subsea world. The frontier has moved from the\n \n xvii \n\n \n 29% of the Earth covered by land to the 71% of the Earth covered by sea. The mineral riches of\n \n the world are hidden beneath those waves. The only way to get to them is with robotics. Stephen Dodd of GRI Simulations contributed to Chapter 4. Tyler Schilling\n \n along with Peter MacInnes, Steve Barrow, and Matt Whitworth of Schilling Robotics were instru\n \n mental in the production of both the manipulator as well as the tooling chapters. Alasdair Murray\n \n and Steve Stepinoff of SubAtlantic and Chris Roper of Saab SeaEye supplied a plethora of materi\n \n als for midsized vehicles and Jim Teague, J. Teague Enterprises, contributed to the chapter on\n \n floatation.\n \n And a special thanks to pioneers of the cables and connector industry, Cal Peters, Kevin Hardy,\n \n and Brock Rosenthal, who completely drafted Chapter 8. Kevin Hardy is President of Global\n \n Ocean Design, specializing in free vehicle component technologies.

He has 32 years experience in the design and\n \n manufacture of EM, signal, power, faired, and neutrally buoyant underwater cables for diverse\n \n applications, including towed instruments, moorings, ROVs, and manned vehicles. Brock Rosenthal\n \n is the President and founder of Ocean Innovations La Jolla, CA, a distributor of underwater con\n \n nectors, cables, and other quality oceanographic hardware. Rosenthal has helped numerous end\n \n users clearly define their operational requirements before selecting their underwater equipment.\n \n Their support in this endeavor is truly appreciated.\n \n But it did not stop there. Practically all of the titans of this industry volunteered their time and\n \n resources to this project. This text\n \n is divided into five logical parts covering the industry and environment, the basics of ROV\n \n technology, payload sensors, intervention tooling as well as practical field applications. In the\n \n last chapter of the book, we look into the future in order to examine what industry analysts feel\n \n is the direction subsea technology is heading with a specific focus on the field of subsea\n \n robotics.\n \n It is often said that for every mathematical formula within a book, the population of book pur\n \n chasers is halved. As authors we certainly appreciate that thought, but seek to go from general\n \n terms to specific as well as from simple to complex toward reaching a broad readership for this\n \n subject. Some of the chapters are heavily focused on theory e.g., Chapter 14 on underwater acous\n \n tics is heavily mathbased while others e.g., Chapters 21 and 22, which focus on field applications\n \n and procedures contain little or no mathematics. The general technology user should feel free to\n \n skip over the mathbased sections, while those with a more academic bent or specific application\n \n should delve into the technical aspects of theory.

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\n \n Chapters 1 and 2 Part 1 seek to paint a background picture of the industry, as well as the envi\n \n ronment, where ROVs operate and this technology applies. Chapters 311 Part 2 drill down to\nthe actual vehicle in a good bit of detail while Chapters 1218 Part 3 branch out into the broad\nsubject of payload sensors. The only subject missing to cover\n \n the full gamut of vehicles i.e., the Work Class ROV, WCROV is highpressure hydraulics. And\n \n that subject will be left for a future iteration of this manual as we continue to refine this work while\n \n the industry and technology continues to evolve.\n \n The divisions parts of this manual each address a separate readership. Part 1 is geared towards\n \n the business side and should be applicable to project managers making use of this technology while\n \n Part 2 focuses specifically on the ROV technician. Part 3 is addressed to the project manager but\n \n should also be of interest to the survey team as well as the ROV technician for gaining a general\n \n understanding of deployed sensor technologies. Part 4 is directed toward intervention technicians\n \n over a broad range of users from Project Manager to Corporate Executive to Regulatory Officials\n \n to, of course, ROV Technicians. And Part 5 wraps it all up with both practical considerations and\n \n a look into the future.\n \n xxv \n\n \n No text of this size can do any measure of justice to the field of ROV technology. The\n \n authors have carefully carved out individual subjects in order to form an introduction into each\n \n field. Published by Elsevier Ltd. These are used in a variety of appli\n \n cations from diver support to heavy marine subsea construction. The market is substantially seg\n \n mented into four broad categories based upon vehicle size and capabilities\n \n 1. Observation class ROVs OCROV These vehicles go from the smallest microROVs to a\nvehicle weight of 200 pounds 100 kg. They Figure 1.

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3 are generally smaller, DCpowered,\n \n inexpensive electrical vehicles used as either backup to divers or as a diver substitution for\n \n general shallow water inspection tasks. The vehicles within this class are typically hand launched and are free flown from the\n \n Control\nConsole\n \n Controller\nSubmersible\n \n Tether\n \n Monitor\n \n FIGURE 1.2\n \n Basic ROV system components.\n \n 51.1 The ROV \n\n \n surface with hand tending of the tether. These also are generally allelectric vehicles\n \n powering prime movers thrusters and camera movement controls with some hydraulic power\n \n for the operation of manipulators and small tooling package options. The vehicle electrical\n \n power is stepped down to a manageable voltage for operation of the various components and\n \n can be either AC or DC power. The specialuse vehicle coverage is outside the\n \n purview of this text.\n \n The general difference between the OCROV and the MSROV is the power transmission and\n \n depth rating. The general difference between the MSROV and the WCROV is the size of the\n \n hydraulic power pack and the horsepower rating for the operation of manipulators and tooling.\n \n Both the MSROV and the WCROV are deeprated vehicles and both can be delivered to deep work\n \n sites. The WCROV, however, can perform heavier tasks than the MSROV is capable of achieving\n \n due to the added muscle of hydraulic actuation of its components versus the electrical actuation of\n \n the MSROV. The MSROV has additional deepwater capabilities along with fiber optic telemetry\n \n for full gigabit sensor throughput. Long\n \n slender vehicles generally have lower drag characteristics at higher speeds but exhibit poor station\n \n holding capabilities. AUVs typically exhibit the classical torpedo shape with a high aspect ratio and minimal\n \n number of thrusters coupled with control fins for longdistance travel at higher speeds.

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This is due to the in situ situational\n \n awareness provided by man as well as the ultimate dexterity of the end effector a hand for a man\n \n and a manipulator claw for the machine. But the costs and danger of placing man in the high\n \n pressure work environment of the deep sea are considerable.The OCROVs can be hand launched over the vessel\n \n bulwarks while larger ROVs require a LARS. Many LARS require special configuration in\n \n order to get the vehicle from the deck, into the water and back again in all sea states without\n \n damage to equipment and danger to personnel. Further, in order to deliver the vehicle to deep\n \n work sites, a TMS is required to manage the soft tether from the depressor weight i.e., heavy\n \n weight holding the vehicle steady at the work site to the vehicle and to protect the vehicle from\n \n damage during transit to the work site. An example of a contract job would be a drill\n \n support assignment whereby a complete section of the rig is dedicated to the ROV spread.\n \n Another would be a dedicated ROV vessel with the LARS and control system integrated into the\n \n superstructure of the vehicle. The exception to this would be a fully integrated ROV vessel\n \n performing shortterm work.\n \n The cost of mobilizing a WCROV spread can be substantial. This\n \n 111.2 Types of ROV services \n\n \n problem is multiplied as the complexity of the equipment increases. In short, mobilizing a\n \n WCROV spread on a new vessel of opportunity for a shortterm assignment is seldom worth the\n \n trouble or the expense. The only way to justify a WCROV spread for callout work is to have a\n \n dedicated vessel with the ROV spread permanently integrated. The nature of the callout business is short\n \n term and very profitable work. The upside to the callout business is there are not many players to\n \n dilute the already industrywide low utilization inherent in callout work.

The downside of the call\n \n out business is the lack of any predictably sustainable work levels. The need for waterborne robotic services begins\n \n with the precasing survey and ends when the pipeline crosses the preselected 1000 fsw 300 msw\n \n curve. The logicdriven vehicles\n \n are the AUVs and fall more within the traditional services of the survey company i.e., outside of\n \n the traditional service offerings of ROV service companies. The deepwater intervention market is the realm of the ROV.\n \n Required of the PM or DR company is ROVs with sufficient capability to deliver sensors and tool\n \n ing for the deepwater environment.\n \n The end product for a DR company is the delivery of either sensors or tooling to the work site\n \n with maximum uptime. The end product of a PM company is to accomplish an assigned project as\n \n outlined by the customer. The DR player has a much\n \n lower risk profile with a correspondingly lower profit upside.\n \n The major players within the industry fall out to either day rate players or project management\n \n players. It de\n \n cides on the risk for downtime the main purpose of a day rate company should when the ROV\n \n encounter operational or maintenance issues. A project management company does not have\n \n that luxury since if the ROV is down the entire mission is compromised.\n \n In a postMacondo offshore minerals extraction world, there is a new concept within the field\n \n support vessel service that has arisen to address newer and more stringent regulations. All field support vessels will naturally be combined DR ROV companies\n \n as well as vessel companies. And the demand will rise rapidly in the oilfields of the developed\n \n world for the integrated deepwater support vessel.\n \n So, the two choices are to be a DR player or a PM player.

The typical DP1 dynamical positioning with no redundancy vessel for production\n \n support remains within the 170 ft 55 m length overall LoA range with a high of 205 ft\n \n 65 m and a low of about 140 ft 45 m. The typical deepwater DP2 platform supply vessel\n \n PSV is in the 300 ft 95 m LoA range. For the ROV spread, a namebrand hydraulic vehicle\n \n i.e., one of the major international WCROV manufacturers with at least 150 hydraulic\n \n horsepower is required as most contracts specify a minimum horsepower rating and many\n \n uninformed customers equate ROV horsepower with ROV capability.\n \n PM player This requirement is more task oriented as the risk of task completion borne by the\n \n PM company is much more logic driven as opposed to market driven. For sensor delivery, the vehicle simply needs to be big\n \n enough to deliver the sensor while having a fiber for full gigabit data throughput. Deepwater fiber opticbased electric MSROVs are certainly sufficient for\n \n practically all sensor delivery tasking. Polling the various tooling manufacturers of diamond wire saws finds that the midsized\n \n diamond wire saw requires a 30 gpm 115 lpm flow rate at 2000 psi 140 bar. The typical\n \n 14 CHAPTER 1 The ROV Business \n\n \n 45 cc auxiliary pump on a 150 hp WCROV provides 20 gpm 75 lpm at 3000 psi 200 bar,\n \n which is the same hydraulic horsepower as 30 gpm 115 lpm at 2000 psi 140 bar. The typical\n \n 150 hp WCROV should be sufficient to cover the highest draw tool initially anticipated for\n \n IRM and most construction tasks. If the ROV company is a DR company, the company has\n \n little choice other than to buy a namebrand system from a major manufacturer. For the MSROV and OCROV company due to the callout nature of the business, vessel\n \n ownership while certainly an option would probably be an expensive luxury as opposed to a\n \n necessity.

At best, the ROV company could purchase vessels and dig into an unserviced or under\n \n serviced niche left open by the void between the larger international PSV companies who offer\n \n ROV services as an added option to the vessel platform and the smaller PSV companies who only\n \n offer vesselonly charters.\n \n PM company The strategy for a PM company is the same as for a DR company with the addi\n \n tion of a project management function. It would be preferable to keep the DR and PM companies\n \n in relatively close geographical proximity to one another so that the engineeringtodeployment\n \n process is done with a teamwork approach allowing for maximum face time with minimal travel\n \n time.\n \n 1.3 ROV economics\n1.3.1 Capital expenditure CAPEX versus day rate\nInvestment in ROV equipment can be quite expensive and financially risky. The cost of capital\n \n involves daily interest charges as well as financial carrying costs. In short, not only does the ROV company require recapture\n \n of its cost of capital, it also requires sufficient revenues to counter the carrying costs of maintaining\n \n the vehicle during both revenue and nonrevenue days as well as compensation for risk involved\n \n 151.3 ROV economics \n\n \n along with some measure of profit. Table 1.6 describes a representative sample of day rates, costs,\n \n and recapture on the various size categories of vehicles.\n \n There is a tradeoff between utilization and day rate in order to achieve an acceptable annual\n \n return on investment ROI so as to substantiate the investment. Contract work typically enjoys a\n \n higher utilization percentage over its callout counterpart. But a contract ROV with a 1000day pay\n \n back period days, revenue to full recapture of the system cost with a 75% utilization will take the\n \n same time period to recapture its investment as a callout system with a 10% utilization depending\n \n upon the combined factors. Table 1.

7 provides a sample of how the same recapture time is achieved\n \n between a high recapture percentage coupled with a low utilization as opposed to a high utilization\n \n coupled with a longer payback period. Often, scientific manned diving or manned submersibles are used for shallow and\n \n deeper water efforts. For the object retrieval function, much heavier vehicles are needed in order to rig\n \n heavylifting gear for retrieval to the surface. This singleshot MCM vehicle is clearly an OCROV hopefully of minimal cost while the\n \n charge deliverythenevacuation vehicle is typically an MSROV with a dexterous electric manipula\n \n tor capability. For the object retrieval ROV, a heavyduty WCROV is needed along with hydraulic\n \n 171.4 ROV services by industry \n\n \n manipulators and deepwater capabilities. The cheaper the per inspection cost the more likely and\n \n often the inspection will take place thus increasing the security proportionately.\n \n 1.4.5 Public safety\nIndustry description The public safety industry is typically the realm of the police and fire depart\n \n ment. By the time the ROV is typically\n \n called in, however, the team is in full recovery mode as opposed to rescue mode. In waters\n \n deeper than 1000 fsw 300 msw, the wellhead and blowout preventer stack have moved from the\n \n surface to the seafloor, requiring all intervention tasks be performed robotically. The requirement\n \n for ROV support during all drilling functions in deepwater has become the industry standard.\n \n Typical mission ROVs for drill support are used from the first spudin initial drill bit penetra\n \n tion into the ocean bottom through to well completion. Missions include observation of the sea\n \n floor environment, mounting of well casing seals and guides, guiding of tooling and drill\n \n equipment into the well along with various other operations.

Recent regulations, in the wake of the\n \n April 2010 Macondo oil spill in the northern Gulf of Mexico, have required a second standby\n \n ROV, operated from a vessel separate from the drilling rig, to manually operate the BOP should\n \n there be a service interruption on the main drilling rig.\n \n Typical vehicle type and configuration The typical ROV size and configuration for drill\n \n support are a larger MSROV or a light WCROV. Like the aviation and maritime counterparts to the ROV\n \n business, the support structure requires not only a deep equipment and spares pool, it also requires\n \n 191.5 Conclusions \n\n \n a thorough training program, procedures, controls, and a commitment to service quality. It is a\n \n financially risky business rife with pitfalls. The content of this chapter explores the makeup of fresh\n \n water and seawater and then goes into the interaction of this substance with the world of robotics.\n \n We will explore the basic concepts of water density, ocean circulation, currents and tides and how\n \n each of these affects the operation of ROV equipment. This section condenses information from complete college curric\n \n ulums; therefore, for further details, please see the references in the bibliography. Special thanks go\n \n to Steve Fondriest of Fondriest Environmental, Inc.It is\n \n also the only planet to have known liquid water currently at its surface. Water can dis\n \n solve more substances and in greater quantities than any other liquid. Of the ocean\n \n coverage, the Atlantic covers 16.2%, the Pacific 32.4%, the Indian Ocean 14.4%, and the margin\n \n and adjacent areas the balance of 7.8%. It is also interesting to note that the Pacific Ocean alone\n \n covers 3.2% more surface area on earth than all of the land masses combined.\n \n 2.1.2 Coastal zone classifications and bottom types\nGeneral coastal characteristics tend to be similar for thousands of kilometers.

Most coasts can be\n \n classified as either erosional or depositional depending upon whether their primary features were\n \n 22 CHAPTER 2 The Ocean Environment \n\n \n created by erosion of land or deposition of eroded materials. Erosional coasts have developed\n \n where the shore is actively eroded by wave action or where rivers or glaciers caused erosion when\n \n the sea level was lower than its present level. Depositional coasts have developed where sediments\n \n accumulate either from a local source or after being transported to the area in rivers and glaciers or\n \n by ocean currents and waves.\n \n Of primary interest to the ROV pilot, with regard to coastal zones, is the general classification\n \n of these zones and its effect upon general water turbidity in the operational area. Depositional\n \n coasts tend to have a higher quantity of suspended solids in the water column, thus a higher turbid\n \n ity and degraded camera performance. Erosional coasts tend to possess fewer suspended particles,\n \n thus featuring better camera optics. The continental margins are, in large part, depositional features. Their charac\n \n teristics are driven by runoff deposited from the adjacent continent.\n \n Sediments are carried from the marine estuaries and then deposited onto the continental shelf.\n \n As the seafloor spreads due to tectonic forces, the sediments fall down the continental slope and\n \n come to rest on the abyssal plain. Clearly, it is\n \n important to understand the operating environment and its effect on ROV operations. To accom\n \n plish this, the properties and chemical aspects of water and how they are measured will be\n \n addressed to determine their overall effect on the ROV.\n \n The early method of obtaining environmental information was by gathering water samples for\n \n later analysis in a laboratory. Temperature is measured via electronic methods, and depth\n \n is measured with a simple water pressure transducer.

Newer environmen\n \n tal probes are available for measuring any number of water quality parameters such as pH,\n \n dissolved oxygen and CO2, turbidity, and other parameters.\n \n The measurable parameters of water are needed for various reasons. An analysis of 1 kg of seawater detailing only the major constituents of dis\n \n solved salts is provided in Table 2.3.\n \n The total quantity of dissolved salts in seawater is expressed as salinity, which can be calculated\n \n from conductivity and temperature readings. Salinity was historically expressed quantitatively as\n \n grams of dissolved salts per kilogram of water expressed as percentage or, more commonly, in\n \n parts per thousand ppt. To improve the precision of salinity measurements, salinity is now defined\n \n as a ratio of the electrical conductivity of the seawater to the electrical conductivity of a standard\n \n concentration of potassium chloride solution. Thus, salinity is now defined in practical salinity units\n \n PSU, although one may still find the older measure of salt concentration in a solution as parts per\n \n thousand or percentage used in the field.\n \n Ocean water has a fairly consistent makeup, with 99% having between 33 and 37 PSU in dis\n \n solved salts. Generally, rain enters the water cycle as pure water and then gains various dissolved\n \n minerals as it travels toward the ocean. At 0 PSU i.e., fresh water, maximum density is approximately 4C with a\nfreezing point of 0C. At 24.7 PSU and above, ocean water has a freezing point of its maximum\ndensity;

therefore, there is no maximum density temperature above the freezing point. The maxi\n \n mum density point scales in a linear fashion between 0 and 24.7 PSU Figure 2.1.\n \n Thus, ocean water continues to increase in density as it cools and sinks in the open ocean.

Due to the shallow water nature of the fresh water collec\n \n tion points, man has placed various items of machinery, structures, and tooling in and around these\n \n locations. The ROV pilot will, in all likelihood, have plenty of opportunity to operate within the\n \n fresh water environment.\n \n The properties of water directly affect the operation of ROV equipment in the form of tempera\n \n ture affecting components and electronics, chemistry affecting seals, incurring oxidation, and\n \n degrading machinery operation, and specific gravity buoyancy and performance. These param\n \n eters will determine the buoyancy of vehicles, the efficiency of thrusters, the numbers and types of\n \n biological specimens encountered, as well as the freezing and boiling points of the operational envi\n \n ronment. The water density will further affect sound propagation characteristics, directly impacting\n \n the operation of sonar and acoustic positioning equipment.\n \n Fresh water has a specific gravity of 1.000 at its maximum density. In the range between 3.98C and the freezing point of water, the molecular lattice structure\nin the form of ice crystals again increases the overall volume, thus lowering its density per unit\n \n volume remember, ice floats. The point of maximum density for fresh water occurs at 3.98C the\npoint just before the formation of ice crystals. At the freezing point of water, the lattice structure\n \n rapidly completes, thus significantly expanding the volume per unit mass and lowering the density\n \n at that temperature point. As a result, lakes and rivers behave differently at the\n \n freezing point than ocean water. As the weather cools with the approach of winter, the surface\n \n water of a fresh water lake is cooled and its density is increased. Surface water sinks and displaces\n \n bottom water upward to be cooled in turn.